Fabrication and Analysis of Thermocol Sandwiched Between Bamboo Fiber-Reinforced Phenol Formaldehyde Composite Laminates

Sudeep Kumar T[1], Sunil K[2]

[1, 2] Department of Mechanical Engineering, Siddaganga Institute of Technology, Karnataka, India.

Email: sudeepkumart@sit.ac.in

Received Date: 25th January, 2018, Accepted Date: 10th February, 2018

Abstract - This paper emphasize on presenting use of natural fibers as reinforcement with a polymeric matrix enabling fabrication of efficient and lightweight composite laminates for various structural applications. An examination of the thermocol sandwiched between Bamboo fiber-reinforced phenol formaldehyde laminates has been attempted. The cross-sectional area, the tensile test and compressive test of these laminates, alongside flexural strength test were analyzed tentatively under similar loading conditions and compared. The laminates presented in the current examination could be potentially be used as a replacement for normal thermocol sheets for the ceiling panels and sidewalls panels in Air-conditioned rooms, Seminar halls and other interior places, because of their advantage of being lightweight.

Keywords - Natural fibers, Thermocol, Bamboo fiber, Phenol Formaldehyde, Composite.

I. INTRODUCTION

This is an era of composite materials it is broadly defined as replacement of conventional materials due to its properties like light weight, high strength, dimensional stability due to which it is very useful. Environmental policies of developed countries are influencing their researchers to consider the effects of their products on environment. In this way, the interest for utilizing natural fibers as a reinforcement of polymer-based composites is increasing in a rapid manner mainly because of its inexhaustible conditions [1].

Almost all natural fibers which are ligno-cellulosic based contains cellulose micro-fibrils in an amorphous matrix of lignin and hemi-cellulose. These fibers comprise of a few fibrils, which run throughout the length of the fiber: every fibril displays a complex layered structure which is made up of a thin primary wall surrounding a thicker secondary layer and is quite similar to that of a single wood fiber [2]. The fibers used in the present investigation are treated as single units at the macro level and compared with the other natural fibers as shown in Fig.1.

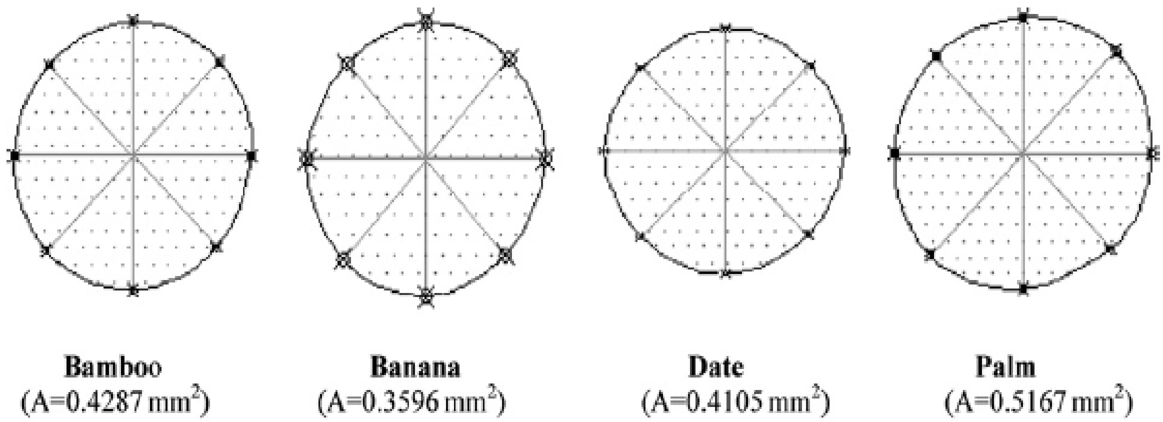

Fig. 1 Various fiber Cross-sections

To the extent of attributes are concerned, bamboos are long, perpetual, tree-like huge size grasses, having a place with the Bambusae family. Previously, the properties fracture related to the bamboo stalks and nodes were analyzed [3]. Bamboo is a regular natural fiber material, and the filaments are distributed in a dense manner at the external surface area, and scantily in the internal surface area. It is obvious that the fracture durability of the bamboo stalk relies upon the volume fraction of its fibers. The bamboo is having multi-nodes and functionally gradient structure, microscopically and in addition macroscopically [4–10]. The impact of water absorption on the mechanical properties of bamboo were also been analyzed [11-15].

Ismail et al. [16] analyzed the curing qualities and the mechanical properties related to rubber composites re-inforced with bamboo fibers, as a function of the fiber loading, and bonding agents such as phenol formaldehyde and methylene tetramine. The conclusion of investigation was that the usage of bonding agents will greatly enhance the adhesion between natural rubber and bamboo fibers. Accordingly, the hardness and tensile modulus of composites will increase with the increase in filler loading and the existence of bonding agents.

