

FABRICATION AND COMPARISON OF MECHANICAL PROPERTIES OF NATURAL FIBRE SANDWICH AND LAMINATE HYBRID COMPOSITES

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Abstract: Composite materials are in existence for a few decades. All of them which are used for different purposes are manufactured by synthetic materials which have a negative impact on environment. So, to decrease the environmental hazards and also considering the economic factors, use of natural fibres is encouraged. This Paper focuses on fabrication and comparison of mechanical properties of laminated and sandwiched hybrid composites. Hybrid fibre composites are fabricated, in which one is natural fibre (woven jute) and the other is synthetic fibre (glass). Alternate layers of natural and artificial fibres are used in case of laminate composites and in case of sandwiched composite, natural jute fibre is used as core and synthetic glass fibre is used as skin. Hand layup process is used for fabrication of specimens. Both specimens are tested for different mechanical properties and the results are compared.

Keywords: Hybrid composites, Jute fibre, Glass fibre, Sandwich, laminate

1. Introduction

Composite material is made by combining two or more materials that have different properties. The two materials do not dissolve with each other and are physically separable [1]. As there are two materials present in the composite, the resultant composite will have the combined properties of both materials. Composites are widely used due to their enhanced physical, chemical and mechanical properties. There are two phases in a composite- the matrix which is continuous phase and the reinforcement, the discontinuous phase. Reinforcement does most of the load carrying work and matrix transfers the load to reinforcement and also helps to place the reinforcement in place [3]. It also protects the reinforcement from various environmental conditions. Composites are

classified in to different categories based on type of matrix and reinforcement used. Among different types of composites, composites made of fibres like glass fibre, carbon fibre, Kevlar are widely used [4]. Among all the fibres, carbon fibre provides great strength with very low weight. But the use of carbon fibre is confined to high end applications due to its high cost. So, the use of glass fibre is predominant in fibre reinforced composites due to its cost effectiveness and high strength. Carbon fibre, glass fibre, Kevlar etc. all are synthetic fibres. Due to the toxicity of the synthetic fibres used in composites and increasing environmental consciousness, research on natural fibre reinforced composite is increasing [1]. As natural fibres are abundantly available in nature and require less processing, they are cost effective option over synthetic fibres. Due to degrading nature of the natural fibres, can help in maintaining a healthy ecosystem. Composite made of only natural fibre may not have higher strength. So, synthetic fibres are used along with natural fibres for good fatigue strength. Such composites made of more than one type of fibre are called hybrid composites. Studies have shown that hybrid composites exhibit better mechanical properties. These natural when fibres woven in the form of sheets, can be used along with glass fibre to fabricate sandwich and laminate composite panels. In sandwich panels, a core material is present in the inner layers which is covered by outer layers called skin and in laminate alternate layers of two materials are present.

2. Literature survey

Composite materials have more specific strength, fatigue characteristics compared to plastics [5]. The studies conducted on natural composites have conveyed that natural fibre composites alone cannot perform well under extreme conditions. So hybrid

composites are given more importance[3]. The specific gravity of polymer matrix increases when glass fibre alone is used in fabrication of composites [4]. The fibre reinforced composite exhibits maximum strength if the fibre content in composite is 70% [7]. The orientations of fibres have a profound impact on the mechanical properties of the composite. Sandwich and laminate composite panels have replaced the conventional plastics and other metal alloys due to their strength to weight properties.

