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DEVELOPMENT AND MECHANICAL BEHAVIOUR OF COIR ROPE, COIR FIBER AND SUNNHEMP FIBER REINFORCED EPOXY COMPOSITE

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Abstract

Researchers are always on the lookout for new materials to replace traditional ones. Natural fiber-based polymer composites are cost-effective and environmentally beneficial alternatives to traditional materials in a variety of basic technical and everyday applications. The creation and mechanical study of natural fibre based polymer composite materials has been attempted. Sunnhemp fibre and coir fibre are employed as reinforcement materials in this paper coir rope, and epoxy resin is used as a matrix. The study is done in three scenarios, taking into account the effect of fibre orientation, fibre volume in matrix, and fibre size in matrix. The coir rope was reinforced in the matrix in the first set of work to account for fibre orientations such as 0°, 45°, and 90°. The mechanical parameters of the material were calculated, including tensile strength and flexural modulus. In the second phase, coir and sunnhemp fibres are gathered from the local area, dried, and chopped for use in the matrix, with the volume fraction of fibre altering. The mechanical characteristics of the fibres and the pure matrix material were compared. The tensile behaviour of coir and sunnhemp reinforced epoxy was calculated at various fibre sizes in the third set of work. The characteristics of fibres vary depending on their orientation and the volume proportion of fibre in the matrix. Reinforcement of coir and senhemp fibres in pure epoxy improves the characteristics. For a fixed proportion of volume percentage, the fibre size variation in the composite does not propose exact patterns for mechanical behaviours.

Keywords : Natural fiber, Coir fiber, Epoxy, Sunnhemp fiber

1. Introduction

Natural fibre reinforced composite materials have been used for over two decades and have proven to be effective. India is an agricultural powerhouse with a lot of promise for natural fibres like coir, sunnhemp, jute, pineapple, and many others. The amount of fibre in the matrix, fibre orientation, and definitely bonding between the matrix and fibres all influence composite preparation. In the composite, the processing procedures are crucial. Vary the percentage of fibre in the matrix to change the properties of polymer composite materials as needed. Due to their unique qualities in wear subjected to alignment, natural fibres have a higher potential in tribological applications with polymer matrix. Since India has such a large potential for using agricultural/plant waste fibre. Coir and sunnhemp fibres are utilising this study for proper implementation in any acceptable technical applications. In terms of cost and environmental factors, it will provide a win-win situation. It has been suggested in the literature that waste fibres have higher strength than synthetic fibres and can be used to make polymer composites if appropriately processed. The following are the goals of this work:

1. To investigate the feasibility of using epoxy to reinforce natural fibres like coir and sunnhemp.
2. To investigate how fibre orientation affects the mechanical characteristics of a coir rope reinforced composite.
3. To create a database for future reference.

To attain the aforementioned goals, research is carried out.

2. Literature review:

In the topic of natural fibre reinforced polymer composites, there is a lot of research going on. Natural fibres are biodegradable, which draws researchers to work in this field, as indicated in a review for numerous natural fibres and their selection procedures [20, 21]. The impact strength of treated and untreated coir polyester composites at various volume fractions and thicknesses of the samples was investigated, and it was discovered that impact energy increases as fibre content and thickness increase [1]. In coir reinforced epoxy composites, the effect of fibre length has been described [10]. Mechanical features such as flexural, impact, density, and density of banana, sisal, and coir fibre reinforced epoxy composites were investigated and suggested for seat automotive applications [2]. The influence of fibre geometry on coir fibres in epoxy composites was investigated [22]. Process, characteristics, treatments, applications, and economic factors are all mentioned in a critical evaluation of coir fibre reinforced composites [15, 16, 24, and 25]. Banana reinforced epoxy composites have been found to have better qualities than raw epoxy when evaluated for fire retardant capabilities [2, 17]. Due to their low cost and low environmental effect, fibres have a lot of potential in the literature for numerous engineering applications. There have been many investigations on the effects of natural fibres and polymer composites on mechanical properties [3, 11]. The usage of coconut shell nanoparticles in automotive bumpers has been described [5]. Multilayered armour and helmet applications for coir reinforced polymer composites have also been suggested in the literature [6, 19]. The preparation of coir and polylactic acid composites using a screw extruder and injection moulding machine at various volume fractions of fibres was described, and their mechanical properties were reported [4]. Jute and Coir reinforced hybrid composites were investigated and reported for various environmental conditions [23]. The use of a modelling method for the investigation of fibre reinforced polymer composites is an excellent idea. Various parameters such as fibre volume fraction, curing duration, and compression force were considered in a factorial study [7]. In ANSYS, several natural fibres are modelled and their attributes compared [18]. Human hair also has a lot of potential in current studies. The possibilities of human hair were suggested in a research article [12]. Aside from mechanical properties of natural fibre composites, tribological research shows that natural fibres can also be used in wear applications. For the amount of filler and sliding distance, the abrasive wear behaviour of bamboo filled polyester composite was investigated. The addition of bamboo powder to polyester has been proven to impact wear behaviour [8]. Similarly, the sliding wear behaviour of jute fibre reinforced polyester composites was investigated for various fibre orientations in the matrix, and it was discovered that wear resistance was greatest in transverse directions compared to linear directions [9]. In the literature, sugarcane fibre reinforced polyester composites were investigated for tribological applications, and it was discovered that sugarcane fibre reinforced polyester composites have better wear qualities than galss fibre [13]. By altering the fibre content in the matrix, green polymers made from bagasse agricultural waste can be created for a cost-effective solution [14].