II. MATERIALS

A. Bamboo Fibers

The thin layer of exodermis (bark) and nodal portions of bamboo are taken out and remaining portion of the hollow cylindrical region of stalk is considered for separating the fiber content. Cylindrical portion of stalk is skinned in the longitudinal way to make strips of approximate thickness 0.5– 1.5mm and around 10mm width. These strips are bundled and soaked in the water for 3 days to make them softer. Once these strips are taken out from water, then they are gently beaten specifically so as to loosen and to isolate the fiber content. With the help of sharp edged knife, the fiber bundle is scrapped and combed. The way of scrapping and combing is repeated until the point when individual fibers of bamboo are isolated [17].

The manually stripped bamboo fibers are dried out under the sunlight. These fiber strips of bamboo material are separated from the stalks which contain gums and the tissues. After the decortications process, the dried fiber is then extracted by degumming which is a chemical process of decomposition. In degumming process, the gummy materials and the pectin are taken off. This procedure of degumming is designed by Gangstad et al. cited by Maiti [18] which has been considered as a basis for the chemical extraction. The process of chemical extraction will yield around 33% of fiber content on weight basis. The chemical composition of bamboo fibers are given in Table 1.

TABLE 1. CHEMICAL COMPOSITION OF BAMBOO FIBER

COMPOSITES	COMPOSITIONS in %
Cellulose	45-50
Hemi cellulose	20-25
Lignin	20-30
Extractives	2.5-5

B. Thermocol

Thermocol or basically known as expanded polystyrene (EPS), offers a non-hydroscopic, odourless, rigid closed cell containing 98% by its volume, still air entrapped in its cells and it is the main reason for its excellent insulation properties. It also gives a rigid structurally strong product to withstand various kinds of loads and vibrations. Properties of thermocol is as shown in Table 2.

TABLE 2. PROPERTIES OF THERMOCOL

PROPERTIES OF THERMOCOL	
Density	15-30kg/m
Compressive strength	0.8-1.6kg/cm
Tensile strength	3-6kg/cm
Application range	-200+80C
Water absorption by % vol. for 7 days in water	0.5%

Numerous construction organizations in India and throughout the world also utilize Thermocol while building ceilings and side walls. Expanded PolySterene , which is usually known as Thermocol, because of its sound absorption properties possess an excellent sound-proofing solution. EPS is additionally utilized for producing Geofoam for facilitating landfills, owing to the material's greater resistance to moisture and heat; it also offers broad dimensional stability and is inert in its nature.

C. Phenol Formaldehyde

Phenol formaldehyde resins (PF) or in other words phenolic resins are synthetic polymers which are obtained by the reaction of phenol or substituted phenol with formaldehyde. Utilized as the basis for Bakelite, PF resins were the primary commercial synthetic resins (plastics) available. They are being generally used for the manufacture of molded products which includes billiard balls, lab countertops, and as adhesives and coatings. They were at once the essential material utilized for the manufacture of circuit boards, but nowadays they are being largely replaced with fibreglass cloth and epoxy resins, as with heat proof FR-4 circuit board materials.

PF resins is a group which is formed by a stage of polymerization reaction which can be either base or acid-catalyzed. Since formaldehyde is available primarily in solution as a dynamic equilibrium of methylene glycol oligomers, the concentration of reactive type of formaldehyde relies upon temperature and pH.

III. Methods

A. Preparation of Bamboo Fiber Laminates

The bamboo is first harvested, and then it is cut off into fibers lengthwise. It is then pressure-steamed, a process called carbonization. The bamboo fibers are inspected and sorted into different grades. Then these selected fibers were processed by simple hand-lay-up method and hot pressed using dispersion-type biodegradable Phenol formaldehyde (PF) resin to produce a PF/Bamboo fiber cross-ply (00/900 orientation) laminates.

B. Fabrication of Sandwich Composite

The PF/Bamboo fiber laminates are cut into required dimensions and piled with Thermocol in between until the desired composite thickness is achieved. In order to sandwich between the bamboo sheet and thermocol, Phenol formaldehyde resin is applied. Here we use the resin in the count of strength and sustainability. The composite is then placed in a mould where it is heated at 350-4000C and pressed into shapes. For setting the shape, pressure of 0.3-1 Mpa is maintained for about 5 minutes. Then it is removed from the mould and allowed to cool at room temperature for 24 hours. The finished Bamboo-Thermocol composite laminate is obtained as shown in the Fig. 2.

Fig. 2 Bamboo-Thermocol composite

IV. Results and Discussion

A. Tensile Test

In this test, the model is cut according to the standard dimensions of a tensile specimen. The experimentation was carried out by using a Universal Testing Machine of 0-20Tons capacity and the specimen before and after the test is shown in the Fig.3.

BEFORE TEST AFTER TEST

Fig. 3 Von mises stress –Cantilever beam

The test method used for conducting tensile strength experiment is IS 1608-2005 and Table 3 shows the various load values measured from the test. The break load on the specimen is 10.32KN.

