# Deformation Studies in Natural Plant Fiber Composites Using Finite Element Analysis

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*Abstract:* Transformation to modernization and industrial revolution engrosses evolution of advanced materials and introduce smart techniques in material modeling as part of predictive analysis. Structural and component design with incorporation of sophisticated materials provides more prominence to predictive capabilities, accuracy, repeatability preciseness, realism and the corresponding tools and theory for its modeling and simulation. Forecast modeling is recognized as a reliable tool is competent to deliver credentials for deployment for innovation to chemical, mechanical and industrial process. Development based institutions/ organizations which is a plus point for businesses. Techniques of simulation are typically employed to fasten the development of product based on the design reliability, efficiency improvement, and facilitate fundamental understanding and learning.

*Key-words:* Finite Element Analysis, Plant Fiber, Composite Material, Jute Fiber.

## 1 Introduction

FEA is used for solving intricate problems in engineering. FEA is an integral component during the design and development of product involving complex geometries, dynamic loadings to estimate the associated behavior, which are difficult to be assessed analytically. Analytical solutions involve dramatic simplification and idealization. Design depends on the predicted results achieved from protection factors and derived based on experience. Complicated design geometry demands higher accuracy thereby prompting the application of finite element analysis. This requires a detailed perceptive of the intricate objects behaviors (physical) which accounts for capability of susceptance to heat transfer, fluid flow and strength. To predict the design behavior and performance; to calculate the safety margin; and identification of the design weakness and design optimization, it is important to employ finite element analysis. This technique is explored also for aerospace, automobiles, infrastructural, electrical, mechanical and magnetic components. Moreover, it is frequently new for construction industries in structural analysis. Besides, FEA is regularly used for Dynamic/ static analysis, Structural/Stress Analysis, and linear and Nonlinear analysis.

Equilibrium requirement, boundary conditions and necessity are the actions followed in FEA for elemental stacking. Accuracy of the solution is examined with respect to convergence as the element “mesh” is tuned and refined. Refinement of mesh is commonly carried out in two approaches. Mesh refinement by increasing the elements number of the model for a distinct field followed by creature factor size reduction termed as h refinement is one method. P-refinement is carried out in which size of element remains unchanged is another method [5], [6]. Nevertheless, the polynomials order employed as functions for interpolation is increased. The objective underlying mesh refinement in these two approaches is to achieve sequential answers that explicate a common union towards ethics instead of the exact solution. For this study, various numerical and physical aspects for deformation, thermal distribution and stress by employing FE matrix, material characteristics reliant on temperatures and matching possessions changes are predicted and evaluated. Numerical modeling and simulation is given beginning effort to realize the responses from computational view point.

## 2 FEA Analysis for Composites Based on Natural Fiber

FEA solution for any physical process comprises two key errands explicitly the formulating mathematical expressions that influence the processes and the corresponding numerical simulation, evaluation and analysis of the modeled system. Mathematical expression requires tough essential information in subjects related and its adaptability towards the mathematical tools. FEA is proven numerical technique exploited for assessing physical processes Composites of natural filament with two apparatus matrix and reinforcement possess differential thermal coefficients. Since, these composites are fabricated, with differential thermal influences and properties when subjected to processes; stresses and the corresponding strain is induced in the natural fiber composite.

Here, static analysis is carried out through 3D modeling by maintaining constant time step for every individual lead step. Preprocessing stage comprises of the defining of element type and properties feeding of material and subsequent appropriate model building and meshing. To achieve optimal solution initial conditions are firstly defined followed by the boundary conditions. Verifications are carried out for the object and its corresponding loading conditions. Subsequently, loading is done for solving and achievement of results.

## 3 Geometric Modelling

Model geometry is build for simplicity by changing the coordinate systems to cylindrical based on default decant. The model being of 3D, isometric display is chosen and the thickness is defined. Key points of coordinates are defined in Figure 1. Natural fiber based composite of rectangular structure is considered in this analysis.

