

Flexural Behavior of Bamboo and Coir Fibre Reinforced Composite with Polyester Resin

S.Hariprasath¹, V.Parthiban², M.Umashankar³, S.Sridhar⁴

^{1,2,3,4}Department of Mechanical Engineering, Narasu's Sarathy Institute of Technology, Salem-636305, India

Abstract- This work is concerned with the evaluation of the effect of manufacturing temperature on mechanical properties of composites. Composites were fabricated using Bamboo fibre/polyester, and Bamboo fibre with varying fibre manufacturing temperature in compression mould method. Bamboo fibre reinforced polyester composites were fabricated with varying temperature of (140, 160, 180 °C). The results showed that Flexural strength of the composite increased with increasing temperature up to 180°C for Bamboo fibre polyester composite. Flexural strengths of Bamboo fibre /polyester composites were found to be higher than those of room temperature process.

Index Terms- Bamboo fiber, Composite, Flexural strength, Polyester, Temperature.

1. INTRODUCTION

The reinforcing material and the matrix material can be metal, ceramic, or polymer. Composites typically have a fibre or particle phase that is stiffer and stronger than the continuous matrix phase and serve as the principal load carrying members. The matrix acts as a load transfer medium between fibres, and in less ideal cases where the loads are complex, the matrix may even have to bear loads transverse to the fibre axis. The matrix is more ductile than the fibres and those acts as a source of composite toughness. The matrix also serves to protect the fibre from environmental damage before, during and after composite processing. When designed properly, the new combined material exhibits better strength than would each material. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications. Van Suchetclan explains composite materials as heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can be also

considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property.

The following are some of the reasons why composites are selected for certain applications:

- High strength to weight ratio (low density high tensile strength)
- High creep resistance
- High tensile strength at elevated temperatures
- High toughness.

The interest in natural fibre-reinforced polymer composite materials is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative.

The natural fibres can be used to reinforce both thermosetting and thermoplastic matrices. Thermosetting resins, such as epoxy, polyester, polyurethane, phenolic, etc. are commonly used today in natural fibre composites, in which composites requiring higher performance applications. They provide sufficient mechanical properties, in particular stiffness and strength, at acceptably low price levels. Considering the ecological aspects of material selection, replacing synthetic fibres by natural ones is only a first step. Restricting the emission of greenhouse effect causing gases such as CO₂ into the atmosphere and an increasing awareness of the finiteness of fossil energy resources are leading to developing new materials that are entirely based on renewable resources.

1.1. OBJECTIVES

- To prepare the natural fibre extraction process and chemical treatment with NaOH.

- A new set of research is carrying out by reinforcement matrix, polyester resin with natural fibre.
- To utilize the composite materials in the corrosive resistance and electrical insulation applications.
- To make a polymer matrix composites as a suitable for manufacturing technology.
- To improve the economy of the farmers by utilizing the by-product of bamboo and coir (natural fibre).

2. METHODS AND PROCESS

Based on the study, the identified problems of the fibre material is found that some research is carried out on composite material, they found out only mechanical properties of fiber. There is a lot of scope to manufacturing methods and study the mechanical behaviour of bamboo yarn and coir fibre composites. So it is decided to carry out research in the above topic and analyses the following mechanical property.

- Flexural Test.

1.2. Bamboo yarn Fiber

Bamboo fabric is a natural textile made from the pulp of the bam-boo grass. Bamboo fabric has been growing in popularity because it has many unique properties and is more sustainable than most textile fibres. Bamboo fabric is light and strong, has excellent wicking properties, and is to some extent antibacterial

Natural colour is light of pale yellow or white. Stiffer than Tampico used in scrub brushes, garage brooms and deck scrubs. Rayon is a regenerated cellulose fiber, which means that a natural raw material is converted through a chemical process into a fiber that falls into a category be-tween naturals and synthetics. The source of cellulose can be wood, paper, cotton fiber, or in this case bamboo.



