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Banana-Carbon Hybrid Composite Reinforced With Epoxy: An Experimental Study

Ram Rudra Murari Rai[1], Yugal Kishor Sahu[2]
M.Tech Student[1], Assistant Proffessor[2]
Department of Mechanical Engineering
Rungta College of Engineering and Technology, Bhilai, India

Abstract:
In the era of globalization and industrialization, the major concern is not only limited to the development, rather the environmental aspect is also being taken into consideration. In recent years the global warming and ecological changes led researchers to develop new material and technique tempted to consider the sustainable development. Among the researcher of composite field the hybrid composite is very immerging topic, in which new properties of composite materials are explored day to day for better utilization. Hybridization of natural and carbon fiber reinforced polymer composites has been developing to build their applications in the field of engineering and technology. In present article aims that development of a new hybrid composite made of Banana & Carbon fiber reinforced epoxy composite and discusses its properties in comparison to Banana epoxy & carbon epoxy composites and banana jute epoxy to establish the new properties of hybrid composite. These properties considered for characterization of composite are tensile strength, flexural strength, impact strength and hardness. It can be observed that percentage of elongation of Banana & carbon epoxy hybrid composite is six times more than that of carbon-epoxy composite and 1.5 times more than that of Banana-epoxy composite. In future, we are going to carry out tests with various compositions and various sizes of fibers of bamboo jute epoxy resin composite.

Keywords: Hybrid composite, epoxy, banana fiber, jute, carbon fiber

I. INTRODUCTION

A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties. The two constituents are a reinforcement and a matrix. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part. The natural fibers are fibers which consist of animal and plant fibers such as flax, hemp, jute, coir, cotton, wool, bamboo, banana, sisal and many others [1, 2].This research is to develop banana fiber from the plant that is available locally throughout the country of India, but rarely used as a fiber source in textile industry. As banana fiber can provide a wide variety of uses in textile and paper industry, the study the application of this locally and widely grown plant species for the sustainable development. Natural fibers are basically set up of cellulose, lignin and hemicellulose. Pectin, pigments and extractives can be found in lower quantities. For this reason, natural fibers are also referred to as cellulosic or lignocellulose fibers [3].Among the various natural fibers banana and jute fibers are very much interest topic to researchers of composite materials. These are the cheapest and commonly available row materials. These fibers are very abundant in India and often inexpensive as compared to other relatively advanced man-made fibers, like glass. There are various advantages of natural fibers on contrast of environment include renewability, biodegradability, recyclability, CO_2 sequestration, and reduced dermal and respiratory irritation. Natural fibers which are biodegradable, affordable, green, and accessible [4], are obtained from naturally available resources such as coconut tree, banana tree, cotton, and jute. Researchers have conducted various studies on the impact of natural fibers on the mechanical and physical behavior of concrete to investigate the extent of improvement. In recent years, extensive studies have been done on the effects of natural fibers in fiber reinforced concrete composites (FRCC) in terms of strength, energy efficiency, and the impact resistance [5–8]. The natural fibers have additional advantages of being easily available and of being producible through recycling of plant materials [9-10]. Because of these, natural fibers can be a potential substitute for the traditional man-made fibers. However, natural fibers have few disadvantages such as high moisture absorption, swelling, limited compatibility with some thermoplastic matrices, low processing temperature, low thermal stability, poor mechanical properties, high biodegradability when exposed to environment, and low dimensional stability [11-13].

Improvement of compression strength, stability, tensile strength, bending strength and wear resistance of sisal/ aramid fiber hybrid composite with micro fibrillation of sisal fibers. The effects of hybridization of coir-jute, sisal-jute and coir-sisal fiber with polyester resins were analyzed. The result shows hybridization play important role for improving mechanical properties of composites. A combination of two or more types of fibers in a single polymeric matrix (also known as a hybrid composite), produces greater stiffness and strength in comparison with individual reinforced polymer composites. Commonly, one type of fiber in the hybrid composite has a low modulus and/or lower cost, such as glass or Kevlar, whilst the other type has a higher modulus and/or higher cost, such as boron or carbon fibers. Low modulus and inexpensive fibers make hybrid composites more tolerant to damage and reduce overall costs, while the more expensive fiber with a high modulus provides load bearing capabilities and composite stiffness. Hence, hybrid composites can provide a high stiffness and strength, improve the impact and fatigue resistance, provide high fracture toughness, and simultaneously cut the weight and/or total cost. Hybrid composites may reduce or replace application of synthetic fibers in application of automobile sector, building industries, aircraft industries. Jute-coir hybrid composites are used in railway coaches for sleeper berth backing, for building interiors, doors and windows besides in transportation sector as backings for seat and backrest in automobiles.

