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FABRICATION AND STUDY OF MECHANICAL PROPERTIES FOR FALSE BANANA AND BAMBOO FIBERS REINFORCED BIO-COMPOSITES

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ABSTRACT

In Southern part of Ethiopia most parts land is covered with false banana plant and natural bamboo forest. Experimental investigation has been carried out to study the effect of false banana and bamboo fibers at different weight percentages of 20, 30 and 40 to modify epoxy resin. 100 kN servo hydraulic universal testing machine under is placement mode of control, digital Rockwell testing was used to test hardness and impact effect. Modifying epoxy resin through false banana and bamboo fibers improve mechanical properties is main focus of this study. The effects of mixing false banana and bamboo fibers on mechanical and physical properties are studied. It is found that 30 wt% of false banana and bamboo fibers mixed epoxy is giving optimum mechanical properties and found to be better than other weight percentages combinations. The addition of false banana and bamboo fibers has improved tensile, flexural and impact properties of epoxy resin and increased water absorption of the material.

Keywords: False Banana And Bamboo Fibers, Modify Epoxy Resin, Mechanical Properties, Improved Tensile, Optimum Mechanical Properties

1. INTRODUCTION

Now a day, Natural fibers are preferable for their appropriate stiffness, mechanical properties and high disposability. Natural fiber from false banana and bamboo fibers is among widely used natural fibers in southern parts of south Ethiopia. It endowed with an abundant availability of natural fiber such as false banana, bamboo (fast growing woody plant and it can be harvested in 3-5 years while the most softwood species used for composite board softwood species used for composite board manufacture requires 10-20 years), banana etc. has focused on the development of natural fiber composites primarily to explore value-added application avenues. Such natural fiber composites are well suited as wood substitutes in the housing and construction sector. Natural fibers are treated with different materials in different modes to increase their strength, durability and sustainability while retaining their inherent degradable character to protect environment from pollution.

Composites, the wonder material with light-weight; high strength-to-weight ratio and stiffness properties have come a long way in replacing the conventional materials like metals, wood etc. The material scientists all over the world focused their attention on natural composites reinforced with false banana, bamboo, banana etc. primarily to cut down the cost of raw materials.

Composites are multifunctional material systems that give uniqueness not available from any distinct material. They are cohesive structures made by physically combining three or more compatible materials, different in composition and characteristics and sometimes in form. Kelly [1967] extremely stresses that the composites should not be regarded simple as a combination of two materials. In the broader significance; the combination has its own distinctive properties. In terms of strength to resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them. Beghezan [1966] defines as "The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their short comings", in order to obtain improved materials.

Composites consist of one or more irregular phases set in an unbroken phase. The irregular phase is usually harder and stronger than the unbroken phase and is called the 'reinforcement' or 'reinforcing material', whereas the unbroken phase is termed as the 'matrix'. Properties of composites are highly dependent on the properties of their constituent materials, their distribution and the interaction among them. The geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent. The shape of the irregular phase (which may by spherical, cylindrical, or rectangular cross-sectioned prisms or platelets), the size and size distribution (which controls the texture of the material) and volume fraction determine the interfacial area, which plays an important role in determining the extent of the interaction between the reinforcement and the matrix. Concentration, usually measured as volume or weight fraction, determines the contribution of a single constituent to the overall properties of the composites. It is not only the single most important parameter influencing the properties of the composites, but also an easily controllable manufacturing variable used to alter its properties.

In its most basic form a composite material is one, which is composed of at least three elements working together to produce material properties that are different to the properties of those elements on their own. In practice, most composites consist of a bulk material (the 'matrix'), and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix. The matrix isolates the fibers from one another in order to prevent abrasion and formation of new surface flaws and acts as a bridge to hold the fibers in place. A good matrix should possess ability to deform easily under applied load, transfer the load onto the fibers and evenly distributive stress concentration.

