

# Comparative Analysis of Glass Fiber and Fiber Metal Laminates for Car Bumper

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**ABSTRACT:** Big or small accidents happening in our day-to-day life, due to increase in number of vehicles used. In four wheel drives, first component of vehicle facing accident is Bumper. We all know bumper's main purpose is giving protection for every component of vehicle as well as human beings, when accidents occur. In this paper investigates the improvement of GFRP car bumper's impact strength by the introduction of non-isotropic laminate composite methodology. The comparative analysis was also done in this paper between GFRP and Glass Fiber with Aluminium lamina by Ansys Workbench 13.

**KEYWORDS:** Glass, Aluminium, Fiber, Car Bumper, Laminate Composites.

## I. INTRODUCTION

Car bumper is a common part for almost all the four wheel drives. Based on the purpose of four wheelers bumper's shape, size, design & materials are vary. In modern cars front bumper plays a crucial role. It must provide safety for the whole vehicle component and human beings when collision happens. It must give the aesthetic property; so it should be designer friendly materials.

In automobiles, a bumper is usually a metal bar or beam, attached the vehicle's front-most and rear-most ends, designed to absorb impact in a collision. Regulations for automobile bumpers have been implemented to allow the car to sustain a low-speed impact without damage to the vehicle's safety systems. The main function of a bumper is to protect the car's body in a slight collision, typically at parking speed. The bumper structure on modern automobiles generally consists of a plastic cover over a reinforcement bar made of steel, aluminum, fiberglass composite, or plastic.

Initial stages of car bumper's materials are in metal. Need of modern car speed needs to reduce the weight of the car and design aesthetics metal materials replaced with plastic and composite materials. Then the bumper material used in cars is GFRP. It was light in weight, high strength, and low price excellent in esthetics.

Fiber metal laminates are good candidates for advanced aerospace structural applications due to their high specific mechanical properties especially fatigue resistance. The most important factor in manufacturing of these laminates is the adhesive bonding between aluminum and FRP layers. In this study several glass-fiber reinforced aluminum laminates with different bonding adhesion were analyzed in ansys (mechanical ACP).

Mechanical strength like Tensile, Compression and Impact strength are compared. It was observed that the impact strength is greater in aluminium GFRP. In addition, FMLs of with good adhesion bonding show better resistance under low velocity impact and their corresponding contact forces are about 25% higher than that of specimens with a weak bonding. Moreover, maximum central deflections in laminates with strong bonding are about 30% lower than that of FMLs with poor adhesion.

## **II. STANDARDS FOR BUMPER**

In most jurisdictions, bumpers are legally required on all vehicles. The height and placement of bumpers may be legally specified as well, to ensure that when vehicles of different heights are in an accident, the smaller vehicle will not slide under the larger vehicle.

### **INTERNATIONAL STANDARDS**

Under the International safety regulations originally developed as European standards and now adopted by most countries outside North America, a car's safety systems must still function normally after a straight-on pendulum or moving barrier impact of 4 km/h (2.5 mph) to the front and the rear, and to the front and rear corners of 2.5 km/h (1.6 mph) at 45.5 cm (18 in) above the ground with the vehicle loaded or unloaded.

### **INDIA**

India is the 10th largest producer of automobiles in the world. The country's attention to vehicle safety requirements has progressed significantly since the year 2000. More than 35 million vehicles are registered in India. In 1989, the Central Motor Vehicle Rules (CMVR) became effective and the rules are greatly enforced today. Under Rule 126 of the CMVR, manufacturers of motor vehicles must allow a separate agency to test prototypes of new vehicle designs for safety requirements. It is necessary for all vehicles in India to have basic safety features, such as seat belts, rear-view mirrors and laminated safety glass for windshields. Also, all vehicles in use must pass a pollution test every six months.

## **III. LITERATURE REVIEW**

Hosseinzadeh RM and et.al in their paper says that bumper beams are one of the main structures of passenger cars that protect them from front and rear collisions. In this paper, a commercial front bumper beam made of glass mat thermoplastic (GMT) is studied and characterized by impact modeling using LS-DYNA ANSYS 5.7 according to the E.C.E. UNITED NATIONS AGREEMENT [UNITED NATIONS AGREEMENT, Uniform Provisions Concerning the Approval of Vehicles with regards to their Front and Rear Protective Devices (Bumpers, etc.), E.C.E., 1994]. Three main design factors for this structure: shape, material and impact conditions are studied and the results are compared with conventional metals like steel and aluminum. Finally the aforementioned factors are characterized by proposing a high strength SMC bumper instead of the current GMT.

