Mechanical Properties of Jute - Aloe Vera Hybrid Natural Composites

D.Muruganandam, J.Jayapriya, M.K.Karthik, D.Raguraman, S.Suraj

Abstract: ***Composite materials has been in use since ages. The introduction of chemical revolution changed the face of composite development. However the environmental impact of polymer composites is becoming a problem that needs to be addressed properly. This brings the situation to revive the natural composites back to day to day use by replacing them in place of synthetic composites. An attempt has been made to study about the behaviour of natural composites namely aloe vera and Jute. The following mechanical properties namely ultimate tensile strength, flexural strength and impact strength are calculated for jute as well as aloe vera. Also the same have been compared with jute and aloe vera hybrid composites.***

Keywords: Natural Composites, Ultimate tensile strength, Aloevera /Jute hybrid composites.

I. INTRODUCTION

History records the first use of composites by Mesopotamians where wooden strips are arranged at various orientations for fabricating plywood. Since then mankind has never looked back and as years progressed, engineers started fabricating composite laminates from different types of materials which were used in larger domain of applications. Development continued to be from naturally available materials until the middle of 18thcentury including the usage of first composite bow. The bow was fabricated using naturally available materials such as wood, bamboo, horns and silk bonded with natural pine resin[2].

During later stages of 18th century, the world saw the chemical revolution where synthetic resins were coming into industry usage. Polymerisation is the process which transforms the material from liquid state to solid state using a cross-inked molecular. This chemical advancement led to the development of many plastic materials such as vinyl, phenolic and polyester which are notable for its strength and rigidity. Bakelite was the first plastic made from synthetic components, was notable for its non conductivity and thermal properties.

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This made the application of composites wide open for variety of applications. The early 1930's saw the developed of various synthetic resins and glass fibers a man made resin which proved to be a game changer in field of composites.

The introduction of glass fibers led to the development of Fiber reinforced polymer (FRP) industry. The necessities of Second World War led way to the mass production of composites especially glass fibers for the production of aerospace components and marine components. By end of Second World War, automobile industry made use of various composite materials which led to rapid development of composites using highly functional materials such as carbon fibers, Kevlar fibers.

The scope of research and development for composite laminates include aircraft composite parts[8] and composite parts applied in marine engineering. With every advancement we are also forced to see the cons of development in the field of composites. The main con concerned with the advancement of composite remains the disposal of waste composites.

Most of the synthetic materials are non-biodegradable which takes a long time to decompose, creating long-term pollution. This leads to restriction in the use of composites for marine applications polluting the sea environment and aquatic based ecosystems.

Hence it is the right time to turn back to our ancient times where natural composites played a major role.

II. MATERIALS AND FABRICATION

Materials

Jute (Corchorus capsularis) is the most important natural fibers available in plenty after cotton. The cultivation of jute depends on the parameters namely climate, season and soil[4]. The typical jute cultivation period extends upto four months after which they grow around 20cm tall. The plants are harvested and tied into bundles and soaked in water for about 20 days.

Retting is the process of extracting fibers from the stem of the plant[1]. There are various retting process available for the extraction of fibers namely mechanical, chemical, steam/vapor/dew, water and microbial retting.

Aloe vera (Aloe barbadensis) is a succulent plant species originated from Arabian Peninsula mostly used for cosmetic and medicinal purposes. It is very short stemmed plant growing in the range of 60-100cm tall.

Fabrication of Specimens

Natural fibers of jute and aloe vera with 0°/90° orientation was obtained and is used along with the LY556 Epoxy resin and HY951 hardener and adhesives. Initially a die of dimensions 300mm x 300mm is made to get proper dimensional composite laminate. The die is made up of rubber so that the final product can be easily taken out without any risk of sticking and damage.

The adhesive and hardener are mixed in the ratio of 10:1 to get proper adhesive quality. The fiber matt is checked for dimensions and extrusions over the specified dimensions are removed using a cutter. The mixed proportion of epoxy resin with hardener is coated on the rubber die in a uniform amount after which the first layer of the fiber is placed on the adhesive layer followed by pressing with the help of roller.

The second layer of adhesive is applied on the fiber in a uniform manner and the process is continued upto three layers. After which the top most layer is pressed hard and laminated with the adhesive to prevent the percolation of water. The handmade composites are hardened by a placing heavy weight on it to get uniform shape. Finally the laminate is checked for pores and incompleteness and the adhesive is applied at those areas and allowed to dry on the sunlight.

