

# Fabrication and characterisation of B-H-G fiber with teak wood particles reinforced hybrid composite

Deenadayalan<sup>1\*</sup>, S. Sivakumar<sup>2</sup>, R. Vishnuvardhan<sup>3</sup>, R. Sathish Kumar<sup>4</sup>

<sup>1</sup>Department of Mechanical Engineering, Hindustan Institute of Technology and Science, Chennai, India.

<sup>2</sup>Department of Mechanical Engineering, Hindustan Institute of Technology and Science, Chennai, India.

<sup>3</sup>Department of Mechanical Engineering, Hindustan Institute of Technology and Science, Chennai, India.

<sup>4</sup>Department of Automobile Engineering, Hindustan Institute of Technology and Science, Chennai, India

\*Corresponding author E-mail: gdeena@hindustanuniv.ac.in

## Abstract

In recent years, natural fiber based hybrid composite materials have replaced many conventional metals and synthetic resin composites in many applications. The natural fibers serve better in the present unsustainable environment due to their properties. The waste wood particles from saw mill can also be added as reinforcement element in the matrix. Hence, to enhance the strength of the composite, fine teak wooden particles are mixed with the composite matrix material. The aim of this work is to develop hybrid fiber reinforced composite with waste teak wooden particles with optimum properties. Therefore it can replace the existing synthetic fiber reinforced composite material for a suitable application. In this work, epoxy resin has been reinforced with the hybrid fibers (Banana, Hemp and E-glass) to develop fiber reinforced plastic (FRP) with a weight ratio of 1:2 hand lay-up technique. The thickness of the composite specimen is obtained by laying up layer of fiber and matrix with wood particle. An experimental investigation of tensile, flexural, impact strength and water absorption capacity of the B-H-G Teak wood particle hybrid composite laminates have been carried out according to the ASTM standard of the composite laminates.

**Keywords:** Banana-hemp-glass fiber, hybrid composites, mechanical properties, natural composite.

## 1. Introduction

In recent research shows the natural fiber composites have superior mechanical properties than synthetic fiber composites due to its intrinsic properties. Natural fiber composites are biodegradable, renewable and light weight compared to synthetic fiber composites [1,2,3]. Some research on hybridization shows natural fiber reduces the environmental pollution and appreciable improvement in the mechanical properties of composites [4,5,6]. Sapuan et al developed a composite with banana fibers. The banana fiber is a waste product obtained from the banana cultivation. It has enough strength to withstand medium loads [7]. Similarly, an investigation was done on hemp fiber with polyester composites and the results shows appreciable changes in the properties [8,9]. Yuanjian and Isaac found that hemp fiber composites with reinforced polyester improve the impact and fatigue behavior [10].

Hemp fiber is having better reinforcement property in the aspect of tensile and toughness. Kabir et al investigated the property of hemp fiber reinforced composites. Due to environmental conditions the properties of hemp fiber will be affected. The chemically treated fiber gives better surface finish. At the same time untreated fibers are having better tensile properties [11].

Teak wood particles are waste product obtained from the saw mill. Teak wood is having high strength compared to other wood materials. This nature material is having high withstanding capability against the environmental condition change. When the teak wood particles are added as reinforced element with any composite materials, this will increase the strength of the composite.

Nowadays the application of these composites are enormously increased in all kind of fields[12,13]. Many researchers are concentrating on natural hybrid composites. The hybrid composite properties will mainly depend on the mixture of elements which will decide its mechanical properties[14,15,16].

In this work, the hybrid banana-hemp-glass fiber with teak wood particles reinforced composite material is fabricated. The hybrid composite laminates are prepared with fixed proportion of hybrid fiber material and variable proportion of teak wood particles. The composite laminates are prepared by hand lay-up process. The mechanical properties such as tensile, flexural, impact strengths and water absorption capacity are studied. The results indicated that the addition of teak wood particles in banana, hemp and glass fiber composite improves the mechanical properties.

## 2. Extraction of fiber material for natural composite

The Material and method used to develop and study about natural fiber (banana and hemp fiber) as a reinforced with teak wooden fine particles mixed in epoxy resin matrix composite and to investigate the mechanical and physical properties for both fibers of banana and hemp composite.