Nitin S. Gokhale, Sanjay S. Deshpande, Dr. Anand N. Thite[14] Manufacturing of a bumper system from aluminum extrusions often involves series of forming operations performed in the soft W-temper condition, and then artificially age-hardening of the components to the material's peak hardness T6 condition. It is probable that proper finite element (FE) modeling of the crash performance of the resulting systems must rely upon a geometry obtained from an FE model following the process route, i.e., including simulation of all major forming operations. The forming operations also result in an inhomogeneous evolution of some internal variables (among others the effective plastic strain) within the shaped components. Results from tensile tests reveal that plastic straining in W-temper leads to a significant change of the T6 work-hardening curves. In addition, the tests show that the plastic predeformation causes a reduction of the elongation of the T6 specimens. In the present work, these process effects have been included in a



user- defined elastoplastic constitutive model in LS-DYNA incorporating a state-of-the-art anisotropic yield criterion, the associated flow rule and a non-linear isotropic work hardening rule as well as some ductile fracture criteria.

Zonghua Zhang, Shutian Liu, Zhiliang Tang discusses that material selection for automotive closures is influenced by different factors such as cost, weight and structural performance. Among closures, the automotive bonnet must fulfill the requirements of pedestrian safety which is evaluated by child and adult headform impactors. The mechanisms of injury are complex, therefore; the Head Injury Criterion (HIC) which shows a measure of the likelihood of head injury arising from an impact is developed. HIC includes the effects of head acceleration and the duration of the acceleration. In this paper a new finite element model has been developed which is capable to simulate head impact phenomenon between headform impactors and composite bonnet. Then the behavior of three identical bonnets made of steel, aluminum and composite have been investigated by the developed model.

In this paper, O. G. Lademo et.al discusses about a rib-reinforced thin-walled hollow tube-like beam (named as rib-reinforced beam) is presented for potential application in vehicle bumper. Through numerical simulation of the bending behavior under impact loads, the rib-reinforced beam is compared with thin-walled hollow tube-like beams filled with and without foam materials (empty beam and foam-filled beam) in crashworthiness. The effects of the shape of the reinforced rib are investigated and the shape optimization design is performed for increasing energy absorption and reducing the initial peak force. A multi-objective crashworthiness optimization formulation including maximum energy absorption, maximum specific energy absorption and minimum initial peak force is constructed based on the ideal point method (IPM). The optimum configuration of the reinforced rib is given with a normalized cubic spline function. Numerical example results show that, compared with the empty and foam-filled beams with same weights, the optimized rib-reinforced beam has higher energy absorption performance and lower initial crash force. It is found that for the fiber reinforced beam little rumple is formed around the compressed indentation, which helps to retard the collapse of the side wall and means more energy absorption.

#### IV. CRACK FAILURE IN GLASS FIBERS

Most of the modern car bumpers made up of glass fiber. For the main purpose of light weight, high strength and good aesthetic look. But when moderate level accident happened, the glass fibered car bumpers will cracked. For example a dog hits by a car. The reason for crack penetration is one layer material and also low ductile property of Glass Fiber.

Glass Fiber is reinforced with Aluminium alloy, where as Aluminium has good ductile property may solve the problem.

#### MATERIALS:

REINFORCEMENT FIBER : Glass Fiber Reinforcement

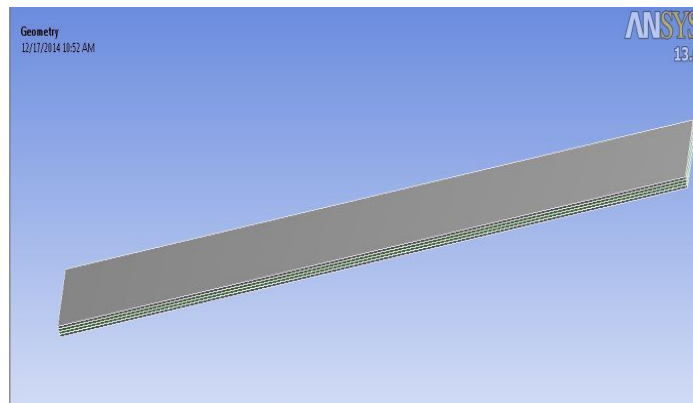
Plastic (oven roving mat type) E-glass.

