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Performance Evaluation of Mechanical Properties of Untreated Woven Natural and Synthetic Fibers Hybrid Epoxy Composite

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ABSTRACT

Technocrats and researchers are attracted to the Polymer Matrix Composite (PMC) material due to its predominant mechanical properties. It has been observed from the literature survey that, use of any of the natural fibers alone from the available category like, Bast fibers e.g. jute, kenaf etc., Leaf fibers e.g. Sisal, Banana etc, Grass fibers e.g. Bamboo, Bagasse, Corn etc., Seed fibers e.g. cotton, Kapok etc., fruits fibers e.g. coir, palm etc. etc. as reinforced elements with matrix for composite not proven enough in strength for the proposed application due to its inbuilt characteristics. That limitation motivated me to do work on hybrid composites. Research is needed to find the better combination of the blend from the decided wt % configuration of fibers. In this paper, by taking the blend of natural fibers (Jute and kenaf) with a synthetic fiber (Glass fibers) with epoxy resin as matrix has been consider for the composite material preparation and its mechanical properties has been reveal as per American Society for Testing and Materials (ASTM) standard. The aim of the current work is to find a better wt % configuration out of the decided. Seven laminates of different configurations have been prepared by taking bidirectional woven fabric with the help of compression molding method. The tensile strength of the hybrid specimen shows maximum ultimate tensile strength 102.10 Mpa and Young's Modulus 6706.90 MPa at maximum force of 7.70 kN.The flexural strength of the hybrid specimen composite shows maximum flexural strength 225.30 MPa. The impact strength of the hybrid material is 11.43 J/M.The hybrid composite material shows the more than 100,000 cycles. This is the highest among the seven examined configurations.

Selection and peer-review under responsibility of the scientific committee of the International Conference on Design and Applications of Multifunctional Materials, Interfaces and Composites.

1. Introduction

Technocrats and researchers are focusing their attention on the utilization of natural elements as reinforcements in the area of material development. Regular filaments might assume a significant part in creating biodegradable composites to determine the current nature and ecological issues. Normal strands are lighter and less expensive; however, they have lower mechanical properties than glass filaments. The utilization of crossbreed filaments might tackle this issue. The greater parts of the investigations on normal strands are worried about single support. It was noticed that the tensile strength of sisal fiber with Glass Fiber Reinforced Polymer (GFRP) reveals better properties than the jute fiber reinforced GFRP composites and jute fiber reinforced GFRP composites execute higher level flexural properties[1].Yahaya prepared woven hybrid kevlar and kenaf composite by hand lay-up method, the individual fibers composites were also prepared for comparison. From the overall observation, it has been noted that, the hybrid composites with kevlar and kenaf with wt. A fraction of the 78:22 ratio exhibited better strength compared to other hybrid composites [2].Author use jute and glass fiber with epoxy resin to make composites material with the help of hand lay-up technique. Pure laminates of individual fibers, each fiber prepared for distinguishing purposes. The result shows that hybrid composite offers remarkable flexural and tensile strength as compared to individual composite laminates specimen [3]. Researcher concluded in his study that the use of synthetic fibers (i.e.. Glass, Carbon, Aramid) in polymer composites is desirable because they provide more accountable mechanical strength than natural fiber-reinforced polymer composites[4].Jute fiber-reinforced com-

