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JUTE-BASED SANDWICH COMPOSITE: FABRICATION AND VIBRATION TESTING

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ABSTRACT

The search for steel and alloy substitutes has been going on for years in an effort to lower the expensive upkeep and repair of structures that have been harmed by corrosion and severe use. A relatively new type of composite materials, fiber reinforced polymer (FRP) is made of fibers and resins and has shown to be both effective and affordable. The most prevalent method for producing FRP is compression molding. "Electric Die for FRP Composites" is a recently created tool that increases the strength of FRP composites. As the name suggests, heat and pressure are applied simultaneously in an electric die, which generates heat using electrical power. As a result, a stronger FRP composite can be produced. This paper's primary goal is to create a composite material with high shock absorbing capacity at cheaper rate compared to other materials. Vibration testing is conducted for the material.

Keywords: *Sandwich Composites Natural fibres, FRP*

INTRODUCTION

Engineered or naturally occurring materials with two or more constituent materials with significantly different physical or chemical properties that remain separate and distinct at the macroscopic or microscopic scale within the finished structure are known as composite materials, often shortened to composites or composition materials. Natural cellulose fibers encased in a lignin matrix make up wood. Straw and mud were mixed to create bricks, the first man-made composite material used in building construction. The Metropolitan Museum of Art's collection of Egyptian tomb paintings still depicts the ancient brick-making technique. Constituent materials are the discrete materials that make up composites. Constituent materials fall into two categories: reinforcement and matrix. Each type must have at least one piece. The matrix material surrounds and supports the reinforcement materials by maintaining their relative positions. The unique mechanical and physical qualities of the reinforcements are imparted to improve the matrix properties. The large range of matrix and reinforcing elements enables the product or structure designer to select the best combination, while a synergism generates material qualities not achievable from the individual constituent materials. Composite materials that are engineered need to be shaped. The reinforcement material can be added to the matrix material either prior to or during its placement within the mold cavity or on the mold surface. The part shape is essentially fixed once the matrix material goes through a melding event. This melting process can take many different forms, such as chemical polymerization or solidification from a melted state, depending on the type of matrix material.Most commercially produced composites use a polymer matrix material often called a resin solution. Various polymers are available based on the initial raw components used. There are countless variations within each of the several broad categories. The most widely used ones include PEEK, Polyethylene, Vinyl Ester, Polyester, Epoxide, Phenolic, Polyimide, Polyamide, and Polypropylene. In addition to powdered minerals, fibers are frequently used as reinforcement materials. The numerous techniques listed below have been developed to either raise or decrease the final product's fiber or resin content. Generally speaking, lay up produces a product with 60% resin and 40% fiber, whereas vacuum infusion, as seen in figure 1, produces a product with 40% resin and 60% fiber. This ratio has a big impact on the product's strength.

Materials	**Type**	**Modulus (GPa)**	**Density ρ(kg/m3)**	**Tensile Strength(MPa)**
Polyethylene	Fibre	E1 = 115	970	$\sigma 1$ = 3500
	Laminate	E1 = 25.5 E2 = 25.5	900	$\sigma 1$ = 860 $\sigma 2$ = 860