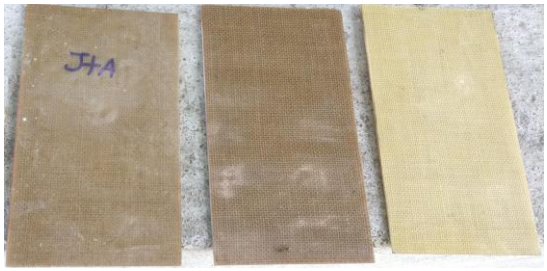

Fig . 1 Laminated Jute, Aloe vera and Hybrid Composites

III. MECHANICAL PROPERTIES

Ultimate Tensile Strength Testing:

The tensile test was carried in universal testing machine with cross head speed of2.5 mm min^{-1}. The specimens used for recording the ultimate tensile strength was prepared as per the standard ASTM D638. Three samples each was subjected to tensile load from laminates prepared frin aloevera, jute and jute/aloe vera hybrid composites. The samples were made in the shape of dog bone or dumb bell in accordance with the ASTM D638standard. The tests were performed on specimens until failure.

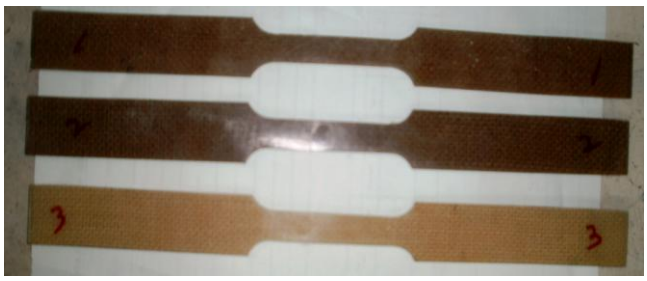

Fig . 2 Tensile Test Specimen as per ASTMD638 Standard.

Initially the composite laminates are clamped to the UTM using suitable fixtures and subsequently axial tensile load was applied until the specimen breaks[5]. The failure load is noted using which the ultimate tensile strength can be calculated and necessary graph plots are generated and recorded for analysis purpose.

Flexural Testing

Flexural Strength can be estimated by conducting three point bending tests. The specimens were prepared in accordance with ASTM D790 measuring 100 mm long, 29.37mm wide and 4.15 mm thick. The three point bending test specifications includes 64 mm distance between the outer supports and the specimens are tested at a strain rate of 0.2 mm/min.

The composite laminates are loaded with standard three point bending setup having cross head speed of 2.5 mm/min. Test is performed on jute, aloe vera as well as jute with aloe vera hybrid specimens. The load is applied continuously until the specimen breaks due to failure. The failure load is noted using which the flexural strength can be calculated and necessary graph plots are generated and recorded for analysis purpose.

Impact Testing

The impact strength of the composite specimens was determined by using a drop impact tester. It is the measure of resistance offered by the composite specimen against fracture by applying heavy impact load.

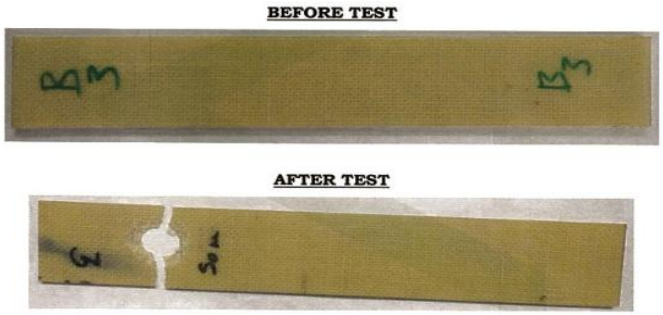

Fig . 3 Drop Impact Test Specimen as per ASTMD2794 Standard.

The composite laminate is fabricated from jute, aloevera and jute/aloe vera hybrid composite laminate as per ASTM D2794 standard and tested under the following lab conditions with diameter of the intender as 12.7mm and a standard weight of 1 kg fall from a height of 50cm. The temperature was maintained at standard room temperature of 27±2°C.