MATRIX : Aluminium (6 SERIES).

Ratio of resin and hardener is 2:1  
Resin : LY556  
Hardener Used : HY951  
No. of FIBER layers : 6  
No. of Aluminium ply : 5

### MODELING:

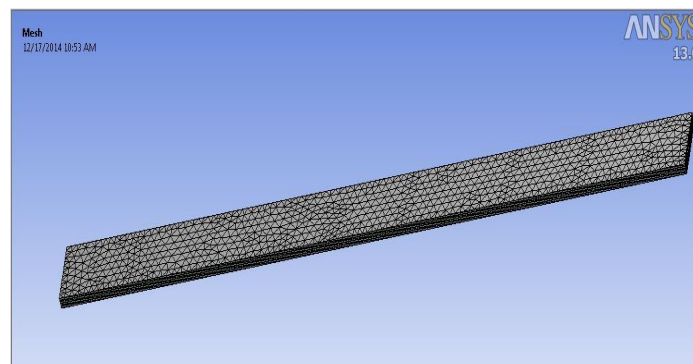
For this paper modeling plays not a big role. Just create two beams with respective dimensions of aluminium and GFRP layers for testing. And create the instance and assembled.



Modeling in ANSYS workbench

### MESHING

Meshing involves division of the entire of model into small pieces called elements.



Meshing of Car Bumper

This is done by meshing. It is convenient to select the free mesh because the car bumper may have sharp curves, so that shape of the object will not alter. To mesh the car bumper the element type must be decided first. Here, the element type is shell 152 node.

### V. MATERIAL PROPERTIES

Material properties are given in mechanical ACP (ANSYS Composite PrepPost) .Because of analyzing composite materials, it will give the result nearer to the experimental value. The properties applied in ANSYS are,

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	2000	kg m <sup>-3</sup>		
3	Isotropic Elasticity				
4	Derive from	Young's M...			
5	Young's Modulus	6.5E+10	Pa		
6	Poisson's Ratio	0.3			
7	Bulk Modulus	5.4167E+10	Pa		
8	Shear Modulus	2.5E+10	Pa		

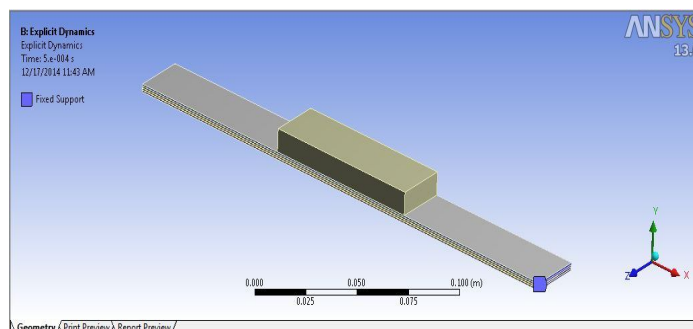
#### Properties of Aluminium

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	5366	kg m <sup>-3</sup>		
3	Isotropic Elasticity				
4	Derive from	Young's M...			
5	Young's Modulus	1.125E+10	Pa		
6	Poisson's Ratio	0.27			
7	Bulk Modulus	8.1522E+09	Pa		
8	Shear Modulus	4.4291E+09	Pa		

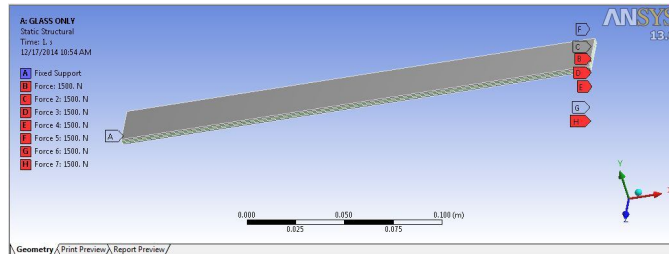
#### Properties of GFRP

### VI. BOUNDARY CONDITIONS

The Car Bumper is mounted on the front part of chassis of the automobile; the frame of the vehicle is connected to the ends of the Car Bumper. The ends of the Car Bumper are formed in the shape of rectangle.. The load is applied along F<sub>y</sub> direction. Same procedure is conducted for composite Car Bumpers. The explicit dynamics method is used for impact strength results.



