Modelling and Analysis of a Honeycomb Sandwich Panel

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Abstract - *A sandwich panel is any structure made of three layers: a low-density core, and a thin skin-layer bonded to each side. Sandwich panels are used in applications where a combination of high structural rigidity and low weight is required. Hence, we have chosen PEEK core and Carbon Fibre facing sheets for our study. Structural Analysis is the determination of the effect of loads on a physical structure. In this project we have performed structural analysis with information's such as structural loads, geometry, support conditions and material properties. The results which include deformations, stresses and displacements are compared with conditions of failure. Thickness of the hexagon cell and facing plates are varied to see how the sandwich panel will perform. We have incorporated the proposed sandwich panel in a car bumper to see how it performs under Impact or Crash. The same Impact/Crash analysis is done for a car bumper using conventional material such as steel. Results of the proposed bumper is compared with the steel bumper to see if it performs better. From these results conclusions and suggestions are drawn.*

Key Words: **Honeycomb sandwich panel, Bumper, Impact analysis, Fusion 360**

1.INTRODUCTION

Honeycomb structure can be found in nature or can be man-made. The structure of a honeycomb is such that it minimizes the amount of material used which thereby results in minimal cost and weight. In mechanical structures stiffness, strength and weight efficiency are some important criteria. In these types of cases, sandwich panels are commonly used. The sandwich panel is made up of facing plates bonded on the upper and lower sides which are strong and stiff with a low-density core material in between. A sandwich panel comprises of three layers: a low-density core and facing sheets bonded on either side of the core respectively. Sandwich panels are commonly used in structures where strength, stiffness, and weight efficiency are criteria which play an important role in the overall composition of the structure. Sandwich Panels are widely used in the aerospace and automobile industry. The purpose of the facing sheets is that it carries all the bending stress. While the less dense core carries all the shear stress. This is the basic way of how a honeycomb sandwich panel works when subjected to load. For entire sandwich panel to have a good stiffness to weight ratio, proper design and choice of materials must be implemented. Honeycomb sandwich panels are widely used in aerospace and automobile industries due to its unique high stiffness to weight ratio properties.For nearly same weight honeycomb sandwich panels can give up to 30 times higher stiffness than plain metallic sheets. These panels are manufactured and pre-fabricated to size and specification.The unique structure makes it a good insulation for heat and sound. The cellular structure of hexagons the hole spacing occupies most of the space. These heat and sound insulation properties make it suitable to be used almost anywhere applicable. Honeycomb Panels are light weighted with a very low density as compared to other products with the same volume.
Based on the studied literature survey we have been able to understand about honeycomb sandwich panels of different materials as well as how the panels react when subjected to a particular pressure or load.
Their high stiffness to weight ratio, high thermal insulation property, and high impact strength has given us a great insight on the working of a sandwich panel. We have also understood how the structural behaviour of a sandwich panel varies with changing parameters such as cell size, height of the core, facing sheet thickness etc.
Literature surveys about bumpers have given us an insight on how a bumper is a vital parameter in a car which is used as a safety precaution for not only the passengers but also for pedestrians. We have studied about the impact energy absorption from collision due to accidents.

It has applications in aircrafts, where performance with respect to mechanical aspects and weight-saving are considered to have utmost importance. Applications in the transportation industry is also existent.

These pre-made panels are extensively designed for use as building envelopes. They are present in industrial and office buildings, cold rooms and also in private houses, whether undergoing renovation or being built. They have a combination of a high-quality product with high flexibility in design. They usually are good in energy efficiency and also considered to be very sustainable.

