Design and Analysis of Banana/Kenaf fiber reinforced epoxy resin based composite material by using catia

Illa Purna Dharma raj
Venkata Abhinay Samanasa
Dasari Naveen Sai
Department of Mechanical Engineering BVC Engineering College, Odalarevu. (A.P)

Assistant Prof. G. Raju
Department of Mechanical Engineering BVC Engineering College, Odalarevu. (A.P)

Abstract: Natural fiber composites (NFCs) also termed as bio composites offer an alternative to the existing synthetic fiber composites, due to their advantages such as abundance in nature, relatively low cost, lightweight, high strength-to-weight ratio, and most importantly their environmental aspects such as biodegradability, renewability, recyclability, and sustainability. Researchers are investigating in depth the properties of NFC to identify their reliability and accessibility for being involved in aircrafts, automotive, marine, sports' equipment, and other engineering fields. Modeling and simulation (M&S) of NFCs is a valuable method that contributes in enhancing the design and performance of natural fibers composite. Based on the recent and relevant investigations found in the scientific literature, an overview focused on the mechanical characteristics of composite materials reinforced with different types of natural fibers is presented such as banana and kenaf. The aim is to introduce the reader to the issues, exploring the actual knowledge of the tension, compression and mechanical characteristics of the composites under the influence of different operating loads and design and analysis of composite materials by using catia software, with the aim of highlighting the most appropriate future research directions to achieve a complete framework on the mechanical behavior of many possible natural fiber composite materials. The composites are added with the epoxy matrix and fibers such as kenaf and banana by taking properties of materials and placed in material library and add material in catia software by analyzing design of composite material objective are planned to evaluate its tension , compression and mechanical behavior of composite material.
Keywords: Natural fibers, material library, structural analysis, design of specimen.

1. Introduction

Natural fibers are becoming popular in recent times especially in composites sector because they have lot of advantages over traditional fibers in terms of low cost, low density, biodegradable and easily processed. Natural fibers are mainly classified into plant fibers, animal fibers, and mineral fibers. Most commonly, composite materials have a bulk phase, which is continuous, called the matrix, and one dispersed, non-continuous, phase called the reinforcement, which is usually harder and stronger. The reinforcement material can be of fibers, particulates, or flakes. The concept of composites is that the bulk phase accepts the load over a large surface area and transfers it to the reinforcement, which being stiffer, increases the strength of the composite. In bio composites, natural fiber act as reinforcement material, and renewable and can be produced at low cost in many parts of the developing world.

Natural fiber composites (bio composites) are primarily composed combination of cellulose, hemicellulose, and lignin, which can be derived not only from leaf, seed, and fruit, but also from other sources such as chicken feathers, and these natural fibers offer number of advantages over existing synthetic fibers. From an environmental perspective, natural fibers are biodegradable and carbon positive since they absorb more carbon dioxide than they produce. Natural fibers also possess a number of advantages in terms of specific material properties.

The surfaces of natural fibers are uneven and rough which provides good adhesion to the matrix in a composite material. The specific mechanical properties of natural fibers have high significance for their utilization in composites. In natural fiber-reinforced composites, fiber acts as reinforcement and exhibits high tensile strength and stiffness. The mechanical properties of reinforcement (fibers) have direct relation with the tensile strength and stiffness of the composite. The selection of suitable reinforcing fibers follows certain criteria such as, thermal stability, fiber-matrix adhesion, long time behavior, elongation at failure, and moreover price and processing costs.

The majority of bio composites presently used is in the automotive, construction, furniture, and packaging industries. The techniques used to manufacture bio composites are based largely on existing techniques for processing plastics or composite materials. These include press moulding, hand lay-up, filament winding, pultrusion, extrusion, injection moulding, compression moulding, resin transfer moulding, and sheet moulding compound methods.

Composite materials used for structural purposes often have low densities, resulting in high stiffness to weight and high strength to weight ratios when compared to traditional engineering materials. In addition, the high fatigue strength to weight ratio and fatigue damage tolerance of many composites also makes an attractive option. Composite mechanical properties are strongly influenced by the mechanical properties, distribution of the fibers, and matrix, and well as the efficiency of stress transfer between these two components. Polymer composites are widely used in many major engineering structural applications. The matrix serves for mainly two important purposes; namely, it bonds the fibrous phase, and under an applied force, it deforms and distributes the stress to the high-modulus fibrous constituent.