Mature banana pseudo-stem was cut into the length of 500mm sliced (longitudinally) in four pieces and each was totally submerged in water for 15 days. After which the stems were removed from water, were loosened by swishing back and forth in a pool of tap water. They were subsequently sun dried for eight hours and further loaded by manual combing. The extracted fiber

were treated with 5% Sodium hydroxide (NaOH) solution for four hours, under total immersion condition to avoid oxidation of the fiber, after which it is washed in over flowing tap water until neutral pH is attained. The treated fibers were dried in an oven for 24 hours at 105°C in order to remove free water, then they were cut into the required dimensions and stored in an air tight container. The stems of the bast plant are dipped in water. After 2 to 3 days the stems are taken from the water and well washed. Sodium hydroxide is used to remove the dirtiness from the skin. Hence, sodium hydroxide in the form of pellets are feed in to the water and well stirred. Then the skin of the bast plant is dipped in to that sodium hydroxide solution. After 4 to 5 days the skin is taken out from the sodium hydroxide and washed thoroughly in water. The hydrogen peroxide is used to remove the gum-ness between the fibers which are in the form of skin. So washed skins were put in to the hydrogen peroxide solution. Epoxy resin is a term used to denote both the basic components and the cured end products. The epoxy resin and the hardener are mixed in the proportion of 10:1.



Figure 1(a): Banana fiber



Figure 1(b): Hemp fiber



Figure 1(c): Teak Wood Particle

Table 1: Chemical Composition of Banana and Hemp Fiber

Parameter	Content in %	
	Banana Fiber	Hemp Fiber
Cellulose	76.6	77.5
Hemi-cellulose	14.6	10.0
Lignin	8.4	6.8
Pectin	0.3	0.9
Wax and fat	0.1	2.9

Teak is a natural wood, ideal for outside furniture. It contains natural oil that protects itself against wet and cold weather. In addition, if it is treated with teak oil, the protection will be more. Compared with all other woods, teak wood is stronger due to their closed grain structure. Teak wood is comparatively expensive material. During cutting process in the saw mill, large amount of wood particles will be obtained. This will be considered as waste material and used for preparing low grade compressed materials. These particles may be effectively utilized for creating composites. The fine clean teak wood particles are taken as

reinforced material and mixed with matrix material such as epoxy resin.

### 3. Fabrication of hybrid natural composites

The base board was cleaned and smoothed by abrasive paper. The outer surface was cleaned with thinner solution and allowed to dry. After drying, the silica gel coating is applied to the mould using a spray gun for getting high quality surface. When the gel coat was cured sufficiently, the board is set for the lay-up. The epoxy resin and hardener are mixed in 10:1 proportion. The natural fibers are dried in sunlight for 3 to 5 hours. The laminates are prepared with banana-hemp-glass fibers with epoxy resin by hand lay process. The size of the laminate is fabricated with 150 x 300 x 4 mm. The entrapped air bubbles are removed carefully with a sliding roller and the mould closed for curing at a temperature of 30°C for 24hrs at a constant load of 10kg. After curing, the composite were extracted from mould plate. The Fabricated samples are placed in dry place for improving solid gel strength of the sample. Repeat the same process for all samples preparation of the hybrid natural composite. The fabricated composite laminates are shown in Figure 2. The composition of hybrid composite laminates is given in table 2.



Figure 2: Finished composite

Table 2: Composition of Hybrid Composite Laminates

Sl. No.	Percentage of Teak Wood Particle	Weight of Teak Wood Particle (gms)	Weight of Hybrid Fibers (gms)	Weight of Resin (gms)
1	0	0	40	160
2	5	10	40	150
3	10	20	40	140

### 4. Mechanical properties of hybrid composite

#### 4.1. Tensile test

The tensile test composite laminates are prepared and tested as per ASTM D638 standards. The test is carried out on three specimens in each category. The test is conducted in the universal testing machine and the results are noted down. The tensile test specimen before and after fracture is presented in fig. 3(a) and 3(b). The mean tensile strength for each category is mentioned in the table 3. The variation in the tensile strength with respect to teak wood particle percentage is shown in figure 4. From the results, it is clear that the tensile strength of the composite material increases with the increase in weight fraction of hybrid wooden particle.

