Evaluation of Mechanical Behavior of Banana and Sugarcane Bagasse Fiber Rein Forced Epoxy Hybrid Composite

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Abstract:
The increasing demand for environmental friendly materials and the desire to reduce the cost of traditional fiber lead to the development of natural fiber composites. Natural fibers presented in the composite have some important advantages such as low density, appropriate stiffness, mechanical properties and renewability. In the present work deal with fabrication and investigation of mechanical properties of banana fiber, Sugarcane Bagasse fiber and reinforced with epoxy resin as natural hybrid composite they are recyclable and biodegradable. The Composites of different combinations with varied fiber content were prepared using hand lay-up technique using epoxy resin and hardener as reinforcing materials. Banana fiber with 30% and were hybridized with 6% of Sugarcane Bagasse with common length to form composites and compared with normal Banana fiber and epoxy resin composites. The results thus obtained signified mechanical properties got improved in Banana -Sugarcane Bagasse hybrid composite with increased Sugarcane Bagasse fiber content from 6%, thus acting as a positive reinforcement in providing extra strength and smooth surface finish to the composite and at the same time the Banana fiber imparted elasticity to the composite.

Key Words: density, appropriate stiffness, Sugarcane Bagasse

1. INTRODUCTION

Requirement for economical and environment-friendly materials has extended an interest in natural fibers. Most of the natural fibres, like softwood Sugarcane Bagasse and banana fibres have been used as reinforcement materials in composite products. In this work, natural sugar cane bagasse have been utilized for similar study. Bagasse is a fibrous residue obtained from sugar cane during extraction of sugar juice. Sera and co-workers studied the effect of reinforcing concrete with bagasse fibres. The bagasse fibers were boiled in water for 30 minutes to remove the sugar prior to using it as reinforcement. In the vast majority of countries in South-East Asia, sugar cane is a commercially grown agricultural crop. Countries like Guadeloupe (The French West Indies) have been using the bagasse as a combustible material for energy supply in sugar cane factories as in thermal power station. But other countries such as Egypt, Cuba, etc. used it in pulp, paper industries and for board materials. Thus, these natural residues are not just helping some nations in their economy, but also reducing or eliminating urban waste.

Over the last few years, a number of researchers have been involved in investigating the exploitation of natural fibers as load bearing constituents in composite materials. The use of such materials in composites has increased due to their relative cheapness, their ability to recycle and for the fact that they can compete well in terms of strength to weight of material. Natural fibers can be considered as naturally occurring composites consisting mainly of cellulose fibrils embedded in lignin matrix. The cellulose fibrils are aligned along the length of the fiber, which render maximum tensile and flexural strengths, in addition to providing rigidity. The reinforcing efficiency of natural fiber is related to the nature of cellulose and it’s crystalline. The main components of natural fibers are cellulose, hemicelluloses, lignin, pectin’s, and waxes I.

1.1 OVERVIEW OF FIBER AND COMPOSITES

The attraction in utilizing natural fiber, for example, distinctive wood fiber and plant fiber as support in plastics has expanded drastically throughout last few years. Concerning the ecological viewpoints if natural fibers might be utilized rather than Banana fibers as fortification in some structural provisions it might be extremely intriguing. Natural fibers have numerous points of interest contrasted with Banana fiber, for instance they have low thickness, and they are biodegradable and recyclable. Also they are renewable crude materials and have generally great Strength and stiffness.

Natural fibers are classified on the basis of the origin of source, into three types
1. Plant Fibers
2. Mineral Fibers
3. Animal Fibers

1. Plant Fibers: Plant fibers are usually consists of cellulose: examples cotton, jute, bamboo, flax, ramie, hemp, coir and Banana. Cellulose fibers are used in various applications. The category of these fibers is as following: Seed fibers are those which obtain from the seed e.g Kapok and cotton. These fibers having superior tensile properties than the other fibers. Because of these reason these fibers are used in many applications such as packaging, paper and fabric. Fruit fibers are the fibers generally are obtain from the fruit of the plant, e.g. banana fiber and coconut fiber. Similarly, stalk fiber are the fibers which are obtain from the stalks (rice straws, bamboo, wheat and barley). Leaf fibers are the fibers those are obtain from the leaves (agave and Banana). Skin fibers are those fibers which are obtaining from the bast or skin surrounding the stem of the plant.

2. Mineral Fibers: Mineral fibers are those which are getting from minerals. These are naturally happening fiber or somewhat changed fiber. It has different classifications they are taking after: Asbestos is the main characteristically
happening mineral fiber. The Variations in mineral fiber are the serpentine, amphiboles and anthophyllite.

3. Animal Fibers: Animal fiber by and large comprises of proteins; cases, silk, alpaca, mohair, downy. Animal hairs are the strands got from creatures e.g. Sheep’s down, goat hair, horse hair, alpaca hair, and so forth. Silk fiber is the filaments gathered from dry saliva of bugs or creepy crawlies throughout the time of planning of cocoons. Avian strands are the fiber from fowls. Composites of natural fiber used for drives of structural, but typically with synthetic thermo set matrix which of course bound the environmental benefits. Now a day’s natural fiber composites application are usually found in building and automotive industry and the place where dimensional constancy under moist and high thermal conditions and load bearing capacity are of importance. Natural fibers like cotton, banana, jute, abaca, pineapple and coir have already been studied like a reinforcement and filler in composites. Among various natural fibers, banana fiber is considered as a potential reinforced in polymer composites due to its many advantages such as easy availability, low cost, comparable strength properties etc. Generally, natural fibers are consists of cellulose, lignin, pectin etc. The detail compositions of few commonly used natural fibers are shown in Table.