Table.1 Tensile properties of fibre and laminates

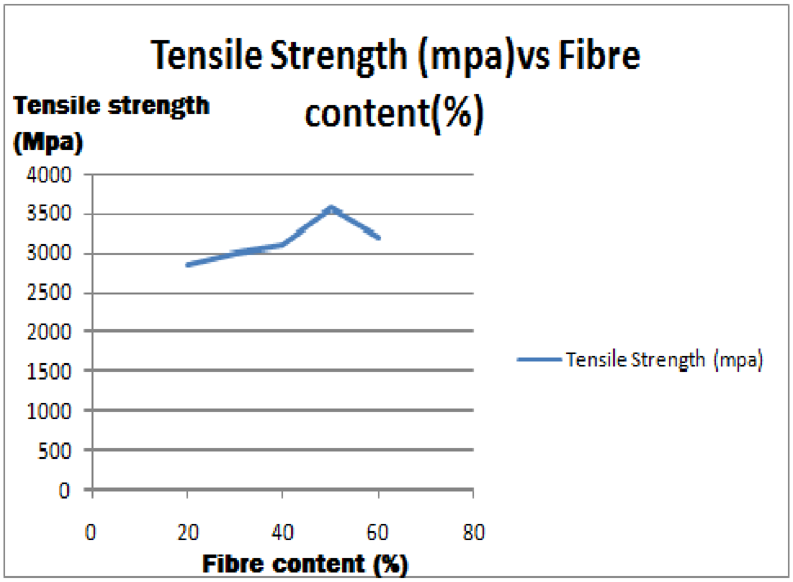

Fig.1 Fiber content Vs Tensile strength

FIBRES AND ITS TYPES

Fibre (also spelled fiber) is classes of materials that are continuous filaments or are in discrete elongated pieces, similar to lengths of thread. They are very important in the biology of both plants and animals, for holding tissues together. Human uses for fibres are diverse. This can be spun into filaments, string, or rope, used as a component of composite materials, or matted into sheets to make products such as paper or felt. Fibres are often used in the manufacture of other materials. The strongest engineering materials are generally made as fibres, for example carbon fibre and Ultra-high-molecular-weight polyethylene. Synthetic fibres can often be produced very cheaply and in large amounts compared to natural fibres, but for clothing natural fibres can give some benefits, such as comfort, over their synthetic counterparts.

NATURAL FIBRES

Natural fibres include those produced by plants, animals, and geological processes. They are biodegradable over time. They can be classified according to their origin

Vegetable fibres are generally based on arrangements of cellulose, often with lignin: examples include cotton, hemp, jute, flax, ramie, and sisal. Plant fibres are employed in the manufacture of paper and textile (cloth), and dietary fibre is an important component of human nutrition.

- Wood fibre, distinguished from vegetable fibre, is from tree sources. Forms include groundwood, thermomechanical pulp (TMP) and bleached or unbleached kraft or sulfite pulps. Kraft and sulfite, also called sulphite, refer to the type of pulping process used to remove the lignin bonding the original wood structure, thus freeing the fibres for use in paper and engineered wood products such as fibreboard.
- Animal fibres consist largely of particular proteins. Instances are spider silk, sinew, catgut, wool and hair such as cashmere, mohair and angora, fur such as sheepskin, rabbit, mink, fox, beaver, etc.
- Mineral fibres include the asbestos group. Asbestos is the only naturally occurring long mineral fibre. Six minerals have been classified as "asbestos" including chrysotile of the serpentine class and those belonging to the amphibole class: amosite, crocidolite, tremolite, anthophylliteand actinolite. Short, fibre-like minerals include wollastonite and attapulgite.

SYNTHETIC FIBRES

Natural cellulose is used to make synthetic fibers like Lyocell, Modal, and rayon. There are two forms of cellulose-based fibers: modified cellulose (like cellulose acetates) and regenerated or pure cellulose (such from the cupro-ammonium process). Reinforced plastics classify fibers into two groups: (i) short fibers, also called discontinuous fibers, with a general aspect ratio (generally speaking, the ratio of fiber length to diameter) of 0 to 60; and (ii) long fibers, also called continuous fibers, whose general aspect ratio is 200 to 500.

JUTE FIBRE

Vegetable fiber: jute is a long, silky, lustrous fiber that can be spun into robust, coarse threads. The genus Corchorus, which has been placed in the Tiliaceae family or, more recently, the Malvaceae family, is the source of the plant material used to make it.When it comes to the quantity and range of applications of vegetable fibers, jute is the most economical natural fiber and is only surpassed by cotton.

USES OF JUTE

After cotton, jute is the most important vegetable fiber for a variety of applications in addition t o agriculture.The main uses of jute are in the production of coarse cloth, sacks, and material for wrapping bales of raw cotton.The fibers are also woven into hessian cloth, area rugs, carpets, cu rtainschair coverings, and linoleum backing.In many of these applications, synthetic materials ar e replacing jute, while in other cases, jute's biodegradable qualities are advantageous and replac ement materials wouldn't be appropriate.Some examples of these applications include growing y oung trees in containers so that the roots can be directly planted without uprooting the tree, and restoring land so that jute cloth stops erosion while the native vegetation takes hold. To manufacture twine and rope, the fibers can be used on their own or combined with other fiber kinds. In Japan, jute rope has long been a common tool for bondage. The coarse ends of the plants, known as jute butts, are used to manufacture cheap cloth. On the other hand, jute's extremely thin threads can be isolated and used to create imitation silk. The relevance of jute for this purpose may rise as jute fibers are also used to manufacture pulp and paper, and as worries about the destruction of forests for the wood pulp used to make most paper grow. Sackings, carpets, wrapping fabrics (cotton bale), and the production of construction fabrics have all long used jute.

