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Impact Analysis of Composite Sandwich Structure Bumper Beam for Passenger Vehicals

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***Abstract*— Bumper is one of the main parts which are used as protection from front and rear collision. Weight reduction is primary concern area of design, in today's automobiles. Fiber reinforced composite are material that may offers advantages in terms of weight and cost when compared with steel and aluminum structure. It has been found that the composite bumper beam offers 30% weight reduction than steel bumper beam.[1]**

The impact bumper beam in front side of automobile is main structure for absorption the kinetic energy at the time of impact. New composite sandwich structure material is introduced in this research paper with glass chopped strand mat, core mat, and epoxy resin to absorb most kinetic energy during impact timing. In this paper the existing steel bumper is replaced with composite sandwich structure bumper beam .fabrication of bumper beam is carried by hand layup process.

***Keywords*— UTM , Tensile testing, front impact, FEA,bumper, Catia-V5,CSM(Chopped Strand Mat)**

I INTRODUCTION

A vehicle has to be designed with minimum weight in order to maximize fuel efficiency and acceleration performance. However, it is particularly difficult to achieve a lightweight body structure for large cars using conventional materials such as steel.[3] FRCs comprises a category of materials that may offer advantages in terms of weight and cost when compared to conventional steel and aluminum alloys

A bumper is a shield made of steel, aluminum, rubber, or plastic that is mounted on the front and rear of a passenger car. When a low speed collision occurs, the bumper system absorbs the shock to prevent or reduce damage to the car. In existing bumper the weight is more. In the present trends the weight reduction has been the main focus of automobile manufacturers.[5]the present work, the steel bumper used in passenger vehicles is replaced with a composite sandwich bumper made of chopped strand mat (CMS), Epoxy resin, core mat composites. The objective was to compare the stress, weight, and cost savings

II MATERIALS AND METHODES

The composite sandwich structure is manufactured with following raw material

1. E glass fiber (chopped strand mat) and core mat.
2. Epoxy resin.
3. Hardener (Methyl Ethyl Ketone Peroxide).
4. PVA liquid (remover).
5. Cobalt (Accelerator).

A *Hand Lay Up Method*

Fig-1 shows Hand lay-up method it is one of the common methods of manufacturing fiberglass composites. A release agent, usually in either wax or liquid form, is applied to the chosen mold. This will allow the finished product to be removed cleanly from the mold.[4] Resin – typically a 2-part polyester, vinyl or epoxy – is mixed with its hardener and applied to the surface. Sheets of fiberglass matting are laid into the mold, then more resin mixture is added using a brush or roller. The material must conform to the mold, and air must not be trapped between the fiberglass and the mold. Additional resin is applied and also possibly additional sheets of fiberglass. Hand pressure, vacuum or rollers are used to make sure the resin saturates and fully wets all layers, and any air pockets are removed. The work must be done quickly enough to complete the job before the resin starts to cure, unless high Resin is a good resistance to most chemicals, good resistance to creep and fatigue, high strength and good electrical properties. To fabricate the composites, fiberglass hand lay-up construction method will be used in this research. There are major advantages of using hand lay-up methods; low molding costs, it is widely and commonly used, it is possibility for large products small series products Specimens of suitable dimension are cut using a cutter for mechanical testing [1]

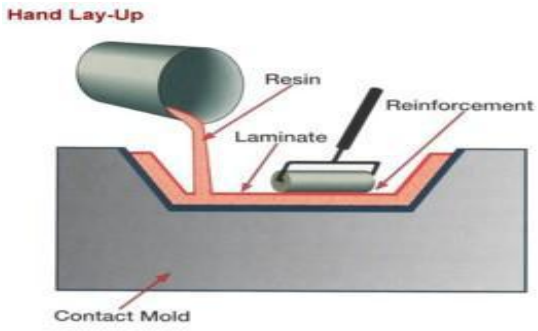
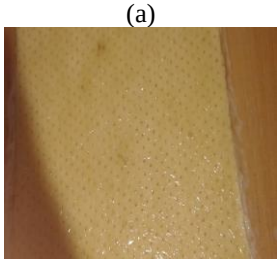