Reinforcement increases the mechanical properties of the neat resin system. All of the different fibers used in composites have different properties and so affect the properties of the composite in different ways. For most of the applications, the fibers need to be arranged into some form of sheet, known as a fabric, to make handling possible.

Different ways for assembling fibers into sheets and the variety of fiber orientations possible to achieve different characteristics. Then interface is a bounding surface or zone where a discontinuity occurs, whether physical, mechanical, chemical etc. The matrix material must "wet" the fibers. Well "wetted" fibers increase the interface surfaces area. To obtain desirable properties in a composite, the applied load should be effectively transferred from the matrix to the fibers via the interface. This means that the interface must be large and exhibit strong adhesion between fibers and matrix.

Composite materials can be classified into many categories depending on the type of matrix material, reinforcing material type.

II LITERATURE REVIEW

Composites have been a field of great interest in the last two decades and a lot of researchers are working in this area. This becomes very important to discuss the prominent works related to the polymer composites and their properties. The purpose of literature review is to provide background information on the issues to be considered in this research and to emphasize the relevance of the present study. Various aspects of polymer composites have been considered with reference to development as well as characterization of polymer composites. Existing literature related to the physical and chemical properties of the composites have been reviewed and a special emphasis has been given to erosion wear characteristics. Knowledge gap in the earlier investigations has been presented to outline the need and objectives of the present work.

Natural fiber reinforced polymer composites have raised a great attention and interest among scientists and engineers in recent years due to the consideration of developing environmental friendly materials . They are high specific strength and modulus materials, low priced, recyclable and are easily available. It is known that natural fibers are non-uniform with irregular cross-sections which make their structures quite unique and much different with man-made fibers such as glass fibers, carbon fibers etc .Various researchers have worked on the natural fibers containing polyolefin's, polystyrene, polyester and epoxy resins. Properties like low cost, light-weight, high specific strength, free from health hazard are the unique selling points of these composites. Though the presence of hydroxyl and other polar groups in the natural fibers leads to the weak interfacial bonding between the fibers and the hydrophobic polymers, these properties can be significantly improved by interfacial treatment. Among the various natural fibers, bamboo fiber is a good candidate for use as natural fibers in composite materials. Jindal has observed that tensile strength of bamboo-fiber reinforced plastic (BFRP) composite is comparatively equivalent to that of the mild steel, whereas their density is only 12% of that of the mild steel. Hence, the BFRP composites can be extremely useful in structural applications. Jain and Kumar have investigated that a uniform strength can be achieved in all directions of the composites by using multidirectional orientation of fibers. Fabricated bamboo fiber reinforced Polybutylenes Succinate (PBS) biodegradable polymer composites[11]. Homogeneous nucleation of PBS spherulites was obtained at temperature above 150˚C. Authors have shown that the size of spherulites increases with addition of bamboo; however the spherulites are not generated from the surface of bamboo fibers with or without treatment at any kneading temperature. The kneading temperature influences the melt visco elasticity above the melting point of PBS.

2.1 Mechanical properties of composites

The attractive physical and mechanical properties that can be obtained with bamboo fiber reinforced composites, such as high specific modulus, strength and thermal stability, have been well documented in the literature. Jain et al. have compared the Bamboo fiber reinforced epoxy composites (BFRP) epoxy with Bamboo fiber reinforced unsaturated polyester composites (BFRP) USP in terms of their cost and mechanical strength. Cost of unsaturated polyester (USP) was found to be only 20% to that of the epoxy resin, whereas the mechanical properties of these two composite were comparable. Thus giving an edge to the USP based composites. BFRP composites have shown more elongation and 10% high tensile strength. These composites can be used for a variety of commercial application such as crash helmet, low cost housing and wind mills. Kumar et al. have studied the effect of coating bamboo fibers with Polyurethane and Polyurethane/Polystyrene Interpenetrating Network (PU/PSIPN) on tensile property of the composites. Both the untreated / alkali treated bamboo fibers were coated with polyethylene glycol based PU and its semi inter penetrating network (SIPN)with PS. It was found that tensile strength of bamboo has increased after coating with PU and PU/PS system.