Hybrid composites have extensive engineering applications where strength to weight ratio, low cost and ease of fabrication are required. Hybrid composites provide combination properties such as tensile modulus, flexural strength and impact strength.

Our aim in this investigation is development of new type of epoxy based hybrid composite with banana fiber and carbon as fibers. The characterization of this composite, in comparison to epoxy based Banana fiber composite and epoxy based carbon composite is made, so that utility of newly developed composite is established. The scope of present work includes the preparation of epoxy based Banana fiber composites, epoxy based carbon composites, combination of banana fiber and jute fiber epoxy hybrid composites and epoxy based carbon and Banana fiber hybrid composites. Comparison of tensile strength tensile modulus, flexural strength, impact strength of prepared composites to establish utility of newly developed hybrid composite.

II. MATERIALS AND METHODS

A. Selection of materials

Among the wide variety of thermosetting polymers available in the market, epoxy resins are widely being used for many advanced composites due to their excellent adhesion to a wide variety of fibers, superior mechanical and electrical properties and good performance at elevated temperatures. In addition to that they have low shrinkage upon curing and good chemical resistance. Due to several advantages over other thermo set polymers, epoxy (LY 556) is chosen as the matrix material and the corresponding hardener HY-951for the present research work. The natural fiber used in this study is Banana fiber and Jute fiber. In synthetic fiber segment here we use carbon fiber in this study. All the row material is collected from different firms from the market.

B. Specimen preparation

Composites are prepared with only carbon as fibre, only Banana as fibre, both Banana and Jute and Banana and carbon as fiber with a total fibre content of 50%. Composition of composite are given in table-1.Hand layup technique is employed for preparation of composites .A split mould of 250X200 mm is used for compressing the specimen. Split mould consists of two parts (i) Top plate of flat surface with 10mm thickness (ii) flat surfaced bottom plate with 10 mm thickness and spacer plates are provided on all four sides for accurate positioning of composite. Epoxy is mixed with hardener and the entire solution is brushed on fibre material. Prepared composite along with mould and spacer plates is kept in the hydraulic press at room temperature as a pressure of 0.5 MPa for two hours. Then mould base is removed from hydraulic press and is kept at room temperature for 24hrs.Cast composite plate is removed from mould box and is cured at room temperatures for 1 week.

Table.1.

Composites	Banana Epoxy	Carbon Epoxy	Banana Jute Epoxy	Banana Carbon Epoxy
Matrix	Epoxy (LY 556)-90% Hardener(HY-951)-10%	Epoxy (LY 556)-90% Hardener(HY-951)-10%	Epoxy (LY 556)-90% Hardener(HY-951)-10%	Epoxy (LY 556)-90% Hardener(HY-951)-10%
Fiber	Banana Fiber	Carbon Fiber	Banana & Jute Fiber	Banana & Carbon Fiber
Composition	Epoxy-50%	Epoxy-50%	Epoxy-50%, Banana-25%, Jute-25%	Epoxy-50% Banana-25%, Carbon-25%

III. MECHANICAL TESTING

The objective of this investigation is to compare the properties of Banana fibre, Carbon fibre, Jute & Banana fibre hybrid composite and Banana & carbon fibre hybrid epoxy composites for establishing utility of newly developed composite. Properties considered are tensile strength, flexural strength impact strength and Rockwell hardness test from the composite plate, specimen are cut to suitable dimension to determine the above properties.