IV. RESULTS AND DISCUSSION

Tensile Test Results

From tensile test performed on jute, aloevera and its hybrid composite specimens as per the ASTM D638 standard, the ultimate tensile strength of the samples as recorded as follows,

Table 1 . Ultimate Tensile Strength Results

S.No	Specimen	Ultimate Tensile Strength (MPa)
1	Jute	27.81
2	Aloe Vera	29.99
3	Jute/Aloe vera Hybrid	33.99

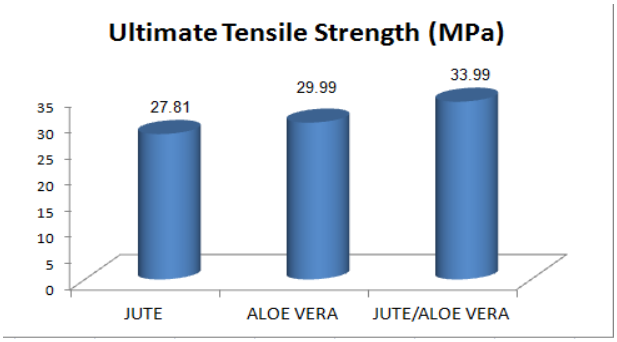

Fig .4 Ultimate Tensile Strength Comparison

From the tabulated results it can be observed that Aloe vera composites have slightly higher tensile strength as compared with that of the jute composites[3]. However the hybrid combination of the jute and aloe vera shows a considerable amount of improvement in strength of about 13.5%.

Flexural Test Results

From three point flexural test performed on jute, aloe vera and its hybrid composite specimens as per the ASTM D790 standard[6], the flexural strength of the samples as recorded as follows,

Table 2 . Flexural Tensile Strength Results

S.No	Specimen	Flexural Strength (MPa)
1	Jute	1.067
2	Aloe Vera	0.867
3	Jute/Aloe vera Hybrid	1.509

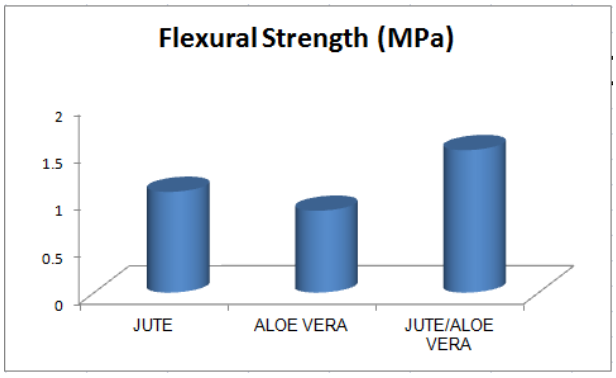

Fig . 5 Flexural Strength Comparison

From the tabulated results it can be observed that Jute composites have slightly higher flexural strength as compared with that of the Aloe vera composites. However the hybrid combination of the jute and aloe vera shows a considerable amount of improvement in strength of about 65%.

Impact Test Results

From the drop impact test performed on jute, aloe vera and its hybrid composite specimens as per the ASTM D2794 standard, the impact resistance was found to be same for all the three specimens measuring about 2J energy range.

V. CONCLUSION

Natural Fibers were extracted from the jute, aloe vera plants and composites were laminated using epoxy as resin. To understand the behaviour of important properties for natural composites, various tests namely tensile test, flexural strength and impact test were performed on those specimens[7]. Also hybrid laminates were made to understand the effect of combination of different natural fibers.

The mechanical tests performed on the composite specimens can be summarized as:

Ultimate tensile strength for Aloe vera laminate exceeds that of jute fiber by a small margin. However the Aloe vera/Jute hybrid laminate seems to be a positive find out where the Ultimate tensile strength increases by 13.5%.

Flexural strength of the Aloe vera is slightly higher than the jute fiber. The Aloe vera/hybrid laminate seems to be a positive find out where the Flexural strength increases by 65%. This increase in flexural strength paves way for these laminates to be used for construction on beam like structures which will have better bending stress.

Drop impact test does not show any considerable variations among these three specimens. To improve the impact strength further modifications can be made by introducing carbon or kevlar fibers as additional reinforcement in between the hybrid laminates.

VI. FUTURE SCOPE OF PROJECT

The mechanical properties observed can be further improved either by adding the constituent natural fibers such as sisal, banana or pineapple in addition to the existing jute and aloe vera. Also the specimens shall be subjected to water absorption tests which can extend the application of natural fibers for marine field applications.

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