SYNTHESIS AND CHARACTERIZATION OF SANDWICH BAMBOO LAYER WITH ARECA FIBER – AUTOMOBILE APPLICATIONS

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ABSTRACT

Automobile bumpers are built to withstand crash forces and shield the car's occupants from harm. They are usually seen at the front and back of a car. Safety grilles, often referred to as grille guards or bull bars, are extra parts that can be attached to the front of a car to provide further security. They are created to safeguard the front of the car and its occupants from harm in the event of a collision with an animal or other obstruction and are normally composed of metal. Plastic, steel, and aluminium are common materials used to make automotive bumpers and safety grilles. Although steel bumpers are strong and can resist a lot of damage, they are also hefty, which might reduce a car's fuel economy. To increase the overall strength and weight of the vehicle, some automakers have begun using cutting-edge materials like carbon fibre in bumpers and grilles. However, even though we are working to create a more environmentally friendly world, using plastic and non-biodegradable products may not be the best solution. The greatest method to improve fuel economy is to lighten vehicle components without compromising safety. The goal of this study is to create a biodegradable composite material that will be utilized to make car bumpers and safety grilles. Although polymer composite materials have been used in the automotive industry for many years, their application has been limited by financial and technical constraints. In this study, a biodegradable composite sandwich construction with a bamboo core and areca fibre lamination was created and bonded using epoxy and hardener. Since impact strength is one of the crucial characteristics of bumpers and safety grilles, the composite structure was manufactured using the vacuum bagging technique and then examined for impact qualities.

Keyword: Epoxy resin, Hardener, Bamboo Material, Areca Fiber

1 Introduction:

The aim of increasing economy and safety is ongoing in the field of vehicle engineering. Automobile bumpers, which are placed strategically at the front and rear of cars, act as strong sentinels against impact forces and provide crucial protection for the people within. The search for novel materials and design paradigms has been sparked by the inherent tension between enhancing a vehicle's safety features and reducing its environmental impact. Safety grilles, sometimes known as grille guards or bull bars informally, are a symbol of this effort since they extend the protective perimeter to deal with interactions with animals and other obstructions. Traditional steel bumpers have unmatched durability, but their heavy weight is a problem for fuel economy. Recent developments in high-tech materials, such carbon fibre, have raised hopes for increased structural resilience, however they are frequently accompanied by environmental worries. The need to reduce non-biodegradable components also drives the investigation of sustainable alternatives. Considering this, the crucial intersection of automotive efficiency, safety, and environmental responsibility beckons the start of a ground-breaking investigation: the creation of a biodegradable composite material set to transform the production of automobile bumpers and safety grilles. The synthesis, construction, and assessment of a novel bio-composite sandwich structure are covered in the sections that follow. In this structure, an areca fibre lamination and a bamboo core are brought together in harmony by careful epoxy and hardener bonding. The study is fundamentally rooted in the field of impact resistance, which is a crucial quality for bumpers and safety grilles. To do this, the designed composite architecture is prepared using the vacuum bagging technique, a technology that has been carefully honed to increase the material's resistance in the face of impact forces. The goal of the journey aligns with an equilibrium where vehicle protection seamlessly harmonizes with ecological consciousness, embodying the ethos of a sustainable and safer automotive future. This dynamic trajectory spans materials synthesis, experimental pragmatism, and automotive safety.

2 Literature Review

It is important to know the significance of the use of bamboo core based composite materials for automobile applications. To explore more on composite materials made of natural fibres, Ayedh Eid Alajmi et. Al. [1] performed tribological studies on epoxy composites made with bamboo fibres. Using a variety of operating parameters, bamboo fibre reinforced epoxy was tested for wear performance, and optical microscopy was used to examine the worn surfaces. The outcomes showed that after the epoxy was reinforced with bamboo fibres, the specific wear rate of the composites decreased. Similarly, Sebastin Joyal J. et al. [2] developed, examined, and analysed the mechanical characteristics of a composite material using bamboo fibre. By means of maceration and compound assimilation techniques, the long bamboo fibre was separated. Epoxy gum was used as the lattice and bamboo fibre as the support in the composite's construction. Tests were conducted to determine the mechanical characteristics, such as malleability, hardness, and effect characteristics. The results were considered and compared, and it was found that the material enhancement can be used in fundamental applications with a strong reliance on its mechanical qualities.

