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An investigation on the Application of Natural Fibre-Reinforced Polymer Composite for design and fabrication of Long Skateboard

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Abstract- Composites are strong and lightweight. Products made with composites are resistant to corrosion from weather and chemicals and are made to last. Composites can be molded into flexible and complicated shapes, giving designers the freedom to create almost any shape or form. Compared to other materials, composites offer several advantages. Designers, engineers, and architects are replacing materials such as steel, aluminum, wood, and granite with composites. Because in head-to-head comparisons, composites are stronger, lighter, more versatile and stand the test of time. Composites are used in numerous markets, including aerospace, architecture, automotive, energy, infrastructure, marine, military, and sports and recreation. Researchers continue to find new ways to use composites to develop life-changing applications. With composites, the possibilities are endless.Fiber-reinforced polymer composite possess not only have high strength to weight ratio, but also reveals excellent properties such as high durability; stiffness; low cost; biodegradability; damping property; flexural strength; and resistance to corrosion, wear, impact, and fire. These wide ranges of diverse features have led composite materials to find applications in spacecrafts, aircraft structures, automobile sector and in sports equipment. Coir and sisal are the most popular natural fibers. India contributes to abundant of world Coir and sisal resources. Sisal is one of the fastest growing plants in world and achieves its complete mechanical properties within 3-4 years. Coir has the highest mechanical strength in all-natural fiber and lowest density. The materials chosen are epoxy resin as matrix and coir mat and woven sisal fiber as the reinforcement.

Index Terms: Natural fiber polymer Composites, Coir, Sisal, reinforcement, Skateboard

I. INTRODUCTION

Based on various studies on natural fibers and their characteristics and requirements, two natural fibers sisal and coir are selected. Naturalfibres have greater specific stiffness and specific strength, more resistance to corrosion. Natural fiber and the glass fiber has high tensile strength, high impact strength and also low cost compared to carbon reinforced composites and conventional metals. So the natural fibers and glass fibers has been used as an alternate to the metals used for skate boards.

The coir fiber is relatively waterproof and is one of the few natural fibers resistant to damage by salt water. Natural fibers like coconut coir (short fibers) and sisal fibers (long fibers) are used in hybrid combination and the fiber weight fraction of 20%, 30% and 40% are used for the fabrication of the composite.

Coir has excellent features because it is more durable than most natural fibers, free of chemical treatment, its strong resistance to salt water and availability. Sisal is easily cultivated with short renewal times with high tenacity and tensile intensity, abrasion resistance, saltwater resistance, acid, and alkali resistance. Due to their low cost, good mechanical properties, high specific strength, non-abrasive, eco-friendly, and bio-degradability characteristics, they are exploited as a replacement for the conventional materials.

Studies indicate that natural fiber composites can contribute to a cost reduction of 20% and weight reduction of 30% when compared to metals.

II. COMPARISON WITH CONVENTIONAL MATERIALS

Composites offer huge weight sparing over existing metals. Composites can give structures that are 25-

45% lighter than the traditional aluminum structures intended to meet the same practical prerequisites. This is because of the lower thickness of the composites.

Contingent upon material frame, composite densities go from 1260 to 1820 kg/in3 (0.045 to 0.065 lb/in3) when contrasted with 2800 kg/in3 (0.10 lb/in3) for aluminum.

Unidirectional fiber composites have rigidity (proportion of material quality to thickness) around 4 to 6 times more noteworthy than that of steel and aluminum.

Fatigue continuance breaking point of composites may approach 60% of their definitive elasticity. For steel and aluminum, this esteem is significantly lower.

Fiber composites are more flexible than metals and can be custom fitted to address execution issues and complex plan necessities, for example, air versatile stacking on the wings and the vertical and the flat stabilizers of air ship.

Fiber fortified composites can be planned with brilliant auxiliary damping highlights. Accordingly, they are less uproarious and give low vibration transmission than metals.

Composites offer lower producing cost basically by decreasing altogether the quantity of itemized parts and costly specialized joints required to shape huge metal auxiliary segments.

As it were, composite parts can wipe out joints/clasp along these lines giving parts rearrangements and incorporated outline.

III.PROPERTIES OF COMPOSITE MATERIALS

- Light weight

Composites are light in weight, compared to most woods and metals. This property is used in manufacturing process of aircrafts, automobiles because less weight means better fuel efficiency and reduced weight increases the speed.