3. Materials and Methods:

Epoxy is utilised as a matrix material in the polymer composite manufacturing process. Coir rope, coir fibre, and sunnhemp fibres are used for matrix reinforcement. For mechanical characterization of the composite, three examples were investigated.

Case 1: Wrapping technique using coir rope reinforced epoxy composite in various orientations.

Case 2: At varying volume fractions, coir and sunnhemp fibre reinforced epoxy composites were used.

Case 3: Coir reinforced epoxy composites with various fibre sizes.

Case 1: Wrapping technique using coir rope reinforced epoxy composite in various orientations.

Coir rope reinforcement in an epoxy matrix at 0°, 45°, and 90° orientations is used to create samples. A wrapping method is presented in which coir rope is cut to the necessary length and wrapped around the mould side by side (with no gap between rope strands) at various angles, such as 0°, 45°, and 90° shown in figure 1. Weight was used to keep the mould and wrap rope together. The epoxy resins and hardener are combined according to the supplier's specifications. The epoxy and hardener are mixed together and applied to the mould by brush, along with the wrap rope. It is stored at room temperature for 24 hours to cure. After curing, the mould is removed from the rope epoxy composite, and samples are prepared for tensile and flexural testing of various coir rope orientations shown in figure 2.

Figure 1: Wrapping coir rope around the mould

Figure 2: Sample preparation at different orientation of coir rope in epoxy

Case 2: At varying volume fractions, coir and sunnhemp fibre reinforced epoxy composites were used

Coir and sunnhemp fibre in chopped form are reinforcing coir and sunnhemp fibre in epoxy resin to create samples. The fibres in the matrix are arranged at random. To make use of waste materials, fibres are collected from the local area. Both coir and sunnhemp fibres are cleaned and dried to remove dust particles before being cut into an average size of 5-6 mm. Proper proportions of epoxy and hardener are combined. For coir and sunnhemp, the fibres are blended at 3% and 5% volume fractions. Hybrid samples are also made with coir and sunhemp fibres in epoxy resin at 3% and 5% volume fractions. The samples are cured for 24 hours at room temperature. Samples are prepared for tensile and impact testing after curing. The details of samples and properties are tabulated in table 1.

Table 1: Details of samples and properties

Description	Sample Coding	Tensile Strength (Mpa)	% Elongation	Impact Strength (KJ)
3% sunhemp fiber and epoxy	A	6.5	12.4	2.5
5% sunhemp fiber and epoxy	B	18.9	2.4	8.1
3% coir fiber and epoxy	C	19.2	4.9	9.5
5% coir fiber and epoxy	D	22	3.65	11.3
3% hybrid (coir and sunnhemp) and epoxy	E	9.5	3.69	5.4
5% hybrid (coir and sunnhemp) and epoxy	F	19.1	2.45	10

Case 3: Coir reinforced epoxy composites with various fibre sizes.

The size of the fibres has a significant impact on the behaviour of composites. Handlayup procedure is used to make samples of coir and sunnhemp in epoxy in sizes of 5mm, 10mm, 15mm, and 20mm. Tensile testing is performed on the samples.

4. Results and Discussion:

The samples are examined for differences in the composite's mechanical properties.