The ultimate properties of the composites depend on many properties such as constituents, size, and shape of the individual reinforcing fibers or particles, structural arrangement and distribution, relative amount of each constituent, and the interface between matrix and reinforcement.

The present work is focused on using maize stalk fiber as a natural fiber and unsaturated polyester (thermoset polymer) as a matrix processed by a simple hand lay-up procedure to produce a composite beam material. Later, the mechanical properties of the material are analyzed using CATIA.

CATIA is the product design software developed and created by Dassault Systems. This is a multinational software company based in France. It is a globally and widely used software that delivers 3D design, Computer-aided engineering solutions, PLM, and Computer-aided manufacturing solutions. The software is commonly used in manufacturing industries and Original Equipment Manufacturers (OEMs) to increase designing, analyzing, and managing new products.

2. Material Selection

The structural materials used in airframe and propulsion systems influence the cost, performance and safety of aircraft, and an understanding of the wide range of materials used and the issues surrounding them is essential for the student of aerospace engineering. Introduction to aerospace materials reviews the main structural and engine materials used in aircraft, helicopters and spacecraft in terms of their production, properties, performance and applications.

Advanced Composite Materials:

An advanced composite material is made of a fibrous material embedded in a resin matrix, generally laminated with fibers oriented in alternating directions to give the material strength and stiffness. Fibrous materials are not new; wood is the most common fibrous structural material known to man. A matrix supports the fibers and bonds them together in the composite material.

Banana fiber:

Banana plant not only gives the delicious fruit but also provides textile fiber, the banana fiber. It grows easily as it sets out young shoots and is most commonly found in hot tropical climates. All varieties of banana plants have fibers in abundance. These fibers are obtained after the fruit is harvested and fall in the group of bast fibers. This plant has long been a good source for high quality textiles in many parts of the world, especially in Japan and Nepal (Mohanty et. al., 2004).Bast fibers, like banana, are complex in structure. They are generally lignocellulose, consisting of helically wound cellulose micro fibrils in amorphous matrix of lignin and hemicellulose. The cellulose content serves as a deciding factor for mechanical properties along with micro fibril angle. A high cellulose content and low micro fibril angle impart desirable mechanical properties for bast fibers. The removal of heavily coated, non-cellulosic gummy material from the cellulosic part of the plant fibers is called degumming (Samal et. al., 2009a).

Banana fibers are obtained from the stem of banana plant (Musa sapientum).Banana fibers can be extracted by utilizing mechanical, chemical or biological methods. Mechanical method does not remove the gummy material from the fiber bundle surface while chemical method causes pollution to the environment. Biological method is most appropriate because it could produce more fiber bundles than other two methods while being environmental friendly (Jannah et.al. 2009).

The essentially hand driven process of extracting banana fiber is now set to change with the invention of the Banana Fiber Separator Machine. The machine has been developed in India by Tiruchirappalli Regional Engineering College - Science & Technology Entrepreneurs Park (TREC-STEP). One more interesting fact associated with the development of this machine is that it uses the agriculture waste of banana harvests to produce silk grade fiber. These silk grade fibers are of immense help to the handicrafts and textile industry (Murali et. al., 2010).

Cellulose (%)	Hemicellulose (%)	Lignin (%)	Moisture content (%)	Density (g/cc)	Microfibrillar angle (degrees)	Tensile strength (MPA)	Young's modulus (GPA)
63-64	19	5.0	10-11	1.350	11	529	28

Kenaf fiber:

Kenaf is known as Hibiscus cannabinus L has a cellulosic source with both economic and ecological advantages. It is a warm season annual fiber crop closely related to cotton and jute. Kenaf has been used as a cordage crop to produce twine, rope and sackcloth. Kenaf has good mechanical properties and can grow quickly as it takes only 150 days to harvest. The kenaf comprises 35-40% bast fiber and 60-65% core fibers by weight of the kenaf's stalk. Kenaf contains approximately 65.7% cellulose, 21.6% lignin and pectin and other composition. It could grow under wide range of weather condition, to a height of more than 3m and a base diameter of 3-5cm. Kenaf has a single, straight, branched stem consisting of two parts, namely outer fibrous bark and inner woody core (Mohanty et. al., 2002).

