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Determination of the Bending Strength of Sisal/Jute Hybrid Polymer Composite for Lightweight Structural Application.

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Abstract: This research work investigated the bending strength of sisal/jute polymer hybrid produced with unsaturated polyester resins for lightweight structural application. In this research work, hybrid composites have been developed using hand layup technique based on percentage combination of Sisal and Jute fibers in the form of laminates prepared from – Unsaturated polyester . The prepared laminate samples were subjected to bending test to evaluate their strength which was based on orientations and fibre percentage combination. Specimen sample designated B4 with composite of Sisal: Jute (50%:50%) - percentage combination laid at 45^0/-45^0 orientation demonstrated the highest bending strength of 50MPa.

Keywords: Sisal, Jute, Hybrid, Bending, Strength.

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I. INTRODUCTION

The bending strength or flexural strength of a material is defined as its ability to resist deformation under load. For materials that deform significantly but do not break, the load at yield, which is a typically measured of deformation/strain of the outer surface, is reported as the flexural strength. The test beam is under compressive stress at the concave surface and tensile stress at the convex surface. Strength refers to the capacity of the section or member to resist a certain types of external action. It depends on the shape and size of cross section, stress strain relationship for the material of which the section or member is made and sometimes on member properties such as unsupported length, end conditions etc. Overall, it indicates the magnitude of the external force that the section or member can resist. If you are considering limit state behaviour and are using a suitable stress strain relation, this capacity could be an ultimate capacity.

The incorporation of several different types of fibres into a single matrix has led to the development of hybrid bio-composites. The behavior of hybrid composites is a weighed sum of the individual components in which there is a more favorable balance between the inherent advantages and disadvantages. Also, using a hybrid composite that contains two or more types of fibres, the advantages of one type of fibre could complement with what are lacking in the other. As a consequence, a balance in cost and performance can be achieved through proper material design (Liao 2003). The properties of a hybrid composite mainly depend upon the fibre content, length of individual fibres, orientation, extent of intermingling of fibres, fibre to matrix bonding and arrangement of both the fibres. The strength of the hybrid composite is also dependent on the failure strain of individual fibres. Maximum hybrid results are obtained when the fibres are highly strain compatible, (Thomas, 2002).

Several studies have been reported on the use of sisal/jute fibers as reinforcements in polymer matrices. Parandaman and Joyaraman (2015) investigated the mechanical properties of Jute/Sisal/Glass and Jute/Banana/Glass Hybrid composite materials on Epoxy resin, the study in an attempt to analyze the effect of hybridization of natural fibres with glass fibres on the mechanical behavior of the composites conducting test to evaluate their tensile, hardness, impact strengths, the results of the hybrid composite samples shown: for Jute/Sisal/Glass (JSG), Tensile modulus of 23.29MPa, Flexural strength of 59.8MPa, Impact strength of 15.01KJ/m^2, compared to that of Jute/Banana/Glass (JBG) which shows maximum Tensile modulus of 42.24MPa, maximum flexural strength of 72.93MPa, maximum impact strength of 26.35KJ/m^2.

The concept of hybrid systems for improved material or structural performance is well-known in engineering design. However, it is the inspiration from natures' own materials that is recently motivating the path towards innovative material and structural designs. Studies on natural materials show how high structural performance can be achieved with non-exotic materials through hybrid combinations assembled in optimized hybrid hierarchical configurations, (Mohanty, 2002).

Plate.1 Extracted sisal fibre

Plate.2. Extracted Jute Fibre

II. MATERIALS AND METHOD

Materials

The materials used for the preparation of the composite were: unsaturated polyester resin (matrix), methyl ethyl ketone peroxide (catalyst), cobalt naphthalene (accelerator), Vaseline (releasing agent) bought from Pascal Scientific Laboratory, Akure, Ondo state. Sisal plant fiber was obtained from Ogbemena garden, Ineni town, Anambra State. Jute plant was obtained from Tiawo Farm, Owode, Ogun state Nigeria.

Equipment

The equipment used include: the metal mould, Bending/Strut Rig Testing Machine in Petroleum Training Institute Effurun strength of materials laboratory, grinding machine, Oven model OV-420 by Gallankamp, Digital weighing balance in Federal University of Petroleum, Effurun, Mechanical Engineering strength of materials laboratory. Other equipment used are: conical flasks, beakers, measuring cylinders, thermometer, stirring rod, volumetric flask and Hand roller.