PU/PS coating on alkali treated bamboo fibers has shown a rise (74%) in the tensile load at break than PU (11%) coating on alkali treated fiber. Lee et al. [26] have fabricated bio-composites of poly (lactic acid) (PLA)/bamboo fiber (BF) and poly (butylene succinate) (PBS)/bamboo fiber (BF).They have investigated effect of lysine based diisocynate (LDI) as coupling agent On properties of bio composites .They have reported that tensile properties and water resistance were improved by addition of LDI. These improvements were due to enhanced interfacial adhesion between polymer matrix and bamboo fiber. Results of enzymatic degradation showed that biodegradability could be adjusted by controlling degree of interfacial adhesion using LDI. They have observed that these bio-composites are beneficial in areas where biocompatibility and environmentally responsible design and construction are required.

Takagi et al. have studied the effect of fiber content and fiber length on mechanical properties of bamboo fiber reinforced green composites (BFGC). Fiber length up to 15mm has given positive effect on tensile strength and flexural strength. It was observed that tensile strength and flexural strength increase with increase in fiber content. Thermal properties and heat resistance of composite were improved by annealing. Chen et al. have fabricated bamboo reinforced polypropylene (PP) composites. Increase in bamboo size has negative effect in both unmodified and modified composite. These results showed that maleic anhydride has improved bonding between bamboo fiber and polypropylene. Okubo et al. [11] have fabricated bamboo fiber reinforced polypropylene composites for ecological Purposes. Polypropylene was modified with maleic anhydride and bamboo was extracted with conventional method and steam explosion method. Poor adhesion was reported between the bamboo fibers and matrix. The modified polypropylene was insufficient to fabricate applicable composite. To reduce the number of voids in composite, it was necessary to decrease the diameter of fiber bundles by dividing these into single fibers. This was possible only by steam explosion technique. Fiber content increased the void formation during processing, which further leads to micro crack information under loading, hence reducing the tensile strength. Incorporation of glass fiber and Compatilizers has improved the tensile strength and tensile modulus. It was reported that moisture absorption of BFRP during aging can be reduced by replacing bamboo fiber with glass fiber and by using Compatilizers. Mechanical properties of BFRP and BGRP have degraded after aging in water.

2.2 Water absorption

New applications and end uses of composites for decking, flooring, and outdoor facilities with strong exposure to atmosphere or contact with aqueous media have made it necessary to evaluate the water uptake characteristics of natural fiber composites. Because of the hygroscopic nature of natural fibers, water uptake of composites containing these fibers as fillers and/or reinforcement can be a limiting parameter for a number of applications of the composites. Water absorption can adversely affect a number of mechanical properties and can also buildup the moisture content in the fiber cell wall and in the fiber–matrix inter phase region.

Moisture buildup in the cell wall could result in fiber swelling and affect the dimensional stability of the product. If necessary, the moisture absorbed in the fiber cell wall can be reduced through the acetylation of some of the hydroxyl groups present in the fiber [21]. The samples are taken out periodically and weighed immediately after wiping out the water on the surface of the sample, using a precise four digit balance to find out the content of water absorbed. All the Samples are dried until constant weight with four digit balance, previous to immersing in water. Percentage of water uptake is calculated by the following equation-

$$\mathrm{WA}(\%) = \frac{W_2 - W_1}{W_1} * 100$$

E.Q.1

W1 = initial weight of specimen g

W2= specimen weight after N hours of water soaking, g

Water absorption behavior of natural fiber thermoplastic composites have been studied by a number of researchers and the effectiveness in reducing the amount and rate of water absorption has been well-documented in the literature. Tajvidi et al. have investigated the long-term water absorption behavior of various natural fiber (wood flour, kenaf fiber, rice hulls, newsprint etc.) polypropylene composites and have also studied the effect of natural fiber type and fiber content. Authors have found that the Chemical composition of the natural fibers is responsible for the different water uptake behavior. It appears that the RH/PP has the lowest water absorption.