Fig.1. Hand Lay Up Method (2)

TABLE I. Composite Sandwich Structure

Types of structure	Material
Composite Sandwich Structure-i	Core mat Between 2 CSM Mat With Epoxy Resin
Composite Sandwich Structure-ii	Core mat Between 4CSM Mat With Epoxy Resin

(a)



(b)

Fig.2. Images of sandwich structure a) Sandwich Structure I b) Sandwich Structure-II

B. *Tensile Testing Of Composite Sandwich Structure:*

Tensile testing were conducted according to ASTM standards D30399(269) specimen strain response rate calculated for150 mm gauge length , width 25 mm,4mm thickness. The testing is done on 40 Ton UTM Machine with flat die for gripping rectangular specimen. Dimension of specimen are as shown below.

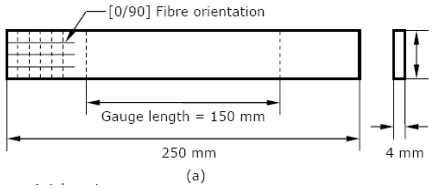


Fig.3. Tensile Test Specimen

a) Tensile Test for Sandwich structure-I**:**

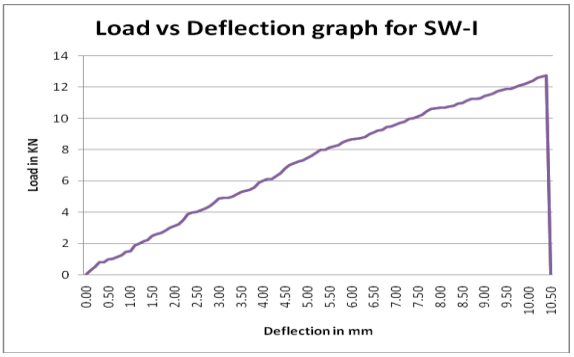


Fig 4: load vs. Defection curve for SW-I

b) Tensile Testing of Sandwich Structure Type 2:

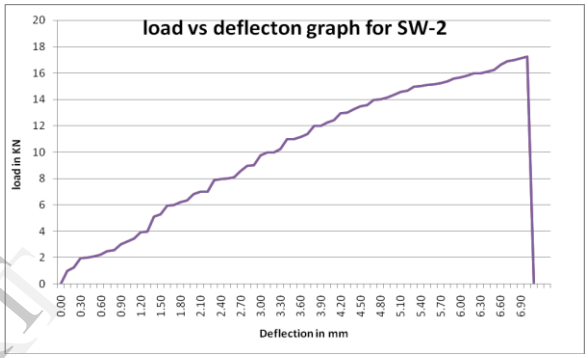


Fig 5: load vs. Defection curve for SW-II

From above graph we can calculate mechanical properties of composite sandwich beam which required for further analysis

TABLE II: Mechanical Properties of SW-I and SW-II

Laminate configuration	Young's modulus (GPa)	Poisson's ratio	Tensile strength (MPa)	Laminate thickness (mm)
composite sandwich structure 1	8.2	0.3	86	4.0
composite sandwich structure 2	11.30	0.3	117	5

C. *Impact Testing of composite sandwich structure:*

Charpy test specimens normally measure 55*10*6mm and have a notch machined across one of the larger faces. The notch dimensions are v-shaped notch, 2mm deep, with 450 angle and 0.25mm radius along the base

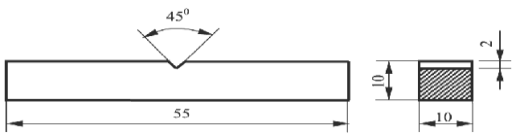


Fig.6.Charpy Test Specimen Specification

TABLE III. Impact Test Result

Discribtion	Composite Sandwich Structur 1	Composite Sandwich Structur	Steel Aisi 5000
Cross Sectional Area In(Mm^2)	40	40	40
Impact Energy (J/Mm^2)	8.5	10	3.4