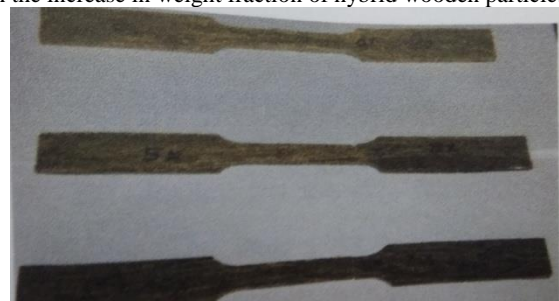


Figure 3(a): Tensile specimen before test

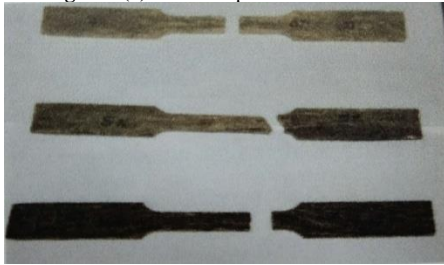


Figure 3(b): Tensile specimen after test

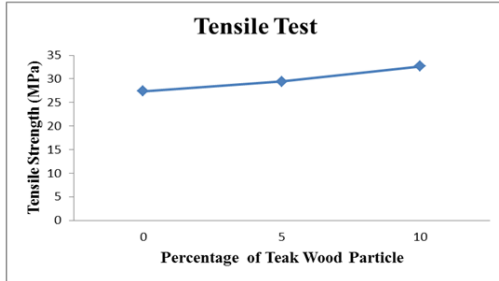


Figure 4: Variation in the tensile strength

4.2. Flexural test

The specimens for the flexural test are prepared based on ASTM D790 standard. The three specimens are taken from each category and three point flexural load is applied using universal testing machine. The flexural test specimens before and after fracture is presented in figure 5(a) and figure 5(b). The mean results of flexural strength of each category are observed and tabulated in table 3. The variation in the flexural strength with respect to teak wood particle percentage is shown in figure 6.

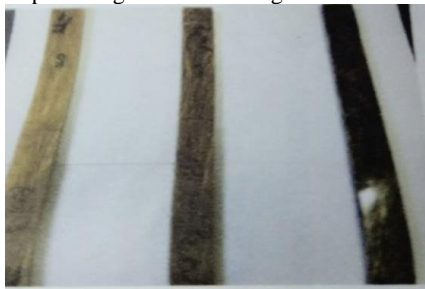


Figure 5(a): Flexural specimen before test



Figure 5(b): Flexural specimen after test

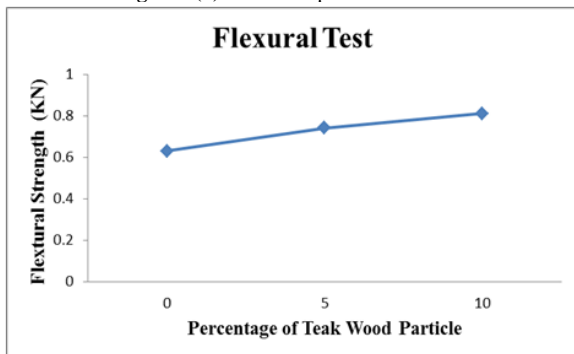


Figure 6: Variation in the Flexural Strength

4.3. Impact test

The impact test specimens are prepared as per the standard ASTM A370 from the hybrid composite laminates. For impact test the specimen edges should be neatly finished in order to avoid stress concentration and unexpected failures. The 'V' notch is also created as per the standard. During the test, the energy required to break the specimens are noted and given in the table 3. The variation in the impact strength with respect to teak wood particle percentage is shown in figure 7.