Nowadays, there are various new applications for kenaf including paper products, building materials, absorbents and animal feeds. In Malaysia, realizing the diverse possibilities of commercially exploitable derived products from kenaf, the National Kenaf Research and Development Program has been formed in an effort to develop kenaf as a possible new industrial crop for Malaysia. The government has allocated RM12 million for research and further development of the kenaf-based industry under the 9th Malaysia Plan (2006–2010) in recognition of kenaf as a commercially viable crop (Salleh et. al., 2012).

Whole stalk kenaf can also be used in corrugated medium. The whole stalk plant material can also be used in non-pulping products such as building materials such as particleboard and within injection molded and extruded plastics. Unlike the pulping process with whole stalk plant material which yields fewer than 46% by weight, the use of non-pulped whole stalk material yields nearly 100% usable materials. The difference is the result of the intentional removal of non-fibrous materials such as lignin's and sugars during the pulping process, whereas the removal of these intercellular materials is not required for the non-pulped products (Anuar and Zuraida, 2011).

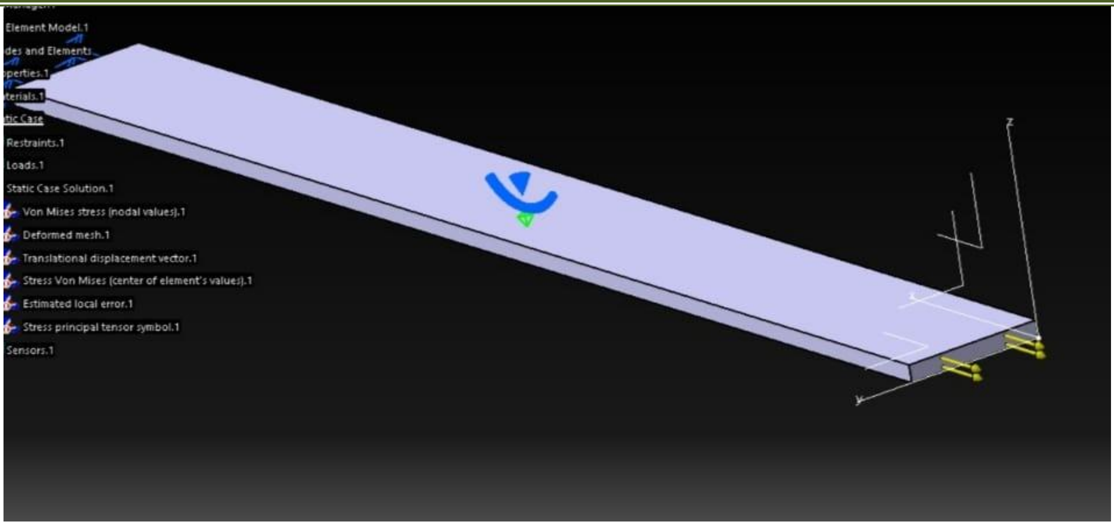
Properties:

Cellulose (%)	Hemicellulose (%)	Lignin (%)	Moisture content (%)	Density (g/cc)	Microfibrillar angle (degrees)	Tensile strength (MPA)	Young's modulus (GPA)
72	20.3	9.3	8.35	1.40	18	930	4