D. *Automotive Bumper Material Testing (spectrometry Test*)

For study impact analysis we have chosen Indian car which is most purchased so most probability of accident so we are try to suggest composite material for weight reduction and high impact strength

Material Testing: car bumper beam specimen was collected from accidental car in car garage

Test Method: IS 8811-1998Method for emission spectrometric analysis of plain carbon and low alloy steels point to plane technique

TABLE IV: Chemical Composition after Spectrometry Test

Element	C	Mn	Si	S	P
%of element	0.12	0.15	0.18	0.085	0.040

From above % of element we get steel AISI4000 steel having following mechanical properties

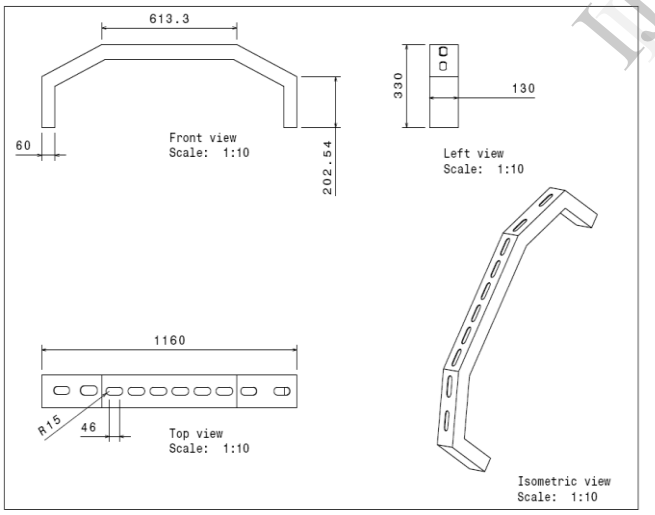


Fig.7. Development of Cad Model Of Bumper Beam In Catia-V5

III. Force Analysis of Car Impact Beam for Steel and Composite Sandwich Structure

For present study we have considered Indian car impact beam for stress analysis, weight reduction, cost reduction PurposeForce analysis in impact beam

Force (F) = m*a (1)

Where, m = mass of the vehicle crashed on the bumper (995kg)

a = acceleration due to gravity (m /sec2)

a = (u -v) / t (2)

Where, v = Final velocity after collapsing (m/sec)

u = Initial velocity before collapsing (m/sec)

u = 8km/hr = 2.22 m/s (taken from NHTSA)

t = time taken for collapsing (sec)

a=1 (2.22-0) / 0.1= 22.22 m/sec2

Force (F) = 995 x 22.222 = 22110.89 N (3)

This force is acted on front side of bumper beam

For analysis we use material properties of existing steel bumper i.e. AISI4000 Steel

IV. The Static-Nonlinear Analysis of Impact Bumper Beam in Ansys 14.5

In this paper we have used Ansys 14.5 tool to achieve project target, The Static-nonlinear analysis is carried out to find out deformation, stress distribution, equivalent stress over bumper beam.

TABLE V: Parameters of Ansys for Steel and composite sandwich structure

Analysis type	Static nonlinear
No of nodes	17840
No of elements	5828
Element size	10mm
Mesh type	Quadrilateral

A. *Analysis of Steel impact beam (Existing Model):*

Result of AISI4000 Steel Impact Beam(Thickness of beam=3mm)

