ANALYSIS OF NANOCELLULOSE REINFORCED EPOXY COMPOSITE PLATE

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Abstract- *Natural fibers are gaining so much attraction for their application to form composites and new material due to their renewable and eco-friendly nature. These natural fiber based weight and low density. Nanocellulose is a natural material obtaind from the chemical treatments of plant based fibers and agricultural residues. In literature the mechanical properties of natural fibers are predicted more such as elastic modulus is higher than Kevlar fiber and specific strength is 7-8 times more than stainless steel. Due to these outstanding properties cellulose based materials are good agent for generating composites and smart materials. In this paper analysis of nanocellulose reinforced epoxy composite plate has been done at various load condition and at a define boundary condition. Nanocellulose based composites are biodegradable and are eco-friendly with nature. Nanocellulose material is used in fields of medical, paper and packaging, electronic and automobile sector.*

Keywords: *Nanocellulose, composites, strength, elastic modulus, material.*

1. Introduction

Nanocellulose is a natural polymer obtained from the extraction of plant based materials and agricultural residues such as sugarcane baggasse, jute fiber waste, rice husk and so on. These nanocellulose particles are very effective for the application areas like paper and pacakaging industry, fillers for composites material by providing good mechanical and thermal properties. Most of the natural fibers are being used with polymer matrix for the formation of composites and shows better strength and stiffness. The major advantages of these natural fibers are their ecofrindly nature, light weight and low density. In some literature reports elastic modulus of nanocellulose reinforced epoxy composite is found in the range of 1.5-2.9 GPa for 5% volume fraction of fiber. Nanocellulose is extracted from cellulose network which consists of ordered (crystalline) and disordered (amorphous) regions. During hydrolysis process the amorphous parts are easily hydrolyzed by acids such as sulfuric acid, phosphoric acid and the crystalline parts are left as remaining which gives nanocrystalline cellulose. For obtaining nanofibrilated cellulose mechanical techniques is used such as high pressure homogenization in which shear and impact forces defibrillate the cellulose fiber in micro – nano range.

2. Nanocellulose and its application

Nanocellulose is obtained from cellulose chain by chemical and mechanical treatments. It is found in three forms namely, cellulose nanofibril, cellulose nanocrystal and bacterial cellulose. These three types of cellulose have different diameter range and are obtained by different process. The diameter range of nanofibrilated cellulose1-100 nm and length is about 500-2000 nm. In case of cellulose nanocrystal it has short rod like shape having diameter ranges from 2-20 nm and the length is in the range of 100-500 nm. Nanocellulose contains hydroxyl groups which are used in surface modification of materials. In some literature it has predicted that nanocellulose have high tensile strength up to 10 GPa and stiffness up to 220 GPa. Nanocellulose is used for various application areas such as in composite fillers, in medical field it is used for drug delivery, tissue repair, blood vessel replacements and implants. In electronic industry it is used in gas and leakage detector, time temperature indicator and sensors for food monitoring. Nanocellulose is also used in paper and packaging industry such as ultraviolet screening packaging and anti microbial packaging.

3. Analysis of stress and deformation for different loading condition

Analysis of nanocellulose reinforced epoxy composite is done in ansys to determine the stress, deformation and other parameters for different loading condition. The data which have been taken from research papers for analysis purpose are given below.

Table 1: Mechanical property for 60% volume fraction of fiber

Property	**Value**
Density	1350 kg/m^3
Young's Modulus	11.67 GPa
Poisson's Ratio	0.29
Shear Modulus	4.523 GPa
Bulk Modulus	9.261 GPa
Tensile Yield Strength	74 MPa

A rectangular solid plate having length 30 mm, width 20 mm and thickness of 2 mm is chosen for the analysis. The geometry of this solid plate is created in ANSYS space claim.