Case 1:

Figure 3 shows the variation in tensile strength with coir rope orientation. The tensile strength of a coir rope reinforced epoxy composite is found to rise as the orientation angle increases. The results are compared to epoxy samples that are pure. The tensile strength of the linear orientation coir rope, i.e. 0° orientation, is 11.5 MPa, whereas the maximum value of 13.3 MPa was attained in the transverse direction with regard to fibre, i.e. 90° orientation. It has been discovered that adding fibres to the epoxy improves the tensile characteristics. The science behind this phenomenon is that reinforce fibres assist in holding the matrix in place, resulting in an improvement in properties. The characteristics improve as the adhesion between the fibres and the matrix improves. The flexural properties of coir rope epoxy composites are shown in Figure 4. The pure epoxy composites have a maximum flexural strength of 5.4 MPa, which is higher than the coir reinforced epoxy composites. For 90° coir rope reinforced epoxy composites, the minimum value was 1.98 MPa.

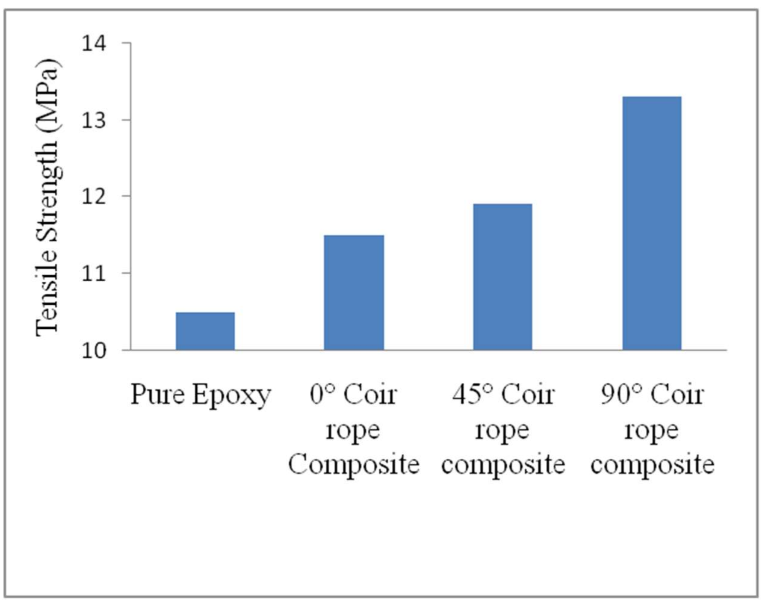

Figure 3: Variation of tensile strength with coir rope orientation

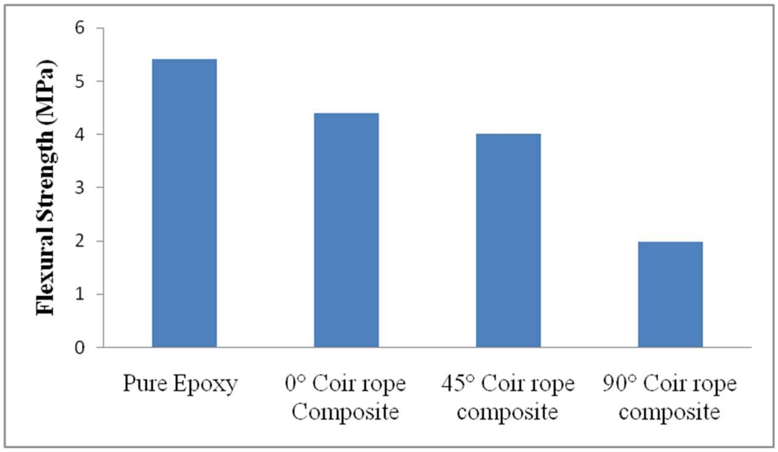

Figure 4: Variation of flexural strength with coir rope orientation

Case 2:

Figure 5 depicts the variation of mechanical attributes (tensile strength, impact strength, and elongation). Tensile strength and impact strength rise when fibre fraction increases from 3 to 5% for both coir and sunnhemp fibre composites, according to test data. The lowest tensile strength was found in a 3 percent sunnhemp fibres epoxy composite, which measured around 6.5 MPa. The greatest tensile strength of 5 percent coir reinforced epoxy composites was 22 MPa. 3 percent sunnhemp epoxy composites had a minimum impact strength of 2.5 KJ and a maximum impact strength of 11.3 KJ for 5 percent coir epoxy composites. Tensile and impact characteristics differ between coir and sunnhemp epoxy composites for both 3 and 5 percent fibre fractions in hybrid composites. The greater the number of fibres in the matrix, the more powerful it is. Coir reinforced epoxy composites have improved mechanical qualities when compared to sunnhemp reinforced epoxy composites.