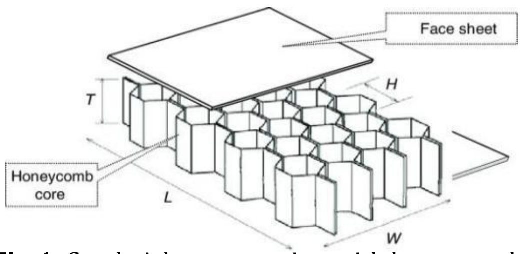

Fig-1: Sandwich construction with honeycomb core

New concepts and sandwich designs are studied, investigated and implemented. Many concepts are developed aimed for in a way such the core has a better functionality in both transferring and distributing applied loads among the facing sheets as well as enhancing toughness of the structure.New material cores are studied for sandwich structure applications. Composites, thermoplastics, Polymers sandwich panels are being studied to see if they perform better than conventionally used sandwich panels such as aluminium, steel, titanium etc.Sandwich panels are being studied not only to improve its overall functionality in transferring and distributing applied loads, but also thermal insulation of panels is being carried out. Different combinations of core and facing sheets are being studied to find out the best suitable sandwich panel to be used for its appropriate application.On studying the mechanical and thermal properties of core and facing sheets and performing structural and thermal analysis on the proposed sandwich panel. We will be able to determine that if it will perform better than conventionally used sandwich panels. The same proposed sandwich panel when incorporated into the bumper of an automobile should have better crash worthiness when compared to a reference bumper.

1.1 OBJECTIVES

- To model a honeycomb sandwich panel on fusion 360 using a aluminum core and peek facing sheets.
- To conduct accurate analysis for various structural loads, geometry, support conditions and material properties from which we obtain results that give us deformations, stresses and strains.
- To further consider the application of honeycomb structured sandwich panel for the design of car bumpers.Obtaining design data of existing bumper model.3D modelling of a bumper on fusion 360.
- Impact analysis on bumper system by using Fusion 360 for Frontal barrier impact ,Pole impact.

1.2 METHODOLOGY

- Modelling of the hexagonal cell structure is done and then extruded. Assembly of group of Hexagonal cells will be generated to form the core of the sandwich panel. Lastly, modelling of the top and bottom rectangular panels are done and the assembled with the core to form the required honeycomb sandwich panel, the modelling of the panel is done on fusion 360.
- Individual Structural analysis (deformation, stress and strain) of core, plates and the entire sandwich panel are studied and analyzed in Fusion 360.
- Three cases will be taken into consideration (DOF as zero & applying pressure on top face, considering the structure as a cantilever beam with UDL load, simply supported beam with UDL). FEM analysis is carried out using fusion 360
- To further use the honey comb structured sandwich panel for modelling of a car bumper.Modelling of the car bumper is done using fusion 360 It is further

transferred onto fusion 360 for analysis to see how the bumper performs under a crash or certain impact.

2. Modelling of honeycomb sandwich panel

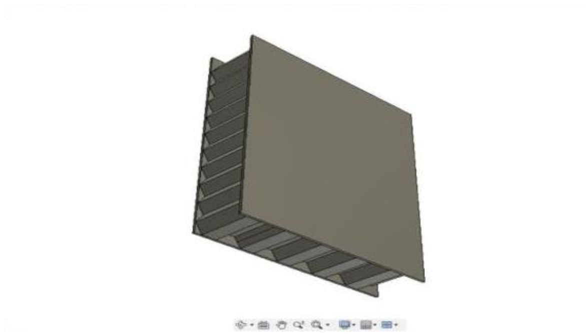

Fig-2: Drafted Honeycomb sandwich panel

- Dimensions of Hexagon Cell: Edge length(d)=3.5 mm;Depth=15mm;Thickness=0.68 mm
- Dimensions of Facing Sheet: Length =71.47 mm;Width =60.911 mm;Thickness=0.7 mm

2.1 MATERIALS USED

The honeycomb sandwich panel is modeled for three different materials.Material-1 is Polyether Ether Ketone - PEEK (Core) &Aluminium high strength alloy (facing sheet). Material-2 is Polyetherimide (Core) & carbon fiber (facing sheet). Material-3 is Aluminum (core & facing sheet). Each load case is done for above three materials and results are noted down.

2.2 LOADING CONDITIONS

- **CASE-1:** We apply pressure on one side of the honeycomb panel by keeping the other side fixed (DOF as zero). A pressure of 30Mpa is applied to the free side of the panel and the results are generated. The results of deformation, Von mises stresses, strain are further noted down.