- High strength

Composites can be designed to be far tougher than aluminum or steel. Though metals are strong in various directions, composites can be planned and designed to be strong in a precise direction.

- Strength related to weight

Strength-to-weight ratio is a material's strength in relation to how much it weighs. Some materials are very strong and heavy, such as steel. This property is to build airplanes—which need a very high strength material having lowest possible weight. Composites can be strong without being heavy. Composites have the highest strength-to-weight ratios in structures.

- Corrosion resistance

Composites have a great abundance against the weather and from harsh chemicals that can damage other materials. Composites are good choices where chemicals are handled or stored.

- High-Impact strength

Composites can be made to captivate impacts—the sudden force of a bullet, for instance, or the blast from an explosion. Because of this reason, composites are applied in bulletproof vests and panels, and to shield airplanes, buildings, and military vehicles from explosions.

- Design flexibility

Composites can be molded into complicated shapes more easily than most other materials. This gives designers the freedom to create almost any shape or form. Most recreational boats today, for example, are built from fiberglass composites because these materials can easily be molded into complex shapes, which improve boat design while lowering costs. The surface of composites can also be molded to mimic any surface finish or texture, from smooth to pebbly.

- Part consolidation

A single piece made of composite materials can replace an entire assembly of metal parts. Reducing the number of parts in a machine or a structure saves time and cuts down on the maintenance needed over the life of the item.

- Dimensional stability

Composites retain their shape and size when they are hot or cool, wet, or dry. Wood, on the other hand, swells and shrinks as the humidity changes. They are used in aircraft wings for example.

- Nonconductive

Composites are nonconductive, meaning they do not conduct electricity. But if electrical conductivity is needed for any reason, it is possible to make some composites conductive.

- Radar transparent

Radar signals pass right through composites, a property that makes composites ideal materials for use anywhere radar equipment is operating, whether on the ground or in the air. Composites play a crucial role in stealth aircraft, such as the U.S. Air Force's B-2 stealth bomber, which is nearly invisible to radar.

➢ Low thermal conductivity

Composites are decent insulators—they do not simply conduct heat or cold. They can be used in buildings for doors, panels, and windows where further protection is required from severe weather.

➢ Durable

Structures made of composites have an extended life and need slight maintenance.

IV NOMINATED FIBERS

Based on various studies on natural fibers and their characteristics and requirements, two natural fibers sisal and coir are selected. Natural fiber and the glass fiber has high tensile strength, high impact strength and low cost compared to carbon reinforced composites, So the natural fibers and glass fibers has been used as an alternate to the metals used for long skateboards. The coir fiber is relatively waterproof and is one of the few natural fibers resistant to damage by salt water. Naturalfibers like coconut coir (short fibers) and sisal fibers (long fibers) are used in hybrid combination and the fiber weight fraction of 20%, 30% and 40% are used for the fabrication of the composite. Coir has excellent features because it is more durable than most natural fibers, free of chemical treatment, its strong resistance to salt water and availability. Sisal is easily cultivated with short renewal times with high tenacity and tensile intensity, abrasion resistance, saltwater resistance, acid and alkali resistance. Due to their low cost, good mechanical properties, high specific strength, non-abrasive, eco-friendly, and bio-degradability characteristics, they are exploited as a replacement for the conventional materials. Studies indicate that natural fiber composites can contribute to a cost reduction of 20% and weight reduction of 30%.

Table 1 provides the properties of Coir and Sisal natural fibers

TABLE 1: Properties of NaturalFibers

Plant fiber	Tensile strength (MPa)	Youngs modulus (MPa)	Elongation at break (%)	Failure strain (%)	Density (Kg/m^3)	Moisture content (%)
Sisal	80-840	9-22	3-5	2-14	1300-1500	11
Coir	106-220	6	15-25	15-40	1150-1250	10

V.EXTRACTION OF NATURAL FIBERS

The sisal fiber was extracted from the leaf using mechanical decorticator. In the first step the bundles of leaves are fed in between rotating rollers. The hard surface is cursed and removed which leaves sisal fibers. These bundles of fiber are thoroughly washed in water for cleaning the fiber surface. In this mechanical process, about 2– 4% of long fibers bundles are obtained. Similarly, the decorticated fibers are dried in the sunlight for a day to remove the moisture content. Ripe coconut husks are soaked in the tap water containers for five months, to decompose the pulp on the shell for removing the husk easily. After water retting, the wet husks are removed for separating the coir fibers from the shell. These coir fibers are combed in a carding frame to separate the fibers into an individual state. The green husk coir fibers are extracted mechanically from the green husk of coconut. Before the extraction of fibers, the green husk bales are to be soaked in water for a week for softening of the outer shell and to remove the coloring matter. The mat form of leaf sheathes are collected from the coconut trees and dipped in water for a week, and thoroughly washed in fresh water and distilled water. This is to be dried in sun light for a week to get pure mat sheaths fiber.

