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Effect of Fly Ash Hybriding on the Mechanical Properties of Banana Fiber Hybrid Composites

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***Abstract*— *Banana fiber reinforced composites have attracted the attention of research community mainly because they are turning out to be an alternative to synthetic fiber. Various reinforcements and hybridization of composite materials results in the desired properties. In this research, banana fibers as reinforcement hybrid with fly ash have been used as composite for characterization of mechanical behavior. Hybrid epoxy polymer composite was fabricated using chopped banana and lengthy fiber and the SME analysis was also studied. It is found that the addition of fly ash with the composite improved the mechanical properties of the composite.*

Keywords—Banana fiber, Epoxy resin, Fly ash, Hardener, Hybrid composite.

I. INTRODUCTION

Banana fiber is widely used as a replacement for synthetic fiber due to their ease of availability and eco-friendly nature. Mechanical properties of banana fiber reinforced natural rubber composites were investigated by many researchers and found that the properties are at par. The properties are further improved by many methodologies such as chemical treatment, hybrid with reinforcement materials, hybrid the matrix materials, etc. Experiments on Hybrid composites proved that they are cost effective, recyclable and biodegradable and may replace or reduce utilization of synthetic fibers in different applications. So in this research the banana fiber composite is hybridized with the fly ash in epoxy resin. Further the SEM studies also conducted to validate the proper mixing of fly ash particles in the epoxy. Hence in this study banana fiber with fly ash is performed and its effect on mechanical properties of the banana hybrid composite is studied.

II. HYBRID COMPOSITE

In this research, an attempt had been made to characterization of hybrid composite. The composite consist of banana fiber, fly ash and epoxy. Banana is an important fruit crop which belongs to the genus MUSA. It grows wild and also cultivated on a large scale as a field crop as well as a backyard crop in households. In India, Banana is cultivated in about 1, 86,000 hectares of land. The plant shows luxuriant growth in rich well drained soil with ample moisture and decaying organic matter. It can also flourish on light sandy or gravely soil as well as on stiff but well drained clay, if the soil is fertile and facilities for irrigation are available. The Pseudo stem portion of the plant contains Fiber suitable for making ropes and twines. Extraction of certain spices of banana fiber and its industrial application has also been reported. The Fiber is located primarily adjacent to the outer surface of the leaf sheath. Well cleaned and brushed decorticated whole leaf sheath yield 80-85% long slender fibers. The Banana fibers possess good physical strength properties. The higher Pentosan content together with gums and mucilage in the sheath of certain spices of banana plant may be a suitable source for producing paper. Although reports are available on utilisation of Banana fiber for textile pulp and paper making, but no reports are available so far on the development of paper using banana sheath fiber. Considering the higher pentosan gums and mucilage contents in the sheath of musa plant, a detailed investigation was undertaken to study the possibility of making composite materials from this banana fiber.

Fly ash is a finely divided residue resulting from the combustion of ground or powdered bituminous coal or sub bituminous coal (lignite) and transported by the flue gases of boilers fired by pulverized coal or lignite. Fly ash is a waste by-product material that must be disposed of or recycled. It consists mainly of spherical glassy particle ranging from 1 to 150 μm in diameter, of which the bulk passes through a 45- μm sieve. Class C fly ash does not require an activator. Alkali and Sulphate (SO4) contents are generally higher in Class C fly ashes. Class C has $SiO_2 + Al_2O_3 + Fe_2O_3 = 50\%$

The chemical compositions of Fly Ash are given in following Table II.

TABLE I: Chemical Compositions of Fly Ash

Chemical Composition	% Value
Silicon dioxide (SiO2)	62.22
Magnesium oxide (MgO)	6.09

Sulphur trioxide (SO3)	3.00
Calcium Oxide(Cao)	5.30
Aluminium Oxide (Al2O3)	7.63
Ferric Oxide (Fe2O3)	7.63

The large family of epoxy resins contains some of the highest performance resins available at this time. The generic term epoxy resin describes a class of thermosetting resins prepared by the ring-opening polymerization of compounds containing an average of more than one epoxy group per molecule. Epoxy resins traditionally are made by reacting epichlorohydrin with bio-phenol, which are linear polymers that cross-link, forming thermosetting resins basically by the reaction with the hardeners. The curing agent for the epoxy resins usually is amine. No volatile by-products are generated during the curing process. During curing, epoxy resins can undergo three basic reactions: 1. Epoxy groups are rearranged and form direct linkages between themselves. 2. Aromatic and aliphatic hydroxyls link up to the epoxy groups. 3. Cross-linking takes place with the curing agent through various radical groups.

