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Development and Evaluation of Biodegradable Composite Material

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ABSTRACT

Conventional materials like steel, brass etc will fail without any indication. Cracks initiation, propagation will takes place with-in a short span. Now a day to overcome this problem, conventional materials are replaced by composite materials. Not only have this conventional materials failed to meet the requirement of high technology applications, like space application and marine applications. In many applications high strength to weight ratio and wear resistance are the essential requirement. Composite materials found to the best alternative with its unique capacity of designing the materials to give required properties.

The best mechanical strength of short coir composite was achieved at fiber content of 20% weight on this study. Tensile and flexural modulus of composites increased with increasing fiber content. Compared with untreated coir fiber, alkali treated coir composite at 20% weight fiber content showed. An increase of tensile strength by 29.6% tensile modulus by 32.6%, flexural strength (FM) by 21.3%.

In this process, rectangular composite will be fabricated and its response under different loadings is found out. By various tests such as tension test, impact test by using different machines and the same test will be performed on other composite specimen of same dimensions and result will be compared.

Keywords: *alkali coir fiber*

INTRODUCTION

Composite Materials

Composites consist of two or more materials or material phases that are combined to produce a material that has superior properties to those of its individual constituents. The constituents are combined at a macroscopic level and or not soluble in each other. The main difference between composite and an alloy are constituent materials which are insoluble in each other and the individual constituents retain those properties in the case of composites, where as in alloys, constituent materials are soluble in each other and forms a new material which has different properties from their constituents. Composite materials can be classified as:

- Polymer matrix composites
- Metal matrix composites
- Ceramic Matrix

Technologically, the most important composites are those in which the dispersed phase is in the form of a fiber. The design of fiber reinforced composites is based on the high strength and stiffness on a weight basis. Specific strength is the ratio between strength and density. Specific modulus is the ratio between modulus and density. Fiber length has a great influence on the mechanical characteristics of a material. The fibers can be either long or short. Long continuous fibers are easy to orient and process, while short fibers cannot be controlled fully for proper orientation. Long fibers provide many benefits over short fibers. These include impact resistance, low shrinkage, improved surface finish, and dimensional stability. However, short fibers provide low cost, are easy to work with, and have fast cycle time fabrication procedures. The characteristics of the fiber reinforced Composites depend not only on the properties of the fiber, but also on the degree to which an applied load is transmitted to the fibers by the matrix phase.

The principal fibers in commercial use are various types of glass, carbon, graphite and Kevlar. All these fibers can be incorporated into a matrix either in continuous lengths or in discontinuous lengths as shown in the Fig.1.1. The matrix material may be a plastic or rubber polymer, metal or Ceramic. Laminate is obtained by stacking a number of thin layers of fiber sand matrix consolidating them to the desired thickness. Fiber orientation in each layer can be controlled to generate a wide range of physical and mechanical properties for the composite laminate.

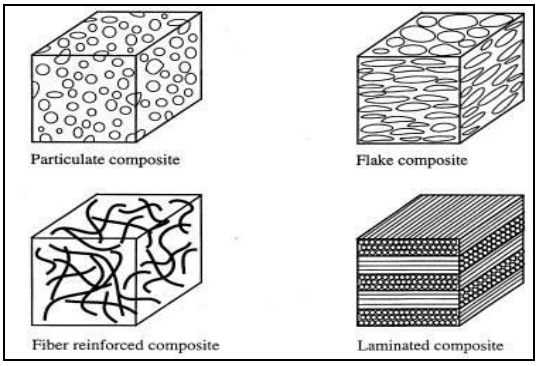


Figure1. *Types of composites*

Effect of Fiber Orientation in Composites

Fiber orientation will have a dramatic effect upon the mechanical properties of a fiber reinforced composite material. Fibers can be oriented by pultrusion or by fabricating the composite from unidirectional layers of uncured material, commonly called "prepreg". An example of unidirectional layers is shown in figure 1.2