Fig-1. Bamboo Yarn

1.3. Chemical processing

It is basically hydrolysis alkylation. The crushed bamboo is cooked with the help of sodium hydroxide (NaOH) which is also known as caustic soda or lye into a form of regenerated cellulose fibre. Hydrolysis alkalisation is then done through carbon disulphide combined with multiphase bleaching although chemical processing is no environmental friendly but it is preferred by many manufacturers as it is a less time consuming process.

1.4. Fiber Physical Properties

The tensile strength of the fiber is measured by means of an instrument named INSTRON 5500R. The critical length of the fiber is 100 mm. The physical properties of Palmyra palm fibres are described in following,

Table-1. Physical properties palm fibres

Strength (g/tex)	34.3
Elongation (%)	16.0
Short fibre index(12.7mm)	5.58
Uniformly index (%)	92.7
UHML(mm)	38.745
ML(mm)	35.62
Moisture (%)	6.5
Micronaire	4.0

1.5. Fiber Chemical Composition Test

The chemical components of any finer determine its strength and endurance capabilities. It is verified that with higher cellulose content exhibit greater tensile strengths and are more suitable for other applications involving higher strength to weight ratio. The chemical composition of bamboo fibre is described in following,

Table-2. Fiber Chemical Composition

Properties	Content
Halo Cellulose content (%)	68.92
Lignin content (%) = 14	21.98
α cellulose (%)	46.52
Ash (%)	1.82

1.6. Bamboo yarn Fiber Preparation

There are two ways to process bamboo to make the plant into a fabric: mechanically or chemically. The mechanical way is by crushing the woody parts of the bamboo plant and then use natural enzymes to break the bamboo walls into a mushy mass so that the

natural fibres can be mechanically combed out and spun into yarn.

1.7. Treatment of bamboo fibre

The most common chemical method of bamboo fabric manufacturing involves the use of carbon disulphide. First, the bamboo is crushed and its moisture kept at about 65%. The substance is then sulfurized by the addition of the carbon disulphide chemical. This step turns the bamboo cellulose solution into gel, which is in turn diluted using sodium hydroxide. The ensuing product is a viscous solution that gets passed through various nozzles and then place into another chemical solution and left to harden. After it has hardened, it gets converted into thread and spun into actual, usable fabric.

1.8. Coir Fibre

Coir is the fibrous material found between the hard, internal shell and the outer coat of a coconut. Other uses of brown coir (made from ripe coconut) are in upholstery padding, sacking and horticulture. White coir, harvested from unripe coconuts, is used for making finer brushes, string, rope and fishing nets. Coir fibres are found between the hard, internal shell and the outer coat of a coconut. The individual fibre cells are narrow and hollow, with thick walls made of cellulose. They are pale when immature, but later become hardened and yellowed as a layer of lignin is deposited on their walls. Each cell is about 1 mm (0.04 in) long and 10 to 20µm (0.0004 to 0.0008 in) in diameter. Fibres are typically 10 to 30 centimetres (4 to 12 in) long. The two varieties of coir are brown and white. Brown coir harvested from fully ripened coconuts is thick, strong and has high abrasion resistance. It is typically used in mats, brushes and sacking. White coir fibres harvested from coconuts before they are ripe are white or light brown in colour and are smoother and finer, but also weaker. They are generally spun to make yarn used in mats or rope.



Fig-2. Coir fibre

1.9. Selection of Resin

Polyester resins are thermosetting and, as with other res-ins, cure exothermically. The use of excessive initiator especially with a catalyst present can, therefore, cause charring or even ignition during the curing process. Excessive catalyst may also cause the product to fracture or form a rubbery material.

1.10. SPECIMEN PREPARATION

Bamboo yarn and coir fibre reinforced composite

A steel mould of dimension (300×300×3) mm was used for casting the composite sheet. . In total about 65% of the total weight ratio is matrix (polyester) and 30% of weight is the bamboo yarn fibre of 270mm length and remaining 5% comprises of coir fibre of 7mm in length.