III. LITERATURE SURVEY

Merlini et al. have studied the effect surface treatment on the chemical properties of banana fiber and reported that treated banana fiber give higher shear interfacial stress and tensile strength when compared with the untreated fiber. Dhieb et al. have studied about the surface and sub-surface degradation of unidirectional carbon fiber and have given many conclusions such as under sliding in demineralized water, the simplest degradation was detected on sliding in anti-parallel direction. Shankar et al. have studied and reported that the ultimate tensile strength value maximum at 15% and then decreases with increasing in fiberstarting from 15% to 20%. They also reported that the flexural strength value decreasing from 5% to 10% (87.31 MPa) and after that the value increased from fiber.

Sumaila et al. have investigated the influence of fiberlength on the mechanical and physical properties of nonwoven short banana, random oriented fiber and epoxy composite and they described that the tensile properties and percentage elongation of the composite attained a maximum in composite fabricated from 15 mm fiber length. They have also reported that the impact energy whereas the compressive strength increases decreased with increasing fiber length, also the mean flexural properties of the composite increased with increasing in fiber length up to 25mm.

Mukhopadhyay et al experimented the banana fibers characteristic depending on the variation of diameter, mechanical characteristic and the effects of the stresses performing on the fracture morphology. The stress-strain curves for changed strain rates were found and fractured surfaces were inspected by SEM. Pothan et al. have investigated on the influence of fiber content and length on short banana fiber reinforced polyester composite material. Laban et al. has studied on the physical and mechanical behaviour of banana fiber reinforced polymer composite and noticed that kraft mashed banana fiber material has better flexural strength. The tensile strength is detected maximum at 30 mm fiber length whereas the impact strength is noticed maximum at 40 mm length of fiber. Consolidation of 40% untreated banana fibers gives 20% rise in the tensile strength and 34% rise in impact strength.

Prasanna and Subbaiah reported that composites material having 20% treated fiber loading possess maximum values for above-mentioned properties than untreated composites, 10% and also 30% treated fibers composites. The interfacial area having main role in influential the strength of polymer material since fiber procedures a separate interface with the matrix. The effects of this study uncovered that short zig-zagfiber composites with great rigidity and element mechanical properties might be effectively ready utilizing banana fiber as reinforcement in a polyurethane matrix inferred from castor oil. The treated banana fiber demonstrated higher shear stress and tensile strength when contrasted with the untreated fiber, showing a solid association between the treated strands and the polyurethane matrix. The hybridization of this reinforcement in the composite shows more terrific flexural quality when contrasted with singular kind of characteristic strands strengthened composites. All the composites shows expand in flexural quality in longitudinal heading.

Selzer and Friedrich et al. studied the carbon fiber reinforced polymer composites and reported that the brittle materials demonstrate a lot of delamination's also interlinear splitting throughout weariness. This implies that in composites with an exceptionally intense grid and great fiber-network bond, various splitting, which ingests a higher measure of vitality, is anticipated, with the goal that at last confined disappointment happens at easier levels than anticipated. The banana and glass fiber bio-composites may be fabricate for outdoors and indoors applications wherever high strength is not necessary, additionally it can considered as the replacement to wood materials and protect the forest resources. There are many reports available on the mechanical and physical properties of natural fiber reinforced polymer composites, but, the effect of fiber length on mechanical behaviour of

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banana fiber reinforced polymer composites is scarcely been reported. To this end, the current work has undertaken with the objectives to investigate the mechanical properties of banana fiber based epoxy composites.