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posite with different loading 20, 25, 30 & 35 wt% prepared with polypropylene as a matrix with the help of the injection molding method. The researchers found that 30 wt% loading of fiber gives acceptable results [5]. The effect of the stacking sequence of the untreated woven jute and glass fabric examined on its mechanical characteristics. The work reveals that the incorporation of glass layers at the extreme position of the laminates offers remarkable properties [6].An experimental study conducted on the hybrid compositeprepared by hemp-banana-glass fibers with epoxy resin. It has been noted that chemically treated fibers offered accountable characterization results as compared to untreated fiber composites [7].Fiber loading percentage changes the strength of the composite material has been observed also affect of different chemical treatments alkali (NaOH) and Silane has been studied and it is revealed that NaOH treated fibers gives the better result as compared to the Silane coupling agent treated fibers composite[8].Biofillers with synthetic fibers were experimentally assessed and the effect of chemically treated fibers to develop hybridized composite materials and their significance were observed [9]. A comprehensive studyreveals the mechanical behavior of randomly oriented natural short fibers with different combinations. In this work, the hybridization of natural fibers and manmade fibers will be utilized as support for the improvement of the proposed composite [10]. Kalaprasad et al.[11] applying the additive rule of hybrid mixtures and the mechanical characteristics of separate composites, the hybrid effect had been estimated. Depending on the proportional volume fraction of the two types of fibers and the hybrid's layer structure, the effect of the hybrid can be either positive or negative has been observed by Marom et al.[12]. The fiber and matrix bonding is having a significant meaning in the performance of composite has been reveal by Thwe et al [13,14]. The effect of chemical treatment has been studied on the natural fibers behavior by Noorunnisa et al [15]. In his study the combine effect of coir-silk fibers with equal proportion and various length. This experimentation reveal that the alkali treated composites offer better physical and mechanical strength.Basavraj et al [16,17,19] utilized abacus technique to find out the best combination of the fabricated laminates of synthetic fibers. In this experimentation and validation study, a suitable configuration has been obtained.Atiqah et al. [20,21,24] observed mercerization technique improved the matrix's and the fiber's surface adherence. The chemically treated sample gives better performance than the untreated sample. From a literature survey, it has been observed that, though natural fibers have good attractive features, they have some hurdles in usage alone. So, for automotive, industrial, sports, etc. applications, hybridization of the different fibers has become essential. This work is proposed to examine the tensile, flexural, impact, and fatigue strength of polymer composites to create more conservative composites with the help of its characterization investigation Structure.

2. Experimental procedure

2.1. Materials

For testing the mechanical qualities, Epoxy resin and hardener are used combined with Bidirectional woven fabrics of jute, kenaf, and E-glass fibers are used with 500/400 g per square meter respectively.

2.2. Composite laminate manufacture

Laminates has been prepared by woven jute-kenaf and E-glass fibers with the help of compression molding method at room temperature. While preparing the laminates the matrix and hardener materials use with the proportion of 100 g in 30 g respectively. The stacking sequence shows in Table 1.Precaution has been taken to prevent void formation during process. Pressure was then applied from the top, and the form was permitted to fix at room temperature for three days. During the course of tension, some polymer extracts from the shape. After three days, the samples were removed from the mold, and subsequent to relieving, the cover was cut into required size for mechanical tests by abrasive cutter.

Table 1
Stacking Sequence of laminate J-Jute,K-Kenaf,G-Glass.

Laminate	Stacking Sequence
L1	JJJJJJ
L2	KKKKKK
L3	GGGGGG
L4	JKJKJKJK
L5	JGJGJGJG
L6	GKGKGKGK
L7	GJKGJKGJK

2.3. Specimen preparation

To accomplish the primary target of the work, it is important to research the mechanical portrayal of the chosen setup. As needed, the example for the mechanical portrayal has been arranged according to the American Society for Testing and Materials (ASTM) standard.

2.4. Tensile test

The tensile test is performed by the standard test technique according to ASTM D 638 has been utilized;

The length of the test example is 165 mm as shown in Fig. 1.The test is performed in Universal testing machine 8086-INSTRON. At the pace of stacking, 10 mm/min was utilized for testing. For each material, three specimens were tested and the mean average was taken for further results discussion.

2.5. Flexural test

Flexural strength has been found as per the D790 ASTM Standard.

A three-point flexural load shown in Fig. 2has been employed with the help of the Universal testing machine 8086-INSTRON. For each material, three specimens were tested and the mean average was taken for further results discussion.

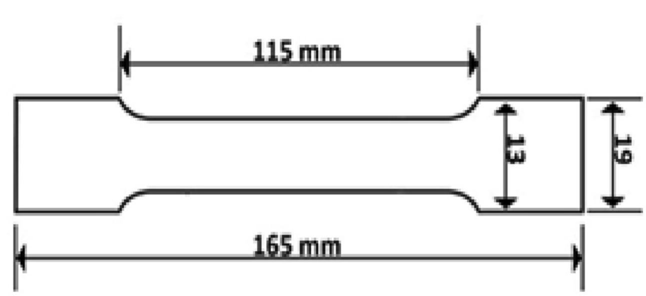

Fig. 1. Specimen for Tensile Strength[22].