III MATERIAL PREPARATIONS

Raw materials are the starting point for development of new materials and quality of new material itself is dependent upon the raw materials. Then come the role of processing techniques to fabricate the new materials and characterizations techniques to ensure their quality. This Section describes the materials and methods used for the processing of all the composites under this investigation. It presents the details of the characterization techniques in terms of mechanical and chemical properties of the composite samples under study.

This section describes about the material used in casting of hybrid composite, their physical properties and chemical properties etc. In this section, the method used to determine the mechanical, physical properties are also discussed.

3.1 Material

The materials which are used to fabricate the bio composite material such as matrix, reinforcing material and other materials which are used to modify the epoxy resin are discussed below.

1. Matrix material

Matrix material is the material, which holds the relative position of the filler material. The composites shape, surface appearance, environmental tolerance and overall durability are dominated by it.

2. Epoxy resin (CY-230)

Epoxy resin has wide range of industrial applications because of their high strength and mechanical adhesiveness characteristic. Araldite CY-230 is a liquid solvent free epoxy resin. Curing takes place at atmospheric pressure and room temperature after addition of hardener.

It is also good solvent and it has good chemical resistance over a wide range of temperature. The physical & chemical properties of CY-230 are given in table-1.

TABLE-1 Physical and chemical properties of CY-230

Resin (Araldite CY-230)	
Physical Properties	Yellow-brown, odorless, tasteless and completely nontoxic
Chemical Properties	Plasticized condensation product of bisphenol-A and epichlorohydrin.

3. Hardener HY-951

Hardener HY-951 is a yellowish-green colored liquid. In the present investigation 9 % wt/wt has been used in all material developed.

4. Reinforcing Element

The addition of reinforcing agents to the resin improves the properties of the material. False banana and bamboo fibers are used as reinforcing agents to improve the different properties of the composites material.

5. False banana and bamboo fibers

Bidirectional False banana and bamboo fibers have been used as a reinforcing material in all composite. These are collected from local sources.

Fig, 1. Bamboo fiber

Fig, 2. False banana fiber

3.2 Methodology

Preparation of Material

1. Fiber

The bamboo sticks and false banana fiber used in the present investigation was arranged from local market. The process of fiber extraction is shown below:

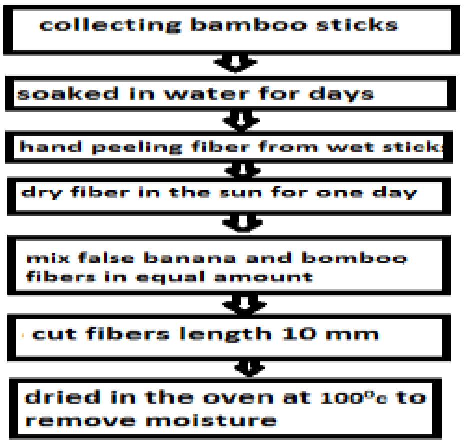

Fig. 3. Preparation of false banana and bamboo fibers

2. Moulds

The mould was made having a simple base and top made of plastic plate having dimensions 220mm×200mm×20mm which was cut from plastic sheet all three sides of sheet was surrounded by a thin strip of plastic having dimension: 2 strips of dimension 220mm×30mm×5mm and 2 strips having dimensions 140mm×30mm×5mm which are fixed to the strip through nut and bolts.

3. Preparation of composite

Epoxy resin (CY-230) will be kept in the furnace at a temperature of 90±10 °C for approximately one hour to remove or vaporize if any moisture or water in the resin and then cooled down to 45°C, after the temp reaches 45 °C, 10 wt% hardener (HY-951) which acts as the curing agent is added to epoxy resin. Then bamboo fibers are added in different ratios of 20, 30, 40 wt% as seen from past investigations and studies. The whole solution is then stirred manually or with the help of mechanical stirrer and then poured in the mould.