IV. EXPERIMENTAL TESTING

Raw materials used for this experimental work are: Banana fiber, Fly ash, Epoxy resin (LY556) and Hardener (HY951). The banana fiber has better adhesion properties when it is in dry condition and poor adhesion in wet condition, so the banana fiber dried for 48 hours in sun light or 24 hours in 70 degree C temperature to remove the moisture content present in it. The hardener (HY951) is used in this study as per the required volume fraction with the resin. Initially the banana fiber was chopped for a length of 15mm approximately. A wooden mold of dimension 300x300x3 mm was used for casting the composite sheet. For different volume fraction of fibers, a calculated amount of epoxy resin and hardener (ratio of 10:1 by weight) was thoroughly mixed with gentle stirring to minimize air entrapment. Then the fly ash is mixed with the mixture thoroughly.

The proportion of the fly ash in the mixture is 5%, 10% and 15%. After keeping the mold on a glass sheet a thin layer of the mixture was poured. Then the required amount of mixed fibers was distributed evenly on the mixture. The remainder of the mixture was then poured into the mold. Care was taken to avoid formation of air bubbles. So after the lay process, it should be compressed using a roller to remove the air entrapment in the composite. Also to avoid further absorption of air or moisture during drying, a weight of 65 kg was applied over the composite and it is allowed to cure in room temperature of 30 degree C for 24hrs. After the composite is fully cured, it has to be separated from themould and cut into required dimensions as per ASTM standards. The obtained composite, cutting mechanism and the specimen is shown in the Figure 1.

Fig.1: Banana Reinforced Fly Ash Composite

Fabricated composite was cut to get the desired dimension of specimen for mechanical testing. For the tensile test, the specimen size was 150 × 15 x 2 mm and gauge length was 70 mm and the specimen has tested in Universal testing machine. The result obtained from the tensile test for 5%, 10% and 15% fly ash with epoxy is shown in the figure 2, 3, and 4 respectively

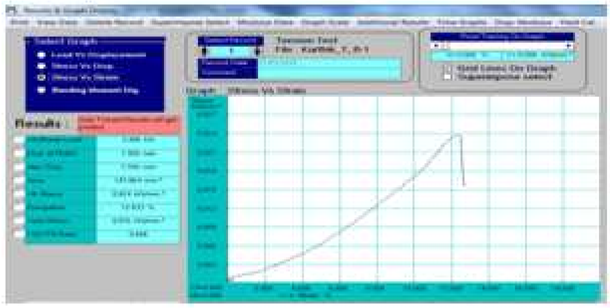


Fig.2: Tensile test of Banana fiber composite with 5% ash content

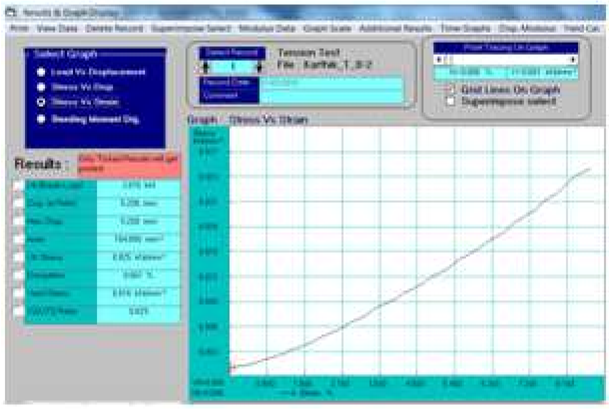
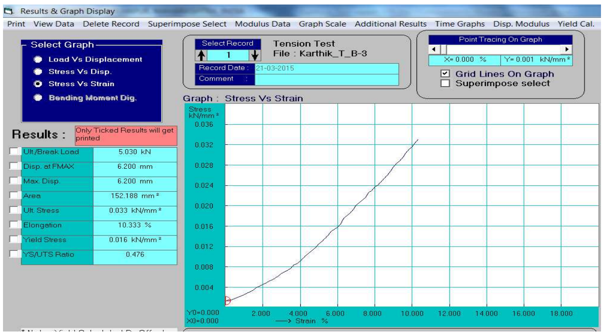


