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Finite Element Analysis of Laminated Natural Fiber Epoxy based Composite

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Abstract- **Nowadays there is rising demand for renewable products and materials in order to avoid the problem of collapse of landfill site, global waste, increasing oil prices. High mechanical strength, renewability and biodegradability are benefits of natural fibers compared to conventional composites. This work emphases on the analysis of mechanical properties of reinforced natural fiber epoxy based composite. A Finite Element Analysis of Natural Fiber epoxy based composite subjected to tensile loading is presented in this paper. To develop three dimensional linear finite element model in order to investigate behaviors of Natural fiber laminated composite material under tensile testing, ANSYS15 software has been used. The property of material was obtained on the basis of some assumptions (with reference to rule of mixture) and model developed with reference to ASTM D638. Also orientation of natural fiber is considered during analysis. After tensile test, the deflection, displacement and maximum value of stress and strain were obtained. This project work provides the research for doing their tensile test analysis for various fiber and resin with help of procedure derived in this project work. The analytical research offers certain practical values in Natural fiber laminated composite with good commercial future.**

*Keywords***— Reinforced Natural Fiber, Laminated, Epoxy, composite, Finite Element Analysis.**

I. INTRODUCTION

Nowadays natural fibre getting more and more importance not only because they are biodegradable or environment friendly but also they are better option to the conventional composites. They possess excellent properties such as recyclable, mechanical properties, modulus, impact strength, stiffness, flexibility, low density compared to glass fibre. But there are certain drawbacks of using natural fibre such as the unmatchable bond between fibres and resins, low resistance to moisture, which in turn lower the use of natural fibre. Various modifications and techniques can be used to enhance fibre/resin compatibility such as coupling agent, bleaching, acetylation. Fibrous plants are available in huge quantity and some of them like banana fibre are agricultural harvests in humid regions of the world.

A laminated composite material consists of numerous layers of a composite mixture consisting of matrix and fibres.[1] Each layer could have similar or dissimilar material properties with different fibre orientations under varying stacking sequence.

The properties of composites very much depend on the fibre length. The strength, modulus, mode of failure and fracture toughness of a composite is not only dependent on the properties of the fibre and matrix, fibre volume fraction and fibre orientation but also on the interfacial parameters of the composite.

II. DESIGN OF COMPOSITES

ANSYS software is used for producing the model and performing the analysis of this study. A laminate is constructed by stacking a number of laminas in the thickness direction. Each layer is thin and may have different fiber orientation. The fiber orientation, stacking arrangements and material properties effect the response from the laminate. The theory of lamination is same whether the composite structure may be a beam, a plate or a shell. Fig. shows a laminated beam considered in in this project analysis.

The following assumptions are made in formulations:

1. The laminated plate consists of arbitrary number of homogeneous, linearly elastic orthotropic layers perfectly bonded to each other.
2. The laminated composite is designed with the use of 'Rule of Mixture'.
3. The deformation of the laminated composite in lateral direction is less than its thickness. Laminated beam is made-up of many layers of orthotropic materials.[2] The length, breadth and thickness of the beam are represented by L, B

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and H, respectively and the model is prepared on *AUTODESK FUSION 360.*

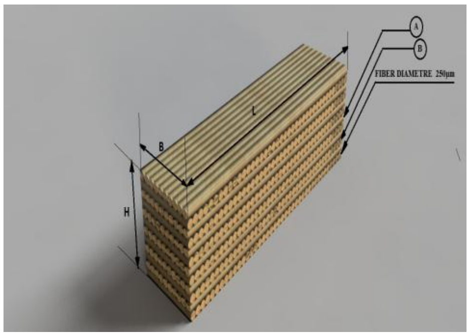

Fig. Laminated Fibre Composite structure generated in AUTODESK FUSION360.

III. ANSYS MODELING

The ANSYS procedure for any type of problem consist of mainly three stages, namely preprocessing, processing stage and post processing stage.[3] In preprocessing stage the element type, material properties and real constants are specified. In the solution stage the boundary conditions and loads are defined. The ANSYS postprocessor stage provides a powerful tool for viewing results.

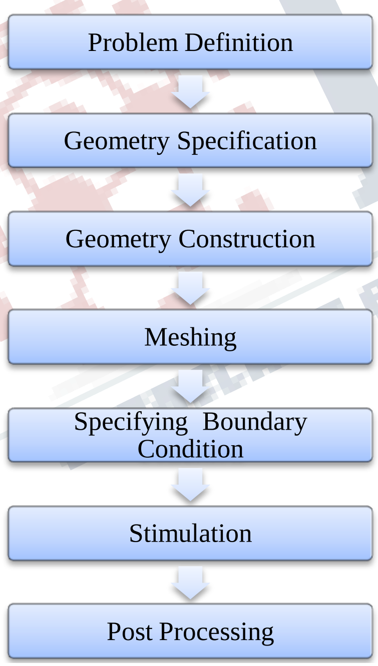

Fig. Stimulation Process in ANSYS[1]

IV. MATERIAL PROPERTIES

1.Fibre Properties[4]

To find Young's Modulus the 'The rule of Mixture' is used. The equation of rule of mixture to calculate Young's modulus is as below.

For Longitudinal Direction[5]:

$$Y_{comp} = Y_F \,.\, V_F + Y_M \,.\, (1- V_F)$$

For Transverse Direction[6]:

$$\mathrm{Ycomp} = \frac{\mathrm{Yf.Ym}}{\mathrm{Vf.Ym} + (1 - \mathrm{Vf})\mathrm{Yf}}$$

Where,

Y_{comp} = Total Young's Modulus of Laminated composite.