A. Tensile Strength: Tensile test is carried out on ASTM-D-638 test standard with universal load applied at both the ends.
The test specimen size was 250 mm x 15 mm x 1 mm. The test was performed on universal testing machine (U.T.M) of 10-tonne capacity. The flat specimens of required size were fixed between the grips of each head of the testing machine in such a way that the direction of force applied to the specimen is coincident with the longitudinal axis of the specimen. Tensile strength equipment used for the study is given in Fig-1

Figure.1. Tensile testing Machine

B. Flexural strength:

The flexural test specimens are prepared as per the ASTM D790 standards. The 3-point flexural test is the most common flexural test and used in this experiment for checking the bending strength of the composite samples. The test specimens of each laminates of banana/carbon fiber reinforced epoxy composites are prepared and tested by applying the three point flexural loading with the help of same UTM. The testing process involves placing the test specimen in the UTM and applying force to it until it fractures and breaks. The result of flexural strength of each specimen is observed and the results are compared. The test specimen was 154 mm x 13 mm x 4 mm. Two parallel roller supports were used to support the specimen and load was given by means of loading nose midway between the supports. Three point bend test is performed span of 40 mm is taken and cross head speed is maintained at 2m/min.

Flexural strength is determined using the equation

$$F = \frac{3PL}{2Wt^2} \quad (1)$$

Where F=Flexural strength in MPa

P=Load applied at Central of specimen in Newton's;

L=span length of specimen in meters;

W=Width of specimen in meters and

t=thickness of specimen in meters.

Three point bend test apparatus used in the study is given in Fig-2.

Figure.2. Three point bend test apparatus

C.Impact Test: For analyzing the impact strength of hybrid composite Izod test is used for impact testing of specimen. The samples clamped into the tester were hit by a pendulum, released from a height. Dial indicator attached to the pendulum rod directly shows the impact strength of the specimen's safety load holds pendulum in its raised position and released when activated. If the pendulum is released, the pendulum quickly hits V-notched specimen. Dimension of specimen are cross section 12.1 mm^2, length: 64 mm and depth of notch is 10.2 mm. Fig. shows systematic diagram of specimen arrangement for Izod test in impact testing machine.

D. The Rockwell hardness: The Rockwell hardness test method is used to measures the permanent depth of groove produced by a force/load on an indenter. Initially, a preload or minor load is applied to the given sample with a diamond indenter. This preliminary test force represents the zero or reference position that breaks through the surface reducing the effects of surface finish. Then, an additional load or the major load is applied to hit the total required test load. To allow elastic healing, this force is held for a predetermined amount of time. The major load is then released and the final position is calculated against the position derived from the minor load, the indentation depth variance between the preload and major load value.

IV. RESULTS AND DISCUSSIONS

This section contains the results obtain from experiment. In the present work, comparison of properties of Banana fiber reinforced epoxy, carbon reinforced epoxy , banana and jute fiber reinforced epoxy and banana fiber & carbon reinforced epoxy composites are compared to establish the extent of utility of newly developed Banana and carbon epoxy hybrid composite. Here tensile test, flexural test, impact test and hardness test are done on the prepared samples and their result are discussed as below:

A. Tensile Strength:

Tensile strengths of the composite specimens are evaluated by the help of Machine ASTM-D-638and the test results for the different samples of composites are presented by bar graph shown in figure 3.It is observed that tensile strength of carbon-epoxy composite is twenty times more than that of Banana-epoxy composites. Tensile strength of jute and Banana epoxy hybrid composite is increased eleven times to that of Banana-epoxy composite. By replacing half of weight of Banana fiber of Banana-epoxy composite with carbon fiber makes the composite fifteen times stronger in tension. Here we concluded that the tensile strength of the Banana carbon epoxy hybrid composites is very better then single natural fiber composites.