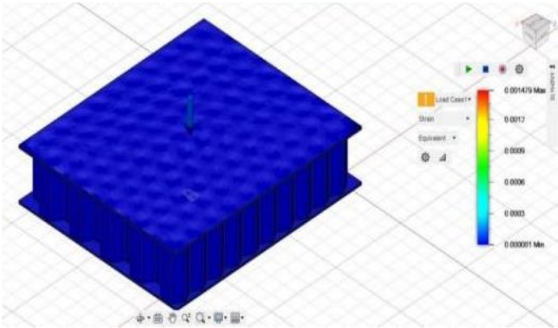

Fig-3: Loading condition on Honeycomb sandwich panel

- **CASE-2:** Consider the whole structure as cantilever beam, now applying the load uniformly.Here we have step by step process on how to do the structural analysis. 30KN is applied on the top face of honeycomb sandwich panel.

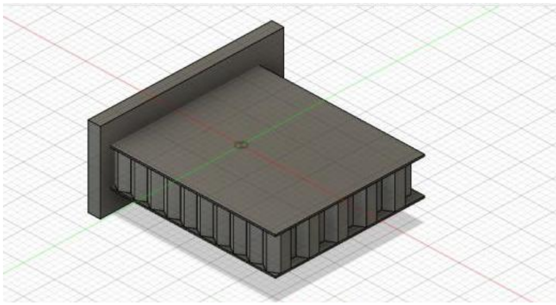

Fig-4: Honeycomb sandwich panel as a cantilever beam

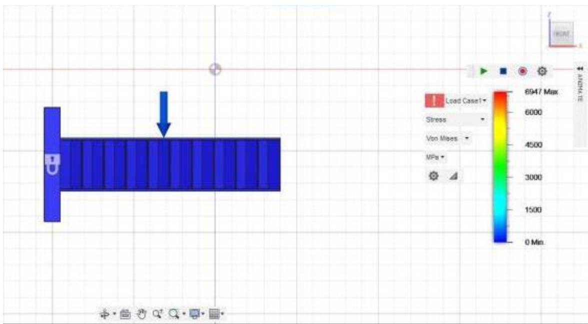

Fig-5: Loading condition on Honeycomb sandwich panel as a cantilever beam

- **CASE-3:** In this case, consider the structure as fixed beam with Uniform Distributed Load of 30KN is applied on the face of honeycomb sandwich panel that means keep right and left sides DOF as zero.

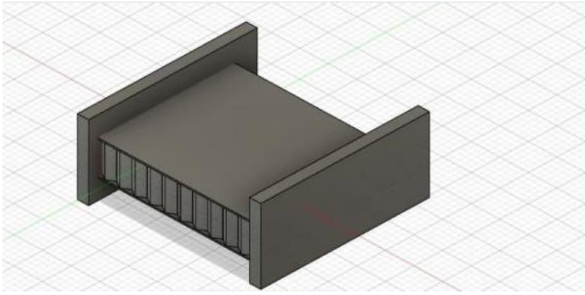

Fig-6: Honeycomb sandwich panel as a fixed beam

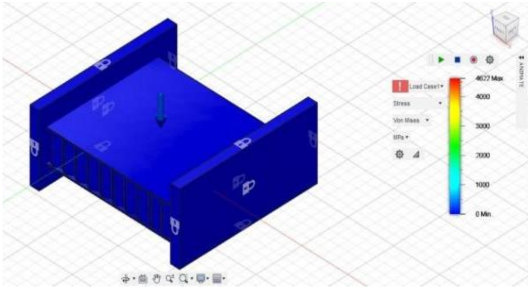

Fig-7: Loading condition on Honeycomb sandwich panel as a fixed beam

2.3 SIMULATION RESULTS

- Results for which the pressure of 30Mpa(load case-1) is applied on the face of the panel. The simulated results are

Materials used	Stress (Mpa)	displacement(mm)	Strain
PEEK and Aluminum high strength alloy	9244	12.74	0.8133
Polyetherimide and Carbon Fiber	11625	7.588	0.7351
Aluminum	8126	3.228	0.1966

- Results for which the uniform distributed load of 30 KN(load case-2) is acted on honeycomb panel as cantilever beam.The simulated results are

Materials used	Stress (Mpa)	displacement(mm)	Strain
PEEK and Aluminum high strength alloy	5217	13.25	0.2236
Carbon fiber and Polyetherimide	6947	7.339	0.2002
Aluminum	2912	3.994	0.06946

- Results for which the uniform distributed load of 30 KN is acted on face of honey comb panel as simply supported beam

Materials used	Stress (Mpa)	displaceme nt(mm)	Strain
PEEK and Aluminium high strength alloy	1056	0.4682	0.0375
Carbon fiber and Polyetherimid e	3326	1.215	0.07791
Aluminium	435.7	0.1642	0.00995

3. CAR BUMPER MADE OF HONEYCOMB SANDWICH PANEL

One application that we are focusing on is the manufacturing of car bumper using honeycomb structure sandwich panel.