4. Casting technique

Casting technique used will be simple hand layup technique followed by post curing by application of load. The whole mixture is poured in the mould is assembled together with the bolts and then held vertically in bench-wise for 24 hers after that it is post cured by pressing the mould with a 25kg weight for 2-3 days and then removed from the mould and left unloaded at normal room temperature for 2-3 days and then the samples of different sizes are cut from it.

TABLE-II Compositions of epoxy filled with bamboo fibers

Designation of Composition	Epoxy Resin (CY230), Wt%	Hardener (HY951), wt%	False banana and bamboo fiber wt%
Neat	100	10	0
20C	100	10	20
30B	100	10	30
40A	100	10	40

IV RESULTS AND DISCUSSIONS

4.1 Mechanical Properties

1. Tensile Test

The tensile properties of the False banana and bamboo fibers filled epoxy resin composite material were determined by 100 kN universal testing machine at fixed strain rate 1 mm/min under displacement control mode. The results are presented in figures 4.

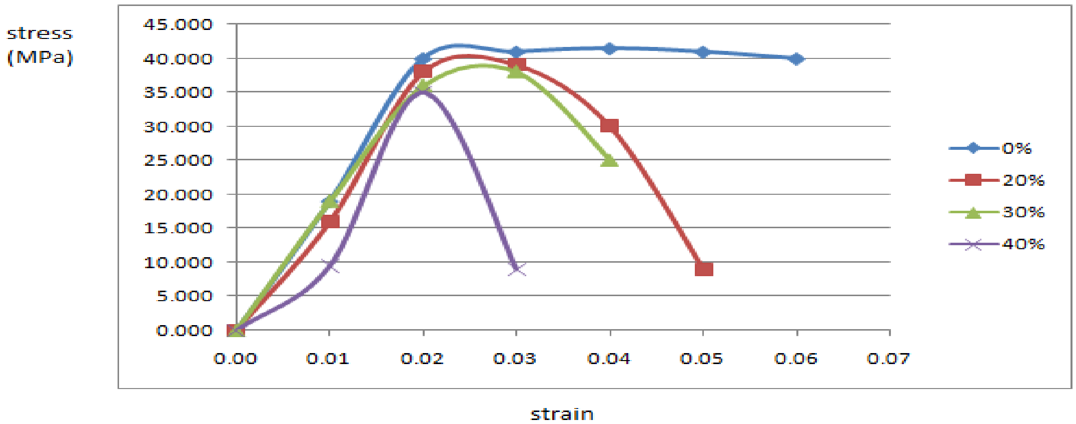

Fig 4. Stress-strain diagram for different wt% of false banana and bamboo fibers

The tensile stress-strain curve for unfilled epoxy resin (10 wt% HY-951 hardener and CY-230 resin) and bio composite material containing 20, 30 and 40 wt% false banana and bamboo fibers is shown in the figure 4. The variations in tensile strengths of the composites are shown in Fig.4. The tensile strength of the false banana and bamboo fibers epoxy composites decreases at 40wt% fiber loading. This decrease in tensile strength is due to the maximum void contents and weak interfacial adhesion in case of composites i.e. when the material is stressed in tension test it tends to elongate and when the material elongates the bond between False banana and bamboo fibers and epoxy resin weakens and leads to the loosening of False banana and bamboo fibers and leads to fracture of material.

2. Flexural Test

The flexural properties have a very important role in structural applications. The flexural properties obtained at different weight percentage of false banana and bamboo fibers have been shown in figures 4, 5. The effect of wt% of false banana and bamboo fibers on flexural strength is shown in figure 7.