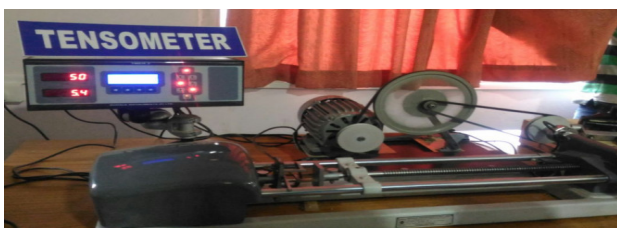
3. Experimental procedure

3.1 Fabrication of specimens

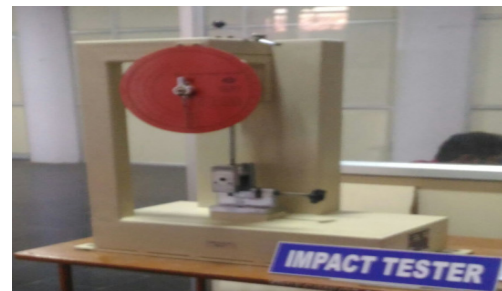
Woven jute fabric is washed thoroughly with distilled water to remove any dirt particles that are accumulated between the fibres. The cleansed fibre is then dried until all the moisture is removed. Polyester resin along with suitable catalyst and accelerator are used. Catalyst MEKP (1.2%) and accelerator cobalt (2%) are mixed in resin. Specimens are fabricated by hand layup process. For sandwich panel, jute fibre is used as core material and glass fibre is used as skin and for laminate panel, alternate layers of jute and glass fibres are used. Resin mixed with hardeners is applied for each layer and when the specimen is still wet, a load of 50 kg is applied for 20 hrs. This removes any voids present between the layers and also provides good surface finish. After hardening, the sandwich and laminate panels are cut in to specimens of required dimensions according to test standards for respective tests with the help of a wheel cutter.

3.2 Experimentation

In order to test the mechanical properties of the specimens, tensile, flexural and impact tests are performed on the specimen. The experimental setups for above tests are shown in below Figure.1



(a)



(b)

Figure 1. Experimental setup: (a) Tensometer for flexural and tensile testing. (b) Izod impact test

3.2.1 Tensile testing

In order to test the tensile strength of laminate and sandwich specimens, a digital tensometer of 2 ton capacity was used. The dimensions of the two tensile test specimens are 160 x 12.7 x 3 mm. Load is applied on the specimens one after the other and deformation produced under each load are recorded. The specimens for tensile testing are shown below in Figure.2.



Figure 2. Tensile test specimens

3.2.2 Flexural testing

Three point bending test is performed on both the specimens on a tensometer according to ASTM standards for finding flexural strength. The specimen is 100 mm long 25 mm wide 3 mm thick. The specimen is mounted on two rollers and the load is applied on the specimen. The flexural strength of the specimen can be calculated by the formula shown in Eq. (1)

$$\text{The flexural strength, } S = 3pl/2bt^2 \quad \text{Eq. (1)}$$

Where p – Maximum load, l – Distance between two rollers, b – width of the specimen, t – thickness of specimen. The Specimens for flexural testing are shown in Figure.3.



Figure 3. Flexural test specimens.

3.2.3 Impact testing

Impact strength is the resistance of a material to bear impact loads and resist crack. To find the impact strength of the specimens, Izod impact test is performed. The dimensions of the specimen are 63.5 x 12.7 x 10 mm. A notch is made at the centre portion of both specimens to perform test. The specimen is mounted on the test apparatus and the test is performed for sandwich and laminate specimen. The impact test specimens are shown in the Figure.4. The impact strength can be calculated by the formula shown in Eq. (2)

$$I = EI/T \quad \text{Eq. (2)}$$

Where EI = Impact energy, T = Thickness of the sample.



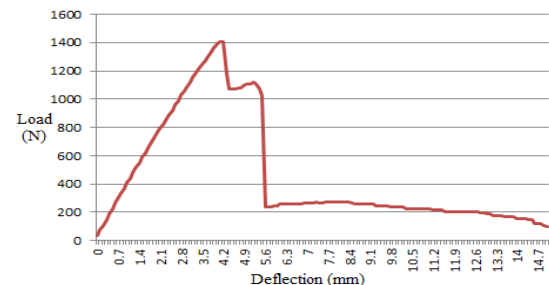
Figure 4. Impact test specimens

4. Results

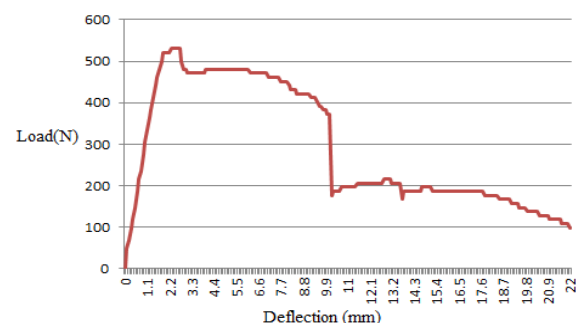
The results obtained from tensometer are recorded and load vs deflection curve is plotted for flexural and tensile tests. The tensile, flexural and impact strengths are calculated for sandwich and laminate specimens by the values recorded from respective tests.