The current generation of bumpers are used in vehicle which are directly connected to the chassis of the vehicle. At the occurrence of an accident the force is transferred to other parts of vehicle. There are no other supports to absorb that impact forces. So, there is a design that needs to absorb impact forces. Impact of accidents are extensively reduced with the application of stiffeners and that resists or absorbs impact forces. The objective of present study is to design and optimization of Automobile Bumper to avoid crashes and for the safety of passengers and pedestrians.

3.1 CRASH ANALYSIS OF A FRONTAL CAR BUMPER

An automobile's bumper is the front-most or rear-most part, intended to allow the vehicle to sustain an impact without harm to the vehicle's safety systems. They are not equipped for reducing damage to vehicle occupants in high-speed impacts but are progressively being designed to moderate damage to pedestrians struck by cars. In 1925, front and rear bumpers ended up as standard equipment of the automotive industry. The bumpers throughout that point are straightforward metal beams attached to the front and rear of a car. Currently, they have evolved into complicated, engineered components that are integral to the protection of the vehicle in low-speed collisions. Today's plastic auto bumpers and fascia systems are aesthetically pleasing, while offering advantages to both designers and drivers. The bulk of modern plastic car bumper system fascia is made of thermoplastic olefins, polystyrene, polyesters, polypropylene, polyurethanes, polyamides, or blends of these with, for instance, glass fibres, for strength and structural rigidity. The prerequisites of a bumper are to absorb a great deal of energy while impact, have good rust resistance, have high strength, light in weight, and simple to manufacture in large quantities.

3.2 MODELING OF CAR BUMPER

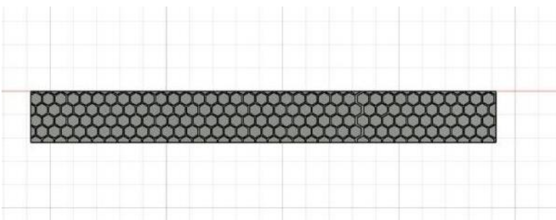

Fig-8: Top view of the honeycomb bumper

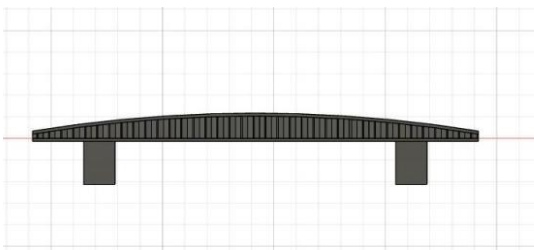

Fig-9: Front view of the honeycomb bumper

3.3 MATERIALS USED

The car bumper made of honeycomb sandwich panel is modeled for three different materials.Material-1 is Polyether Ether Ketone - PEEK (Core) & Aluminium high strength alloy (facing sheet). Material-2 is Polyetherimide -PEI (Core) & carbon fiber (facing sheet). Material-3 is High density Polyethylene(Core) & ABS plastic(facing sheet). Each load case is done for above three materials and results are noted down.

3.4 TEST CASES

➢ **CASE-1: WALL IMPACT**

under wall impact the car bumper is tested for two conditions

- ✓ If the car is travelling at 60km/hr and hits the wall for this condition the simulation is done.
- ✓ If the car is travelling at 80km/hr and hits the wall for this condition the simulation is done.
- ✓ The wall is made of Steel.
- ✓ The above test conditions is done for the three different materials mentioned in the materials used.