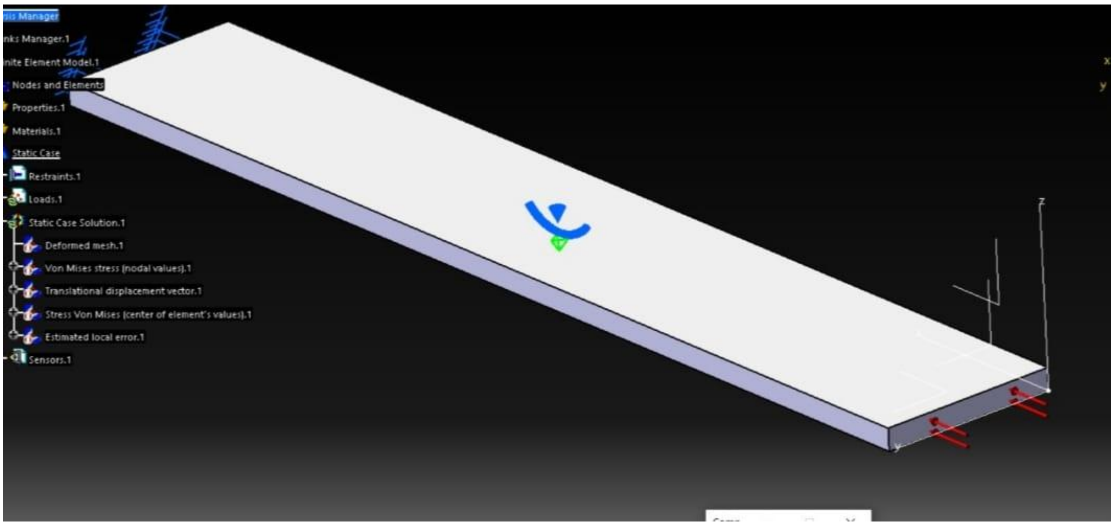
3. Specimen Design

In the project we are going to analyze the mechanical strengths, the objects has to undergo Tensile, Compressive & Flexural tests. To perform these tests, the objects have to be printed as per the ASTM standards design required for these tests. So first the objects called as specimens, CATIA model has to be designed using the CATIA designing software.

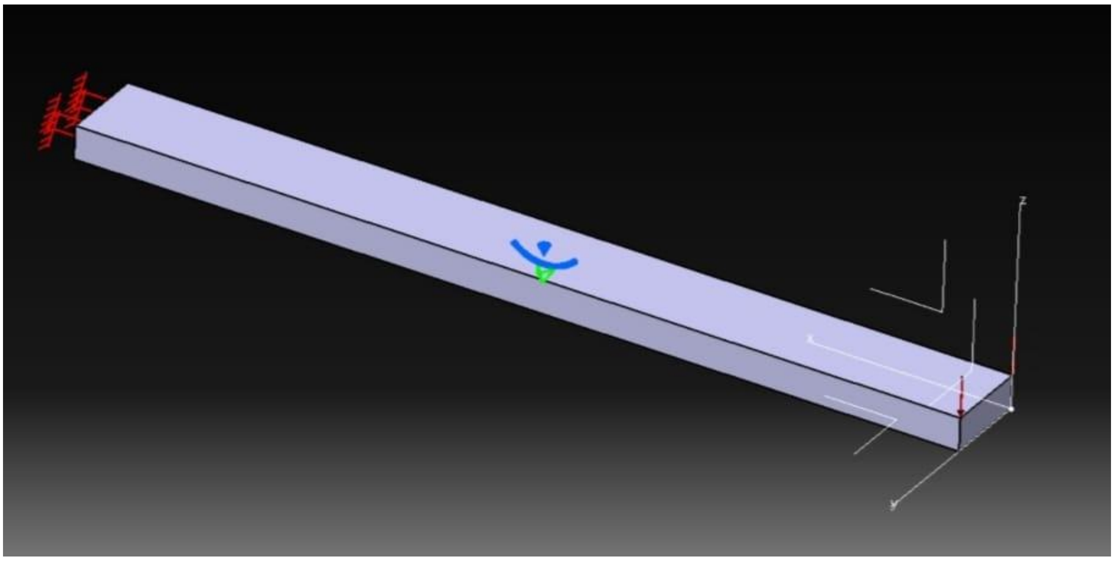
S.no	ASTM CODE	DIMENSIONS	TEST
1.	ASTM D3039-17	250*25*3	TENSILE
2.	ASTM D3410	150*25*3	COMPRESSION
3.	ASTM D790	80*80*3	FLEXURAL