4.1. Flexural test results

Load vs Deflection for sandwich and laminate specimen are shown in Figure.5.



(a)



(b)

Figure 5. Load vs Deflection curve (a): For laminate specimen (b): For sandwich specimen

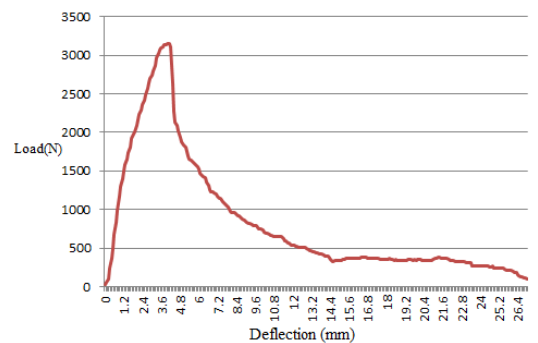
From the above plots, it can be observed that the laminate specimen can withstand a maximum load of 1403N and the deflection at that load is 4.2mm whereas the sandwich specimen can withstand a maximum load of 530N and the deflection at that point is 2.7mm. The laminate specimen exhibited more load bearing capacity than sandwich. The calculated flexural strengths of laminated and sandwich specimens are tabulated in Table.1

Table 1. Flexural strengths of sandwich and laminate specimens

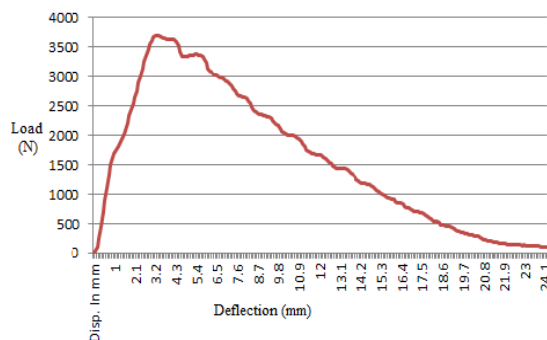
	Laminate	Sandwich
Flexural strength (Mpa)	598.61	138.0208

4.2. Tensile test results

Load vs Deflection curves plotted are shown in Figure.6.



(a)



(b)

Figure 6. Load vs Deflection curve (a): laminate specimen (b): sandwich specimen

From the above plots, laminate specimen can withstand a maximum load of 3148N and the deflection at that load is 4.1mm and sandwich specimen can withstand a maximum load of 3698N and the deflection at that load is 3.5mm. The sandwich panel can bear more weight when compared to laminate specimen. Both sandwich and laminate specimens exhibit ductile properties i.e., as the load gradually increases the deflection increased and at a certain point, maximum load is applied and even after the load is decreased, the deflection or deformation keeps on increasing. The calculated tensile strength of sandwich and laminate specimens are shown in Table.2.

Table 2. Tensile strength of laminate and sandwich specimens

	Laminate	Sandwich
Tensile strength (Mpa)	82.6	97.060

4.3. Impact test results

From Izod impact test, the impact energy for laminate is 18.2 joules and for sandwich specimen is 15 joules. The calculated impact strengths are shown Table.3.

Table 3. Impact strength of laminate and sandwich specimens.

	Laminate	Sandwich
Impact strength (joules/mm)	1.82	1.5

5. Conclusion

The hybrid composite specimens were tested for the tensile, flexural and impact properties and their respective strengths were calculated. From the results obtained, it is observed that the laminated specimens have more flexural and impact strengths when compared to sandwich specimens. Whereas tensile strength is greater for sandwich composite specimens and both sandwich and laminate composite specimens exhibited ductile properties. The composite fabricated is lighter in weight and laminated composite is proven to withstand loads same as in case of certain applications like prosthetics, automobile body components.

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