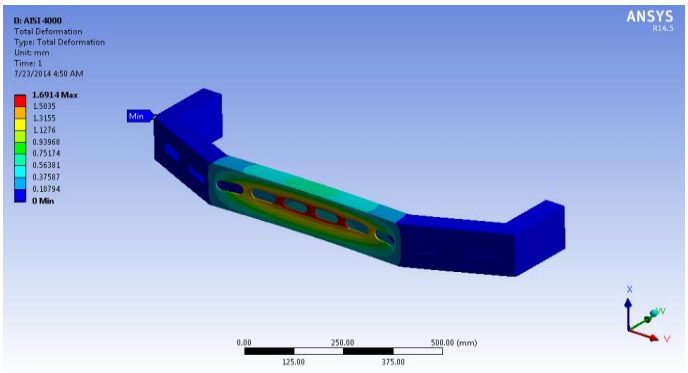


Fig 8: Total deformation of steel impact bumper beam

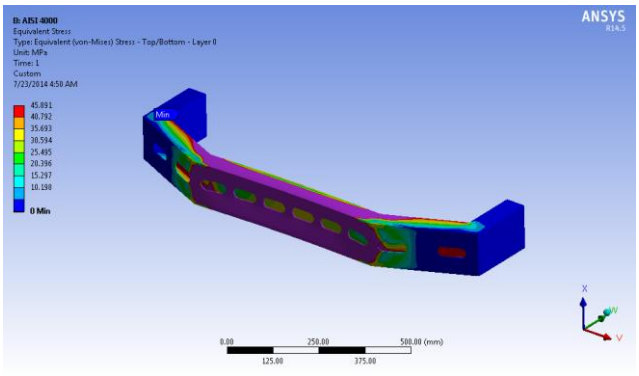


Fig 9 : Equivalent (Von-Mises) Stress of Steel Impact bumper beam

B. *Analysis of Composite Sandwich structure impact Beam*

Thickness of composite Sandwich Structure beam is made twice For analysis of Impact bumper beam which is made up of composite sandwich structure we have to assume, All mechanical properties which is obtained after experimentation is same in all direction

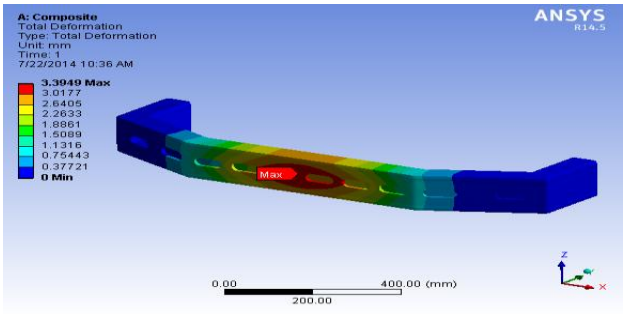


Fig 9: Deformation in composite sandwich structure impact beam

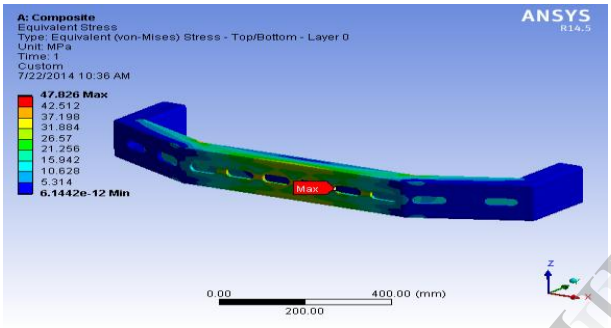


Fig 10: Equivalent (Von-Mises) Stress of composite sandwich structure impact beam

V. Result and Discussion

After static nonlinear analysis of existing impact bumper beam of car we can replace existing bumper by composite sandwich structure bumper which having low weight and cost

TABLE VI : Result comparisons of Composite and AISI 4000 Steel impact bumper beam

Discription	Steel Impact Beam	Composite Impact Bumper Beam	% of reduction
Weight(Kg)	7.559	4.65	38.52%
Cost (Rs)	3600	1500	58.33%
Impact Strength(J/mm^2)	3.45	10	-
Equivalent Strength(N/mm^2)	45.89	47.826	-

VI. Conclusion

- Existing Bumper Impact beam is made up of steel can be replaced by composite sandwich structure bumper beam with increase in thickness having same strength but less weight (38.52 % weight is reduced)
- Cost of Impact Bumper beam made up of composite is can be reduced up to 58.33 %
- Impact energy absorption due to use of core mat is maximum as compared to steel material

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