Structural Modelling and Impact Variation Study of a Car Bumper at Varying Speeds.

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Abstract- The fuel efficiency and emission gas regulation of passenger cars are two important issues in nowadays. The best thing is to increase the fuel efficiency without sacrificing safety is to employ thermoplastic materials in to the cars. Bumper is the one of the part having more weight. The bumper is made of steel, Aluminium, rubber, or plastic that is mounted on the front and rear sides of a passenger car. The bumper is to absorb the shock to prevent or reduce damage to the car. In this report the steel bumper is replaced with various other thermoplastic bumpers to study their characteristics at different speeds.

In this the most important variables like materials, structures and impact conditions are studied for the analysis of bumper beam, in order to improve the crashworthiness during collision. The simulation of a bumper modelling using Pro/Engineer, and impact analysis is done by COSMOSWORKS by varying the speeds.

I. INTRODUCTION

Today the numerical models reproduce all details of vehicles. With the analysis and employing upwards of 1,000,000 elements, it may take few days to solve the problem even by the modern multiprocessor computers. The bumper is a structural member attached with front and rear ends of the motor vehicle. Nowadays the development of the automobile technology is more and more light weighing materials like Thermoplastics are applied to the automobile body. Thermoplastic has rate dependant properties. This is due to the viscoelastic properties of Polypropylene which is used as matrix in the material. The bumper is a structural component, which contributes to the crashworthiness or occupant's protection during a front or rear collision. There is an interest among the researchers to move from conventional materials such as plastic, aluminium, or steel to materials such as polymeric based composites in the bumper system. For a composite material bumper system has been made using sheet moulding compound with random chopped glass fibre composites.

II. LITERATURE SURVEY

S. Prabhakaran et al (2012) said that the fuel efficiency and emission of gas regulation in passenger cars are two important issues in nowadays. The best way is to increase the fuel efficiency without sacrificing safety is to employ fibre reinforced composite materials in the cars.

Mahesh Agnihotri et al (2012) in their report explained that nowadays, there are many software packages that make it easy to display and describe an imaginary idea in better quality and a better sense.

Dong Wook Lee et al (2008) proposed an innovative inflatable bumper concept, called the "I-bumper", is developed in this research for improved crashworthiness and safety of military and commercial vehicles.

Svoboda Jiri et al (2006) concerns with the bumper system design optimization for leg form impact.

Mohd. Nizamuddin et al (2004) said that bumper fascia is a component, which contributes to vehicle crashworthiness during front or rear collisions.

III. METHODOLOGY

3.1 Modelling with PRO-E

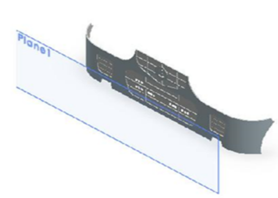


Fig: 3.1a. Model of bumper modelled using PRO-E.

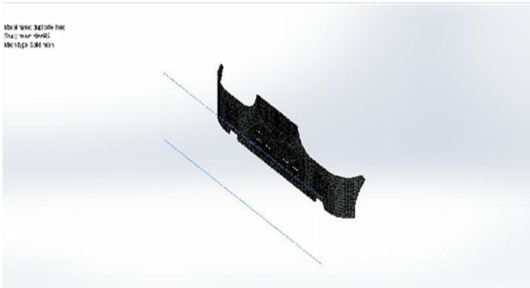


Fig 3.1b. Meshed bumper model using COSMOS Works.

3.2. IMPACT ANALYSIS OF STEEL BUMPER

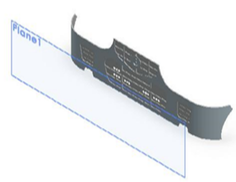


Fig3.2a..model of steel bumper

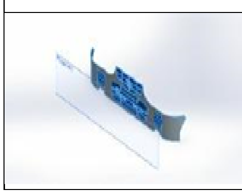
<L_MdInf_SldBd_ Nm/>	**Treated As**	**Volumetric Properties**
	Solid Body	Mass:51.5281 kg Volume:0.0660617 m^3 Density:7800kg/m^3 Weight:504.976 N

Table 3.2a Volumetric properties of steel

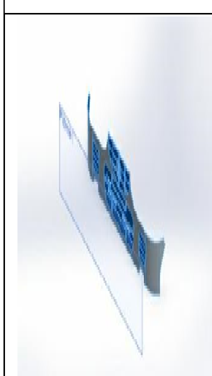
Model Reference	Properties
	Name: Chrome Stainless Steel Model type: Linear Elastic Isotropic. Default failure criterion: Max von Mises Stress Yield strength: 1.72339e+008 N/m^2 Tensile strength: 4.13613e+008 N/m^2 Elastic modulus: 2e+011 N/m^2 Poisson's ratio:0.28 Mass density: 7800 kg/m^3 Shear modulus: 7.7e+010 N/m^2 Thermal expansion coefficient: 1.1e-005 /Kelvin

Table3. 2b material properties of steel.