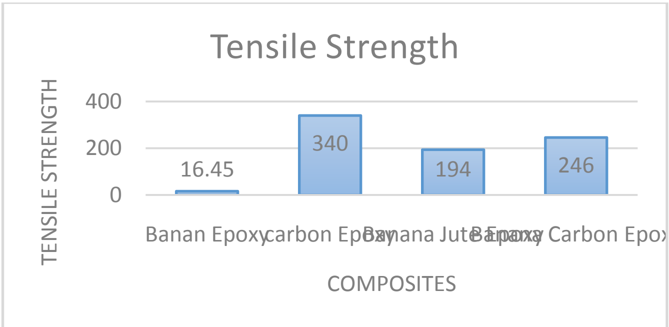

Figure.3.Effect of fiber loading on Tensile Strength

B. Percentage elongation of composites:

The percentage of elongation of various composites are shown in fig 4. According to the bar graph here we concluded that the carbon fiber epoxy composite exhibited least percentage of elongation. The percentage of elongation of Banana epoxy composite is four times to that of carbon epoxy composite. It can be observed that percentage of elongation of Banana & carbon epoxy hybrid composite is six times more than that of carbon-epoxy composite and 1.5 times more than that of Banana-epoxy composite. It can be observed that Banana & carbon epoxy hybrid composite exhibited moderate tensile strength with reasonably good amount of percentage of elongation i.e. ductility. Hence though tensile strength of Banana & carbon epoxy hybrid composite is less than that Banana & carbon epoxy hybrid composites can be used in place of carbon epoxy composite and thus reducing the final cost and improvement in ductility. Here we concluded that the tensile strength and ductility of Banana & carbon epoxy hybrid composite is much higher than that of Banana epoxy composite and Banana and jute hybrid composites.

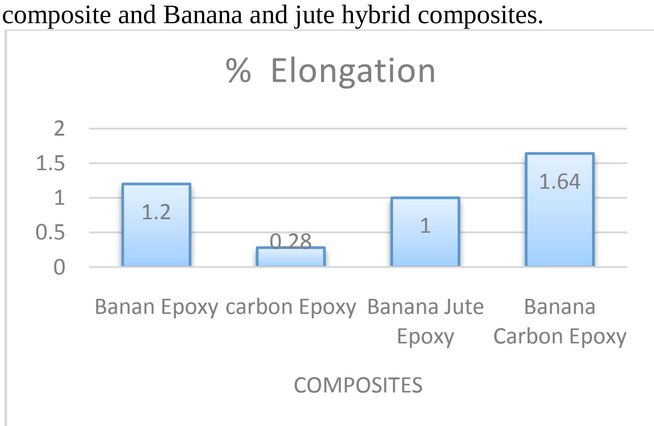

Figure.4.Effect of fiber loading on Percentage of elongation

C. Flexural Strength:

The flexural strength represents the highest stress experienced within the material at its moment of yield. It is measured in terms of stress. The effect of fiber loading on flexural strength of the different composite samples is given in fig.5. It can be observed from the study that by 50% of fiber content of Banana epoxy composite with carbon, the flexural strength is increased 3.5 times. Here according to this investigation flexural strength of Banana fiber & carbon epoxy hybrid composite is, though slightly less, comparable to that of carbon-epoxy compositebut in contrast of cost the Banana carbon epoxy composite is very effective.

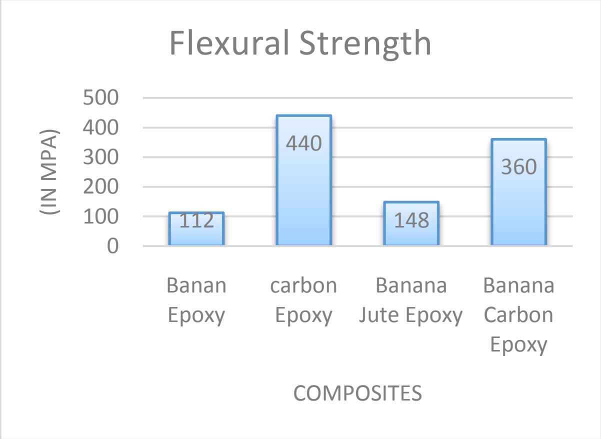

Figure.5. Effect of fiber loading on Flexural Strength

D. Impact Strength:

The effect of fiber loading on impact strength is given in fig.6.The carbon epoxy composite exhibited least impact strength, whereas banana jute epoxy composite recorded highest impact strength among the composites considered. Impact strength of banana & carbon-epoxy hybrid composite is slightly less than that of banana epoxy composite. 36% of improvement of impact strength is registered for Banana & carbon epoxy hybrid composite, when compared to that of carbon-epoxy composite.