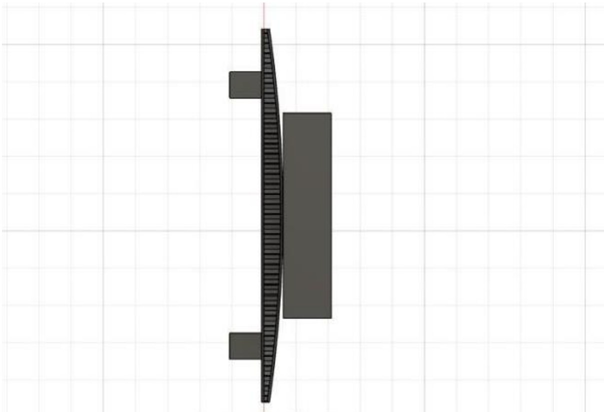

Fig-10: Front view of the honeycomb bumper on Collision with a wall

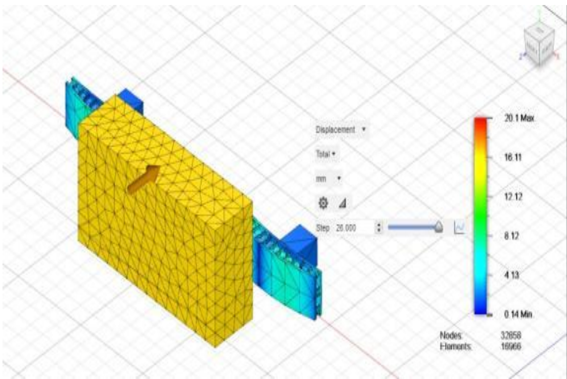

Fig-11: Displacement results when the bumper crashes into a wall for material-1 at 60Km/hr

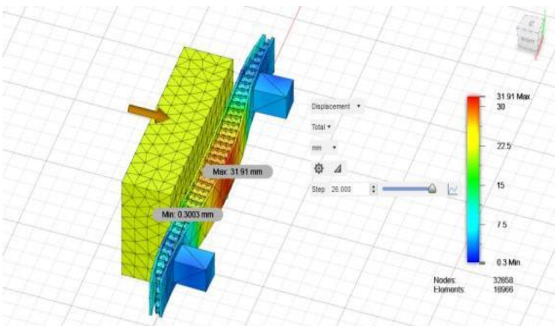

Fig-12: Displacement results when the bumper crashes into a wall for material-2 at 80Km/hr

Similarly the simulation is carried for different materials and different test cases.

➢ **CASE-2: POLE IMPACT**

under pole impact the car bumper is tested for two conditions

- ✓ If the car is travelling at 60km/hr and hits the wall for this condition the simulation is done.
- ✓ If the car is travelling at 80km/hr and hits the wall for this condition the simulation is done.
- ✓ The wall is made of Steel.
- ✓ The above test conditions is done for the three different materials mentioned in the materials used.

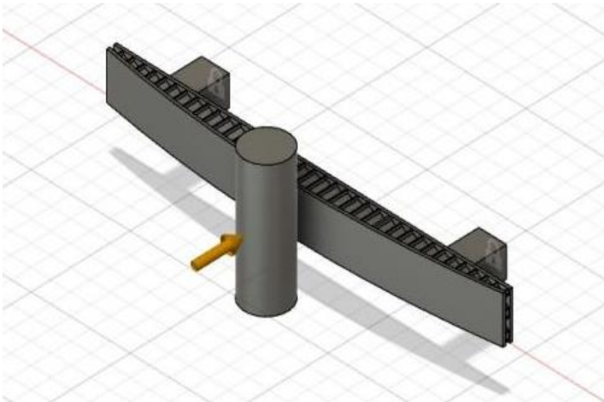

Fig-13: Isometric view of the honeycomb bumper on Collision with a pole

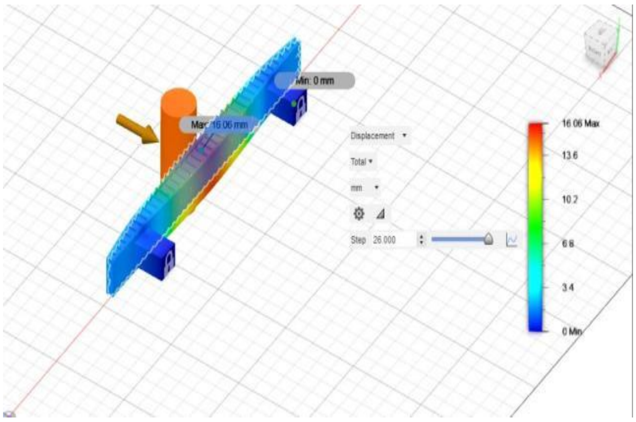

Fig-14: Displacement results when the bumper crashes into a pole at 60km/hr for material-1