Method

The fabrication of the various composite materials is carried out through hand lay-up technique. Sisal and jute fibre strands are the reinforcement in the unsaturated polyester, Methyl ethyl ketone accelerator and Cobalt catalyst at a ratio of 10:1:0.5. The laminate samples for bending test were prepared. Each laminate were loaded in resin fraction, arranged in the orientation of $90^0/90^0$, $90^0/45^0$, $0^0/0^0$, $-45^0/45^0$, $30^0/60^0$and in fibres combination percentage ratio of sisal to jute at 50:50, 67:33, 33:67, sisal alone, jute alone, with reference to a control sample of nil fibre (resin alone) and mild steel. The prepared laminate samples were allowed to cure under room temperature after been consolidated with a roller load weight of 50g, at 4hrs before sample is removed from the mould. Then, specimens are cured in the air for another 12hrs after removing from the mould.

III. EXTRACTION OF FIBRES

Retting and Hand Isolation of fibres

The process involves steeping and keeping the bast plant of Jute and the leaf plant of the sisal in submerged in water for a period of time not less than 30 days, allowing the immersion to be 10-15cm from the top. Through this process, bacteria act on the soak plant. The bacteria acting on it releases enzymes which also act and allows the plant to soften as much as possible. The fiber was properly washed with ordinary water and re-soaked for total removal of the lignin still attached. The fibre was then dried, brushed. Proper drying is important as fibre quality depends largely on moisture content. Dried fibres are combed and sorted.

Fibre Surface Treatment

The treatments of sisal/jute fibres was done with alkali, the process is called mercerization wherein Sodium hydroxide is used to break hydrogen bonding in the network structure of the fibre’s cellulose, thereby increasing the fibre’s surface roughness. This treatment also removes lignin, wax and oils covering the external surface of the fibre’s cell wall, de-polymerizes the native cellulose structure and exposes short length crys-tallites. Fibre surface treatments improve the interfacial adhesion between the fibre surface and the matrix, thereby giving good mechanical properties to the resulted polymer composites. 5% w/v Sodium hydroxide solutions were prepared in 500ml beaker by diluting 20g pellets of sodium hydroxide in 400ml of distilled water. The treatment of the sisal fibres provide improved wettability, mechanical properties and water resistance.

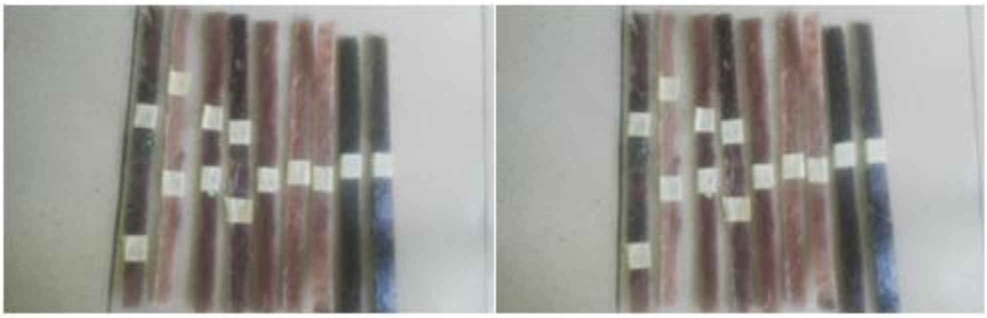

Plate 3: Bending Test Samples already prepared

Plate 4: Bending test sample on fix support at both ends.

Plate 5: Bend test sample under induced force of 200N

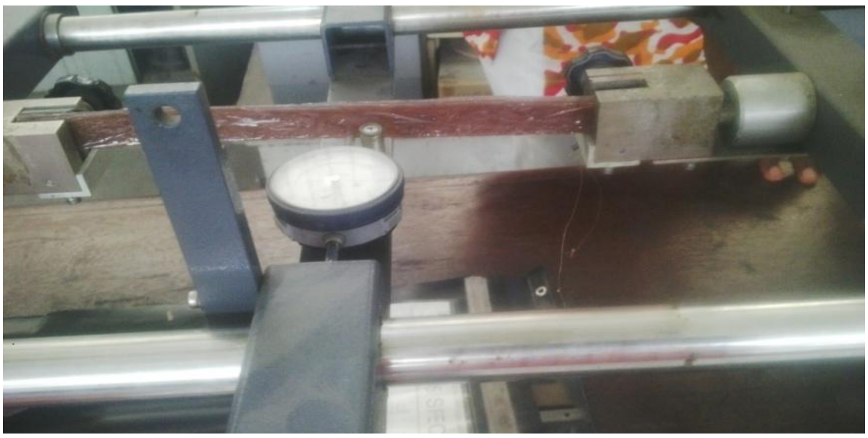

Plate 6: Deflection of Bending test sample

Plate 7: Samples after bend test

Sisal /Jute Hybrid Percentage Combination

Maximum hybrid results are obtained when the fibres are highly strain compatible.