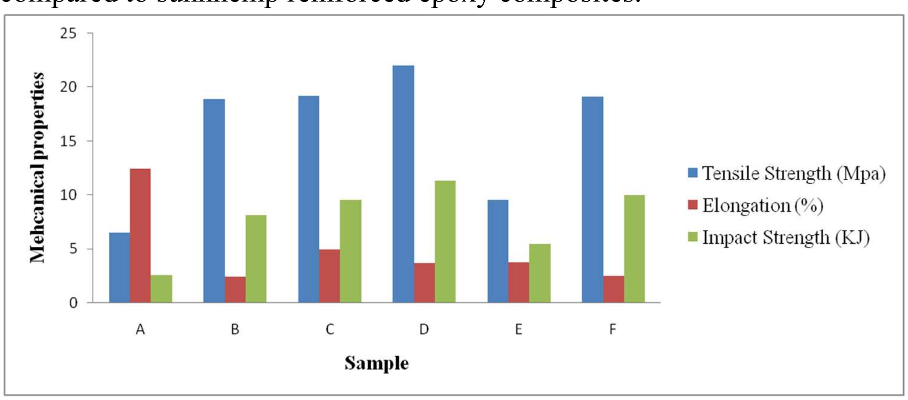

Figure 5: Variation of mechanical properties of the samples

Case 3:

For fixed proportions of fibre fraction in matrix, tensile strength was measured for varied fibre sizes of coir and sunnhemp fibres. In Figure 6, the data is compared to that of pure epoxy. The highest tensile strength was recorded as 42.9 MPa for 5mm size coir reinforced epoxy composites and the minimum tensile strength was reported as 21.1 MPa for 10mm size sunnhemp reinforced epoxy composites as a result of fibre size variation. The trend for tensile property fluctuation was inconsistent, with closure values that did not follow normal patterns.

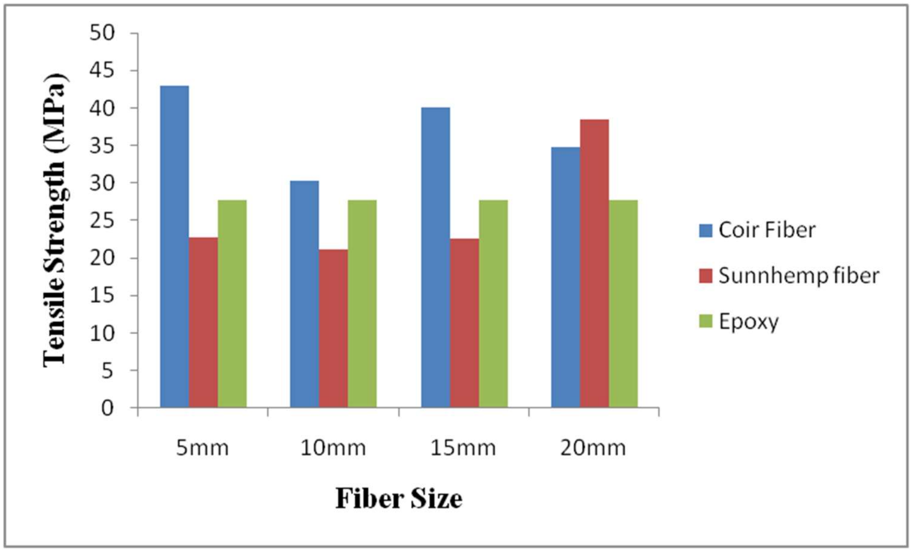

Figure 6: Variation of Tensile properties as per fiber size

5. **Conclusion and future scope:**

In this study, an attempt is made to evaluate the mechanical performance of natural fibre based polymer composites as well as the use of waste material in polymer composite creation. Three key aspects were investigated: fibre orientation, fibre size, and fibre loading. Coir rope, waste coir, and sunnhemp fibres can all be used to make natural fibre polymer composites, according to the findings. The following are the main points:

1. In the hand layup process, a wrapping method was successfully used to give coir rope orientation in coir rope reinforced polymer composites. As the orientation angle rises, the tensile strength of the coir rope reinforced epoxy composite increases but the flexural characteristics drop.
2. Tensile and impact strength increase when fibre fraction increases from 3 to 5% for both coir and sunnhemp fibre composites, according to test data.
3. The influence of fibre size for various experimental setups in paper does not reveal accurate patterns and does not predict performance.

Natural fibres can be used to generate natural fibre based polymer composites for suitable applications, based on the aforementioned observation. In terms of future research, a greater emphasis is necessary on a few variables such as water absorption and fire resistance of natural fibres.

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