VI CHEMICAL TREATMENTS

Chemical treatments can be adopted for improving the mechanical and surface properties of fiber-reinforced composites due to the fundamental problem associated with NFs known as hydrophilic nature. The NF composites exhibit poor mechanical properties even in hybridization with synthetic fibers. NFs are more moisture absorbent and exhibit lower strength than synthetic fibers. Pre-treatment processes is developed to improve the compatibility of NFs with polymer matrices and to enhance the mechanical characteristics of the composites. The alkali treatment approach is one of the effective techniques applied for enhancing the attachment of NFs with epoxy resin. The impact of coupling agent NaOH in alkali treatment will result in NFs to possess an increase in crystallinity, thermal stability, and surface roughness.

VII.SELECTION OF MATRIX

Matrix provides a barrier against adverse environments, protects the surface of the fibers from mechanical abrasion and it transfers load to fibers. The most common matrices currently used in NFCs are polymeric as they are light weight and can be processed at low temperature. Based on the study on characteristics and requirement of matrix, epoxy resin is selected. Interfacial bonding between fiber and matrix plays a vital role in determining the mechanical properties of composites. Since stress is transferred between matrix and fibers across the interface, good interfacial bonding is required to achieve optimum reinforcement, although, it is possible to have an interface that is too strong, enabling crack propagation which can reduce toughness and strength. For bonding to occur, fiber and matrix must be brought into intimate contact; wettability can be regarded as an essential precursor to bonding.

Matrices hold and protect the fibers from environmental and physical damage. Keeping the fibers separated decreases cracking and redistributes the load equally among all fibers. Thus, the matrix contributes greatly to the properties of the composites. The ability of composites to withstand heat, or to conduct heat or electricity depends primarily on the matrix properties since this is the continuous phase. Therefore, the matrix selection depends on the desired properties of the composite being constructed.

VIII POLYMERS

The matrices of choice for manufacturing process are polymers.A polymer is a substance consisting of many atoms bonded together in a long chain. Polymeric matrices are used because they are light weight and easy to fabricate. There are two general types of polymer matrices: thermoset and thermoplastic. Thermoset polymers (such as epoxy) cure into an irreversibly hardened material. Thermoplastic polymers are capable of being repeatedly softened by the application of heat and hardened by cooling the polymer.

IX. FABRICATION TECHNIQUE

Hand lay-up method is selected as the fabrication method.

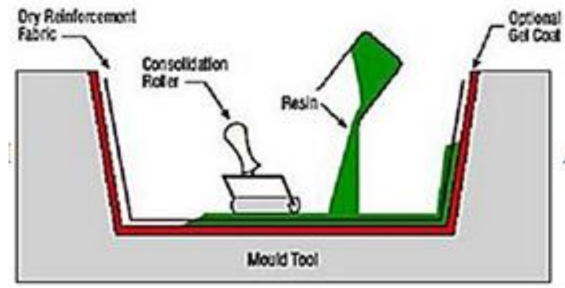

Fig.3.4. Hand lay-up method

Hand lay-up is a simple method for composite production. Amold must be used for and lay-up parts unless the composite is to be joined directly to another structure. Themold can be as simple as a flat sheet or have infinite curves and edges. For some shapes, molds must be joined in sections so they can be taken apart for part removal after curing. Before lay-up, the mold is prepared with a release agent to ensure that the part will not adhere to the mold. Reinforcement fibers can be cut and laid in the mold. It is up to the designer to organize the type, amount and direction of the fibers being used. Resin must then be catalyzed and added to the fibers. A brush, roller or squeegee can be used to impregnate the fibers with the resin. The lay-up technician is responsible for controlling the amount of resin and the quality of saturation. shows the basic process of hand lay-up.