### Properties of Fibers

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Cellulose (wt%)</th>
<th>Hemicellulose (wt%)</th>
<th>Lignin (wt%)</th>
<th>Pectin (wt%)</th>
<th>Moisture (wt%)</th>
<th>Waxes (wt%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>85-90</td>
<td>5.7</td>
<td>-</td>
<td>0-1</td>
<td>7.85-8.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Bamboo</td>
<td>60.8</td>
<td>0.5</td>
<td>32</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Flax</td>
<td>71</td>
<td>18.6-20.6</td>
<td>2.3</td>
<td>22</td>
<td>8-12</td>
<td>1.7</td>
</tr>
<tr>
<td>Hemp</td>
<td>70-74</td>
<td>17.9-20.4</td>
<td>3.7-5.7</td>
<td>0.9</td>
<td>6.2-12</td>
<td>0.8</td>
</tr>
<tr>
<td>Jute</td>
<td>61.1-71.5</td>
<td>13.6-20.4</td>
<td>12-13</td>
<td>0.2</td>
<td>12.5-13.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Kenaf</td>
<td>45-47</td>
<td>21.5</td>
<td>8-13</td>
<td>3.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Ramie</td>
<td>68.6-76.2</td>
<td>13.1-16.7</td>
<td>0.6-0.7</td>
<td>1.9</td>
<td>7.5-17</td>
<td>0.3</td>
</tr>
<tr>
<td>Sisal</td>
<td>66-78</td>
<td>10-14</td>
<td>10-14</td>
<td>10</td>
<td>10-22</td>
<td>2</td>
</tr>
<tr>
<td>Coir</td>
<td>32-43</td>
<td>0.15-0.25</td>
<td>40-45</td>
<td>3-4</td>
<td>8</td>
<td>-</td>
</tr>
<tr>
<td>Banana</td>
<td>63-64</td>
<td>19</td>
<td>5</td>
<td>-</td>
<td>10-12</td>
<td>-</td>
</tr>
</tbody>
</table>

### 2. Problem Description

In this paper a series of fracture problems in polymer composite materials are identified, their methods of solution are briefly discussed, and some sample results are presented. The main problem of interest is the determination of the hardness and tensile state in the neighborhood of localized imperfections such as cracks and inclusions which may exist in the composite. Particular emphasis is placed on the evaluation of quantities such as the hardness and tensile intensity factors, which may be used directly or indirectly in connection with an appropriate fracture criterion for the prediction of fracture initiation and propagation load levels. The topics discussed in the paper include hardness and tensile in layered composites and inclusion problems in bonded materials. This polymer composition type (30% banana+ 6% Sugarcane Bagasse+ 64% epoxy resin) increase the hardness and tensile of the material.

3. Fibers

#### 3.1 Cotton Fibers
- Cotton is a soft fibre that is obtained from cotton plants and grows as a boll.
- It is mainly grown in regions having black soil and warm conditions.
- In India cotton is basically grown in Maharashtra, Punjab, Rajasthan, Madhya Pradesh, Gujarat etc.
- It is one of the most commonly used fibres.
- When cotton plants start flowering, they give flowers of yellowish-white colour which turns red after a few days.
- Slowly, flowers change into cotton balls.

#### 3.2 Jute Fibers
- Jute fiber is obtained only from the stem of the jute plants.
- It is mainly grown in the rainy season.
- Jute mainly grows in regions having alluvial soil which is found in the delta regions of the Ganges and Brahmaputra rivers.
- In India, jute is basically grown in the states of Bihar, West Bengal and Assam.
- Jute is sometimes also called as the golden fiber. It is soft, shiny and long fiber with a silky texture.
- Jute plant is about 3 meters in height and bears yellow flowers in a few months.
3.3 BAMBOO FIBERS

Bamboo fabrics are made from pure bamboo fiber yarns which have excellent wet permeability, moisture vapor transmission property, soft hand, better drape, easy dying and splendid colors. It is a newly founded, great prospective green fabric.

5. Bamboo decorating series

It has the functions of antibiosis, bacteriostatic and ultraviolet-proof. They are very advantageous for utilization in the decorating industry. Along with the badly deterioration of atmosphere pollution and the destruction to the ozonosphere ultraviolet radiation rays are more and more becoming a problem for human beings. Long-time exposure to ultra violet radiation will cause skin cancer. Wallpapers and curtains made from bamboo fiber can absorb ultraviolet radiation in various wavelengths thus they lessen the harm to the human body. More important, bamboo decorating products will not go moldy due to damp. Curtains, television covers, wall papers and sofa slip covers can all be made from bamboo fibers.

3.4 FLAX FIBERS

Art of producing Linen from flax plant was known earlier than 2500 BC, though flax production was introduced to the industry in 12th century. Flax fibers have been used for textile utilization such as woven, knitting and technical textiles for many centuries. Raw materials that we get from flax can be applied in bio-polymers, aerospace and automotive industries as well as for production of agro fine chemicals. In the last few years, new achievements have been made in the research field of bust fibers (especially flax). New varieties, new technology for processing and most importantly broadening the area of application of flax have been achieved.