3.2.1 STUDY RESULTS AT 45 KMPH

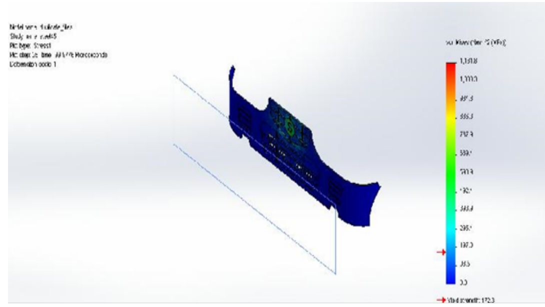


Fig 3.2.1a: Stress plot at 45 kmph

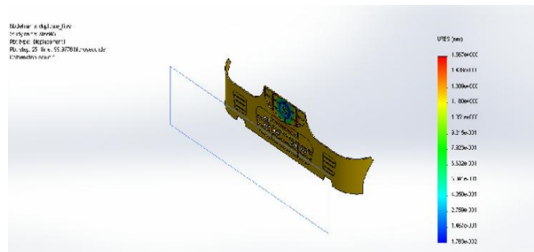


Fig3.2.1b:Displacement plot at 45 kmph

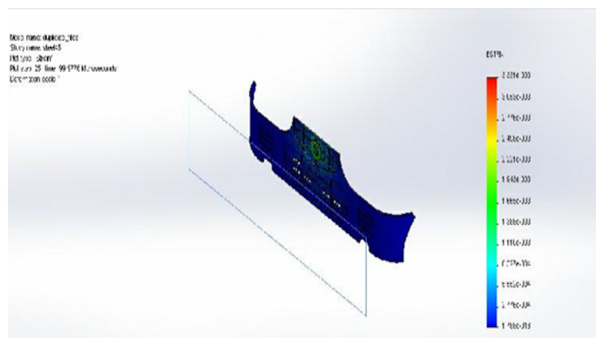


Fig3.2.1c Strain plot at 45 kmph

3.2.2 STUDY RESULTS AT 75 KMPH

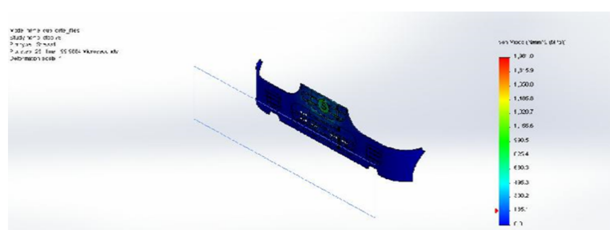


Fig3.2.2a: Stress plot at 75 kmph

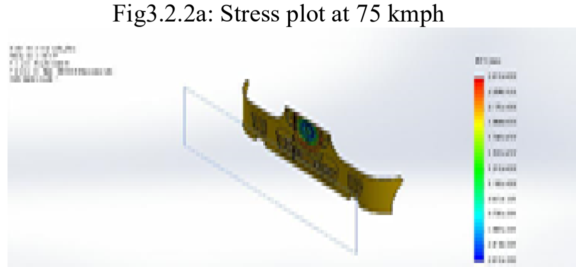


Fig3.2.2b: Displacement plot at 75 kmph

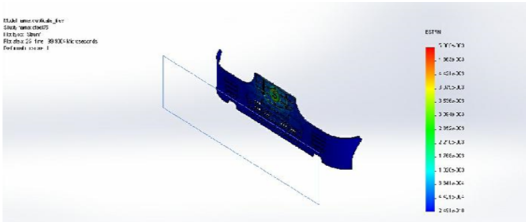


Fig 3.2.2c: Strain plot at 75 kmph

3.3. IMPACT ANALYSIS OF ABS PLASTIC BUMPER

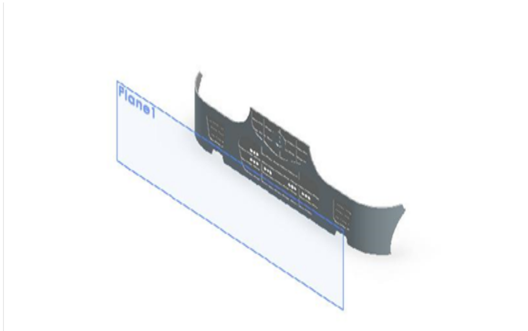


Fig 3: Model of ABS Plastic bumper

<L_MdInf_SldBd_Nm/>	Treated As	Volumetric Properties	Document Path/Date Modified
	Solid body	Mass:6.738 29 kg Volume:0.0 0660617 m^3 Density:102 0kg/m^3	D:\Project\ duplicate files.SLDPRT Jun19 10:32:38 2013

Table 3.3a: Volumetric properties of ABS Plastic

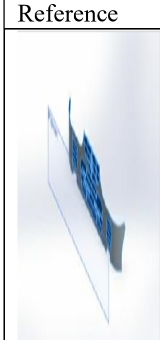
Model Reference	Properties
	Name: ABS Model type: Linear Elastic Isotropic. Default failure criterion: unknown. Tensile strength: 4e+007 N/m^2 Elastic modulus: 2e+009 N/m^2 Poisson's ratio: 0.394 Mass density: 1020 kg/m^3 Shear modulus: 3.189e+008 N/m^2