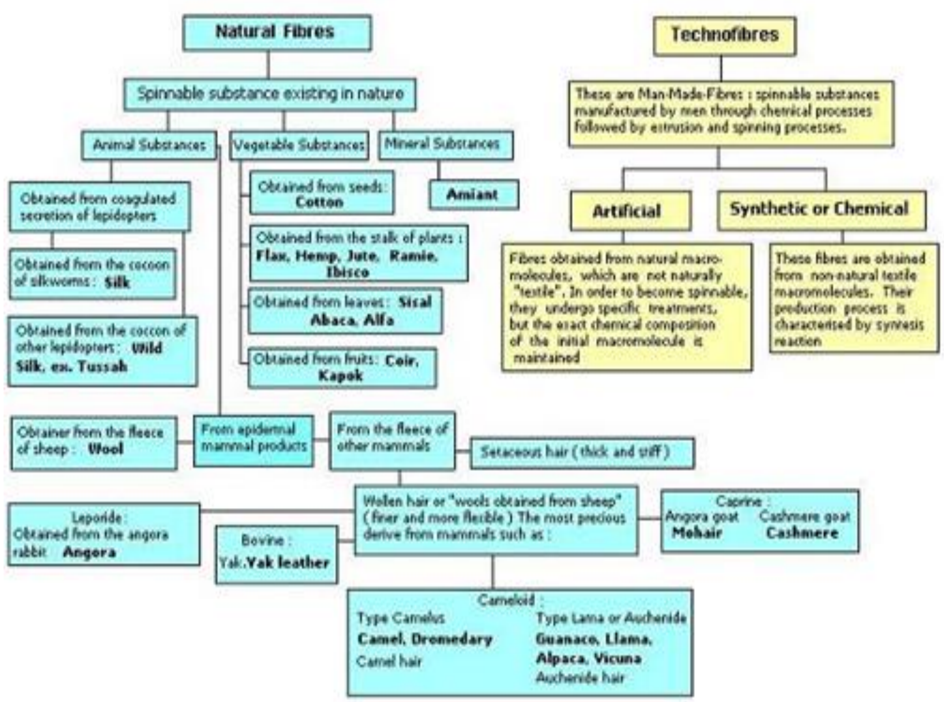

Fig.2 Fibre Classification

In the past, jute was employed in traditional textile machinery as textile fibers with cellulose, or vegetable fiber, and lignin, or wood fiber. However, the real breakthrough occurred when jute and related fibers were used by the automotive, pulp and paper, furniture, and bedding sectors in conjunction with their non-woven and composite technologies to create nonwovens, technical textiles, and composites. As a result, jute's perception as a textile fiber has altered, and it is now

gradually moving in the direction of its new identity as wood fiber. Jute has peaked as a textile fiber and is unlikely to recover, but it has many positive qualities as a wood fiber. Images of knitted jute fabric and jute plants are displayed in Figures 3 and 4. Jute is used in the manufacture of a number of fabrics such as Hessian cloth, sacking, scrim, carpet backing cloth (CBC), and canvas. Hessian, lighter than sacking, is used for bags, wrappers, wall-coverings, upholstery, and home furnishings. Sacking, a fabric made of heavy jute fibres, has its use in the name. CBC made of jute comes in two types. Primary CBC provides a tufting surface, while secondary CBC is bonded onto the primary backing for an overlay. Jute packaging is used as an eco-friendly substitute.

Fig.3 Jute Plant

Fig.4 Knitted Jute Fabric

DIFFERENCE BETWEEN NATURAL AND SYNTHETIC FIBRES

NATURAL FIBRE PROPERTIES

Animals or plants are the source of natural fibers. Given that the fabric is made of renewable materials, it is a green option for sewing tasks. Natural fibers are used to make fabrics like cotton, linen, wool, and silk. Sheep, alpacas, and silkworms are the most frequently utilized animal species in the creation of natural fiber fabrics; goats and rabbits are also utilized. A wide range of plants are utilized to make natural textiles. The plant that is most frequently utilized to make natural cloth is cotton. Bamboo's quick rate of renewal is contributing to its growing popularity. Hemp, flax, and pineapple leaves are among other plants that are used to make natural textiles.