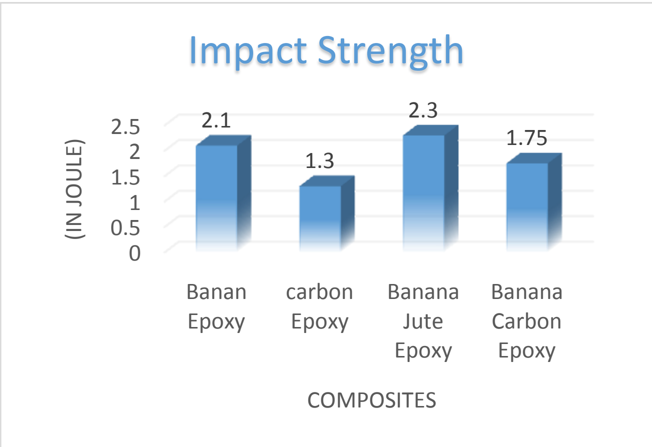

Figure.6.Effect of fiber loading on Impact Strength

E. The Rockwell hardness:

The hardness of the composite sample analyzed by the Rockwell hardness test machine as per the results which is shown in the bar graph in figure.7, the carbon epoxy shows the highest hardness, the Banana epoxy composite has least hardness, the hybrid composite of Banana carbon and epoxy has better hardness then natural fiber composites.

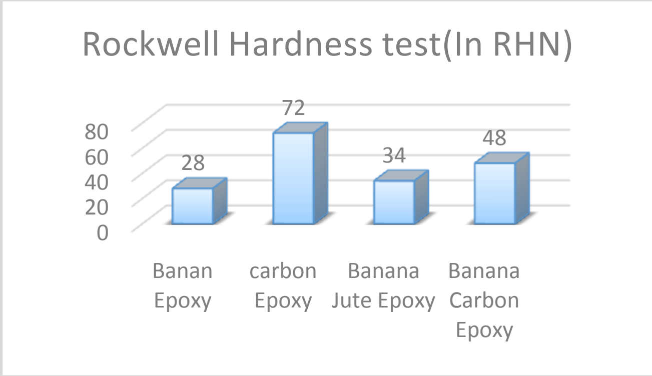

Figure.7. Rockwell Hardness test

V. CONCLUSION

In the present study a new type of hybrid composite is introduced and the mechanical properties of that hybrid composite is investigated experimentally. Here Banana carbon epoxy composite is developed as hybrid composite, which is combination of natural and synthetic fiber epoxy based composite. The different mechanical test for evaluating its properties has been done i.e, tensile test, flexural test, impact test and hardness test. Along with thee more composite samples are prepared. These are banana epoxy, carbon epoxy and jute & banana hybrid natural fiber composite. Comparing between these four composite samples our investigation is performed. Tensile strength of banana & carbon epoxy hybrid composite is almost equal to that of carbon-epoxy composite and considerably higher than that of banana epoxy composites. It can be observed that percentage of elongation of Banana & carbon epoxy hybrid composite is six times more than that of carbon-epoxy composite and 1.5 times more than that of Banana-epoxy composite. Flexural strength had been observed from the study that by 50% of fiber content of Banana epoxy composite with carbon, the flexural strength is increased 3.5 times. Here according to this investigation flexural strength of Banana fiber & carbon epoxy hybrid composite is, though slightly less, comparable to that of carbon-epoxy composite. The carbon epoxy composite exhibited least impact strength, whereas banana jute epoxy composite recorded highest impact strength among the composites considered. Impact strength of banana & carbon-epoxy hybrid composite is slightly less than that of banana epoxy composite. 36% of improvement of impact strength is registered for Banana & carbon epoxy hybrid composite, when compared to that of carbon-epoxy composite. The carbon epoxy shows the highest hardness, the Banana epoxy composite has least hardness, the hybrid composite of Banana carbon and epoxy has better hardness then natural fiber composites.

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