1. Bamboo intimate apparels

It include sweaters, bath -suits, mats, blankets, towels have comfortable hand, special luster and bright colors, good water absorbance. Bamboo fiber has a unique function of anti- bacteria, which is suitable to make underwear, tight t-shirt and socks. Its anti-ultraviolet nature is suitable to make summer clothing, especially for the protection of pregnant ladies and young children from damages of ultraviolet radiation.

2. Bamboo non-woven fabric

It is made by pure bamboo pulp, which has similar properties as viscose fibers have. However, bamboo has wide prospects in the field of hygiene materials such as sanitary napkin, masks, mattress, food packing bags due to its anti -bacteria nature.

3. Bamboo sanitary materials

It includes bandages, masks, surgical clothes, nurse swears and so on. The bamboo fiber has a natural effect of sterilization and bacteriostatic and therefore it has incomparably wide foreground on application in sanitary material such as sanitary towels, gauze mask, absorbent pads, and food packing and so on. In the medical scope, it can be processed into the products of bamboo fiber gauze, operating coat and nurse dresses etc. Because of the natural antibiosis function of the bamboo fiber the finished products need no adding of any artificial synthesized antimicrobial agent. Therefore bamboo fiber products will not cause skin allergies and at the same time it has a competitive advantage in the market.

4. Bamboo bathroom series

It enjoys good moisture absorption, soft feel and splendid colors as well as anti-bacteria property which are very popular in home textiles. Bamboo towels and bath robes have a soft and comfortable hand feeling and excellent moisture absorption function. Its natural anti bioisfungion keeps bacterium away so that it will not produce bad odor.

Figure 3.3 Bamboo Fibers

Figure 3.4 Flax Fibers

Physical properties of flax fiber:

1. Length: The average length of flax fiber varies from 90-125 centimeters. The length of individual fiber cells varies from 6-65 mm with an average diameter of 0.02mm.

2. Color: Brownish, ivory, grey, light, yellowish.

3. Tensile strength: Tenacity varies from 6.5 to 8 gm/denier.

4. Elongation: Elongation at break is approximately 1.8 % (dry) and 2.2% (wet).

5. Specific gravity: 1.54

6. Effect of moisture: M.R = 12% (std)

7. Effect of heat: Highly resistant to decomposition up to 125°C. The fibers begin to discolor after crossing temperature limit. Heat conductance is good.

http://ijesc.org/
8. Abrasion resistance: Moderate
9. Dimension stability: Good but tends to crease easily.

Chemical properties of flax fiber
1. Effect of acids: Flax fiber is easily damaged by high concentrated acids. But it is not affected by low dense acids if washed immediately.
2. Effect of alkalis: Flax fiber has an excellent resistance to alkalis. It is not degraded by strong alkalis.
3. Effects of bleaches: Cool chlorine and hypochlorite bleaches don’t affect flax fiber.
4. Dyes: It is not suitable for dyeing. But it can be dyed by direct or vat dyes.

‘Customization’ is a process to produce finer and shorter flax fibers which are used in blending with other fibers with lowest level of impurities. It is an upcoming trend of development of natural fiber base material. Fiber bundles are broken down to their ultimate fiber cells via mechanical or chemical means. These broken flaxes are called ‘cottonized’ flax. These individual fibers are 25 to 40 nm of length. It is used in car construction companies as an anti-noise fabric and also used for medical purposes.

3.5 RAMIE FIBER

Innovation sees no limit and Indian consumers can expect something big coming up in the textile industry like fabrics and textiles woven from fine quality Ramie fiber. Ramie (pronounced Ray-me) is one of the oldest vegetable fibers and has been used for thousands of years. It was used in mummy cloths in Egypt during the period 5000 - 3000 BC, and has been grown in China for many centuries.

Figure 3.5 Ramie Fibers

Ramie (Boehmeria nivea), commonly known as China grass, white ramie, green ramie and rhea, is one of the group referred to as the bast fiber crops. The ramie plant is a hardy perennial belonging to the Urticaceae or Nettle family, which can be harvested up to 6 times a year. It produces a large number of unbranched stems from underground rhizomes and has a crop life from 6 to 20 years. The fibers need chemical treatment to remove the gums and pectin found in the bark.

The process of transforming the ramie fibers into fabric is similar to the process used for manufacturing linen from flax. The true ramie or 'China Grass' is also known as 'white ramie' and is the Chinese cultivated plant. It has large heart shaped, crenate leaves covered on the underside with white hairs that give it a silvery appearance. Boehmeria nivea var. tenacissima is believed to have originated in the Malay Peninsula and is known as 'green ramie' or 'rhea'. Green ramie has smaller leaves than true ramie and is better suited to tropical climates.

The fiber is very fine like silk, and being naturally white in colour does not need. Chemically ramie is classified as a cellulose fiber, just as cotton, linen, and rayon. The leading global producers of ramie are China, Taiwan, Korea, the Philippines and Brazil. Ramie is often blended with cotton to make woven and knit fabrics that resemble fine linen to coarse canvas. Ramie is commonly used in clothing, tablecloths, napkins and handkerchiefs. It is often blended with cotton in knit sweaters. Outside the clothing industry, ramie is used in fish nets, canvas, upholstery fabrics, straw hats and fire hoses.

Advantages of Ramie
- Resistant to bacteria, mildew, alkalis, rotting, light and insect attack.
- Extremely absorbent (this makes it comfortable to wear)
- Dyes fairly easy.
- Natural stain resistance.
- Increases in strength when wet.
- Withstands high water temperatures during laundering.
- Smooth lustrous appearance improves with washing.
- Keeps its shape and does not shrink.
- Strong and durable (It is reported to have a tensile strength eight times that of cotton and seven times greater than silk).