X.CALCULATION

To fabricate the composite material, the appropriate volume proportions are calculated. The calculation has based on the dimensions of the material for fabrication. In this calculation, volume of the composite material was calculated. The product of volume of composite material, density of the fiber/resin and volume percentage of fiber/resin is the volume fraction of the fiber/resin. In our project, the coir and sisal are taken as 50:50, so volume of the fiber/resin is same. The factor density of the fiber/resin places the major in the volume of the fiber/resin. Table.3.1 shows the calculated value of the volume fraction for the fibers Coir and Sisal and the resin. Volume fraction was in the unit of “g”, for resin because of its liquid state it was poured in the beaker and weighted in the weighing machine for required weight and noted the value in “liters”.

Volume of the composite material = (Length x Breadth x Thickness) of the material in mm^3

Volume of the fiber/resin = Volume of composite material x density of fiber/resin x volume % of fiber/resin

Selected Dimensionsof Composite Material:

1. Length = 20 cm
2. Breadth = 20 cm
3. Thickness = 5 mm

DENSITIES:

1. Coir fiber = 1.25 g/cm^3
2. Sisal fiber = 1.15 g/cm^3
3. Resin =1.4 g/cm^3

S. no	Resin volume %	Fiber volume %	Coir fiber volume fraction in 'g'	sisal fiber volume fraction in 'g'	epoxy resin volume fraction in 'g'
1.	0.8	0.1	25	23	224
2.	0.7	0.15	37.5	34.5	196
3.	0.6	0.2	50	46	168

X METHODOLOGY

Wooden pattern is the cheapest casting pattern and is preferred for mold making process. Specimen is made using mold and the mold is made using the glass fiber, specimen for various types of specimens can be obtained from the die. The fiberglass mold process begins with an object known as the plug or buck. After the plug has been formed, it is sprayed with a mold release agent. The release agent will allow the mold to be separated from the plug once it is finished. The mold release agent is a special wax, and/or PVA (Polyvinyl alcohol). Polyvinyl alcohol, however, is said to have negative effects on the final mold's surface finish. Once the plug has its release agent applied, gelcoat is applied with a roller, brush, or specially designed spray gun. The gelcoat is pigmented resin, and gives the mold surface a harder, more durable finish.

Once the release agent and gelcoat are applied, layers of fiberglass and resin are laid-up onto the surface. The fiberglass used will typically be identical to that which will be used in the final product. In the laying-up process, a layer of fiberglass mat is applied, and resin is applied over it. A special roller is then used to remove air bubbles. Air bubbles, if left in the curing resin, would significantly reduce the strength of the finished mold. The fiberglass spray lay-up process is also used to produce molds, and can provide good filling of corners and cavities where a glass mat or weave may prove to be too stiff. Once the final layers of fiberglass are applied to the mold, the resin is allowed to set up and cure. Wedges are then driven between the plug and the mold to separate the two. The component-making process involves building up a component on the fiberglass mold. The mold is a negative image of the component to be made, so the fiberglass will be applied inside the mold, rather than around it. As in the mold-making process, release agent is first applied to the mold. Colored gelcoat is then applied. Layers of fiberglass are then applied, using the same procedure as before. Once completed and cured, the component is separated from the mold using wedges, compressed air, or both.

XI CONCLUSION

Composites materials gained enormous popularity in the research and manufacturing industries due to their desirable properties that cannot be achieved by any of the constituent materials acting alone. For lowering the harmful effects of advanced materials on the environment the complete degradation of the materials is necessary and quite challenging at the same time. We conclude that these NFRPCs are superior to the synthetic fiber reinforced composites due to the attractive features as follows:

(1) These NFs are cheap and sustainable.

(2) Techniques like chemical treatments, coating of different materials on NFs and hybridization technique can be implemented to enhance the mechanical and physical properties of NFRPCs.

(3) The environmental effects of NFRPCs are quite low which makes them suitable for various sustainable engineering applications

(5) Prediction of mechanical behavior of materials using numerical tools could allow the design of innovative and novel materials and overcome the time delay and complexity of conventional processes. These numerical techniques proved to be both times saving and environmentally friendly. Bio-composites with the use of the natural bio-degradable materials reveal unforeseen properties being environment friendly. As a future scope the investigation of hybridization of natural biodegradable materials with synthetic materials as constituents of the composite

structure which helps to boosts strength and hardness of material being environment friendly can be achieved.

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