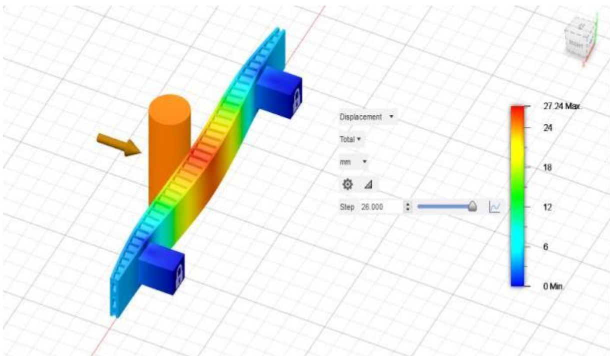

Fig-15: Displacement results when the bumper crashes into a pole at 80km/hr for material-1 Similarly the simulation is carried for different materials and different test cases.

3.5 COMPARISON OF SIMULATION RESULTS

3.5.1 Comparison of wall Impact analysis

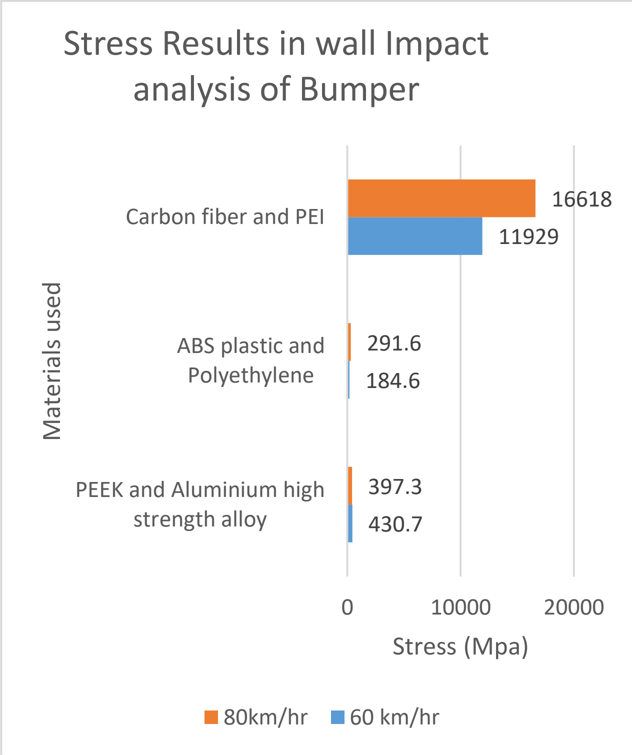

Fig-16: Stress Comparison Results in wall Impact Analysis of Bumper

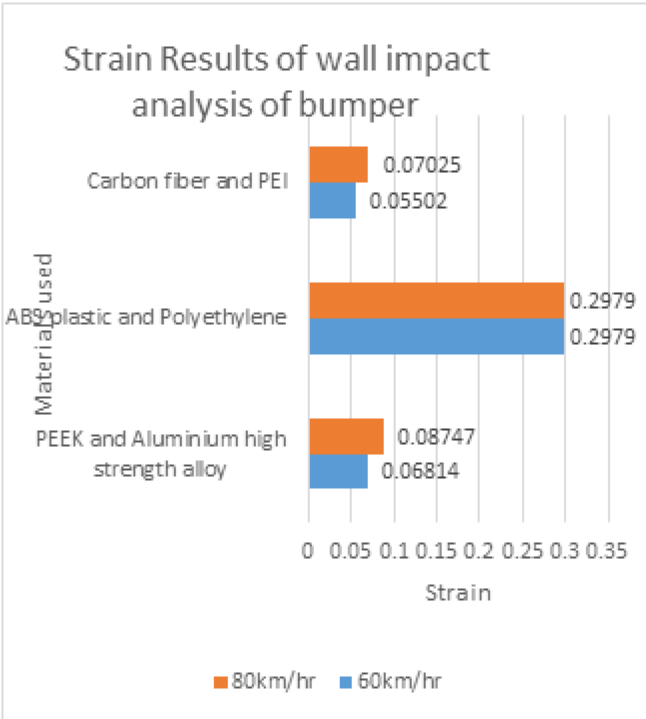

Fig-16: Strain Comparison Results in wall Impact Analysis of Bumper

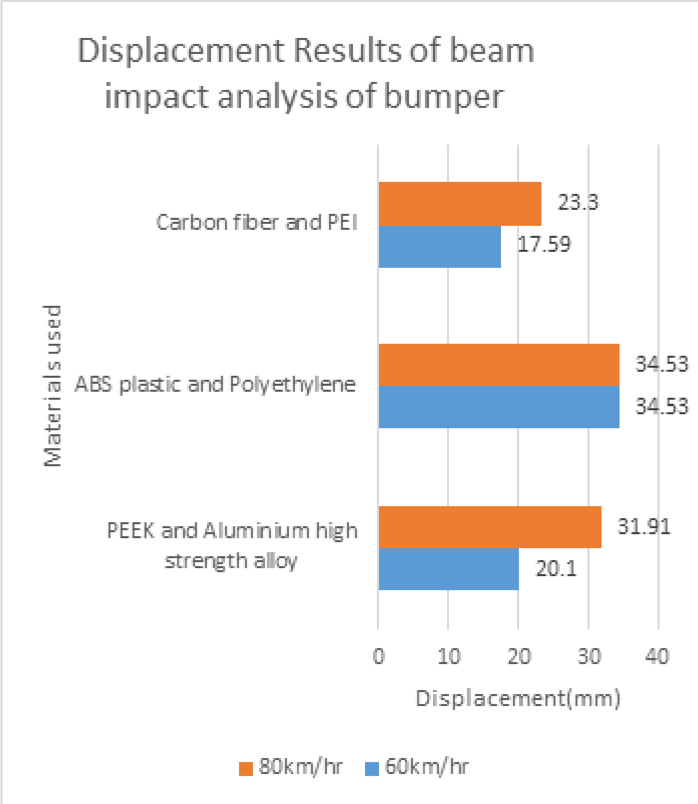