Table 3.3b: material properties of ABS Plastic

3.3.1 STUDY RESULTS AT 45 KMPH

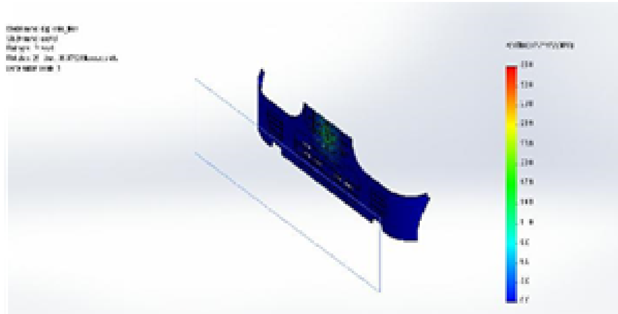


Fig 3.3.1a: Stress plot at 45kmph

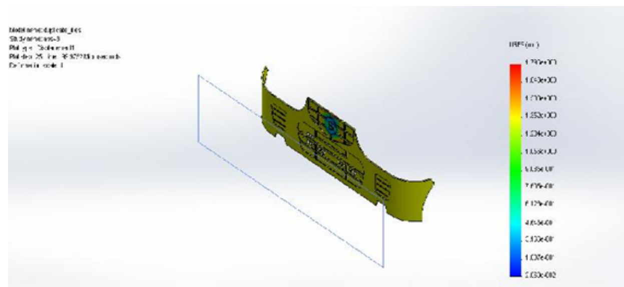


Fig 3.3.1b.Displacement plot at 45kmph

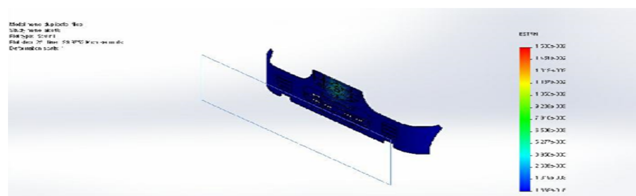


Fig 3.3.1c.Strain plot at 45kmph

3.3.2 STUDY RESULTS AT 75 KMPH

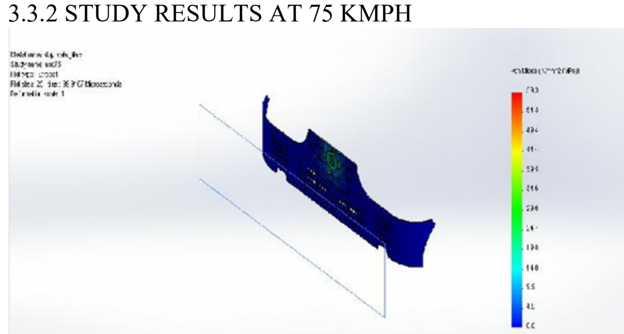


Fig 3.3.2a Stress plot at 75kmph

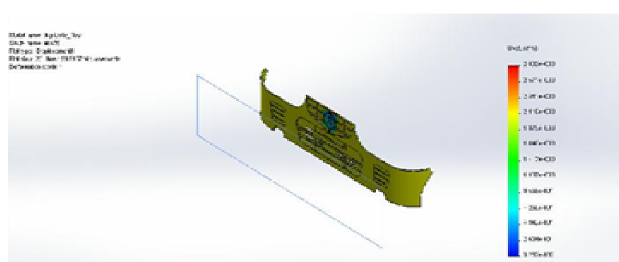


Fig 3.3.2b.Displacement plot at 75kmph

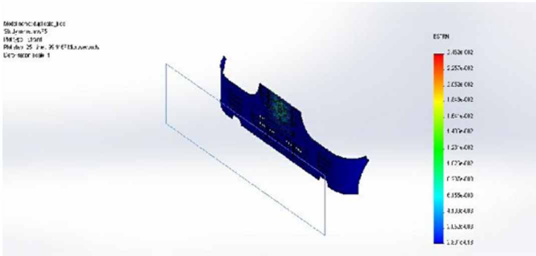


Fig 3.3.2c.Strain plot at 75kmph

3.4. IMPACT ANALYSIS OF PEEK BUMPER