SYNTHETIC FIBRE PROPERTIES

One artificial product generated by humans is synthetic fiber, which is produced chemically. Chemicals are pushed through microscopic pores in spinnerets, which are where synthetic fibers are made. Although there is a vast array of different man-made materials, polyester is the most widely used synthetic material. Synthetic textiles including spandex, nylon, and acetate are frequently utilized. Because they are more durable than natural materials, synthetic fabrics offer a significant benefit. However, because they are simpler to sew on, natural materials are excellent for novices. Generally speaking, choosing between natural and synthetic fabrics depends on the kind of project being undertaken.

CHARACTERISTICS OF NATURAL AND SYNTHETIC FABRIC BLENDS

Fabric blends are made by mixing natural and synthetic fibers, as the name would imply. A fantastic method to achieve the precise look or feel you want in a cloth is to use fabric that is made by mixing two different types of fibers. Although they might be irritating to the skin, natural fibers are quite warm. A fabric can be given durability, warmth, comfort, visual appeal, luster, or any combination of these attributes by combining natural and synthetic fibers. Fabric businesses easily carry a wide variety of fabric mixtures. The most popular blends are cotton and polyester, which work well for most sewing jobs. Generally speaking, fabric blends require less maintenance than either natural or synthetic fibers.

HOW FABRIC IS MADE

Fabric mixes, synthetics, and natural materials are all made in a similar manner. Fabric can be knit, non-woven, or woven. Knit materials are the most comfortable to wear, woven fabrics are the most robust, and nonwoven fabrics are typically the least priced. Woven: Plain, twill, and satin are the three weave varieties that are utilized in woven fabrics. Every one of them has variations that give it a distinct look. Some common woven textiles are taffeta, poplin, and muslin.

Nonwoven: A synthetic method is used to glue fibers together to generate nonwoven fabrics. This kind of fabric is not very durable and is more often used in crafts than apparel. One type of nonwoven fabric is felt. Knit: The most comfortable fabric to wear is knit cloth since it can stretch. Numerous knit styles exist, such as jersey, double knit, stretch, and interlock knit. Knit variations are available for textiles that are natural or synthetic.

Not every cloth is the same, and some are more manageable than others. Picking a cloth for a sewing project becomes challenging because of this. To assist in the decision-making process, suitable fabrics are included on the reverse of patterns. Each fabric option has pros and cons, so choose wisely after taking the sewing project into account. There is no one ideal fabric. Online creation is possible for custom fabric.

COMPOSITE AND ITS CLASSIFICATION

The term composite can be defined as a material composed of two or more different materials, with the properties of the resultant material being superior to the properties of the individual material that make up the composite.The two major classifications of composites are natural and synthetic which is shown in figure 5&6

Fig 5 Natural

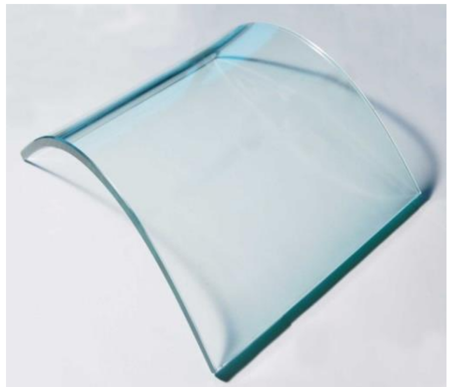

Fig.6 Artificial or synthetic composite

FABRICATION OF JUTE FIBRE POLYETHYLENE COMPOSITE

Using a closed-mould technique, natural jute fiber reinforced polymeric composite is created. Figure.7 depicts a single view of a male and female mold, which is mostly utilized in the manufacture of composites. The fibers are weighted in accordance with the fiber volume ratio to create jute fiber composite. The fibers are systematically sorted based on weight to ensure homogeneity. First, the weighted fibers are split into two groups and knitted together to create a layer that resembles a cloth mesh. The second layers go through the same procedures again. Before fabrication, as will be discussed below, the additives and polymeric resin are inserted into the mould die to divide the two layers. First, the catalyst is measured for 0.9% of the resin volume, and the resin is measured based on the intended volume. To make sure the mold surface is wetted, a part of the mixture is poured into the mold. Next, without changing the orientation of the fibers, the first layer of fibers is softly deposited. To soak the fibers, a further quarter of the fluid is then poured. The air is removed with a trowel. The second layer of fibers is laid after another quarter of the liquid has been poured. Using a hydraulic press, the final quarter of the mixture is poured before the mold is closed and screwed. After a whole day, the composite plate is taken out of the mold. Every specimen undergoes the same procedures twice. Seven days after the composite is fabricated, it is prepared for testing to make sure the resin has completely cured and hardened. After that, the material is tested for vibration.