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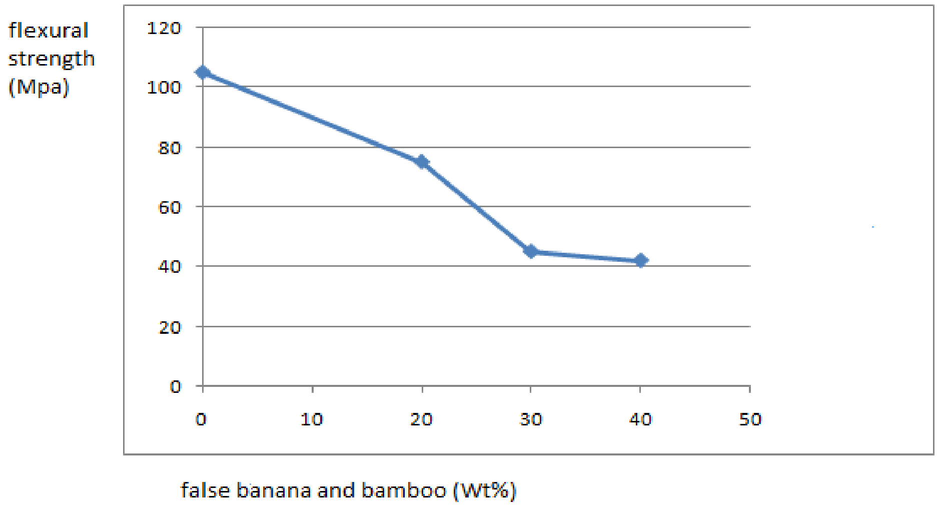