Tensile Test Specimen



Compression Test Specimen

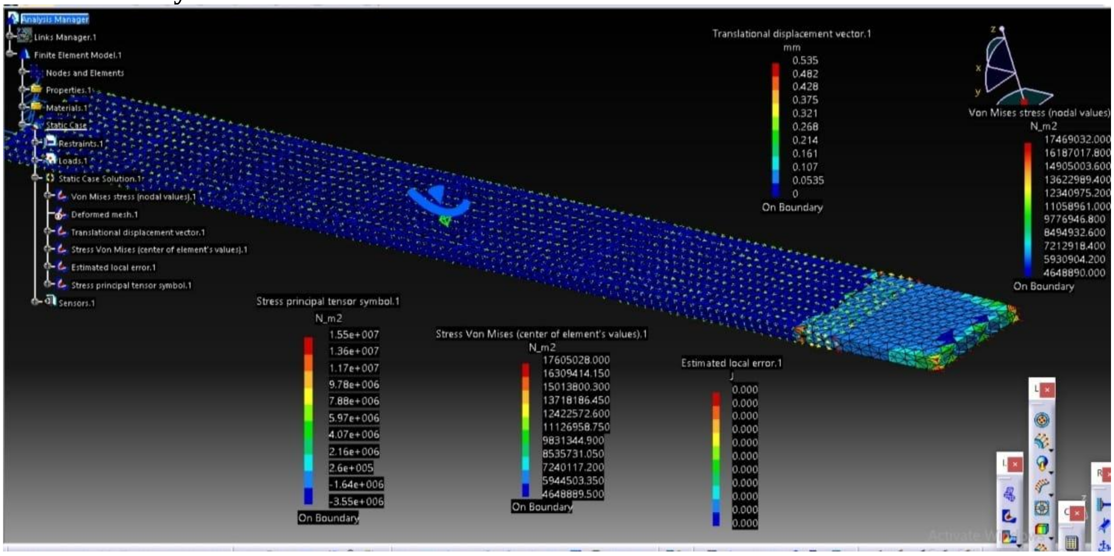


Bending Test Specimen

Software Analysis:

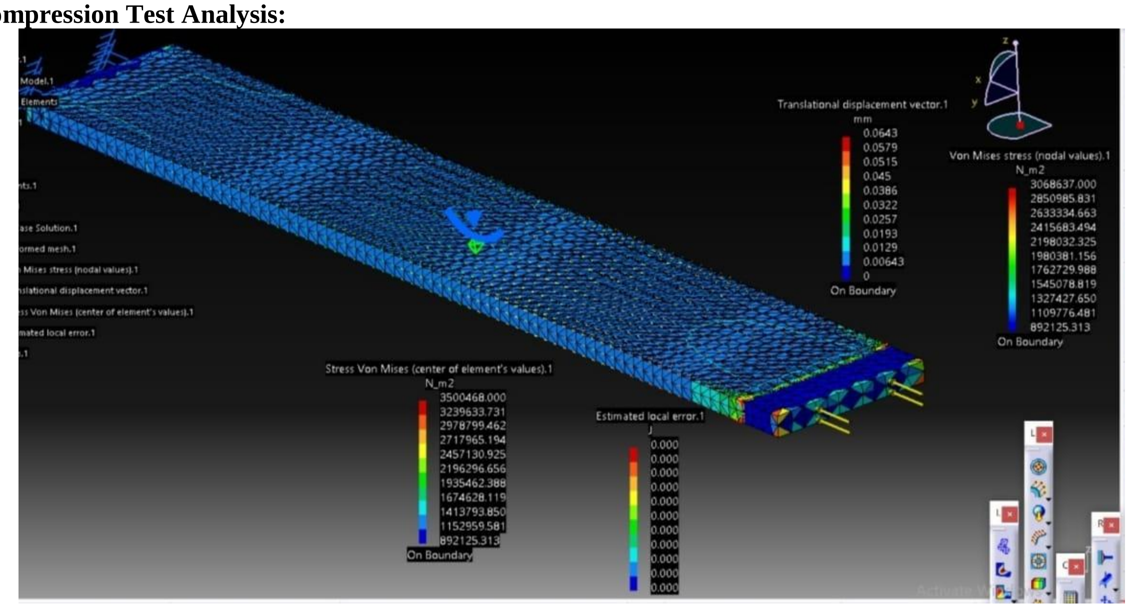
The Software analysis has been made on natural composites. That is the structural properties of the banana and kenaf fiber is considered. Here we can use a CATIA Software to find out structural analysis of reinforced epoxy composites. Engineered Composites have actually been in use for thousands of years. It is the combination of the physical properties of each material that gives the composite material many of its physical characteristics. Today's advanced composites, like carbon fiber, bring together combined properties we've come to know – lightweight, strong, durable and heat-resistant. Today, the benefits of components and products designed and produced in composite materials – instead of metals, are well recognized by many industries.