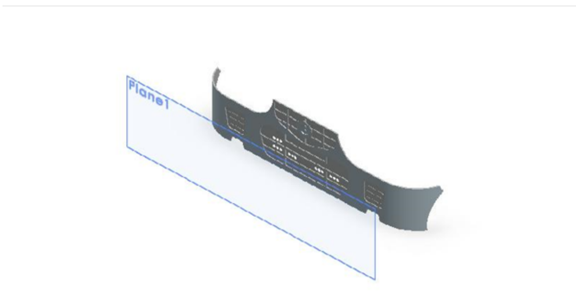


Fig 3.4.model of PEEK bumper

<L_MdInf_SldBd_Nm/>	Treated As	Volumetric Properties	Document Path/Date Modified
	Solid body	Mass:8.65408 kg Volume:0.006606 m^3 Density:1310 kg/m^3 Weight:84.81 N	D:\Project\duplicate_files.SLDPRT Jun 19 12:53:26 2013

Table3.4a.Volumetric properties of PEEK

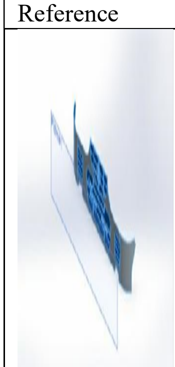
Model Reference	Properties
	Name: Polyetheretherketone. Model type: Linear Elastic Isotropic. Default failure criterion: Unknown Tensile strength: 9.5e+007 N/m^2 Compressive strength: 1.25e+008 N/m^2 Elastic modulus: 3.9e+009 N/m^2 Poisson's ratio: 0.4 Mass density: 1310 kg/m^3