Bamboo based composite materials are needed to be tested thoroughly for the safety of the passenger on the automobiles and Olumide Osokoya [5] explored a few polymer composites that are helpful in doing so to demonstrate the benefits of using polymer composites in place of conventional materials for a car bumper beam. He emphasized on how these composites are made as well as their benefits. A material selection software was used to compare the potential materials, and the results indicate that the carbon-fibre-epoxy composite has a specific tensile strength that is around 360% larger than steel and 275% greater than aluminium. Also, it was found to have the same specific tensile strength as steel and aluminium are two materials with lower cost per kilogram of material: nylon-6-nanoclay nanocomposite and glass-fibre-reinforced polypropylene composite.

3 Problem Statement

- To fabricate a sandwich architecture made of Bamboo, Epoxy and Areca Fiber for automobile safety grilles and bumper applications, thus preparing a composite material which is lighter and has good strength when biodegradability also considered when compared to conventional materials used.
- To find the impact characteristics of the sandwich architecture.
- To determine if specimens prepared with holes in bamboo sticks, which are filled with epoxy, have better strength than the specimens prepared with bamboo sticks which do not have holes.
- To determine whether the strength depends on the epoxy filled inside holes and the diameter of bamboo used in the core of the sandwich structure using one way Analysis of Variance (ANOVA)

4 Material Preparation

Bamboo sticks are measured for diameter and chopped into 200mm-long pieces. Since the diameters of the bamboo sticks vary with length, the cut pieces are grouped together based on similar diameters to prevent an uneven surface. Since the diameter of bamboo sticks fluctuates gradually, a 200mm stick's diameter can vary from 1 to 2 millimetres throughout its length. So, the bamboo sticks are divided into the following groups according to their diameters as follows:

Figure 1: Bamboo Sticks

Group	Diameter Range
A	11.00mm-12.99mm

B	13.00mm-14.99mm
C	15.00mm-16.99mm

Table 1: Diameter Groups of Bamboo Sticks

Before assembling a composite sandwich, any extraneous protrusions are filed, and the cut components are cleaned. Areca Fibre sheets are divided into 210mm*210mm-sized pieces, and the cut pieces are then cleaned to remove any dust. To prevent the required cut pieces from having uneven edges, the areca fibre and bamboo sticks are cut in excess proportions.

Figure 2: Areca Fibre Sheet

The bamboo sticks with holes are also cut in dimensions of 200mm and grouped in the above-mentioned diameter groups separately. The mixture of epoxy and hardener is prepared by mixing epoxy with hardener thoroughly with a ratio of 10:1. The surface on which the vacuum bagging process was to be done was cleaned by scraping out the waste epoxy and cleaning it with wax. After cleaning, a layer of epoxy and hardener mixture was applied on the surface. On top of that, a cut piece of areca fibre was kept, and epoxy is applied again on top of that surface. The bamboo sticks are arranged on the areca fibre with very minimal gap between them and then epoxy was poured on the assembly of bamboo sticks and spread evenly. Then another layer of areca fibre was kept on top of the bamboo sticks assembled.

To make sturdy and light-weight pieces for composite production, vacuum bagging was employed. It entails placing a composite layup or mold inside of a vacuum bag, sealing the bag, and then pressing down on the material with a vacuum pump to remove air. A consolidated and cured portion with increased mechanical qualities is produced by curing the composite materials in an oven or press. To create high-quality composite parts, vacuum bagging is frequently utilized in the aerospace, automotive, marine, and other industries.

After that, the sandwich composite structure was prepared for vacuum bagging processing. Sealant tape, Peel ply, Release Film, Vacuum Bag Plastic, Breather Fabric, and Vacuum Bagging Motor are necessary for vacuum bagging. To prevent air from entering the vacuum that will be formed around the composite construction, sealant tape was put across the plastic vacuum bag. Peel ply was kept on top of the sandwich composite's top areca fibre. Peel ply need not be used if a shining finish is desired on both sides. Release film was preserved on top of the peel ply, and the breather cloth was placed on top of it. Once breather fabric was kept, the vacuum bagging motor pipes are to be kept near the sandwich composite to facilitate maximum vacuum near the composite and the vacuum bag plastic was kept on top of that and sealed from all sides with the sealant tape applied. Once it is ensured that all the sides are sealed, the motors are turned on and the sandwich is subjected to vacuum for 3-4 hours as shown in the Figure 3.