Disadvantages of Ramie
- Low in elasticity.
- Lacks resiliency.
- Low abrasion resistance.
- Wrinkles easily.
- Stiff and brittle.
- Necessary de-gumming process.
- High cost (due to high labor requirement in production, harvesting and decortications.)

The main producers of ramie today are China, Brazil, Philippines, India, South Korea and Thailand. Only a small percentage of the ramie produced is available on the international market. Japan, Germany, France and the UK are the main importers; the remaining supply is used domestically (in the country in which it is produced).

Uses
Despite its strength, ramie has had limited acceptance for textile use. The fibers extraction and cleaning are expensive, chiefly because of the several steps involving scraping, pounding, heating, washing, or exposure to chemicals. Some or all are needed to separate the raw fiber from the adhesive gums or resins in which it is unsheathed. Spinning the fiber is made difficult by its brittle quality and low elasticity; and weaving is complicated by the hairy surface of the yarn, resulting from lack of cohesion between the fibers. The greater utilization of ramie depends upon the development of improved processing methods.

Ramie is used to make such products as industrial sewing thread, packing materials, fishing nets, and filter cloths. It is also made into fabrics for household furnishings (upholstery, canvas) and clothing, frequently in blends with other textile fibers (for instance when used in admixture with wool.
shrinkage is reported to be greatly reduced when compared with pure wool.) Shorter fibres and waste are used in paper manufacture.

3.6 HEMP FIBERS

Hemp is a very versatile plant that has myriad uses. In the USA, it accounts for a huge number of wild plants that grow without much care and particularly in the wild. These are sturdy plants that can withstand severe frost and need very little water or rain to foster good growth. History bears witness that hemp was a widely cultivated commercial crop and the uses of hemp fiber have many and multifarious. Hemp fibers have been used for centuries to manufacture clothes, bags, shoes, paper, building materials, and insulation purposes. It is also used as a food and is not the same as cannabinoids used for intoxication purposes. Apart from all this hemp oil is also used in the cosmetics and medical industry and has been put to multiple uses.

![Figure 3.6 Hemp Fibers](image)

It is one of the safest, organic and economic plants that can be used to ensure ecological and environmental sustainability. Hemp seeds have been used as a sustainable source of nutrition in healthy diets and have been used in cuisines across the world since time immemorial. When one thinks exclusively just about the uses of hemp fiber, it’s almost dazzling how multi-purpose the crop is.

The top FIVE uses of Hemp Fibers are:

1) To make clothes or textiles

Hemp fiber has been used since ancient times to make textiles. It is easily available and readily cultivable. It is cheaper than most textiles that are obtained organically and way more ecologically sustainable than those synthesized chemically. The fabric obtained from hemp are good for sensitive people too and don’t cause allergies. These textiles are ready to work on and we have an heirloom of civilizational history that testifies how diverse craftsmanship existed create beautiful pieces of hemp textiles. Ornate designs and patterns have often been added to hemp textiles to make them one of a kind. It is a very workable fabric and hence can be put to multiple uses even in the contemporary world.

2) As building material

Hemp is cheaper than wood and it is a better material to be used for insulation purposes. Wood or timber is costly. These days it is not advisable to cut down trees keeping in mind the huge loss it causes to our environment and biodiversity. Moreover, why would one use something that’s costlier, harder to acquire and at the same time not as good as out should be when there’s a cheaper and more efficient alternative? Hemp provides better insulation and can be packaged easily between the building materials. It therefore is again a very useful alternative and one that is environment friendly too.

3) To make shoes

As bizarre as this may sound but hemp fibers have been used to make sturdy shoes that provide both comfort and durability. Shoes bear most of our weight and often wear out easily. Leather is a material that is used for a very long time to make shoes that last a long time. However, leather, that is after all processed animal hide is costly and the prices of creating leather from animal skin is not just costly but also time consuming. Hence finding a cheaper and more environmentally friendly option is the need of the hour.

While many designers and shoemakers have tried to come up with synthetic materials like rubber or reusable polymers like plastics, hemp fibers are a way better option. They are readily available and growing in abundance in the wild. Even if cultivated as an industrial crop, the overall cost of production is considerably low and does not harm the flora and fauna of the planet. Of late, fashion has shifted from being sober to being outrageous while at the same time revealing greater understanding of culture and history as well as sensitivity to the planet and issues pertaining to it. Keeping up with this trend, Hemp shoes pull off an intriguing comeback. Perhaps, better than the fashion prevalent centuries ago.

4) To make paper

This is the most common and basic usage of hemp fibers. Paper has been historically produced from plants. Of late, it has also been recycled and it is not uncommon to see paper made from recycled paper. There were times when thin slices of birch bark were used as paper. This natural paper wasn’t however always obtained from dying birch trees as is actually ecologically feasible. Later, trees were cut down to produce paper. This led to mass deforestation on a large scale. This has negatively affected our planet and it is of paramount importance that we find an alternate raw material to create paper. Hemp fibers help resolve this problem. Hemp being easily cultivable and versatile cash crops can be easily used as raw material to create a good quality paper from hemp fiber for our uses. This would serve as an organic and natural resource of paper, one of the most indispensable materials of everyday life.