Table 3.4b.material properties of PEEK

3.4.1 STUDY RESULTS AT 45 KMPH

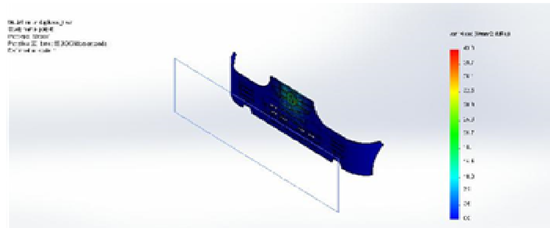


Fig 3.4.1a.Stress plot at 45kmph

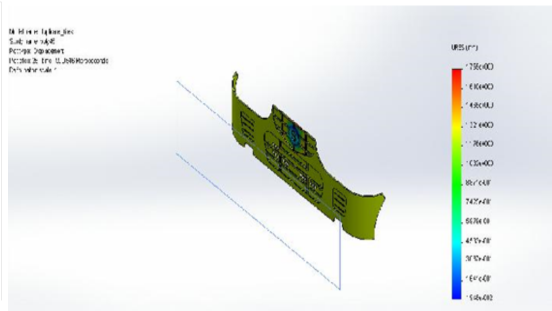


Fig 3.4.1b.Displacement plot at 45 Kmph

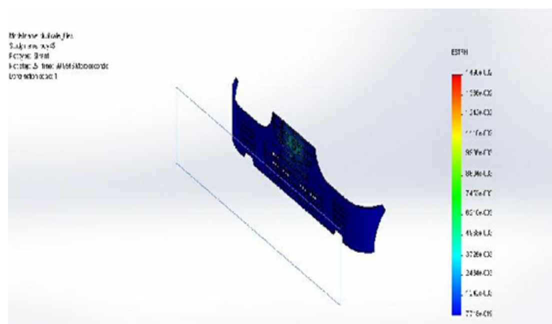


Fig 3.4.1c.Strain plot at 45 Kmph

3.4.2. STUDY RESULTS AT 75 KMPH

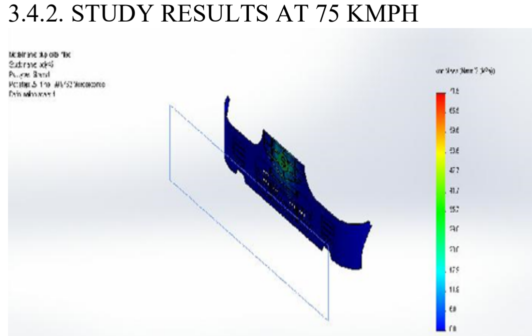


Fig 3.4.2a.Stress plot at 75 Kmph

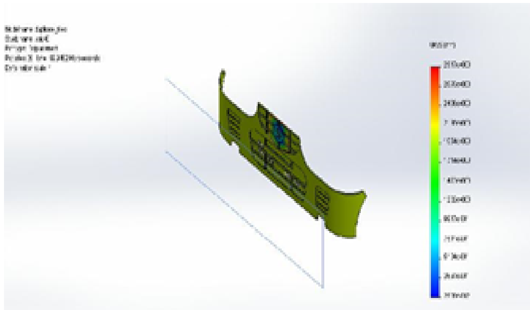


Fig 3.4.2b.Displacement plot at 75 Kmph

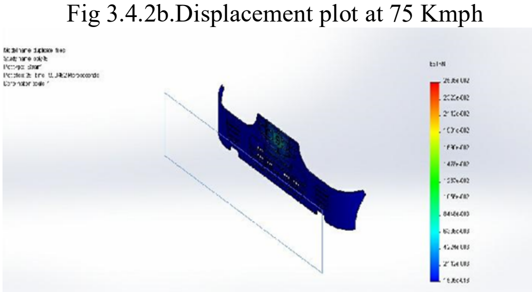


Fig 3.4.2c.Strain plot at 75 Kmph

IV. RESULTS AND DISCUSSIONS

RESULTS OF FEA ANALYSIS

The results of the analysis were stress, displacement and strain values distribution along the car bumper model are analysed to determine the peek values at 45, 75 and they are shown in tables below.

Material	Stress (N/mm^2)	strain	Displacement (mm)
Steel	1181.8	0.00333097	1.56706
ABS plastic	35.8113	0.0158314	1.79629
PEEK	43.3362	0.014904	1.75466

Table 4.1.Results using Impact speed of 45kmph

Material	Stress (N/mm^2)	Strain	Displacement (mm)
Steel	1981.02	0.0053047	2.60958
ABS plastic	59.2588	0.0246197	2.80215
PEEK	71.4809	0.0253453	2.91703

Table 4.2.Results using impact speed of 75Kmph

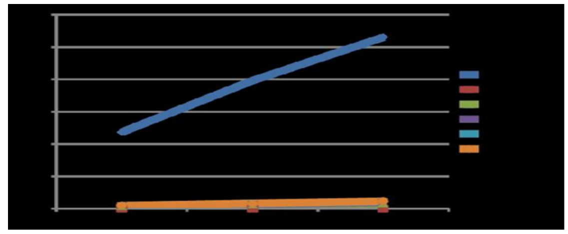


Fig4.1a.Graph showing Stress vs. Impact Speed for different materials.

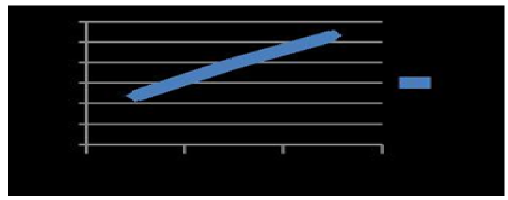


Fig 4.1b Graph showing Stress vs. Impact Speed for steel.