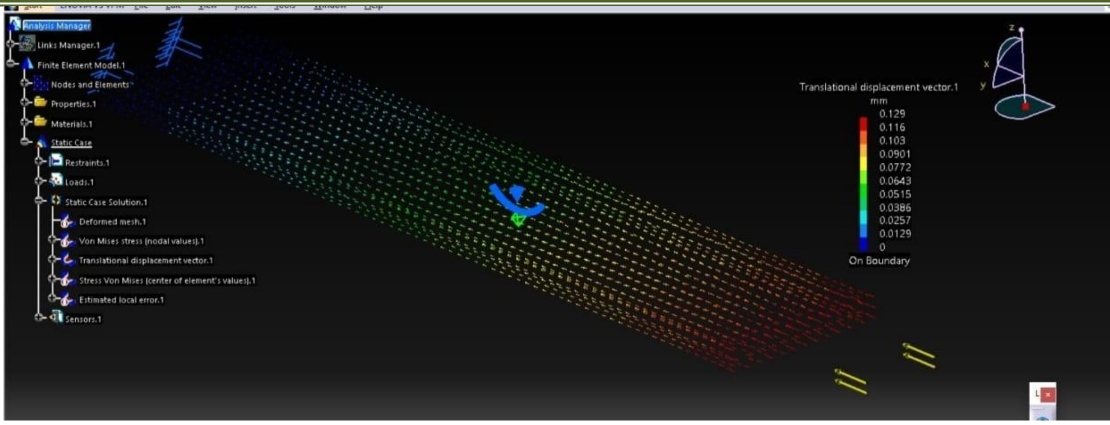
Tensile Test Analysis:



Various loading and boundary conditions like fixed support, tensile load are applied for appropriate parts. Here one end of specimen is fixed and for other end tensile load is applied. The above Figure shows loading and boundary conditions of composite specimen.

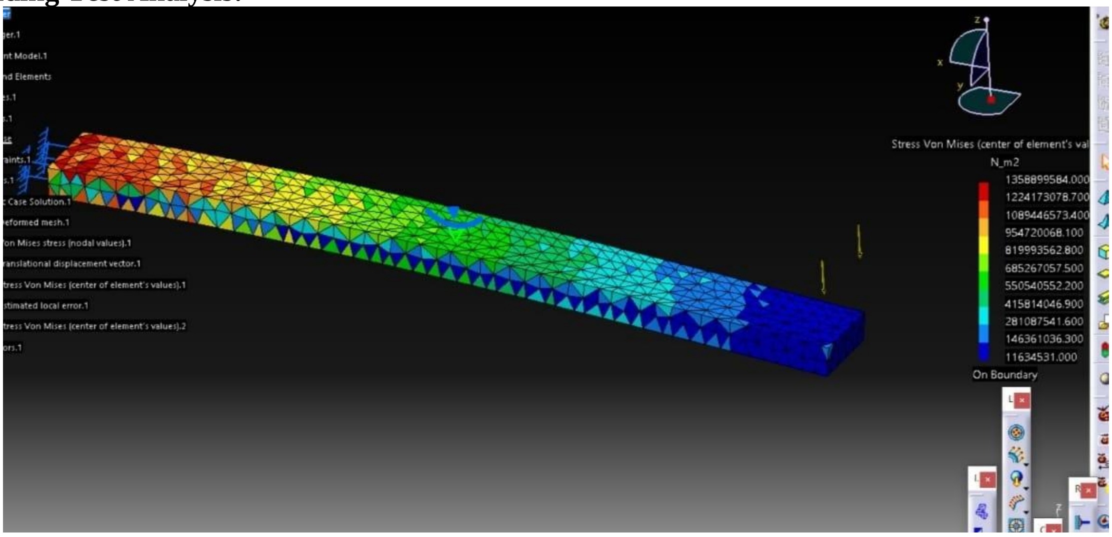
Compression Test Analysis:

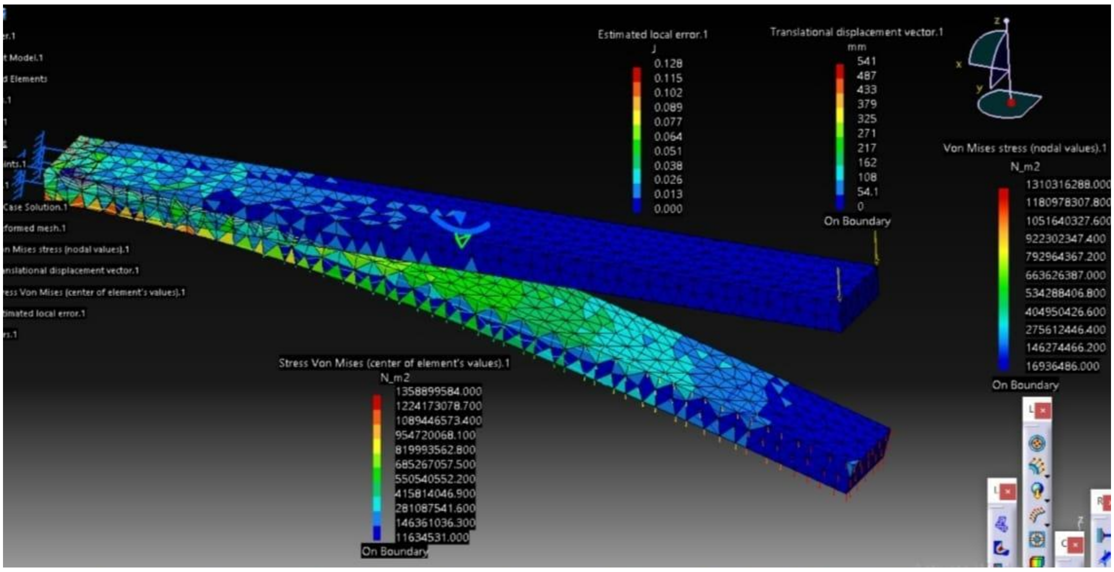




Various loading and boundary conditions like fixed support, compressive load are applied for appropriate parts. Here one end of specimen is fixed and for other end tensile load is applied. The above Figure shows loading and boundary conditions of composite specimen.

Bending Test Analysis:





Various loading and boundary conditions like fixed support, bending load are applied for appropriate parts. Here one end of specimen is fixed and for other end tensile load is applied. The above Figure shows loading and boundary conditions of composite specimen.

4. Results and Discussion

Tensile Test Result:

In this test one is fixed and different tensile loads are applied on free end. The composite material behaves differently at different loads. At 500 N von mises stress is max. 17469032 N/m^2 and min.of 4648890 N/m^2 is observed and translational displacement min.0 and max. 0.535 mm. is observed.

Compression Test Result:

In this test one is fixed and different compression loads are applied on free end. The composite material behaves differently at different loads. At 500 N von mises stress is max.9205911 N/m^2 and min.of 2676376 N/m^2 is observed and translational displacement min.0 and max. 0.193 mm. is observed.

Bending Test Result:

In this test one is fixed and different bending loads are applied on free end. The composite material behaves differently at different loads. At 400 N von mises stress is max.1310316288 N/m^2 and min.of 16936486 N/m^2 is observed and translational displacement min.0 and max. 54.1 mm. is observed.

5. References

[1]. Saravana Bavan, G. C. Mohan Kumar, "Finite Element Analysis of a Natural Fiber (Maize) Composite Beam", Journal of Engineering, vol. 2013, Article ID 450381

[2]. K. Mohanty, M. Misra, and G. Hinrichsen, “Biofibres, biodegradable polymers and biocomposites: an overview,” Macromolecular Materials and Engineering, vol. 276-277, pp. 1–24, 2001.

[3]. F. T. Wallenberger and N. Weston, Natural Fibers, Plastics and Composites, Kluwer Academic Publishers, 2003.

[4]. W. D. Callister, Materials Science and Engineering: An Introduction, John Wiley and Sons, New York, NY, USA, 1999.

[5]. J. L. Tsai and Y. K. Chi, “Effect of fiber array on damping behaviors of fiber composites,” Composites Part B, vol. 39, no. 7-8, pp. 1196–1204, 2008.

[6]. A. Le Duigou, P. Davies, and C. Baley, “Interfacial bonding of Flax fibre/Poly(l-lactide) bio-composites,” Composites Science and Technology, vol. 70, no. 2, pp. 231–239, 2010.

[7]. Mhajan G.V, Aher V.S.(2012), "Composite material: a review over current development and automotive applications" International journal of scientific and research publication, 2, 11, 2250-3153.

[8]. M.R.Sanjay, G.R.Arpitha, L.Laxmana Naik, K.Gopalakrishna, B.yogesha, “Applications of Natural fibers and its Composites: An overview”, Natural resources, March2016, 7, 108-114.

[9]. Tushar Sonar, Shirish patil , Vikram Deshmukh , Rishi Acharya, “Natural Fiber Reinforced Polymer Composite Materials-A Review “, IOSR Journal of Mechanical and civil Engineering, exist : 2278-1684, p_ISSN : 2320-334X, PP 142_147, 2015.

[10]. G.Rathnakar, H Shivanan (2013),”Experimental Evaluation of Strength and Stiffness of Fiber Reinforced Composites under Flexural Loading” International Journal of Engineering and Innovative Technology, 2, 7, 2277-3754.