5) To make ropes or cords

Hemp Fibers have good tensile strength and can be used to make ropes and cords. In fact, this is another of the ancient uses of hemp fibers. Ropes were a common commodity and hemp was a readily available fiber to create them.
Although other fibers have been used to create biodegradable ropes in the past, like coconut and jute fibers, yet nothing works as well as hemp. Ropes and coils have also been put to multiple uses and one such is to create beautiful works of art. Ropes aren’t just woven to be used to tie things or hang things, they have been historically used to create ornate artifacts. Hemp ropes too have been used similarly in the past. As the modern world seeks new organic and sustainable materials for everyday use, hemp fibers find themselves being put to such uses more often now.

3.7 BANANA FIBERS

The South India Textile Research Association, Coimbatore, demonstrated its technology for spinning and yarn-making to make banana fiber suitable for blending with other fabrics in the textile industry. The Tamil Nadu Agricultural University highlighted the significance of fiber-based nonoil wraps for extending the shelf life of horticultural commodities in super markets. The Central Institute of Agricultural Engineering, Coimbatore, displayed its machine developed for minimal processing of the central core stem. ICAR-NRCB has already expressed its keenness to promote cluster development for mechanical extraction of fiber, and development of fiber banks to cater to the demands of the fiber industry and sustainable business models. An incubation center in Tirupur is promoting production of banana-silk clothing.

3.8 SUGARCANE FIBERS

There is an array of raw materials to choose from when it comes to apparel. There are natural fibers, as well as man-made fibers. The natural fibers have been around for centuries and with every progressive step that fashion world is taking, the demand for conventional fabric i.e. natural fibers is rising. Fibres extracted from banana or jute bark, from palm or screw pine leaves, from seeds of cotton, from siki or madhurkati grass, from cocoons of insects, are well-liked. Even before anything like man-made fibre came into existence, natural fibres were ruling the world of apparel and there were several blends available even then. Today, the textile industry is flooded with blends of fabrics. The rise in demand for novel fibers has led to innovative ideas surging in textile industry. Sugarcane bagasse, which is an abundant waste fibrous residue of sugarcane, is used in apparel industry. Sugarcane is grown to extract sugar from its stalk. After the juice is extracted, the remaining sugarcane fiber pulp is called bagasse. Internationally, Brazil is a major producer of sugarcane with harvest expected to be 595.13 million tons in 2013. Up until recently, bagasse was treated as a waste product, and was often set ablaze, thereby causing air pollution. This residue also is consumed as a fuel for mill boilers, animal fodder, and raw material for paper, etc., while surplus amount of is still left to be further disposed of. Bagasse is also used as a raw material in several types of building boards, production of ethanol and polypropylene composites. However, the yearly global production of 800 million tones of sugarcane, which results in 240 million tones of bagasse, should have found a more useful purpose - Apparel. Sugarcane bagasse is a complicated material that consists of roughly 50 percent of cellulose and 25 percent of hemicellulose and same percent of lignin.

In the apparel industry, bagasse is utilized for production of textile rayon fibers such as viscose, modal and lyocell. The bagasse is shredded, broken down with eco-friendly chemicals or other chemicals, and then when it is still in a liquid form, it is shot at very high pressure through tiny holes. This long strand of fiber is then solidified and spun into yarn. Rayon fibers are thus produced.

Since rayon is manufactured from organically occurring polymers, it is considered as a semi-synthetic fiber. Sugarcane rayon is glossier and more silk-like than wood pulp rayon. Sugarcane rayon, in particular, has a delightful luster, however, this could also merely be a manufacturing difference, and not a material difference. The extraction of bagasse fibers from sugarcane rind is performed in two different steps: mechanical separation and chemical extraction. Several factors are considered such as solutions of sodium hydroxide with different concentrations and time of reaction. One of the reasons for increasing attention to bagasse is the disposal of agricultural residues and the need for boosting the sugarcane industry's profits. While, the sugarcane fiber has been accepted by textile industries, there are still certain qualities, which are desirable
for a fibre to be useful for textile purposes. Some of the basic requirements include the length of the fiber, which should be several hundred times the width, as this ensures that the fibers can be twisted together to form a yarn. The actual length of the fiber is also significant. The bagasse fiber can be noticeably long, but it should not be shorter than 6 to 12 mm. If the fiber is not of the desired length it might not hold together.

The length of extracted fiber bundles depends on extraction conditions and the extraction process. The fineness of the fabric is determined by the width of the fibre bundles. The bagasse fibers must also be strong to withstand spinning and weaving processes. Fibre strength is typically determined by tensile strength referred as 'tenacity'. Tenacity is the breaking load in grams divided by the linear density. Linear density, the mass or weight of a unit length of fiber, is given as grams per 1000m and called 'tex', or as grams per 9000m and called 'denier'. The tenacity of the sugarcane fibers also varies as per the extraction conditions.

Grasses such as sugarcane should not be confused with bast fibers, which represent fibers that are obtained from the stem or stalk of the plants. Grasses such as sugarcane have stems which contain several fibers, but they are not classified as bast fibers because of the arrangement pattern of the fibers. In regular bast fibers the bundles are in a definite ring pattern, while in sugarcane the fibers are more randomly dispersed. Sugarcane stalk characteristics are different in different variety. The usual commercial varieties grown under normal field conditions have a height of 1.5 to 3 meters and are 1.8 to 5 cm in diameter. The stem surface can vary in color and it can be greenish, yellowish or reddish.