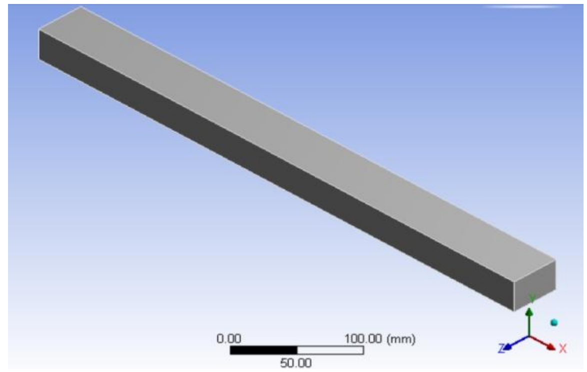


**Figure 1:** Natural Fiber Composite Geometry used for FEA

All lines are sub-divided into three fundamentals for soft and uniform meshing which are exclusive of two lengthier sides division into eight finite elements. Subsequent to the mesh size choice, method is allowed to mesh all marked areas. The meshing in FEA is illustrated in Figure 2.

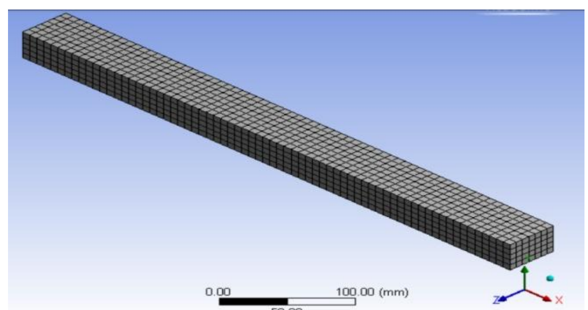


**Figure 2:** FE Model Meshing

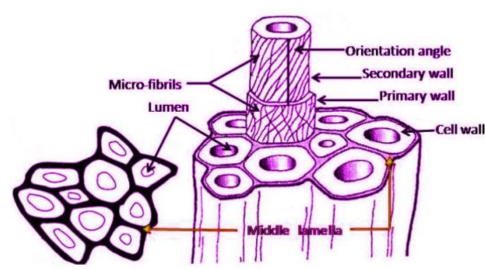


**Figure 3:** Morphological Structure of Jute Fiber

The jute fiber fractious segment and the structures reconstructed as 3D are used in this FEA (Figure 3). Chemical composition of jute is given in Table 1.

TABLE 1
CHEMICAL COMPOSITION OF JUTE

| Constituents (in % of bone dry weight of the fiber) | Jute C.capsularis |
|---|---|
| Alphacellulose | 60.0 - 63.0 |
| Hemicellulose | 21.0 - 24.0 |
| Lignin | 12.0 – 13.0 |
| Fats and Waxes | 0.4 – 1.0 |
| Pectin | 0.2 – 1.5 |
| Proteins/Nitrogenous matter, ect. | 0.08 – 1.9 |
| Ash | 0.7 – 1.2 |

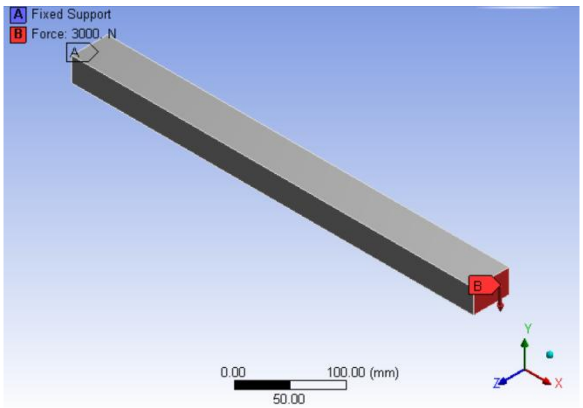


**Figure 4:** FEA Analysis-Mechanical Loading (Static Structural)

The stress distribution achieved overall is then recognized with the 3Dimensional structure. FEA computations are used for investigating the dislocation following subjecting to motorized load altered by thermal expansion. Typically, the natural fiber based composites comprises of a reinforcing and matrix particles. Literature (Zhao et al. 2007 & Zhang et al. 2003) shows that reinforcement material arrangement and orientations significantly influences during changing of CTE. For this study, a load of approximately 3000N force is applied at node B with node A strongly fixed acting as cantilever beam. The model being symmetrical about the axis, only one portion of the arrangement is structured while allowing for it as cantilever beam. ANSYS we used for the analysis with the application of suitable boundary conditions and the corresponding loading parameters.

## 4 Results and Discussion

The deformation and stress distribution simulated with the mechanical properties of jute based natural fiber composite specimens, subjected to static load circumstances, and are conceded out as shown in Figures 5 and 6 respectively. Maximum stresses are the mean values of elements center employed in the FEA. The numerical results predicting the stress data for the samples are recorded. Validation of simulated and true results, reveal that the proposed model is valid to an extent if not accurate and additional superior alteration is essential to attain greater accuracy. Compositions of complex protein components available in jute could not be considered due to unavailability of such provisions in the software which reduces the accuracy of prediction.