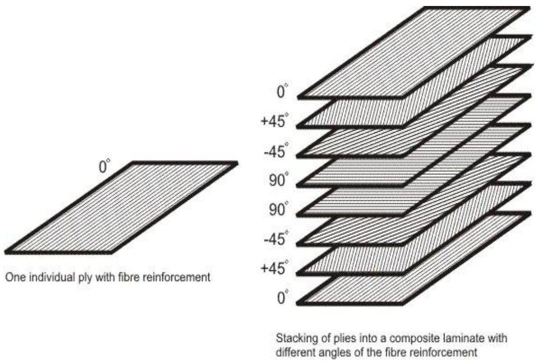


Figure2. *stacking of plies*

In most laminates, it is desirable to have a variety of fiber orientations so that the desired directional properties can be obtained. The various unidirectional layers are stacked together to form a laminate. An example of this is shown in for a four layer laminate.

Various stacking sequences (or "layup") can be chosen. If all the fibers are chosen to be in one direction, then the maximum possible strength for this composite will e obtained in that direction. However, a unidirectional composite will have a very low strength transverse to the fiber direction. Since fiber orientation dramatically affects strength and stiffness, a notation system has been developed to indicate the orientations.

Development Procedure

This chapter describes the details of processing of the composites and the experimental procedures followed for their mechanical characterization. The raw materials used in this work are

1. Coir fiber
2. Cotton
3. Epoxy resin
4. Hardener

Coir Fiber

Coir fiber is a biodegradable material and it takes less time to degrade in the earth. It is available from coconut tree and is a renewable source. It is a naturally woven.

Figure2.1. *Coir fiber*

Cotton

Cotton is a natural fiber and it is harvested from the cotton plant. The properties of cotton are many – it is soft, versatile and strong – to mention a few. These qualities make it ideal for clothing and many other items. In fact, no other material is quite like cotton. Discover more attributes of the cotton below

Figure2.2. *Cotton fiber*

Resin

The primary function of the resin is to transfer stress between the reinforcing fibers, acts as a glue to hold the fibers together and protects from the environmental damage.

Resins are divided into two major groups known as thermoses and thermoplastic. Thermoplastic resins become soft when heated and may be shaped or molded while in heated semi-fluid state and become rigid when cooled. Thermo set resins on the other hand are usually liquids or low melting point solids in their initial form. When used to produce finished goods these thermosetting resins are "cured" by use of catalyst, heater combination of the both, when cured solid thermo sets can't be converted to original liquid form. The most common thermosetting resins used in the composite industry are the unsaturated polyesters, epoxies, vinyl esters and phenol.

Figure2.3. *Resin*

Specimen Preparation

The fabrication of the various composite materials is carried out through the hand lay-up technique. Short coconut coir fibers (Figure3) are reinforced with Epoxy LY 556 resin, chemically belonging to the 'epoxide' family is used as the matrix material. Its common name is Bisphenol A Diglycidyl Ether. The low temperature curing epoxy resin (Araldite LY 556) and corresponding hardener (HY951) are mixed in a ratio of 10:1 by weight as recommended. The Epoxy resin and the hardener are supplied by Ciba Geigy India Ltd. The coir fiber is collected from rural areas of Orissa, India. Three different types of composites have been fabricated with three different fiber lengths such as 5mm, 20mm and 30mm. Each composite consisting of 30% of fiber and 70% of epoxy resin. The designations of these composites are given in Table 3.1. The mix is stirred manually to disperse the fibers in the matrix. The cast of each composite is cured under a load of about 50 kg for 24 hours before it removed from the mould. Then this cast is post cured in the air for another 24 hours after removing out of the mould. Specimens of suitable dimension are cut using a diamond cutter for mechanical testing. Utmost care has been taken to maintain uniformity and homogeneity of the composite.

Designation of Composites

Composites Compositions

C1 Epoxy (70wt %) +Coir Fiber (30wt %)

C2 Epoxy (70wt %) +Coir Fiber (30wt %)

C3 Epoxy (70wt %) +Coir Fiber (30wt %)

Procedure

Step -1: Clean the surface with a neat cloth to remove the dust particles present.

Step- 2: Apply PVC on the cleaned surface so that the removal of object will be easy.