Fig.3: Tensile test of Banana fiber composite with 10%



ash content

Fig.4: Tensile test Banana fiber composite with 15 % ash content

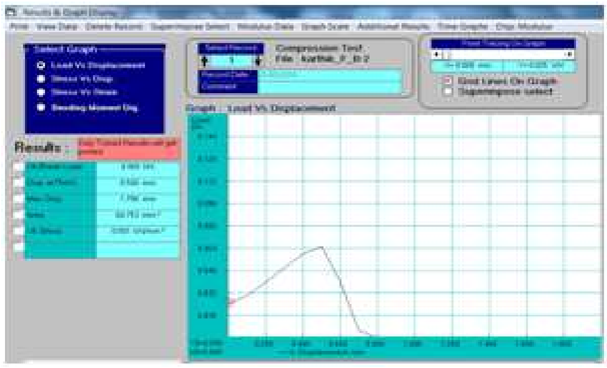


Fig.5: Flexural test of Banana fiber composite with 5% ash content

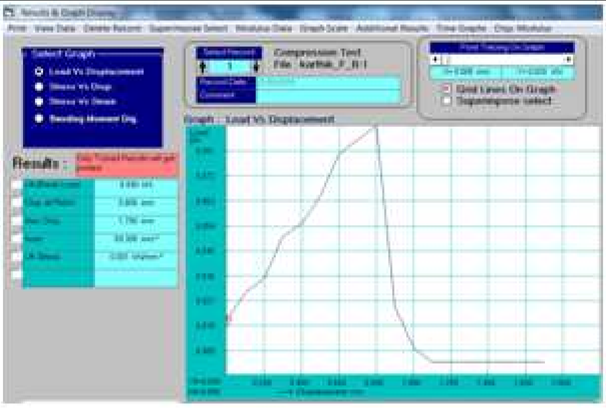


Fig.6: Flexural test of Banana fiber composite with 10% ash content

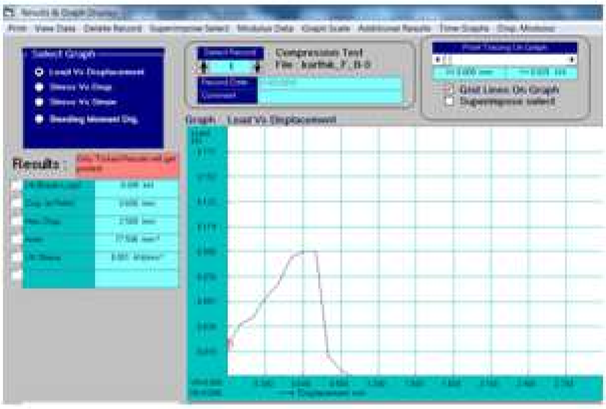


Fig.7: Flexural test of Banana fiber composite with 15% ash content

Test Specimen dimension for impact test was 60 mm × 15 mm. Impact testing was conducted in impact testing machine and the result of the impact testing is shown in the Table II

TABLE II: Impact Test Result

Sample id	Joules
Banana-Fly ash 5%	0.05
Banana- Fly ash 10%	0.1
Banana- Fly ash 15%	0.05

V. SEM ANALYSIS

It is a analysis done after testing over the impact test samples using a SEMI-ELECTRON MICROSCOPE to find out the structural formation. The Specimen and the SEM images of banana fiber composite with 5%, 10% and 15% fly ash with epoxy respectively are shown in the Figure 8.

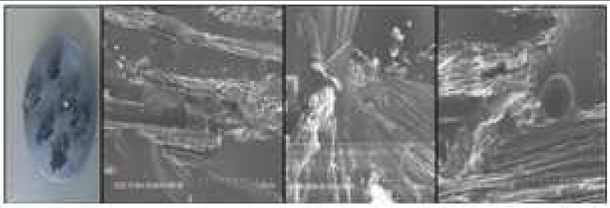


Fig.8:Banana fiber specimen and SEM for 5%, 10% and 15% fly ash

VI. CONCLUSION

The test results showed that the tensile strength for banana fibre hybrid composite with 15 5 fly ash is having higher strength. This is higher than banana fibre and comparable with that of pure glass fibre composite. Also flexural strength of banana fibre hybrid composite is higher. Hence proper mixing of fly ash with the epoxy with banana fibre reinforcement will give better mechanical properties.

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