WORKING

The compression molding process, depicted in Figure. 8, involves inserting a preheated polymer into an exposed, heated mold chamber. After sealing the mold with a top plug, pressure is used to push the material into every crevice of the mold. Pressure and heat are kept constant during the procedure until the polymer cures. The majority of applications now use thermoset polymers, while thermosets and thermoplastics can also be used in the compression molding process. Additionally, woven textiles, chopped strands, randomly orientated fiber mats, and unidirectional tapes can be used to crush mold advanced composite thermoplastics. Compression molding is a plastic molding technique that utilizes large volume and high pressure, making it appropriate for creating intricate and robust items. Moreover, its quick cycle time and high production rate, a lot of companies in the car sector have opted to manufacture parts using compression molding.

Fig.7 Male & Female mold

Fig.8 Compression Molding Process

VIBRATION TESTING

In order to conduct vibration testing on a structure, a forcing function is typically introduced together with a shaker of some kind. Alternatively, a shaker's "table" is fitted with a DUT (device under test). Electronic hydraulic shakers, or servo hydraulic shakers, are utilized for forcing at relatively low frequencies. Electrodynamic shakers are utilized for frequencies higher than that. On the DUT-side of a fixture, one or more "input" or "control" points are typically maintained at a predetermined acceleration. Maximum vibration level (resonance) or minimum vibration level (anti-resonance) is experienced by other "response" sites.The random and sine tests are the two most common kind of vibration tests. The purpose of sine (one-frequency-at-a-time) tests is to evaluate the device under test's (DUT) structural response. In general, a random test that includes all frequencies at once is thought to be more closely mimic a real-world setting, like the inputs from a road for a driving car. The majority of vibration testing is done in one DUT axis at a time, even though most real-world vibration occurs in various axes simultaneously. MIL-STD-810G, released in late 2008, Test Method 527, calls for multiple exciter testing.

VIBRATION ANALYSIS

The basic mass-spring-damper model can be used to understand the principles of vibration analysis. In fact, one can represent even a complicated structure like an automobile body as a "summation" of basic mass-spring-damper models. A basic harmonic oscillator is the mass-spring-damper type. Its behavior can be explained mathematically in the same way as other basic harmonic oscillators, like the RLC circuit. Figure.9 illustrates how the damping factor improves up to a 4 mm foam thickness limit before progressively decreasing as foam thickness increases. The Frequency can be calculated by using the below formula

$$f_i = \frac{\beta_i^2}{2\pi L^2}\sqrt{\frac{EI}{\rho A}}$$

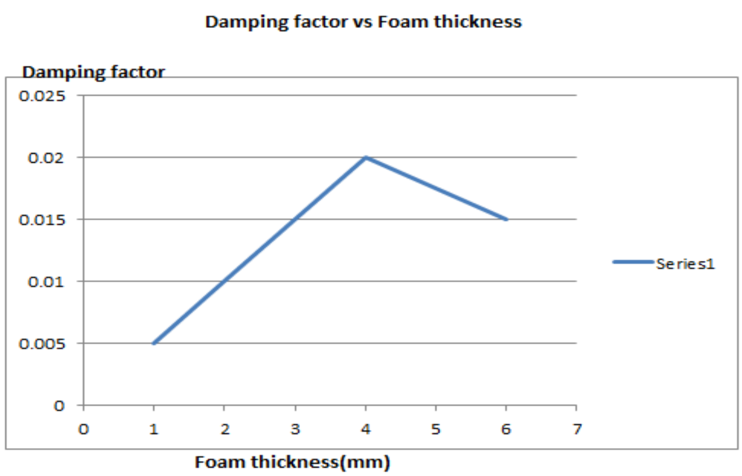

Fig.9 Foam thickness Vs Damping factor

CONCLUSION

Due to its technical superiority over synthetic fibers, research and development efforts conducted by many agencies have demonstrated that natural fibers are a versatile material that can be used for high-tech applications as well as rural ones. Using these naturally occurring materials is crucial to reduce energy consumption and environmental impact associated with the manufacturing of man-made synthetic composites. However, in order to prevent any setbacks throughout the completion of the entire process for upscaling technology from lab scale to commercial level, more research and development is needed for the extraction and characterisation of the fundamental materials, i.e., fibers.

SCOPE FOR FUTURE WORK

There is a lot of room for further research after this study. It can be applied to more recent composites with different reinforcing phases, and analysis of the ensuing experimental results can be done.

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