Fig-17: Displacement Comparison Results in wall Impact Analysis of Bumper

3.5.2 Comparison of pole Impact analysis

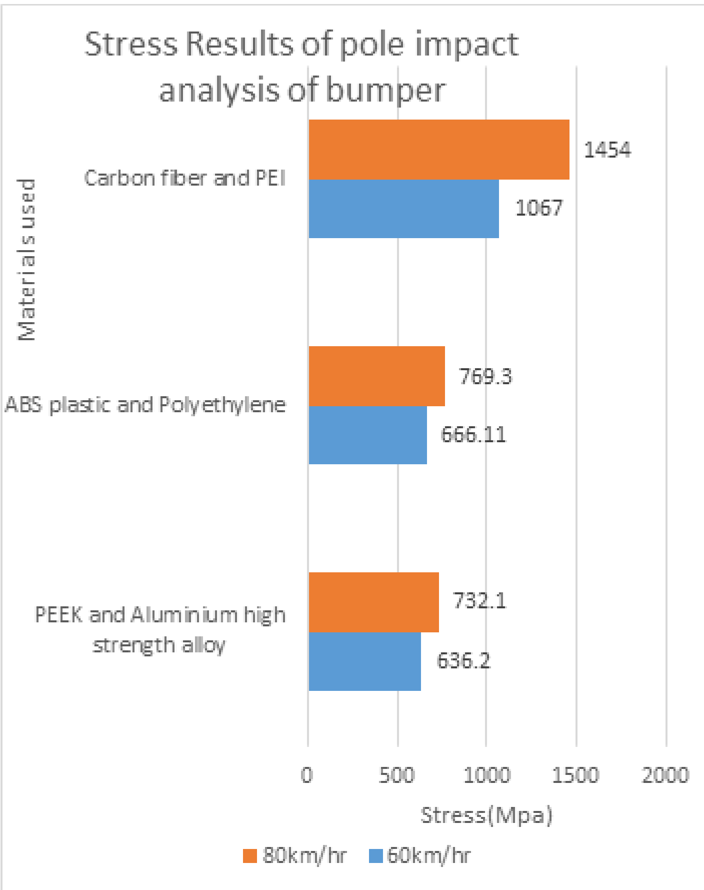

Fig-18: Stress Comparison Results in pole Impact Analysis of Bumper

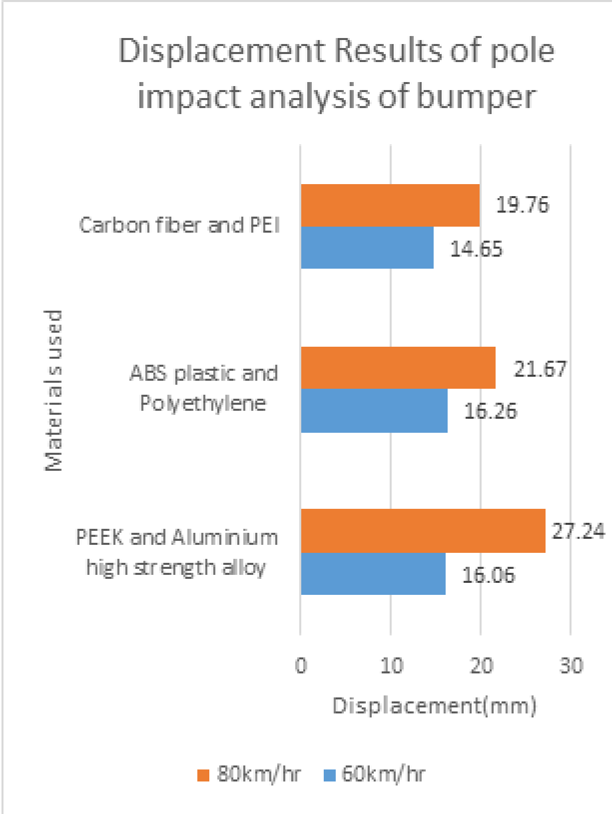

Fig-19: Displacement Comparison Results in pole Impact Analysis of Bumper

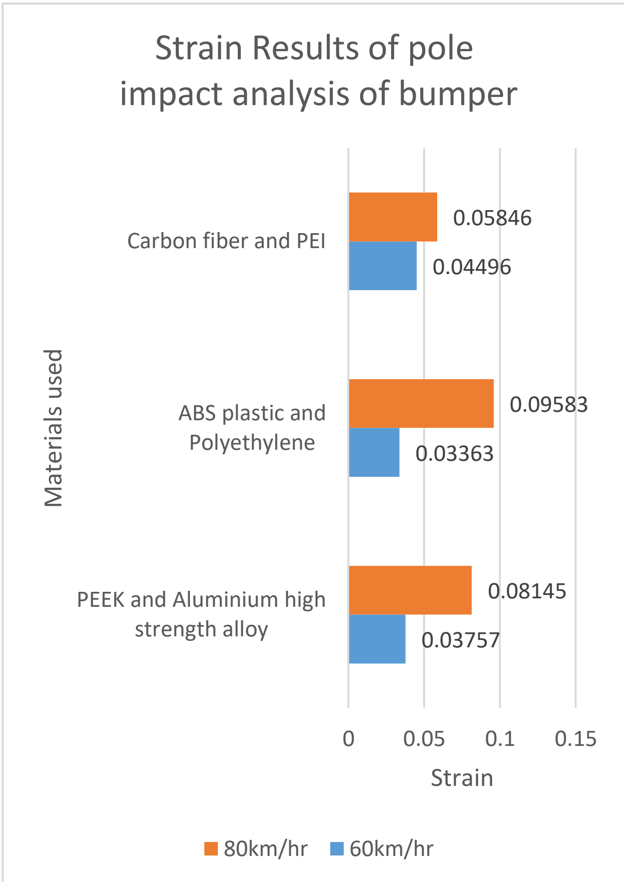

Fig-20: Strain Comparison Results in pole Impact Analysis of Bumper

4. CONCLUSIONS

In this study static structural analysis is done for the modelled Honeycomb Sandwich Panel and dynamic analysis is done for the modelled bumper. The conclusions obtained from this study are:

A bumper that is made of a honeycomb sandwich panel the maximum strain is concentrated on the honeycomb core and very less percentage of the strain is transferred from the core on to the holds, which is further attached to the car Therefore, a honeycomb sandwich panel can be used to make car bumpers as most of the damage is taken by the core during impact which improves the safety of the car.

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