A calculated amount of polyester resin (65% by weight) was thoroughly mixed with gentle stirred to minimize air entrapment. After keeping the mould on a polyethylene sheet a thin layer of the mixture of fiber and matrix (10:1) were poured into the mould. Care was taken to avoid formation of air bubbles. Pressure was then applied from the top and the mould was allowed to cure at 120°C, 140°C and 160°C temperature for 4 hrs.

This procedure was adopted for preparation of composite specimens consisting of fiber 35% and resin 65%. The weight fraction of fibres with particular length should be chosen and mixed in the bowl and spread uniformly on the mould of plat size 270*270*3mm and compressed by applying a load of 20 tons by hydraulic compression to get a single mat. Resin mixed with accelerator and catalyst is poured over the compressed fiber mat and the pressure is applied till the complete closure of mould. The samples are prepared and cured at room temperature.



Fig-3. Bamboo and Coir Fibre Reinforced Composite

1.11. MECHANICAL TESTING

After fabrication the test specimens were subjected to various mechanical testing as per ASTM standards. The mechanical test that carried out is flexural test. The specimen size and shape for corresponding tests are as follows.

Flexural Test

Flexural strength is defined as a materials ability to resist deformation under load. It is a 3-point bend test, which generally promotes failure by inter laminar shear. This test is conducted as per ASTM D790 standard using UTM. The dimension of the specimen is (13x127x3) mm. It is measured by loading desired shape specimen with a span length at least three times the depth.

Flexural MR is about 10 to 20% of compressive strength depending on the type, size and volume of coarse aggregate used. The MR determined by third point loading is lower than the MR determined by centre point loading, sometimes by as much as 15%.

The maximum fiber stress at failure on the tension side of a flexural specimen is considered the flexural strength of the material. Thus, using a homogeneous beam theory, the flexural strength in a three point flexural test is given by;

$$\sigma_f = (3P_{max} L) / 2bh^2$$

Where,

P max= maximum load at failure

b = specimen width

h = specimen thickness

L = specimen length between the two support points



Fig-4. Specimen for Flexural Test

A compression moulding machine is the machine where the fabrication of the bamboo and coir/polyester composite is being done. The dimension of the plates where which the moulding is being done is 300*300*3 and this standard is on based on ASTM standard.

3. RESULTS AND DISCUSSIONS

This chapter presents the mechanical properties of the Bamboo and coir fiber /polyester, composites prepared for this present investigation. Details of processing of this composites and the tests conducted on them have been described in the previous chapter. The results of various characterization tests are reported here. These includes evaluation of flexural strength, has been studied and discussed.

3.1. FLEXURAL TEST

The flexural test was performed by the three point bending method according to ASTM D790, and cross head speed of 2 mm/min. six specimens were tested, and the average was calculated. The specimen was freely supported by a beam, the maximum load was applied in the middle of the specimen, and the flexural modules are calculated from the slope of the initial portion of the load deflection curve.

6 specimens are being tested with each being manufactured in three different temperatures that is 140 °C, 160 °C, and 180°C. Two specimens each in single temperature range. Specimens are in the dimensions (125*13*3mm).

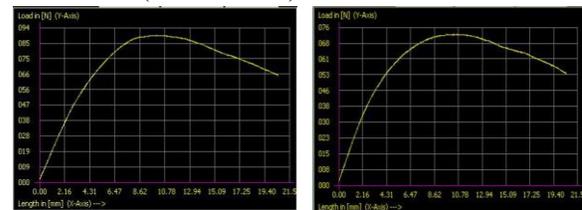


Fig-5. Load vs Length properties of 140°C fabricated compo-site material (sample 1& 2)