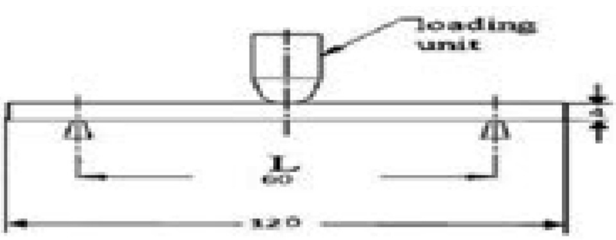

Fig. 2. Three Point load test Setup for Flexural Strength [16].

2.6. Impact test

The Izod impact strength test has been conducted as per ASTM standard D256.

The specimen dimensions are 64 × 12.7 × 3.2 mm as shown in Fig. 3 [18]. The Izod impact test is performed at a low-speed impact test for the unnotched specimens. Use the AIT-300 N Pendulum Swing Testing Machine. Striking Velocity: 5.6 m/*Sec*, Striking Hammer Weight: 18.7Kg, Swing Diameter: 1600 mm.

2.7. Fatigue strength

Fatigue strength is the highest load per unit area that a material can withstand for an applied number of cycles without breaking.

The specimen prepared for the fatigue test as shown in Fig. 4 is as per ASTM Standard.

3. Result and discussion

In the present work, the untreated jute kenaf fibers were used with E-glass fibers and developed the hybrid composite. Then the specimens have been prepared as per the ASTM standard and the test has been performed to evaluate the mechanical characterization of the composite material using a universal testing machine and the impact testing machine. The experimental results have been noted and presented in the following tables.

3.1. Tensile strength analysis

The tensile strength of the fiber with different combination shown in the Table 2.

The sample L7 shows that the maximum tensile strength is about 102.10 MPa followed by the L3 and L6 laminates, respectively. The maximum load taken by the laminate L7 is 7.70kN, which is the highest load affordability followed by L3 and L6 laminate composites. The tensile strength of the L7 laminate composite is 11.14 % and 28 % higher compared to L3 and L6 laminate composites. The modulus of the sample is shown in Table 1 and it has been observed that the L7 combination gives Young's Modulus of around 6706.90 Mpa. That is the highest among the rest of the combinations taken for examination. The L3 and L6 composite combinations show the Young's Modulus 5957.21Mpa and 6261.24Mpa respectively which is 9.87 % and 5.22 % less than the L7 laminate composite combination.

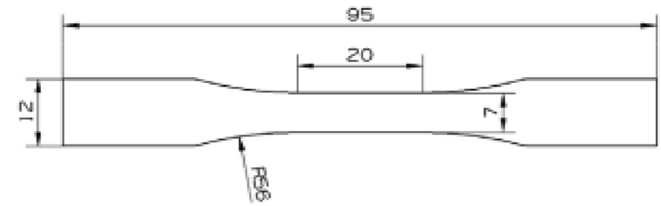

Fig. 4. Test specimen for fatigue Strength[23].

Table 2
Result of Tensile Strength Experimentation.

Laminate	UTS(MPa)	Modulus(Young's) (MPa)	Maximum Force(kN)
L1	35.12	2805.57	2.32
L2	45.73	4484.55	3.02
L3	90.45	5957.21	5.99
L4	61.10	5137.13	4.03
L5	53.89	5260.84	3.56
L6	74.47	6261.24	4.93
L7	102.10	6706.90	7.70

3.2. Flexural strength analysis

The flexural strength of the fiber with different combinations is shown in Table 3; the sample L7 shows the maximum flexural stress is about 225.30 MPa followed by the L3 and L6, respectively. The maximum load taken by the L7 fiber is about 470 N, which is the highest load sustained followed by L3 and L6 fiber composites.

