Asian Review of Mechanical Engineering
ISSN: 2249-6289 (P) Vol.12 No.1, 2023, pp.39-43

DOI: https://doi.org/10.51983/arme-2023.12.1.3674

Composite Laminates for Aerospace and Packaging Fields

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(Received 18 March 2023; Accepted 23 April 2023; Available online 30 April 2023)

Abstract - **Composite materials have become increasingly popular and widely used in the present world due to their unique combination of properties that cannot be achieved by any single material. In the current study the mechanical properties of composite laminates (Jute, palm and banana fibers) were fabricated by varying groundnut husk and seashell powders quantities (5, 10, 15 and 20gms) in epoxy resin using hand layup technique. In according to the ASTM standards, a mixture of Epoxy (LY556) and Hardener (araldite) HY951 is used. The ratio of epoxy to hardener is 10:1. The material will be properly mixed for some time before being used to create laminates. Samples were fabricated with different compositions of jute, palm and banana fibers. Tensile, Compression properties of laminates were analyzed by testing composite laminates on universal testing machine. In this context the weight ratio of groundnut husk to seashell powder is 2:1. Analysis states that both the powders have impact on the mechanical properties of laminates. The impact of groundnut husk powder is slightly more on the laminates mechanical properties (tensile, compression) when related to seashell powder.**
Keywords: **Composites, Natural Fibers, Seashell, Groundnut Husk Powders, Hand Layup Method, Mechanical Properties**

I. INTRODUCTION

A composite material is a sort of substance made of two or more different types of materials, when combined they exhibit qualities and features that are distinct from those of the constituent materials. These substances are made by mixing a matrix substance like resin or a polymer with a reinforcing substance like fibers or particles. Typically, the matrix material is weaker and less stiff than the reinforcing material, providing the composite better strength and stiffness characteristics. Fiber-reinforced polymer composites have gained importance in many fields of application due to their exceptional qualities such as durability, resilience, and great strength for high atmospheric conditions. The majority of a composite is made of a weak component called "Matrix" that holds the reinforcement firmly in place and a strong component called "Reinforcement" that can bear loads.

The usage of synthetic fibers creates environmental problems, which has led to an increase in natural fiber research in recent years. Due to their biodegradability, availability, and strength, natural fibers might eventually replace synthetic fibers [1]. Hybrid fiber reinforced composites are made up of two or more different types of fibers. The jute and banana fibers were chosen for their durability, moisture absorption capacity, and availability. In order to join the fibers and transfer a consistent load, epoxy resin is employed as a matrix [2].

Hand lay-up is the simplest and earliest open moulding method utilized in the creation of composites [3]. It is a time-consuming, inefficient process that works best for producing large components. The wet lay-up method, often known as the hand lay-up method, is one of the industries oldest processes. It is relatively simple approach in which each sheet is simply handled by hand and is stacked up to the necessary thickness in layer by layer form. This method requires a lot of work and takes longer than current manufacturing procedures, while becoming safe. The quality is determined by the employee skills. The aircraft's range can only be extended so far using this technique. When properly developed, the new composite material exhibits more strength than each of its component materials. Home furnishings like seats, cots, tables, windows, switchboards, door panels, and ceilings are typical examples of how composite materials are used. Composite materials have many applications in sports and automobile sectors [4-5].

The natural fiber Jute is long, silky, and shiny. It can be twisted into heavy, durable threads. It is made by plant species of the corchorus genus [6]. One of the more inexpensive natural fibers is jute. When 0.8% palm fiber is used, the maximum load and flexural strength of composites are improved by around 13.4 and 16.1%, respectively. One of the natural fibers that can be obtained from Palmyra tree leaves is called palm fiber. The stem of the banana plant is used to produce a natural fiber known as banana fiber. One of the foods that is consumed the most on earth is the banana. 62–64 percent cellulose, 19 percent hemicelluloses, and 5 percent lignin are the main components of banana fiber. It has the best mechanical qualities of all the natural fibers. Many studies have focused on the banana fiber in an effort to improve the mechanical properties of composites [7]. Seashells that have been collected and are of a specific thickness and size can be crushed into a fine powder and added to epoxy resin as a chemical admixture to boost the strength of the composite since seashells contain calcium [8–11].