Fig.5 Effect of False banana and bamboo fibers (wt %) on flexural strength

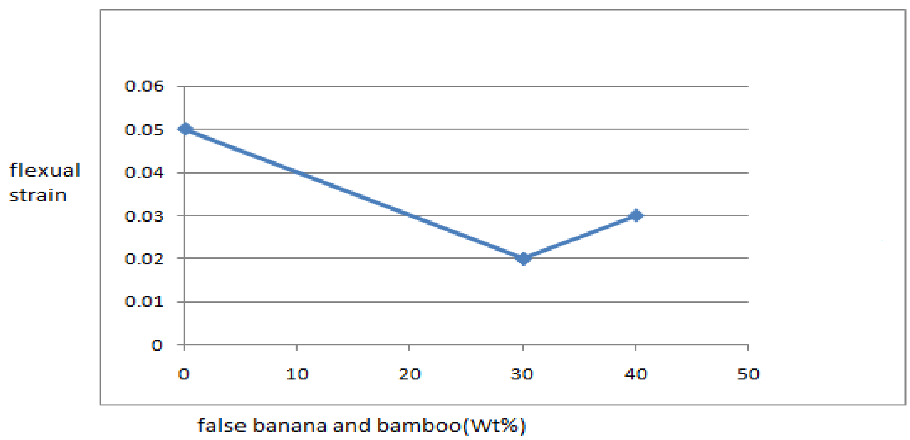

Fig.6. Effect of False banana and bamboo fibers (wt %) on flexural strain

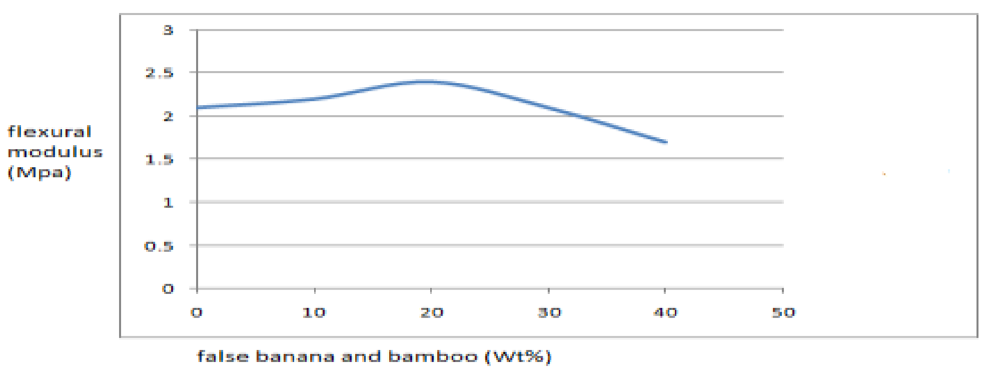

Fig.7. Effect of False banana and bamboo fibers (wt %) on flexural modulus

It is observed that flexural strength decrease with an increase in false banana and bamboo fibers wt% in epoxy resin. It is observed that flexural strain fist decreases with an increase in bamboo fiber wt% in epoxy resin and then increases with an increase in wt% from fig.7.In fig.8 flexural modulus decreases with an increase of wt% of false banana and bamboo fibers in epoxy resin. False banana and bamboo fibers provide a resistance initially due to which the gradient of initial straight line of load displacement curve is more which leads to increase in flexural modulus.

3. Hardness Test

In this study the hardness test have been conducted on L scale on Digital Rockwell hardness testing machine.

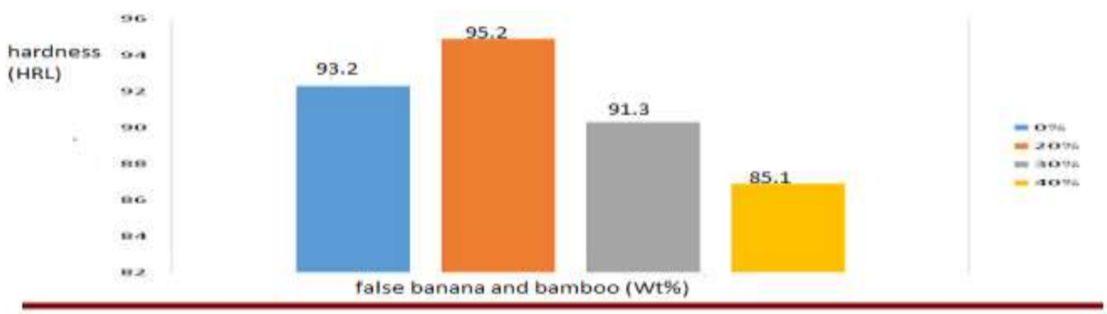

Fig.8. Effect of wt% of false banana and bamboo fibers on hardness

From figure 8 this can be seen that hardness of false banana and bamboo fibers reinforced composite decreases with the increase in wt% of false banana and bamboo fibers. This may be due to the softness or low hardness of false banana and bamboo fibers.

4. Impact Test

The results obtained by the impact tests are shown in table 3. The impact strength is calculated by the formula given in equation 4.1. Figure 9 shows impact strength with different wt% of false banana and bamboo fibers.

TABLE-III Impact properties of false banana and bamboo fibers filled epoxy resin composite.

False banana and bamboo fibers (Wt %)	Impact energy (J)	Impact energy/ Width (J/m)	Impact strength (kJ/m^2)
0	0.1311	27.32	2.7144
20	0.2652	45.96	4.61
30	1.5921	212.811	18.88