Bagasse also is used to produce composites of natural fibers. Composite is a mixture of dispersed particles held together by a bonding agent of inorganic or organic origin. Some composites of natural fibers are used by the automobile industry, for textiles, for construction materials, with inorganic and organic matrices and more recently, recycled composites made of natural fibers are bonded with thermoplastic polymers.

Earlier, the Japanese dominated or rather had a sole authority over producing sugarcane fiber for apparel purpose. In Japan, several companies used blend of sugarcane and selvage denim to reproduce some of the finest quality jeans. The cane used in the process is sweet sorghum, commonly known as sweet millet. It's a very common grass, which is produced all over the world. It is mainly used for making a molasses-like syrup and animal feed.

The Japanese companies mixed sugarcane fiber with sweet sorghum, which in turn gave the fabric a sweet smell. Since then, sugarcane fabric has been successful in invading worldwide attention. There are several benefits of garbing in fabric which contain several fibers, but they are not classified as bast fibers because of the arrangement pattern of the fibers. In regular bast fibers the bundles are in a definite ring pattern, while in sugarcane the fibers are more randomly dispersed. Sugarcane stalk characteristics are different in different variety. The usual commercial varieties grown under normal field conditions have a height of 1.5 to 3 meters and are 1.8 to 5 cm in diameter. The stem surface can vary in color and it can be greenish, yellowish or reddish.

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Bagasse also is used to produce composites of natural fibers. Composite is a mixture of dispersed particles held together by a bonding agent of inorganic or organic origin. Some composites of natural fibers are used by the automobile industry, for textiles, for construction materials, with inorganic and organic matrices and more recently, recycled composites made of natural fibers are bonded with thermoplastic polymers.

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4. MATERIALS

4.1 Banana Fibers

Banana fibers are extracted from the stem of banana plant. The fibers are extracted through hand extraction machine composed of serrated knives. The peel is clamped between the wood plank and knife and hand-pulled through, removing the resinous material. The extracted fibers are sun-dried which whitens the fiber. Once dried, the fibers are ready for knotting. A bunch of fibers are mounted or clamped on a stick to facilitate segregation. Each fiber is separated according to fiber sizes and grouped accordingly. To knot the fiber, each fiber is separated and knotted to the end of another fiber manually. The separation and knotting is repeated until bunches of unknotted fibers are finished to form a long continuous strand. This Banana fiber can be used for making variety of products.

Figure 4.1 Banana woven

4.2 Sugarcane Bagasse (SCB)

Bagasse is the fibrous residue which remains after sugarcane stalks are crushed to extract their juice. It is mainly used as a burning raw material in the sugar mill furnaces. The low caloric power of bagasse makes this a low efficiency process. Also, the sugarcane mill management encounters problems regarding regulations of clean air from the Environmental Protection Agency, due to the quality of the smoke released in the atmosphere. Presently 85% of bagasse production is burnt. Even so, there is an excess of bagasse. Usually this excess is deposited on empty fields altering the landscape. Approximately 9% of bagasse is used in alcohol (ethanol) production. Ethanol is not just a good replacement for the fossil fuels, but it is also an environmentally friendly fuel. Apart from this, ethanol is a very versatile chemical raw material from which a variety of chemicals can be produced. SCB wastes are chosen as an ideal raw material in manufacturing new products because of its low fabricating costs and high quality green end material. It is ideal due to the fact that it is easily obtainable given the extensive sugar cane cultivation making its supply constant and stable. The associated costs of extraction, chemical modifications and/or other pre-treatments of SCB in the transformation process to ready-to-be used materials are potentially reduced as the complex processes are simplified by the mere usage of Bagasse. When appropriate modifications and manufacturing procedures are applied, bagasse displays improved mechanical properties such as tensile strength, flexural strength, flexural modulus, hardness, and impact strength. Bagasse is also found to be easily treated and modified with chemicals besides blending well with other materials to form new types of composite materials. It also satisfies the greening requirements by being biodegradable, recyclable and reusable. The compression and injection molding processes were performed in order to evaluate which is the better mixing method for fibers (sugarcane bagasse, bagasse cellulose and benzylated bagasse) and Polymer matrices.
4.3 Composition of Bagasse

The bagasse fiber reinforced polymer composites performance depends on several factors, including fibers chemical composition, cell dimensions, microfibrillar angle, defects, structure, physical properties, and mechanical properties, and also the interaction of a fiber with the polymer. In order to expand the use of bagasse fibers for composites and improved their performance, it is essential to know the fiber characteristics. Bagasse consists of approximately 50% cellulose and 25% each of hemicelluloses and lignin. Chemically, bagasse contains about 50% α-cellulose, 30% pentosans, and 2.4% ash. Because of its low ash content, bagasse offers numerous advantages in comparison to other crop residues such as rice straw and wheat straw, which have 17.5% and 11.0%, respectively, ash contents, for usage in microbial cultures. Also, in comparison to other agricultural residues, bagasse can be considered as a rich solar energy reservoir due to its high yields and annual regeneration capacity.