According to rule of mixture,

$$X_H = X_1V_1 + X_2V_2 \quad (1.)$$

where, X_H is property of the hybrid, X_1 and V_1 shows the property as well as the volume fraction of the first fibre, and X_2 and V_2 ,as that of the second fibre. Properties of the hybrid composite may not follow from a direct consideration of the independent properties of the individual components. A positive or negative hybrid effect can be defined as a positive or negative deviation of a certain mechanical property from the rule of mixture behavior respectively. When bulk properties are combined in a hybrid, as in structural composites, the best that can be obtained is often the arithmetic average of the properties of the components, weighed by their volume fractions.

IV. BENDING TEST RESULTS

Table 1. Summarized test results of developed maximum sisal/jute hybrid polymer strength in comparison to mild steel reference bending strength.

MECHANICAL PROPERTY	SISAL/JUTE HYBRID POLYMER COMPOSITE MAX. STRENGTH	REFERENCE STRENGTH OF MILD STEEL
BENDING STRENGTH	50.5MPa	280MPa

Reference: Mild steel, Bending Strength 280MPa

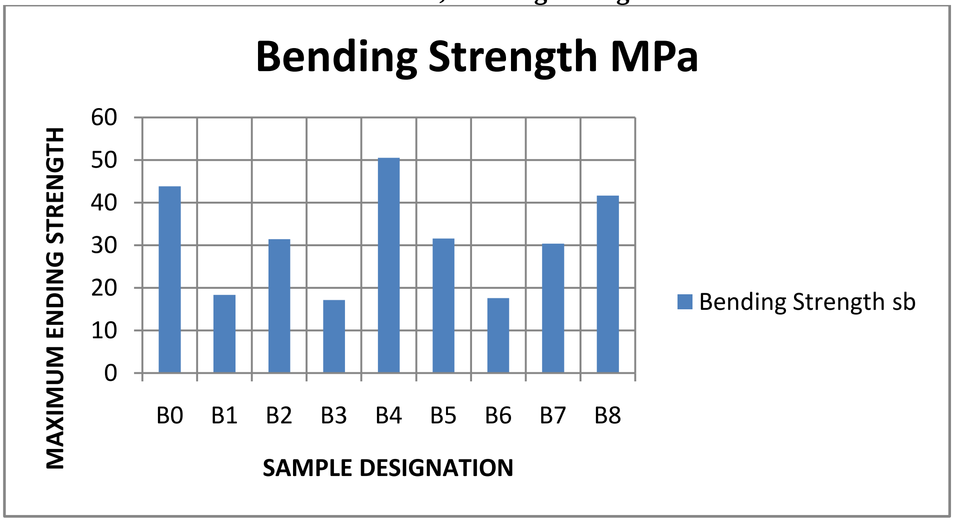

Fig. 1.: Graph of Bending Test Samples of Sisal/Jute Fibres Percentage Combination Prepared at 0.4 Volume Fractions Using Unsaturated Polyester Resin result.

Discussion of Bending Test results

The bending test was conducted in accordance with samples according to ASTM D790 with specimen dimension of 300mm X 20mm X 5mm using the strut/bend testing rig. The machine model is SM105 and the serial number is Z4076/5. The induced load was 200N and the calculated buckling/bend load is 2738N. It was observed that the unreinforced specimen sample designated B0 demonstrated the highest bending strength of 43.83MPa. Specimen sample B4 with composite of Sisal: Jute (50%:50%) - percentage combination laid at 45^0/-45^0 orientation demonstrated the highest bending strength of 50.55MPa. This is 15.3% improvement over the virgin unreinforced specimen sample B0. This when compared to the bending strength of mild steel is 18%. This was followed by specimen sample designated B8 with composite of Sisal: Jute (33%:67%) - percentage combination laid at $90^0/90^0$ orientation demonstrated the bending strength of 41.66 Map. This was followed by specimen sample designated B2 with composite of Sisal: Jute (0%:100%) - percentage combination laid at $90^0/90^0$ orientation demonstrated the bending strength of 31.4MPa.

APPLICATION: From the bending test results on laminates which demonstrate good bending strength of 50MPa with the capacity to be used the production of automobile body parts such as Rear suspension tower, Front suspension attachment, Bumper.

V. CONCLUSION

It was observed that increase in percentage combination of sisal and Jute fibers exhibited superior bending strength at balance of 50:50 percentage of Sisal: Jute fibers. The bending strength of the composite depend to a large extent on the interfacial bonding strength between the matrix and fiber reinforcement, the orientation of fiber, other reinforcement(ribs, wire mesh), and the inherent properties of the composite ingredients. Improvement in the bending strength of composite helps the composite to withstand more stress while being used in lightweight structural parts.

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