Groundnut is a healthy leguminous crop that is grown mostly for seed and oil around the world. The components of groundnut shells are lignin, cellulose, and hemicelluloses. The waste left over after the groundnut seed is extracted from the pod is groundnut shells. It is a typical agro-industrial waste product that, when exposed to the elements, degrades very slowly. But groundnut shells contain a variety of bioactive and functional components that are useful to people. It could be used in the paper, Bio-energy, food and feed industries [12]. The method of extracting peanut oil leaves behind groundnut husk powder. The peanut husks, sometimes referred to as the outer shells are ground into a fine powder to create it. The powder has a light colour and a grainy, rough texture. It is used both as a soil conditioner to enhance soil fertility and structure and as an element in feeding livestock. Moreover, it acts as a bulking agent or filler in several industrial applications.

The purpose of this project is to produce natural fiber composite materials with varied compositions to improve the mechanical properties by using widely available natural fibers, such as jute, palm and banana fibers in combination with groundnut husk and sea shell powders. These are analyzed by looking at the composite's tensile and compression properties.

II. PREPARATION OF LAMINATES

In the current research Jute, palm, banana fibers and sea shell, groundnut husk powders was used as composite materials. The laminate pieces were made by using hardener HY951 and epoxy resin LY556 in a 1:10 ratio. The composite laminates are prepared by using manual hand layup method shown in Fig. 1 and their compositions in Table I.

Fig.1 Preparation of Laminates

TABLE I COMPOSITION OF LAMINATES

Laminates	Palm Fiber		Jute Fiber		Banana Fiber		Groundnut Husk Powder in Resin	Sea-Shell Powder in Resin	Epoxy Resin
	Number of layers	In grams	Number of layers	In grams	Number of layers	In grams	In grams	In grams	In grams
P+J+J+P	2	18	2	21.5	0	0	0	5	120
J+P+J+P	2	18	2	21.5	0	0	0	10	120
J+B+J+B+J	0	0	3	35	2	32	15	0	200
B+J+B+J+B	0	0	2	24	3	53	20	0	230

To prevent the composite mat from sticking to the surface, a thin PVC clear film sheet is used at the top and bottom of the mould. Hand layup technique is used to prepare four composite mats. To avoid air bubbles on the mat surfaces, rubber wipers are utilized.

These mats are let up to 24 hours in the sun to firm. Each mat is divided into three laminates after hardening in accordance with ASTM requirements for tensile and compression testing's.

III. RESULTS AND DISCUSSION

A. Tensile Test

The laminates L-1, L-2, L-3, and L-4 had their tension properties put to the test using a UTM machine in accordance with ASTM D3039 standard. The measurement sample is (200 x 25 mm). In order to perform the test, a uni-axial force must be applied through both ends of the specimen until it fractures.

Fig. 2 shows samples before tensile test and The tested samples are shown in Fig. 3. Result analysis is followed by a calculation of the composite laminates' ultimate tensile strength. In Table II, these findings are summarized.

Fig. 2 Samples before tensile test

Fig. 3 Samples after tensile test

TABLE II TENSILE TEST RESULTS

Laminates	Maximum Load (N)	Tensile Strain (mm/mm)	Tensile Modulus (Gpa)	Ultimate Tensile Strength (Mpa)
L1	831.39	0.00660	1.96	14.85
L2	1235.99	0.00995	2.67	22.07
L3	2707.75	0.01898	2.64	27.77
L4	1675.26	0.01574	3.06	15.95

The results indicate that the laminate-4 gives better tensile modulus than the other laminates considered. When compared to other laminates, laminate-3 exhibits high tensile strain and strength. The laminate-3 outperformed the other types of laminate composites and exhibits high strength in its ultimate tensile strength (UTS). Laminate L-3 exhibits maximum load than the other laminates.

B. Compression Test

All laminates were put through a stress test using a fixture that was based on the ASTM D695 standard. The compressive characteristics of laminates L-1, L-2, L-3, and L-4 were evaluated using a UTM machine in accordance with the ASTM standard.

The test item measures (200 x 20 mm). A uni-axial force is applied through both ends of the specimen throughout the test, continuing until the specimen fractures. These findings are summarized in Table III. Fig. 4 shows the samples before compression test and the fractured samples are shown in Fig. 5.