Figure2.4. *Cuttting the fiber*

Step-3: Preparation of resin. Take equal parts of resin and binder then mix them to make the solution at atmospheric temperature only.

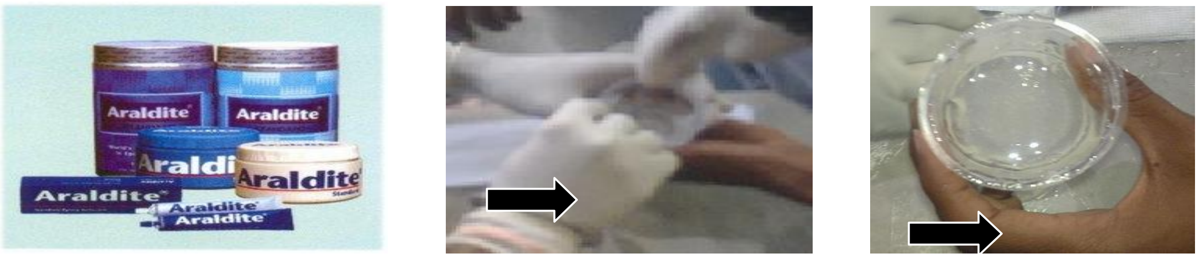


Figure2.5. *Mixing of resin*

Step-4: Take a layer of coir in a specified shape.

Step-5: Place the coir fiber of one layer on the PVC coated surface

Figure2.6. *Fiber*

Step-6: Apply the resin on the coir fiber.

Figure2.7. *Adding the resin*

Step-7: Arrange one-by-one in parallel direction and place one layer over another layer.

Similarly apply resin to the layers as above mentioned.

Step-8: Place the lamina in open atmosphere to dry.

Fabricated Samples

Figure2.8. *Sample work pieces*

Evaluation of Samples

Specimens before Testing

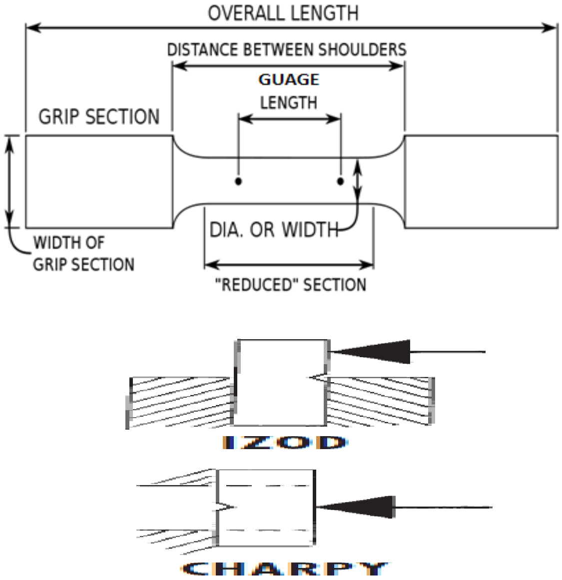


Figure3.1. *Hardness test*

Figure3.2. *Tensile test pieces*

Experimental Set Up and Loading Arrangement for the Specimens for Tensile Test and Impact Test

Figure3.3. *Experimental set up and loading arrangement for the specimens for tensile test and impact test*

Result Analysis

Table1.

S. No	Specimen	Impact Strength (J)		Tensile Strength (MPA)	Compression Test (KN)
		Charpy	Izod		
1	Cotton Fiber	480	450	132	300
2	Natural Fiber	460	423	120	350

Table2.

S.No	Specimen	Youngs Modulus (GPA)	Poision Ratio	Elongation In (MM)
1	Cotton Fiber	4.2	0.75	8
2	Natural Fibre	3.5	0.62	25

Melting Point of Matrices

S.No	Specimen	Max.Temperature Limit(^{0}c)
1	Cotton Fibre	305^{0}C
2	Natural Fiber	295^{0}C

After Heat Treatment

S.No	Specimen	Izod In (J)	Charpy In(J)
1	Cotton Fiber	410	460
2	Natural Fiber	450	480

Analysis for Cotton and Palm Fibre Composite Material (Tensile Test)

ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behaviour, and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled-physics capabilities involving acoustics, piezoelectric, thermal–structural and thermo-electric analysis.