#### Boundary Conditions for impact strength

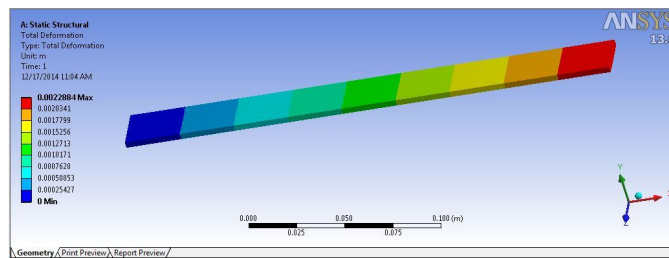


**Boundary Conditions for tensile strength**

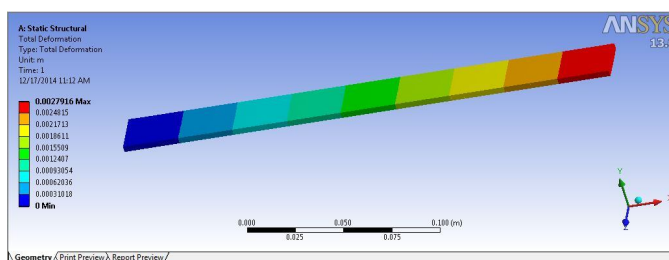
## VII. ANSYS RESULTS

### TENSILE STRENGTH

This is carried out by applying a load of 1000N at the one end and another end was fixed. And the analysis is carried out by the above mentioned four approaches. Goodman's and Gerber's approach:



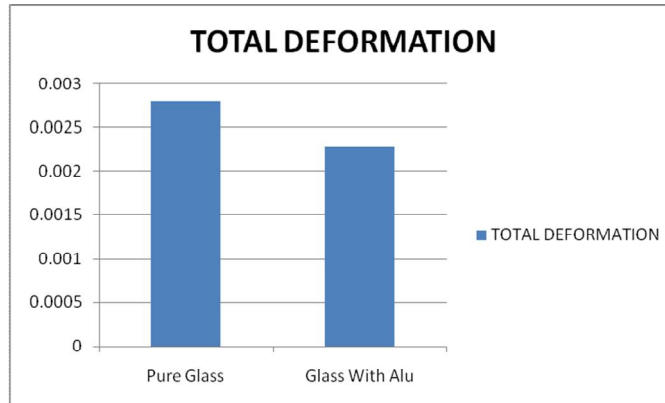
**Glass with Aluminium**



### GFRP

MATERIAL	TOTAL DEFORMATION
Pure Glass	0.0028916 m
Glass With Aluminium	0.0023884 m

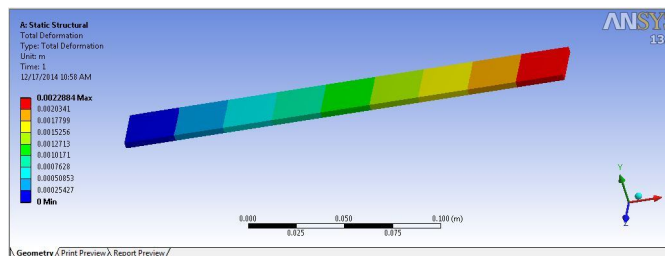




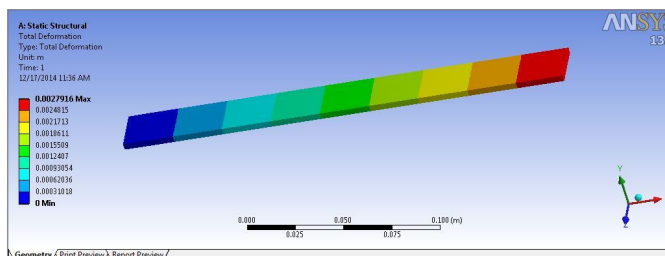
From the above graph, we can predict that the tensile strength of GFRP is lower than the Glass fiber with aluminium matrix.

### COMPRESIVE STRENGTH

This is also carried out by the same boundary conditions of tensile stress but the applied load 1000N was towards the fixed end.