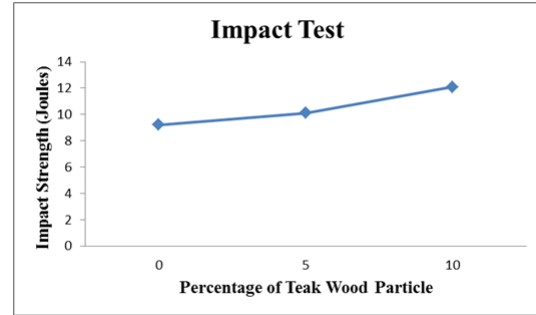


Figure 7: Variation in the Impact Strength

When quantity of teak wooden particle in resin increased, the impact strength of the hybrid composite material will also increase.

Table 3: Experimental Testing Results of Hybrid Composite Laminates

Sl. No.	Percentage of Teak Wood Particle	Tensile Strength (Mpa)	Flexural Strength (KN)	Impact Strength (joules)
1	0	27.36	0.63	9.2
2	5	29.42	0.74	10.11
3	10	32.65	0.81	12.1

4.4. Water absorption test

Water absorption test is used to determine the amount of water absorbed under specified conditions. The water absorption capacity of the composite is determined by immersing the pre-dried composite samples in ordinary water, distilled water and sea water separately at room temperature for fourteen days. The specimens are carefully taken out from the water to remove excess amount of water on the surface and wiped with a clean dry cloth. The ordinary water immersed specimen is shown in figure 8. The specimens are immediately weighted to an accuracy of 0.001gms. The specimens are dried in normal room temperature for twenty four hours. Again the specimens were weighted. The moisture absorption capacity is calculated by the weight difference. Water absorption is expressed as increased in weight percentage. Percentage of water absorption = (Weight of Wet Specimen – Weight of Dry Specimen) / Weight of Dry Specimen) x 100. The experimental results of water absorption test are given in the table 4. The variation in the percentage of water absorption in different types of water is clearly indicated in the figure 9.

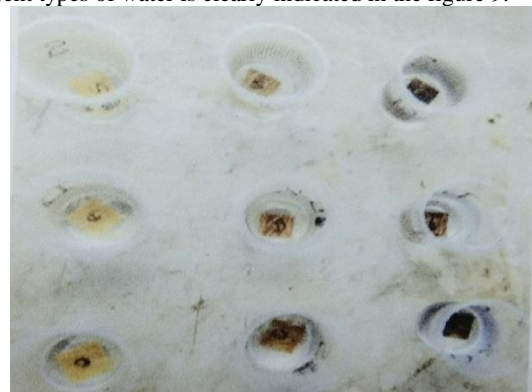
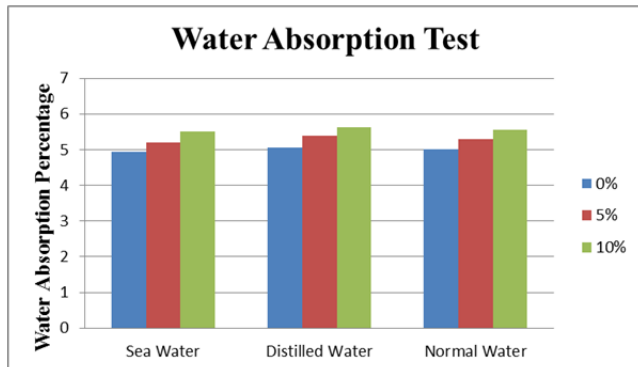


Figure 8: Specimen after immersed in Ordinary water

**Table 4:** Experimental results of Water Absorption Test

Percentage of Teak Wood Particle	Percentage of Water Absorption		
	Ordinary Water	Distilled Water	Sea Water
0	4.94	5.05	5
5	5.20	5.40	5.30
10	5.50	5.63	5.56

The table 4 shows the readings of water absorption test carried out for the composite material sample such as 0%, 5%, 10%. The water absorption test is carried out in different waters such as sea water, distilled water and normal water. The below mentioned graph shows that the water absorption is more in the 10% distilled water. From the results, it is clear that when wooden particle percentage increases the water absorption capacity will also increase. In 10% of particle content have high amount of teak wooded particle which will increase the absorption capacity.