40	0.6711	74.936	5.991

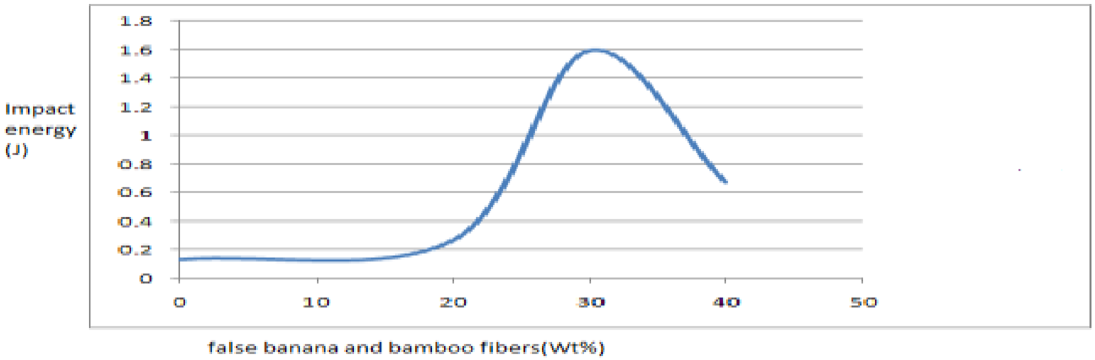

Fig.9. Effect of wt% of false banana and bamboo fibers on impact energy

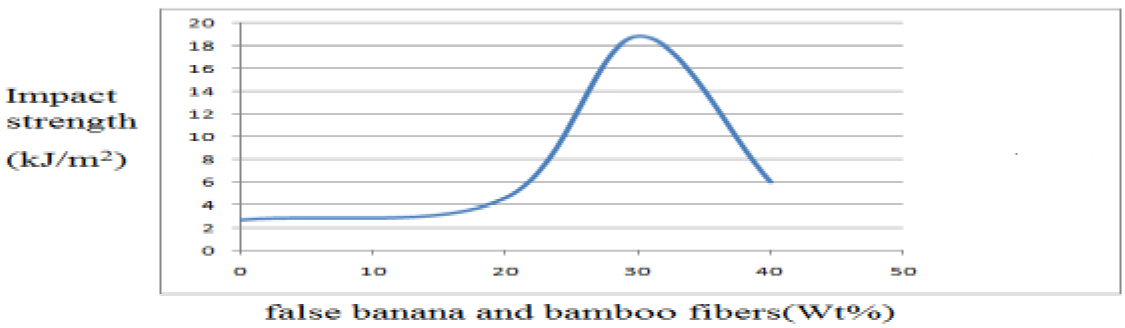

Fig.11 Effect of wt% false banana and bamboo fibers on impact strength

4.2 Water Absorption Test

Water absorption is a very important test for natural particles and fibers reinforced composites to define their potential for outdoor working. The performance of these composites may suffer while they are exposed to environmental conditions for long time. The water absorption test provides information about the adhesion between the particles and the matrix in the interface region, as higher the adhesion between the matrix and the particles fewer will be sites that could store water and will lead to lower water absorption.

V CONCLUSIONS

false banana and bamboo fibers reinforced epoxy composites have been fabricated with varying fiber concentration. The experimental analysis has shown that false banana and bamboo fibers reinforcement in the epoxy matrix has improved the mechanical properties of composite structure. The composites have been fabricated using the hand-lay-up method, which is one of the simplest methods to fabricate the composites under normal conditions. The fabricated composites are of good quality with appropriate bonding between the fiber and resin. However the presence of voids is unavoidable in composite fabrication, particularly through hand-lay-up route. The presence of pores and voids in the composite structure significantly affect a number of mechanical properties and even the performance of the composites. Higher void contents usually mean lower fatigue resistance and greater susceptibility to water penetration. While studying the fiber variations, the increase in fiber loading has improved the hardness but reduced the tensile strength and flexural strength of the composites. This decrease is attributed to the inability of the fiber to support the stress transferred from the polymer matrix. Also the poor interfacial bonding generates partial spaces between the fiber and matrix material, hence resulting in a weak structure.

Impact strength of composites also increased up to 20wt% fiber loading and then decreased at 30wt% fiber loading. Reduction of impact strength at 30wt% fiber loading was due to micro-spaces between the fiber and matrix polymer, and as a result causes numerous micro-cracks when impact occurs, which induce crack propagation easily and decrease the impact strength of the composites. Absorption of composites in water has been tested. Percentage absorption of chemicals in false banana and bamboo fibers epoxy composite increased with increase in fiber content. Water absorption of composites increased with increase in fiber loading. The hydrophilic nature false banana and bamboo fibers is responsible for water 161 absorption. Water absorption of particulate filled composites has been found to be less than the unfilled composites.

The analytical and experimental investigation of the present work has been lead to the following conclusions:

- Successful fabrication of unfilled false banana and bamboo fibers epoxy composites is possible by simple hand lay- up technique.
- The mechanical properties such as tensile strength, flexural strength, impact strength and hardness of bamboo-epoxy composites are found to be superior as compare to the neat epoxy composites.

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