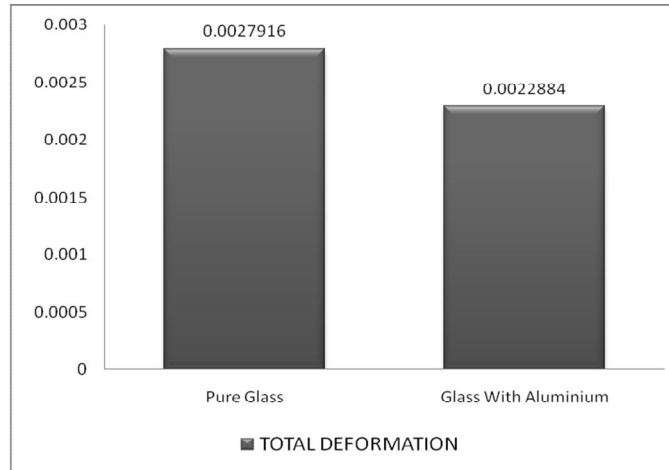


**Glass with Aluminium**



**GFRP**

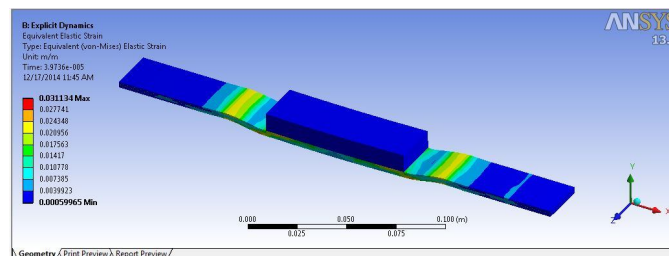
MATERIAL	TOTAL DEFORMATION
Pure Glass	0.0027916 m
Glass With Aluminium	0.0022884 m



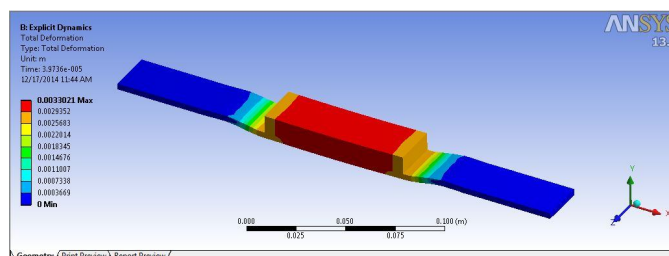
The result was nearer to tensile strength.

### VIII. IMPACT STRENGTH

For impact strength analysis two ends are fixed and load applied at the center of bumper. The analysis mode used in the ansys is Explicit analysis. Input velocity for that is  $4 \times 10^{-5}$  as per the standard. And hitting materiel is considered as concrete block properties.



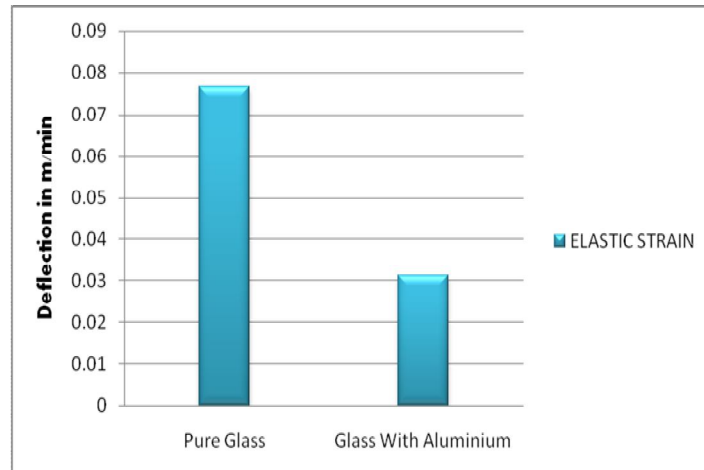
Glass with Aluminium



GFRP

MATERIAL	ELASTIC STRAIN (VON-MISES)
Pure Glass	0.076388
Glass With Aluminium	0.031134





## IX. CONCLUSION

From the obtained result we find that the tensile and impact strength of the glass fiber with Al is higher than the glass fiber alone. This will effect in the application like automobile, aeronautical and marine structures. This result will produce the more fusible and dynamic properties in the composite structure. The strength of the glass fiber with al is more than the glass fiber laminate. In the flexural strength of will not be increased during the reinforced the al with glass fiber ,but during the testing the glass fiber with al specimen was not broken which cause the bending only. So that the elastic property will be high when compared to that of glass fiber alone. After releasing the load the glass fiber al specimen's was tried to regain to original level, which will increase the elastic property of the laminate. Also conclude that, even when increases the strength also will not effect on the actual weight and cost of the laminate since that al is lighter and cheaper.

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