The flexural strength of the L7 fiber composite is 10.91 % and 22.13 % higher compared to L6 and L3 composites. The stress–strain values show that the L7 composite sample gives 2 % displacement and L3, and L6 show 1.31 % and 1.71 % Flexural Strain (Displacement) at yield, respectively.

3.3. Impact strength analysis

The impact strength of the fiber with different combinations is shown in the following Table 4, with three specimens of each configuration used for the test and an average mean of these taken for further conclusion.

The sample L7 shows the maximum impact strength is about 11.43 J/m followed by the L6 and L5 respectively. From the above tabulated representation of the impact strength of all samples L7

Table 3
Result of Flexural Strength Experimentation.

Laminate	Flexural Stress (MPa)	Young's Modulus (MPa)	Maximum Force (kN)
L1	74.96	6697.27	0.15
L2	87.93	11648.31	0.19
L3	200.69	15254.79	0.43
L4	146.46	9347.56	0.31
L5	148.64	7600.07	0.32
L6	175.42	11186.26	0.37
L7	225.30	12588.35	0.47

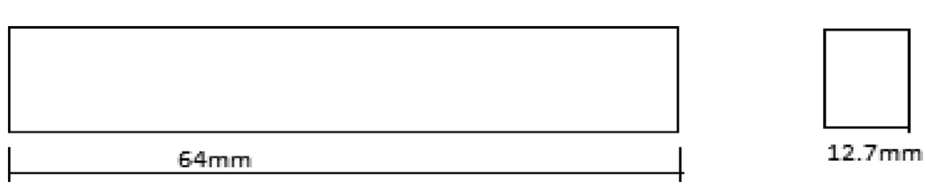

Fig. 3. Schematic representation of Impact Test Specimen [24].

Table 4
Result of Impact Strength Experimentation.

Laminate	Trial 1 Impact strength(J/m)	Trial 2 Impact strength(J/m)	Trial 3 Impact strength(J/m)	Mean Avg. Impact strength(J/m)
L1	5.70	5.40	5.54	5.55
L2	5.36	4.96	5.19	5.17
L3	6.04	6.54	6.69	6.42
L4	7.18	6.88	7.06	7.04
L5	7.18	7.48	7.66	7.44
L6	7.87	8.37	8.36	8.20
L7	11.17	11.47	11.65	11.43

Table 5
Result of Fatigue Strength Experimentation.

Laminate	Number of Cycles
L1	2000
L2	1500
L3	50,000
L4	6000
L5	10,000
L6	21,000
L7	120,000

configuration shows better results as compared to all remaining combinations.

3.4. Fatigue strength analysis

It is the exhaustion strength in which greatest pressure that a material can endure for a given number of cycles without breaking.The fatigue strength of the fiber with different combination shown in the following Table 5,

The L7 laminate withstands more than one lakh cycles before failing followed by the L3 and L6 laminates fifty thousand cycles and twenty-one thousand cycles respectively. This L7 laminate show is the highest among the rest of the laminates which were considered for the experimentation.

4. Conclusion

Considering the examination of the mechanical properties of various layered stacking groupings of Jute, Kenaf, and glass epoxy composites, the accompanying remarks can be drawn which are viewed as most noteworthy among all arrangements of laminates.

- The tensile strength of the hybrid specimen shows a maximum ultimate tensile strength of 102.10 MPa and Young's Modulus 6706.90 MPa at a maximum force of 7.70kN. The tensile strength of the L7 laminate composite is 11.14 % and 28 % higher compared to L3 and L6 laminate composites
- The flexural strength of the hybrid specimen composite shows a maximum flexural strength of 225.30 MPa with maximum withstand load of 470 N.
- The impact strength of the L7 laminate (hybrid composite) material is 11.43 Joule/M. It is observed that the impact strength of the hybrid material is 28.25 % and 34.90 % more than L6 and L5 laminates respectively.
- The fatigue strength of the L7 laminate (hybrid composite) material withstands more than 100,000 cycles.
- Overall observations and results of all considered seven combinations of natural and synthetic fibers L7, i.e. Hybrid combination gives better strength results as compared to L1, L2, L3, L4, L5, and L6.

CRediT authorship contribution statement

Makarand B Shirke: . **Santosh N Shelke:** Supervision.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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