Y_F = Young's Modulus of the Banana Fibre (Natural Fibre)

Y_M= Young's Modulus of the Matrix (Resin) V_F= Volume Fraction of the Banana Fibre (Natural Fibre)= v_f/v_c

A) Following properties are used while designing layer A

B)

For Layer A

Sr. No.	Name of Property	Value	
1.	Poisson's ratio	0.284	
2.	Modulus of Elasticity	E_x	25710 MPa
		E_y	26100 MPa
		E_z	21299 MPa
3.	Shear Modulus	G_x	10012 MPa
		G_y	10164 MPa
		G_z	8294 MPa

For Layer B

Sr. No.	Name of Property	Value	
1.	Poission's ratio	0.284	
2.	Modulus of Elasticity	E_x	26100 MPa
		E_y	25710 MPa
		E_z	21875 MPa
3.	Shear Modulus	G_x	10164 MPa
		G_y	10012 MPa
		G_z	8518 MPa

2. Resin Properties

Sr. No.	Name of Property	Value
1.	Poission's ratio	0.3
2.	Modulus of elasticity	10500 MPa

IV. FINITE ELEMENT MODEL

As mentioned earlier, by using *ANSYS15* software we prepared model of laminated natural composite. The composite is made up of several layers of fibres having alternate 0° and 90° orientation along with epoxy resin as a matrix. The laminated composite contains total 76 layers and having 0.25 mm.

The tensile test is generally performed on ASTM D638 (type III) specimens. The commonly used specimen for tensile test are dog-bone type and straight-side type with or without end tabs. The uni-axial load is applied during analysis of laminated composite at one end and by fixing other end. The tensile test results such as stress, strain and deformation are analysed.

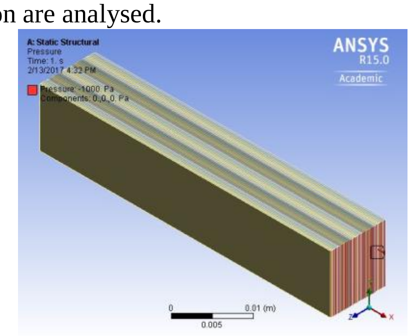

Fig. ANSYS model of laminated composite

V. RESULTS AND DISCUSSIONS

Load-Deformation Relation[7]

Load-Displacement curves of the laminated composite material was obtained from finite element analysis by using ANSYS 15 software & was plotted by using analytical results. The x-axis indicates deformation (m) value and y-axis indicates applied load (N) value.

From the graph we can see that deformation is directly proportional to the applied load.

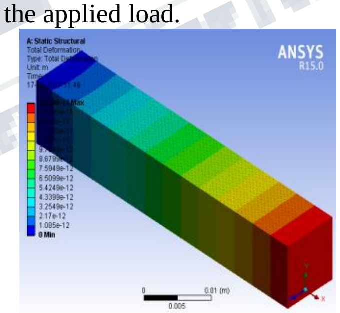

Fig. ANSYS image for Load-Deformation Relation

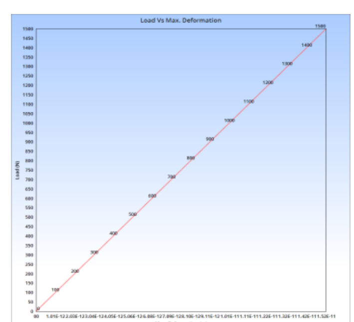

Fig. Graph of Load-Deformation relation

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Load-Max. Stress Relation

Load-Max. Stress curves of the laminated composite material was obtained from finite element analysis by using ANSYS 15 software & was plotted by using analytical results. The x-axis indicates Max. Stress (MPa) value and y-axis indicates applied load (N) value.

The graph represents that as applied load increases the stress induced in the composite gradually increases.

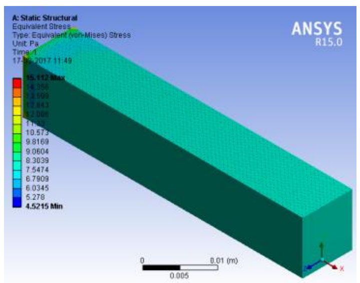

Fig. ANSYS image for Load-Stress Relation

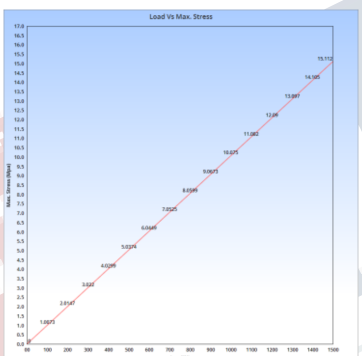

Fig. Graph of Load-Max. Stress relation

Load-Max. Strain Relation

Load-Max. Strain curves of the laminated composite material was obtained from finite element analysis by using ANSYS 15 software & was plotted by using analytical results. The x-axis indicates Max. Strain value and y-axis indicates applied load (N) value.

The graph depicts the similar variation as seen in the load-stress relation graph.

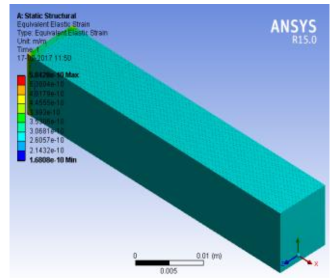

Fig. ANSYS image for Load-Strain relation

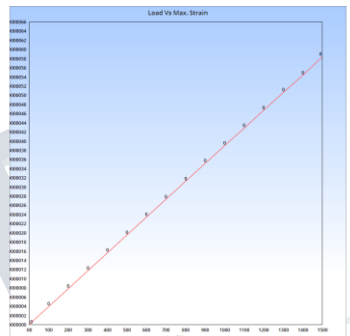

Fig. Graph of Load-Max. Strain relation

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