Fig. 4 Samples Before Compression test

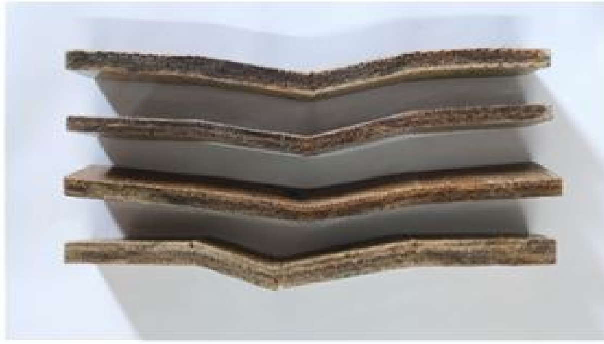

Fig. 5 Samples Before Compression test

TABLE III COMPRESSION TEST RESULTS

Laminates	Maximum Compressive Load (N)	Compressive Strain (mm/mm)	Compressive Strength (Mpa)	Compressive Modulus (Gpa)
L1	684.94	0.00428	8.56	2.37
L2	678.94	0.00415	8.48	2.92
L3	1821.03	0.01058	11.21	1.86
L4	2117.88	0.01368	12.10	1.67

The findings show that, compared to the other laminates taken into consideration, laminate-2 provides a higher compressive modulus. Laminate-4 exhibits a higher compressive strain when compared to other laminates. In comparison to other composite varieties, laminate-4 excelled them and exhibited excellent strength. More than the other laminates laminate L-4 shows the maximum load.

C. Comparison of Tensile and Compression Loads

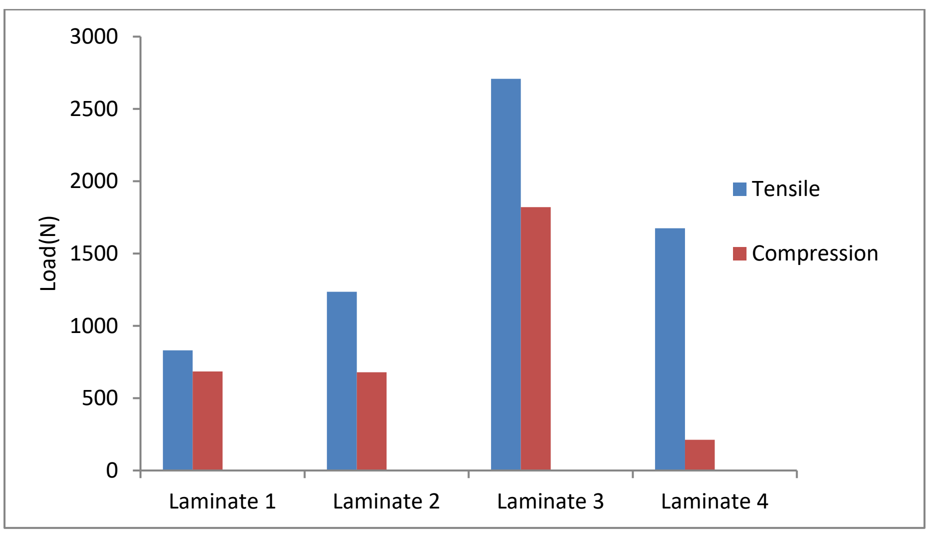

Fig. 6 Load Graph

Using the raw data, a load graph is generated after the laminates have completed mechanical testing, as seen in figure 4. The results show that laminate-3 has better tensile and flexural loads than other laminates.

IV. CONCLUSION

In this investigation palm, jute and banana fibers and groundnut husk and sea shell powders are used to fabricate laminates by using hand layup method. From tensile and compression tests following conclusions are as follows. The addition of groundnut husk powder to epoxy resin (LY556) had slightly increased the composite laminates tensile and compression properties when compared to addition of seashell powder in epoxy resin (LY556). Laminate 3 exhibited more tensile and compression properties than other laminates. This is due to presence of more jute and banana fiber contents in the stacking sequence. Moreover, the difference in the laminates tensile and compression properties are very low. Both the seashell and groundnut husk powders enhanced the composite laminates mechanical properties. The optimal composition or stacking sequence depends on the specific applications and requirements. From the current study laminate-3 (J+B+J+B+J with 15 grams of groundnut husk powder in epoxy resin) is suggested in aerospace and packaging fields.

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