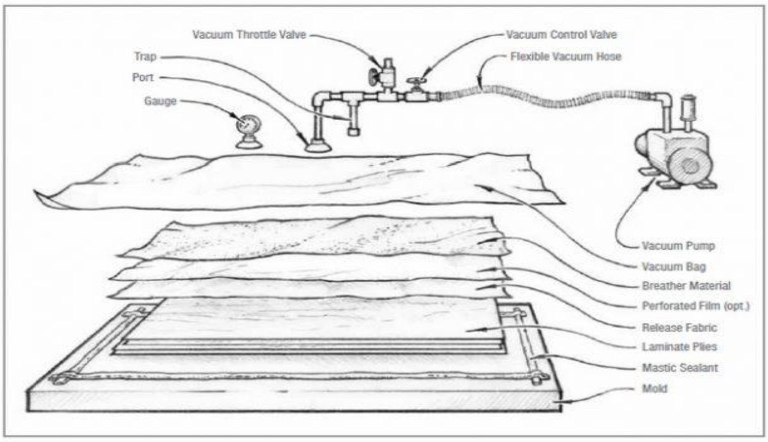


Figure 3: Schematic of Vacuum Bagging Process

After 3-4 hours, the specimen is kept the same way for 1 day for drying up the epoxy. Next day, the vacuum bag, release film, breather fabric and the peel ply are removed, and the specimen was carefully removed from the surface. The surface is then cleaned, and the specimen prepared is cut as per the dimensions required for the test as shown in Figure 5.

Figure 4: Vacuum Bagging Process

Figure 5: Prepared bamboo composite specimens

5 Testing

A mechanical test for assessing the impact resistance of materials is the low velocity drop weight impact test. To do this, a weight is dropped at a slow speed onto a sample of the material, and the energy absorbed by the sample during the impact is then measured. A weight is raised to a specific height and then dropped upon the sample, which is typically supported horizontally, during the test. The material deforms and absorbs energy as the weight strikes the sample, producing a stress wave that travels through it. The UTM measures the quantity of energy absorbed. The low velocity drop weight impact test is useful for evaluating the impact resistance of materials that are subjected to low velocity impacts, such as those that occur in accidental drops, collisions, or other low-speed impacts. It is commonly used to evaluate the impact resistance of materials used in automotive, aerospace, and construction applications. The test provides important information on the ability of a material to withstand impact and prevent fracture or other forms of damage. The results of the test can be used to improve the design and selection of materials for impact-resistant applications.

Figure 6: Drop weight impact testing machine.

Dimensions of the specimen: According to ASTM D7136, the specimen should be of the dimensions 100mm*150mm for the low velocity drop weight impact test. The prepared composite is cut into the above-mentioned dimensions for the test.

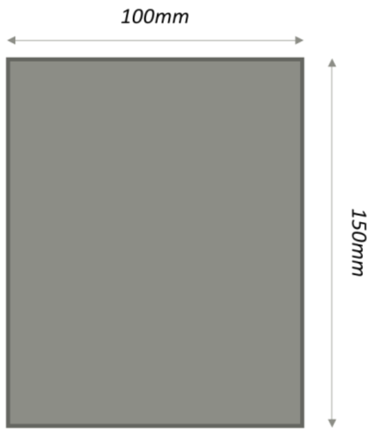


Figure 7: Specimen specifications for Drop Weight Impact Test as per ASTM D7136

Figure 8: Specimens prepared for Drop Weight Impact Test

6 Test Parameters

The composite material specimens, which were prepared using bamboo sticks without holes and bamboo sticks with holes filled with epoxy were tested for flexural test as per the ASTM D7136 Standard for Low Velocity Impact Testing of Composite Materials. Different specimens were prepared with bamboo sticks with and without epoxy, grouped as shown in Table 3, were tested and the ANOVA Analysis was performed to realise the effects of epoxy on Maximum Force Absorbed and Displacement caused by impact test, tested with the following test parameters.