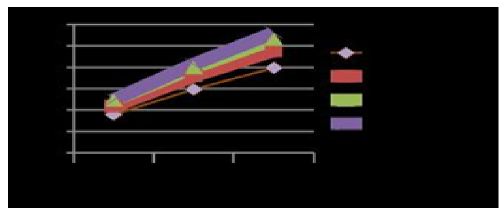


Fig 4.1c Graph showing Stress vs. Impact Speed for different materials.

In graph 4.1a, shows that the stress value of steel is recorded maximum for all the speeds. In fig 4.1c among the other four materials the ABS registered the least stress value, which is measured to be 35.8113 Mpa, 59.2588 Mpa and 79.2475 Mpa for 45, 75 and 100 Kmph respectively, correspondingly steel registered the stress values of 1181.8 Mpa, 1981.02 Mpa and 2652.49 Mpa.

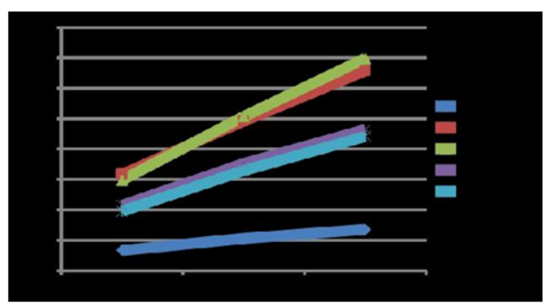


Fig 4.2: Graph showing Strain Vs. Impact Speed for different materials

In fig 4.2, a graph plotted for stain vs. speed shown that the steel has the least strain.The maximum difference between steel and ABS is negligible, as the maximum difference is found to be around 0.026 at the speed of 100 Kmph.

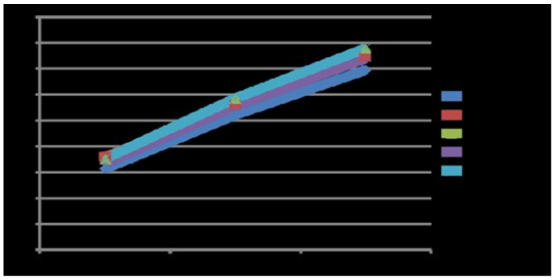


Fig 4.3: Graph showing Displacement Vs. Impact Speed for different materials

In the displacement graph, difference in displacements between the materials is almost overlapping with each other and the maximum difference between all the materials put together are in the limits of maximum of 0.5mm.

From above three graphs ABS shows a better display compared to the other material and a little compromise in strain and displacement values was also obtained. Hence ABS can be selected as the best material for the manufacturing of car bumpers.

MATERIAL COST ANALYSIS

Material	Steel	ABS
Cost Per Kg.	Rs 65/	Rs 85/
Weight of bumper	51.5281 Kgs	6.73829 Kgs
Total Material Cost	Rs 3349.33/	Rs 572.76/

Cost analysis of steel and ABS

From the table it can be clearly seen that the cost of the ABS is almost 6 times lesser than that of steel to produce the same volume of bumper.

The cost saved by using ABS material = 3349.33572.76

= Rs 2776.57/

Hence by using ABS as bumper material an amount of Rs 2776/ is saved and also the strength of the bumper is increased.

V. CONCLUSION

1. In this project, the modelling of bumper was done in Pro-e software and Impact analysis was done by using COSMOS Works. FEM gives the prediction of critical area from the viewpoint of Impact analysis using drop test.

2.Finally, different materials were used as bumper material and impact analysis is done by drop test by varying speeds.

3.In consideration with strain and displacement, ABS produced good results compared with other materials. Hence ABS can be selected among the other materials.

4. Though steel has good strain and displacement values, the weight becomes the cause for poor selection of material.

5.This study hopes to give information for the manufacturer to improve the impact loading of the Car Bumper.

6. It can also help to reduce cost and times in research and development of new product and this study will help to understand more the behaviour of the Car Bumper during impact load.

VI. REFERENCES

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[6] Steve Ickes MTek, “Development of Low Density Glass Mat Thermoplastic Composites for Headliner Applications”-Inc. Paper No. 2000-01-1129.

Web sites:

[7] http://Www.mtab.web/.

[8] http://Www.nhtsa.com/.

[9] http://Www.azom.com/.

[10] http://www.plastemart.com/.

[11] http://www.teoma.com/.