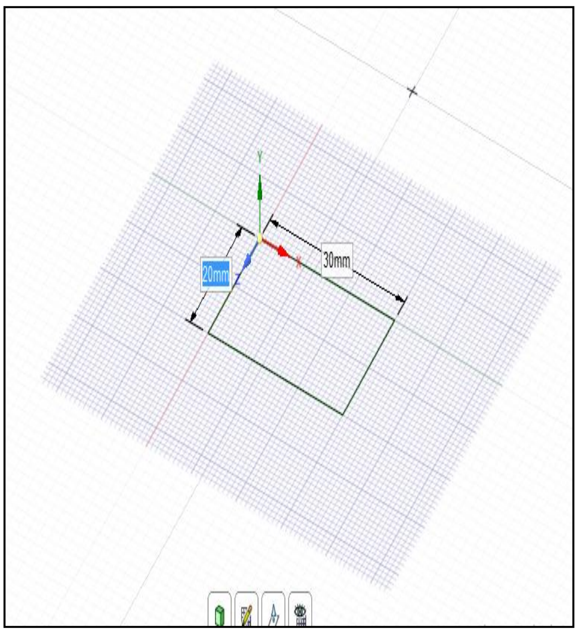

Fig.1. Dimension of solid plate

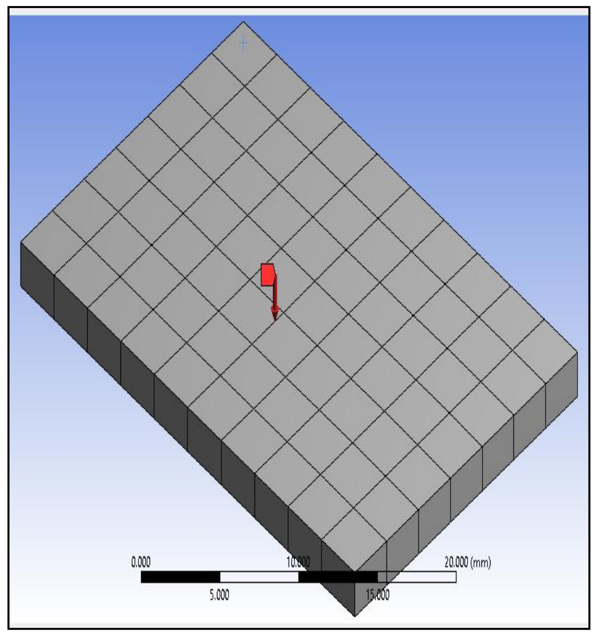

Fig.2. Meshed Plate with simple supports and force

The load of 500 N is applied at centre of solid plate further the behavior of stresses, deformation and strains are calculated on the surface of solid model. The behavior of solid model for stresses, strain and deformation are shown below.