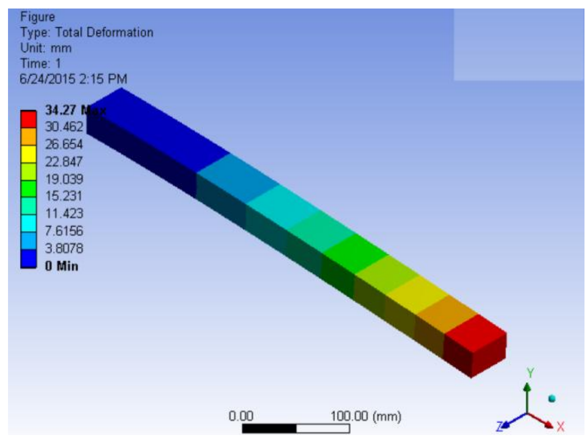


**Figure 5:** Total Deformations on Subjecting to Static Loading

Figure 6 shows that the deformation cataract in suitable restrictions and natural jute filament fiber composites can be an apt alternative for engineering materials that are conventional being used for structural and other applications. It also establishes that the jute fibers in polymer matrix and the resins of reinforcement are strongly bonded and exhibits good adhesive. The young's MI governs the bending moment experienced by the samples on subjecting it to loading. Maximum deformation is achieved at the load edge (at 34.27 mm) and gradually decreases while towards the fixed side. Another prominent observation in deformation is its uniformity. The density recorded is $1.3e^{-009}$ tons $mm^{-3}$.

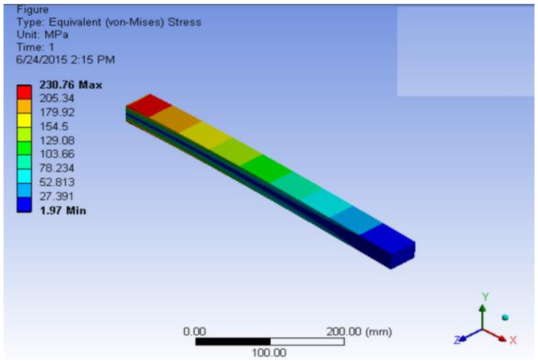

**Figure 6:** Distribution of Stress

Figure 6 illustrates the equivalent stress distribution which is based on Von-Misses analysis. The stress is maximum at 230.76Mpa on the fixed edge. By applying 3000 N of force on the opposite edge, the bending stress at the constant edge gradually appears to propagate towards the point of application of load. They are governed by the substance of the matter and the molecules kinetic energy on application of indirect energy. The bonding between the reinforcement and the matrix also play a important position through stress allotment reflecting the same in its pattern. The overall material data from this study is given in Table 1.2 along with the poisons ratio and young's modulus.

TABLE 2
MATERIAL DATA

| Temperature C | Young's Modulus X direction MPa | Young's Modulus Y direction MPa | Young's Modulus Z direction MPa | Poisson's Ratio XY | Poisson's Ratio YZ | Poisson's Ratio XZ | Shear Modulus XY MPa | Shear Modulus YZ MPa | Shear Modulus XZ MPa |
|---|---|---|---|---|---|---|---|---|---|
| | 37540 | 91200 | 91200 | 0.23 | 3.9e-002 | 3.9e-002 | 3550 | 3550 | 3550 |

## 5 Conclusions

FE analysis is used for composites based on jute natural fiber to evaluate and establish the retort of the equipment to static structural loading conditions. A defined force is engaged on the jute natural fiber composite in cantilever position and the response in substance characters and alterations in substance properties are recorded. Stress distribution total deformation is simulated using a developed 3D model which reveal that the responses are within the acceptable range as per industrial standards and further illustrates a consistent and sturdy bonding between the matrix and the reinforcement. The developed model presents an insight into the numerical predictions of the material behavior. Though this is a preliminary model developed with an objective of achieving basic understanding, inclusions of properties of functional groups /proteins and bonding and enlargements in jute fiber cannot be defined into the substance properties and the provision is lacking in the software, leading to a reduction in accuracy. However, the software features and procedures can be empowered and fine tuning of the model can be carried out for exact predictions. On successful implementation, the model can be explored for all the plant and animal based natural fiber composites during design and product development.

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