**Figure 9:** Water absorption in different types of water

## 5. Conclusion

In this experimental study, the mechanical properties of hybrid natural composite have been investigated. The strength of 10% hybrid fiber reinforced teak wooden particle composite is higher than the 0% and 5% teak wooden particle sample. Teak wooden particles resin with natural fiber which improves the strength of the composite material. The results reveal that the highest tensile, impact and flexural strength was obtained at 10% fiber content composite, because of closed grain structure and good bonding strength of teak wooden particle with resin materials. The result of absorption test shows that the water absorption at distilled water is more compared to ordinary water and sea water. Hence, it is concluded that the optimum properties can be achieved at 10% teak wood particle content of hybrid natural composite.

## Reference

- [1] Pickering KL, Aruan Efendy MG & Le TM, "A review of recent developments in natural fibre composites and their mechanical performance", *Composite: Part A*, Vol.83, (2016), pp.98-112.
- [2] Murali Mohan Rao K, Mohana Rao K, Ratna Prasad AV, "Fabrication and testing of natural fiber composite; Vakka, sisal, bamboo and banana", *Material and Design*, Vol.31, (2010), pp.508-513.
- [3] Laly AP, Zachariah O & Sabu T, "Dynamic mechanical analysis of banana fiber reinforced polyester composite", *Composite Science and Technology*, Vol.63, (2003), pp.283-293.
- [4] Vasanta VC, Udayakumar PAR, "Mechanical characterization of coir and rice husk reinforced hybrid polymer composite", *Progress in Polymer Science*, Vol.24, (1999), pp.221-74.
- [5] Ganesan M & Valarmathi TN, "Tensile strength of teak wood saw dust-cashew nut shell liquid resin composite", *IJEDR*, Vol.2, No.(1), (2014), pp.2321-9939.
- [6] Sakthivel M & Ramesh S, "Mechanical properties of natural fiber (Banana, Coir, Sisal) polymer composite", *Science Park*, Vol.1, No.1, (2013).
- [7] Sapuan SM, Leenie A, Harimi M & Beng YK, "Mechanical properties of woven banana fibre reinforced epoxy composites", *Materials and Design*, Vol.27, (2006), pp.689-693.

- [8] Ramesh M, Sri Ananda Atreya T, Aswina US, Eashwara H & Deepa C, "Processing and mechanical property evaluation of banana fiber reinforced polymer composite", *Procedia Engineering*, Vol.97, (2014), pp.563-572.
- [9] Yan L, Yiu WM & Lin Y, "Sisal fiber and its composite: A review of recent developments", *Composite Science and Technology*, Vol.60, (2000), pp.2037-2055.
- [10] Yuanjian T & Isaac DH, "Impact and fatigue behavior of hemp fibre composites", *Composites Science and Technology*, Vol.67, (2007), pp.3300-3307.
- [11] Kabir MM, Wang H, Lau KT & Cardona F, "Tensile properties of chemically treated hemp fibres as reinforcement for composites", *Composites Part B: Engineering*, Vol.53, (2013), pp.362-368.
- [12] Herrera-Franco PJ & Valadez-Gonzalez A, "A study of the mechanical properties of short natural fiber reinforced composite", *Composite: part B*, Vol.36, (2005), pp.597-608.
- [13] Murali Mohan Rao K & Mohan Rao K, "Extracting and tensile properties of natural fiber: Vakka, date and bamboo", *Composite Structures*, Vol.77, (2007), pp.288-295.
- [14] Venkateshwaran N, Elayaperumal A, Alavudeen A & Thiruchitrabalambam M, "Mechanical and water absorption behavior of banana/sisal reinforced hybrid composite", *Materials and Design*, Vol.32, (2011), pp.4027-4021.
- [15] Bhoopathi R, Ramesh M & Deepa C, "Fabrication and Property Evaluation of Banana-Hemp Glass Fiber Reinforced Composite", *Procedia Engineering*, Vol.97, (2014), pp.2032-2013.
- [16] Meriem F, Rachid RR, Alexandre V, Fakhreddine D & Mohamed Haddar, "Improvement of Natural Fiber Composite Materials by Carbon Fibers", *Journal of Renewable. Materials*, Vol.5, No.1, (2017), pp.38-47.