4.4 Epoxy Resin

Epoxy or polyepoxide is a thermosetting polymer formed from the reaction of an epoxide “resin” with a polyamine “hardener”. Epoxy has a wide range of applications, including fiber-reinforced plastic materials and general-purpose adhesives. The resin consists of monomers or short-chain polymers with an epoxide group at either end. Most common epoxy resins are produced from a reaction between epichlorohydrin and bisphenol-A, although the latter may be replaced by similar chemicals. The hardener consists of polyamine monomers, for example, Triethylenetetramine (TETA). When these compounds are mixed together, the amine groups react with the epoxide groups to form a covalent bond. Each NH group can react with an epoxide group, such that the resulting polymer is heavily cross-linked and thus, becomes rigid and strong. The process of polymerization is called “curing”, and can be controlled through temperature and the choice of resin and hardener compounds; the process can take minutes to hours. Some formulations benefit from heating during the curing period, whereas others simply require time and ambient temperatures. Industrial Specifications and Notifications of Materials are shown in Table 5.1.

Table 4.1. Properties of materials.

<table>
<thead>
<tr>
<th>Company code</th>
<th>Color</th>
<th>Specific gravity</th>
<th>Viscosity @ 25 ºC</th>
<th>Epoxy Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Di Ethyl Tetra Amine</td>
<td>EH 758</td>
<td>Transparent, liquid</td>
<td>0.95–1.05</td>
<td>--</td>
</tr>
</tbody>
</table>

4.5 Sodium Hydroxide Pellets

The poor adhesion between fiber and matrix is commonly encountered problem in natural-fiber reinforced composites. To overcome this problem, specific physical and chemical treatments were suggested for surface modification of fibers by investigators. Alkali treatment is one of the simple and effective surface modification techniques which are widely used in natural fiber composites. The alkali treatment found to be effective in improving the tensile and flexural properties while the impact strength decreased.

5. MATERIAL PREPARATION

5.1 Banana Fibers

The epoxy composite reinforced with pseudo-stem banana fiber was prepared by the hand lay-up method. The fibers were extracted from banana stems by hand and dried in...
sunlight for 12 hours until all the moisture was removed. The banana fibers used for the study are shown in Figure.

5.2 Sugarcane Bagasse

BAGASSE FIBER The sugar cane bagasse is a residue widely generated in high proportions in the agro-industry. It is a fibrous residue of cane stalks left over after the crushing and extraction of juice from the sugar cane. Bagasse is generally gray-yellow to pale green in color. It is bulky and quite non uniform in particle size. The sugar cane residue bagasse is underutilized, renewable agricultural material that consists of two distinct cellular constituents. The first is a thick walled, relatively long, fibrous fraction derived from the rind and fibro-vascular bundles dispersed throughout the interior of the stalk. The second is a pith fraction derived from the thin walled cells of the ground tissue. The main chemical constituents of bagasse are cellulose, hemicellulose and lignin. Hemicellulose and cellulose are present in the form of hollow cellulose in bagasse which contributes to about 70% of the total chemical constituents present in bagasse. Another important chemical constituent present in bagasse is lignin. Lignin acts as a binder for the cellulose fibers and also behaves as an energy storage system.

5.2.1 Properties of Sugarcane bagasse

Properties The physical properties of bagasse fiber are critical, and include the fiber dimensions, defects, strength and structure. Shown in Tab.2 Physico-mechanical properties of bagasse fibers

<table>
<thead>
<tr>
<th>Properties</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young’s modulus (GPa)</td>
<td>17</td>
</tr>
<tr>
<td>Density [g/cm³]</td>
<td>1.25</td>
</tr>
<tr>
<td>Tensile strength (MPa)</td>
<td>290</td>
</tr>
</tbody>
</table>

5.3 Chemical Treatment

Alkali treatment of natural fibers, also called mercerization, is the common method to produce high-quality fibers. Mercerization leads to fibrillation, which causes the breakdown of the composite fiber bundle into smaller fibers. Mercerization reduces fiber diameter, thereby increasing the aspect ratio, which leads to the development of a rough surface topography that results in better fiber-matrix interface adhesion and an increase in mechanical properties. Moreover, mercerization increases the number of possible reactive sites and allows better fiber wetting. Mercerization has an effect on the chemical composition of the flax fibers and degree of polymerization. The degree of polymerization is the number of repeat units in an average polymer chain at time $t$ in a polymerization reaction. The length is in monomer units. The degree of polymerization is a measure of molecular weight and molecular orientation of the cellulose crystallites due to cementing substances, such as lignin and hemicelluloses, which are removed during the mercerization process.

5.3.1 Properties of Hardener

In the present work, the hardener (EH758) has been used. The properties of the hardener are shown in Table 1.

5.3.2 Banana Fiber Treatment

Banana fibers were immersed in 5% NaOH solution for two hours at room temperature, as shown in Figure 4.2. Following the alkali treatment, the fibers were washed thoroughly by immersion in water tanks, followed by running water. The material was then filtered and dried at 80 °C for 24 hours. The banana fiber immersed in 5% NaOH solution. The banana fibers obtained after the final washing are shown in Figure 6.2.

5.4. PREPARATION OF COMPOSITE SPECIMEN

5.4.1 Fabrication of Composites

Composites consist of one or more discontinuous phases embedded in a continuous phase. The discontinuous phase is usually harder and stronger than the continuous phase and is called the ‘reinforcement’ or ‘reinforcing material’, whereas the continuous phase is termed as the ‘matrix’. Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. The composite properties may be the volume fraction sum of the properties of the constituents or the constituents may interact in a synergistic way resulting in improved or better properties. Apart from the nature of the constituent materials, the geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent. The concentration distribution and orientation of the reinforcement also affect the properties. The shape of the discontinuous phase (which may by spherical, cylindrical, or rectangular cross-sanctioned prisms

<table>
<thead>
<tr>
<th>S. No</th>
<th>Banana Fiber Length (mm)</th>
<th>Banana Fiber volume (%)</th>
<th>Sugarcane Bagasse Fiber volume (%)</th>
<th>Epoxy resin volume (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
<td>30</td>
<td>6</td>
<td>64</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>30</td>
<td>6</td>
<td>64</td>
</tr>
<tr>
<td>3</td>
<td>75</td>
<td>30</td>
<td>6</td>
<td>64</td>
</tr>
</tbody>
</table>
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.