TABLE 3. Tensile test results

Tests	Results
Initial Area (mm^2)	474.32
Break Load (KN)	10.32
Ultimate Tensile Load (KN)	21.75

B. Three point Bending Test

In this test, two ends of the model are fixed and the load is applied at the centre. The results are as shown in the Fig.4 and the break load on the model is 900N as shown in Table 4.

TABLE 4. THREE POINT BENDING TEST RESULTS

Sample	Results
1	900 N

BEFORE TEST AFTER TEST

Fig.4 Three point Bending test result

C. Compression Test

Compression tests were carried out using UTM machine and results are obtained as shown in Fig.5 and the load taken by the specimen is given in Table 5.

TABLE 5. COMPRESSION TEST RESULTS

Sample	Results
1	1.7 KN

BEFORE TEST AFTER TEST

Fig.5 Compression test result

V. CONCLUSION

The test results of these sandwich materials are less comparatively better then bare thermocol and bamboo sheets which are commonly used in ceiling panels and sidewalls panels. Hence, it can emphatically be stated that the fibers considered herein deserve to be included in the list of natural reinforcements in composites for the design of lightweight materials. Following are the potential areas where these composites can be used;

- Floor and office panels.
- Office cubical and interiors.
- Floor panels for quick fix shelters.
- Can replace ply-woods for Computer / TV tables.
- Used in factories, auditoriums and other places as acoustic insulation.

REFERENCES

[1] K. Murali Mohan Rao, K. Mohana Rao, "Extraction and tensile properties of natural fibers: Vakka, date and bamboo", Composite Structures, Vol. 77, pp. 288-295, 2007.

[2] Poddar P, Islam MS, Sultana S, Nur HP and Chowdhury AMS, "Mechanical and Thermal Properties of Short Arecanut Leaf Sheath Fiber Reinforced Polypropyline Composites: TGA, DSC and SEM Analysis", Journal of Material Sciences & Engineering, Material Sci. Eng., Vol. 5, No. 5, Available: http://dx.doi.org/10.4172/2169-0022.1000270, 2016.

[3] Amada S, Untao S. "Fracture properties of bamboo", Composites Part B, Vol. 32, pp. 451-459, 2001.

[4] Lakkard SC, Patel JM, Mechanical properties of bamboo, a natural composite. J Fibre Sci Tech, Vol. 14, pp. 319-322, 1981.

[5] Nogata F, Takahashi H, Intelligent functionally graded material: bamboo, Compos Eng., Vol. 5, No. 7, pp. 743-751, 1995.

[6] Nogata F, Intelligent modeling mechanisms and design concepts of functionally graded materials in natural composites, In: Proceedings 5th Intl. Symp. Functionally Graded Materials, October 26-29, p. 331-337, 1998.

[7] Amada S, Ichikawa Y, Munekata T, Nagase Y, Shimizu H, "Fiber texture and mechanical graded structure of bamboo", Composites Part B, Vol. 28, pp. 13-20, 1997.

[8] Chuma S, Hirohashi M, Ohgama T, Kasahara Y, "Composite structure and tensile properties of mousou bamboo", J. Mater Soc. Japan, Vol. 39, pp. 847-851, 1990.

[9] Jain S, Kumar R, Jindal UC, "Mechanical behavior of bamboo and bamboo composite", J. Mater Sci., Vol. 27, pp. 4598-4604, 1992.

[10] Godbole VS, Lakkad SC, "Effect of water absorption on the mechanical properties of bamboo", J. Mater Sci. Lett., Vol. 5, pp. 303-304, 1986.
[11] Okubo K, Fujii T, Yamamoto Y, "Development of bamboo-based polymer composites and their mechanical properties", Composites Part A, Vol. 35, pp. 377-383, 2004.
[12] Thwe MM, Liao K, "Effects of environmental aging on the mechanical properties of bamboo-glass fiber reinforced polymer matrix hybrid composites", Composites Part A, Vol. 33, pp. 43-52, 2002.
[13] Thwe MM, Liao K, "Durability of bamboo-glass fiber reinforced polymer matrix hybrid composites", Compos. Sci. Technol., Vol. 63, pp. 375-87, 2003.
[14] Ismail H, Shuhelmy S, Edyham MR, "The effects of a silane coupling agent on curing characteristics and mechanical properties of bamboo fibre filled natural rubber composites", Europ. Polym. J., Vol. 38, pp. 39-47, 2002.
[15] Ismail H, Edyham MR, Wirjosentono B, "Bamboo fibre filled natural rubber composites: The effects of filler loading and bonding agent", Polym Test, Vol. 21, pp. 139-44, 2002.
[16] Yao W, Li Z, "Flexural behavior of bamboo-fiber-reinforced mortar laminates", Cem. Concr. Res., Vol. 33, pp. 15-19, 2003.
[17] Maiti R, World Fiber Crops., New Delhi, India: Oxford IBM Publishing Co. Pvt. Ltd., pp. 71-73, 1997.