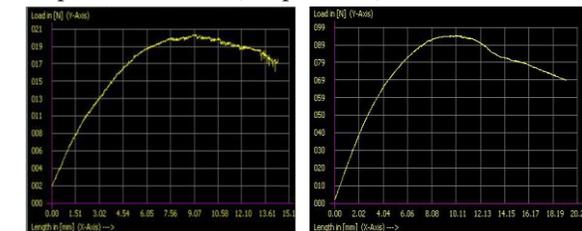


Fig-6. Load vs Length properties of 160°C fabricated composite material (sample 1& 2)

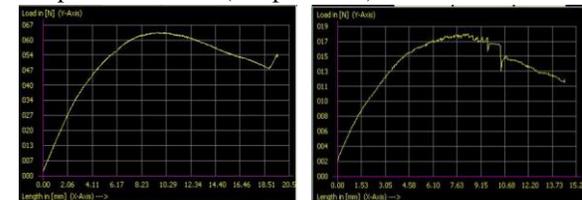


Fig-7. Load vs Length properties of 180°C fabricated composite material (sample 1& 2)

The above results are the flexural test of the specimen at various temperature ranges. Flexural strength is a combination of the tensile and compressive strength and varies with the interfacial shear strength between the fiber and matrix. Flexural test in various mechanisms such as tensile, compressive, shearing etc. will take place simultaneously.

The flexural properties of bamboo and coir fiber/polyester composites at different manufacturing temperature are shown in fig.5, 6, and 7. Flexural strength is a combination of the tensile and compressive strength and varies with the interfacial shear strength between the fiber and matrix. Flexural test in various mechanisms such as tensile, compressive, shearing etc. will take place simultaneously. In order to achieve effective fiber reinforcement, interfacial strength between the fiber and matrix is the most essential factor. The maximum flexural strength is being observed as 76.137MPa on the specimen which is manufactured in 160°C with flexural modulus 3342.687GPa.

Table-3. Summary results of flexural testing

Samp le no.	CS area (mm ²)	Peak load (N)	Flexural strength (MPa)	Flexural Modulus (GPa)
1	39.000	89.369	72.183	2856.128
2	39.000	72.614	58.649	2849.004
3	39.000	20.346	16.433	817.461
4	39.000	94.264	76.139	3342.687
5	39.000	63.569	51.344	2132.345
6	39.000	18.090	14.611	859.111

3.2. Comparison between bamboo/ polyester composite vs bamboo and Coir/polyester composite material

Comparison have been made with simple bamboo/polyester composite material with bamboo and coir/polyester composite material and it is noted that the value of flexural strength and flexural modulus of the two materials have large difference and also the bamboo and coir/polyester composite have very large strength compared to the one with only bamboo as the reinforcement. The comparison graph is being plotted here with both values of materials.

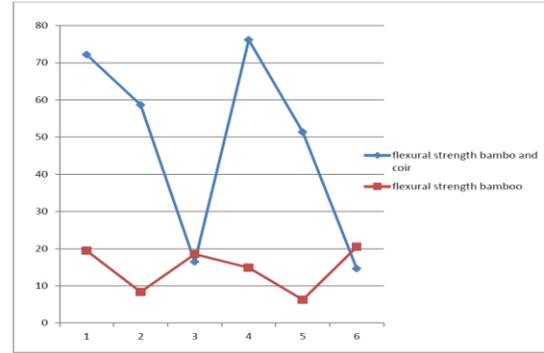


Fig-8. Comparison of bamboo/polyester composite vs bamboo and Coir/polyester composite

4. CONCLUSION

In this work, flexural properties of bamboo yarn and coir fibre/polyester composites were investigated. The flexural properties of the composites as a function of temperature of manufacturing were analysed

- The flexural strength of bamboo yarn and coir fiber/polyester composite improved by increasing temperature of manufacturing up to 180 °C.
- The result summary is being analysed and it is being compared with the previously fabricated bamboo yarn/polyester composite and it is noted that the flexural strength of the material has a considerable increase and the material is double strong comparatively.

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