A plate of dimensions 290 × 290 × 3 mm was fabricated by this process. First, the epoxy-banana-Sugarcane Bagasse composite was fabricated. The matrix material was poured slowly into the mold to avoid trapping air. The mixture was left for 2 minutes until it became a little tacky. After that, the banana fiber ply was laid uni-directionally on the matrix layer, which was covered by another layer of matrix poured slowly onto the surface of the fiber ply. A small pressure was applied by using a roller to distribute the matrix material and to avoid the formation of voids. Then, chopped coir fibers (25–75 mm) were laid on the matrix layer.

6. EXPERIMENTATION

6.1 Tensile Test

A tensile test, also known as a tension test, is probably the most fundamental type of mechanical test performed on any material. Tensile tests are simple, relatively inexpensive, and fully standardized. As the material is being pulled, we can establish its strength together with how much it will elongate. The point of failure of the material is of significant interest and it is typically called its “Ultimate Tensile Strength” (UTS). For some materials (e.g., metals and plastics), the departure from the linear elastic region cannot be identified easily. Therefore, an offset method is allowed to determine the yield strength of the tested material. These methods are discussed in ASTM D3039 (metals). An offset is specified as a percentage of strain (for metals, it is usually 0.2% from E8, and sometimes for plastics a value of 2% is used).

6.2 Impact test

The impact test specimens are prepared according to the required dimension following the ASTM-D256 Length = 65mm, width =13 mm, thick = 3mm standard. During the testing process, the specimen must be loaded in the testing machine and allows the pendulum until it fractures or breaks. Using the impact test, the energy needed to break the material can be measured easily and can be used to measure the toughness of the material and the yield strength.

6.3 Hardness test

Fabricated composite was cut in dimension of ASTM D-785 20 mm × 20 mm for hardness test. The hardness test was conducted in Rockwell hardness test machine. The load was applied 0.3 kgf on the composite and the holding time was 10 second. Hardness is defined as the ability to oppose to indentation, which is obtained by measuring the stable depth of the indentation. In the Rockwell hardness test a square base pyramid shaped diamond is used for testing. The experimental set up for hardness test.

6.4 Water absorption test

The experimental set up for hardness test.

Figure 6.1 Tensile Test

Figure 6.2 Compression molding machine

Figure 6.3 Izod Testing Machine

Figure 6.4 Water absorption test
Fabricated composite was cut in dimension of 20 mm × 20 mm for water absorption test. The water absorption test was carried out 1 liter water. ASTM D 5229 Length = 20mm, width = 20mm, thick = 3 mm. The sample work piece dipped in 1 liter water tank and the dipping time was hour. Compare the treated (water absorption) sample and untreated (without water absorption) sample. Find the mass of the working sample.

7. EXPERIMENTATION

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![Figure 7.1 UTM Testing Machine](image)

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7.2 IMPACT TEST

![Figure 7.2 Izod Testing Machine](image)

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![Figure 7.3 Rockwell Testing Machine](image)

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7.4 WATER ABSORPTION TEST

![Figure 7.4 water absorption test](image)

Fabricated composite was cut in dimension of 20 mm × 20 mm for water absorption test. The water absorption test was carried out 1 liter water. ASTM D 5229 Length = 20mm, width = 20mm, thick = 3 mm. The sample work piece dipped in 1 liter water tank and the dipping time was hour. Compare the treated (water absorption) sample and untreated (without water absorption) sample. Find the mass of the working sample.
8. RESULTS AND DISCUSSION

The use of composite materials in the different fields is increasing day by day due to their improved properties. Engineers and Scientists are working together for number of years for finding the alternative solution for the high solution materials. In the present study natural fibers are added to the sugarcane bagasse reinforced composite materials and their effect on mechanical properties is evaluated and their properties are compared.

8.1 TENSILE TEST

8.2 IMPACT TEST

8.3 HARDNESS TEST

8.4 WATER ABSORPTION

9. CONCLUSION

Thus the Banana-Sugarcane Bagasse fiber reinforced with epoxy resin composite samples are fabricated and tested. The hybrids composite are subjected to mechanical testing such as tensile, impact test, hardness and water absorption test. Based on the results, the following conclusions are drawn:

- The results indicated that banana- Sugarcane Bagasse fiber reinforced with epoxy resin composite specimen gives tensile strength is high. The Maximum tensile force (MTF) of the Banana - Sugarcane Bagasse fiber reinforced with epoxy resin composite sample is in the range of 105.74.
- The maximum impact strength is obtained for the Banana - Sugarcane Bagasse fibre reinforced with epoxy resin composite specimen and has the value of 18.06 joules.
- The Rockwell hardness test the strength obtains 22.03 HRC.
- The 10% water absorption is obtained for the Banana - Sugarcane Bagasse fiber reinforced with epoxy resin composite specimen and has the value of 153sec

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