Parameter	Value
Height of the specimen	150mm
Width of the specimen	100mm
Support	100mm apart
Mass of falling load	4.01 kg
Height of fall	0.255m for WHI1 and HI1, 0.204m for WHI2 and HI2

Table 2: Test Parameters for Impact Test

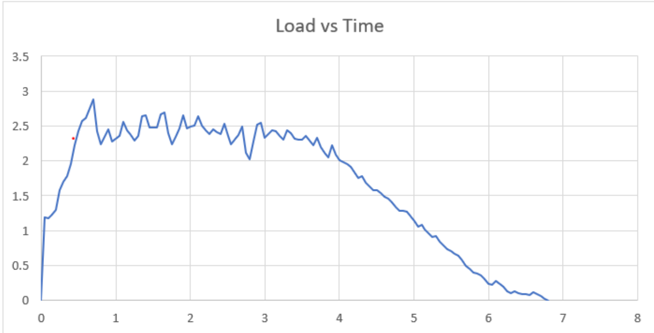
Group	Description
1	Bamboo composite without epoxy
2	Bamboo composite with epoxy in holes of bamboo sticks

Table 3: Groups of specimen types

Figure 9: Specimen after Drop Weight Impact Test

7 Observations:

Test Setup & Result	
Specimen Number	B10
Reference Number	B1
Height of Fall (mm)	255
Mass(Kg)	4.01
F1(KN)	0.015
Fmax (KN)	2.885
ti(ms)	2437.35
t1(ms)	2336.65
t2(ms)	2402.2
[t2-t1] (ms)	65.55
Vi(m/sec)	2.19
Vt(m/sec)	2.24
Emax(J)	9.6
Eabs(J)	8.8



Test Setup & Result	
Specimen Number	10
Reference Number	B3
Height of Fall (mm)	255
Mass(Kg)	4.01
F1(KN)	0.015
Fmax (KN)	3.37
ti(ms)	1313.45
t1(ms)	1213.2
t2(ms)	1278.6
[t2-t1] (ms)	65.4
Vi(m/sec)	2.19
Vt(m/sec)	2.24
Emax(J)	9.6
Eabs(J)	7.8

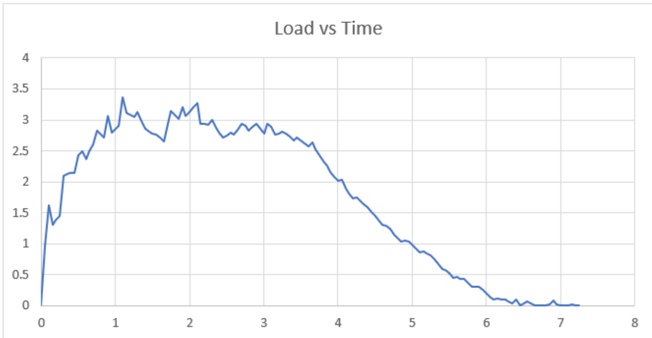


Figure 10,11, Test results and graph of load vs time for specimens without epoxy in bamboo sticks and for specimens with epoxy in the holes of bamboo sticks

From the above figures we can infer that the specimens with epoxy in the holes of bamboo sticks have better maximum force absorption capacity and the average displacement caused due to the impact are also less when compared to the specimens which do not have epoxy in bamboo sticks.

ANOVA Analysis:

Factor Information

Factor	Levels	Values
Group	2	1, 2

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Group	1	1.4400	1.4400	4.97	0.156
Error	2	0.5800	0.2900		
Total	3	2.0200			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.538516	71.29%	56.93%	0.00%

Means

Group	N	Mean	StDev	95% CI
1	2	4.800	0.707	(3.162, 6.438)
2	2	3.600	0.283	(1.962, 5.238)

Pooled StDev = 0.538516

Figure 14 : ANOVA Analysis for Max Force Absorbed (kN) vs Group.

Figure 14 shows that the kind of specimen has no bearing on the displacement that the impact test causes because the p-value is greater than 0.05 (for the 95% confidence interval). As a result, we are unable to evaluate whether the epoxy addition increases the material's value in terms of its impact strength feature.

8 Conclusions:

- Using Areca Fiber, Epoxy, and Hardener with the Vacuum Bagging Process, the bamboo composite material was successfully prepared with two different types, namely specimens without holes in bamboo sticks and with holes filled in epoxy in bamboo sticks.
- The bamboo composite specimens were tested for impact properties, which is one of the key properties for the bumpers and safety grilles of automobiles.
- The material was evaluated for its impact properties, and the results of the one-way ANOVA showed that the effects of the specimen type on the displacement and the maximum force absorbed after impact were insignificant.
- In comparison to specimens without holes and epoxy in the bamboo sticks, specimens with holes and epoxy in the bamboo sticks were able to bear more force.

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