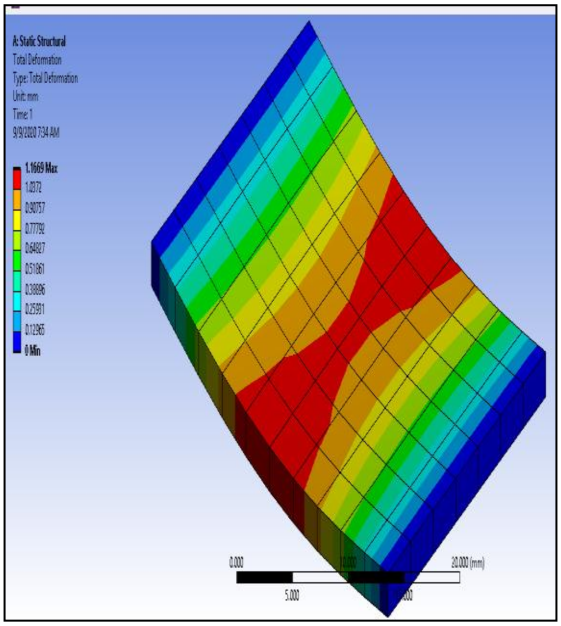

Fig.3. Total deformation of model

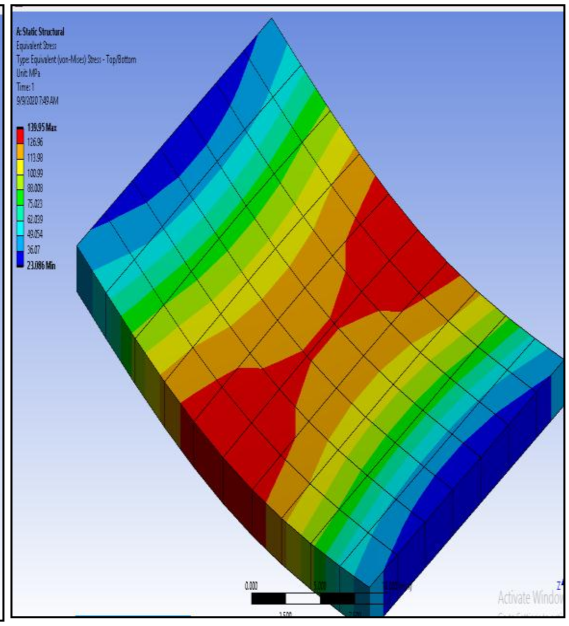

Fig.4. Von-Mises equivalent stress

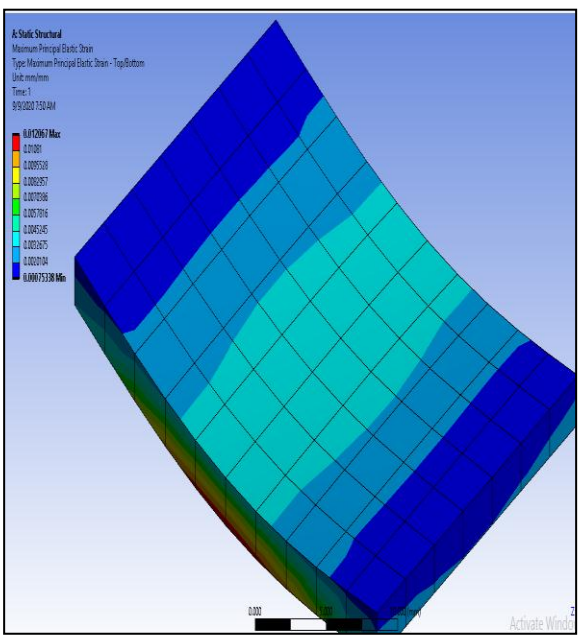

Fig.5. Principal elastic strain behavior

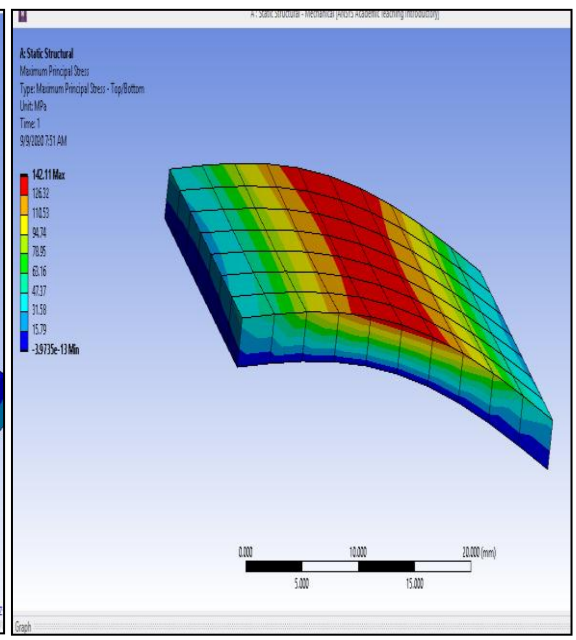

Fig.6. Principal stress Behavior

Similarly the analysis of these properties is done at different load of 900 N at mid section and the boundary condition remains same as simple supports at end points.

4. Results and discussion

The properties at both 500 N and 900 N are obtained for the model and are listed below in the table. Values of stress, strain, deformation and strain energy are calculated by ANSYS software for the solid model.

Table 2: Properties at 500 N load

Parameters	Maximum value	Minimum value
Principal stress	142.11 MPa	-3.9735e-13 MPa
Total deformation	1.1669 mm	0
Von –Mises equivalent stress	139.95 MPa	23.086 MPa
Principal elastic strain	0.012067	0.00075338
Strain energy	4.8015 mJ	0.19092 mJ

Table 3: Properties at 900 N load

Parameters	Maximum value	Minimum value
Principal stress	255.8 MPa	-3.089e-13 MPa
Total deformation	2.1004 mm	0
Von –Mises equivalent stress	251.9 MPa	41.554 MPa
Principal elastic strain	0.02172	0.0013561
Strain energy	15.557 mJ	0.61859 mJ

5. Conclusion and future scope

1) Natural resources based fibers have potential to replace the synthetic materials for industrial application. They have good specific strength and stiffness due to their light weight and low density.
2) For the same boundary condition of solid model on increasing the load value the properties such as principal stress, total deformation, Von-Mises stress, strain energy and principal elastic strain are increasing.
3) For a load value the properties are maximum at top surface of model such as principal stress and principal strain.
4) The future scope of natural resources based fiber for composites are very bright due to their eco-frindly nature and good mechanical and thermal properties.
5) Cellulose based composites and nano-composites are playing crucial role in industrial application like electronic industries, packaging industries and medical fields.

6. REFERENCES

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