Analysis of tensile test on natural fiber composite material and cotton fiber material by using ABACUS –PART1.

Procedure

Step-1:

Create a Part

This is the first step to draw the tensile test specimen. in this we go to the (OR) select the

Modelling space - 3D

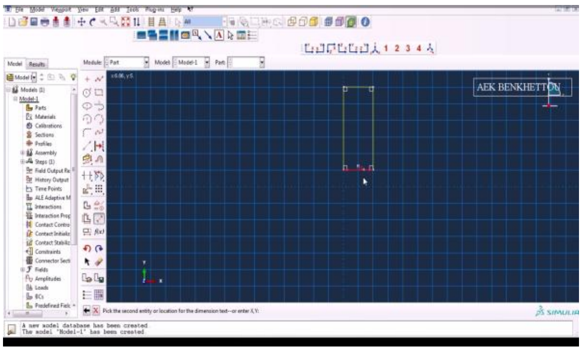
Type - Deformable Base feature

Shape - Solid

Type - Extrusion

Approximate size - 200, click continue

Draw the tensile test specimen of natural palm fiber composite and cotton fiber composite with our given standard dimensions These dimensions are same for both two composite materials.



Step-2:

Edit Basic Extrusion

We can click the Extrusion, and then one dialog box will come, in this we can entered the depth of the specimen

Depth of the specimen = 14mmThen click the Ok button

Step-3:

Property

In this we can select the mechanical properties and then we can click the Elastic and given the properties of the specimen

Young's modulus = 2e^9

Poisson ratio = 0.75

Then click the ok button

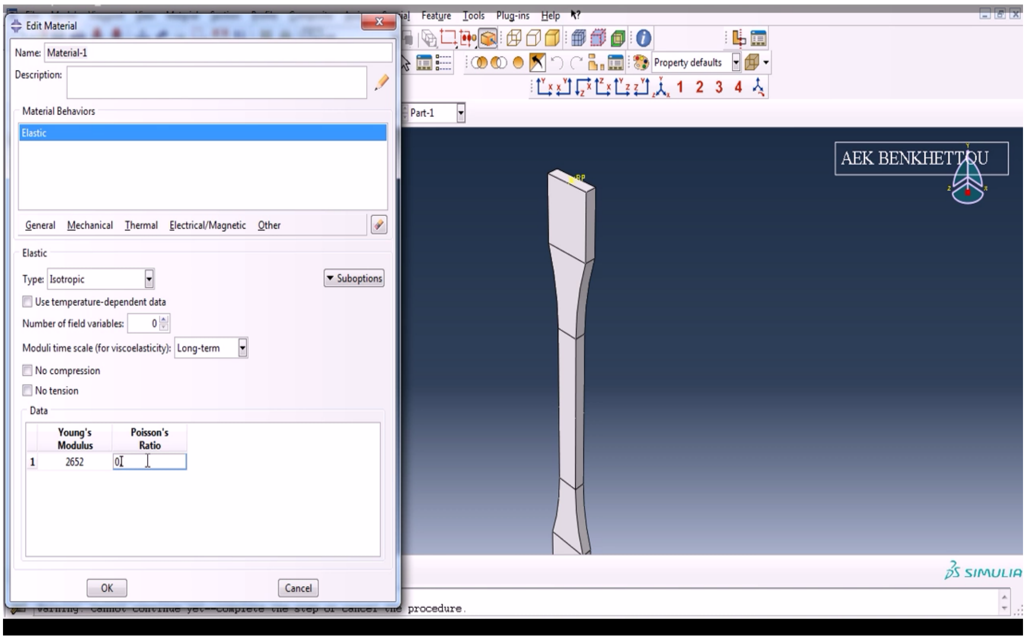


Figure5.2. *Properties of the specimen*

Step-4:

Apply Load

In this we can create boundary condition and then we can click the initial cell and then click the ok button

Next click the displacement/rotation, and then click ok button, Load =2000N

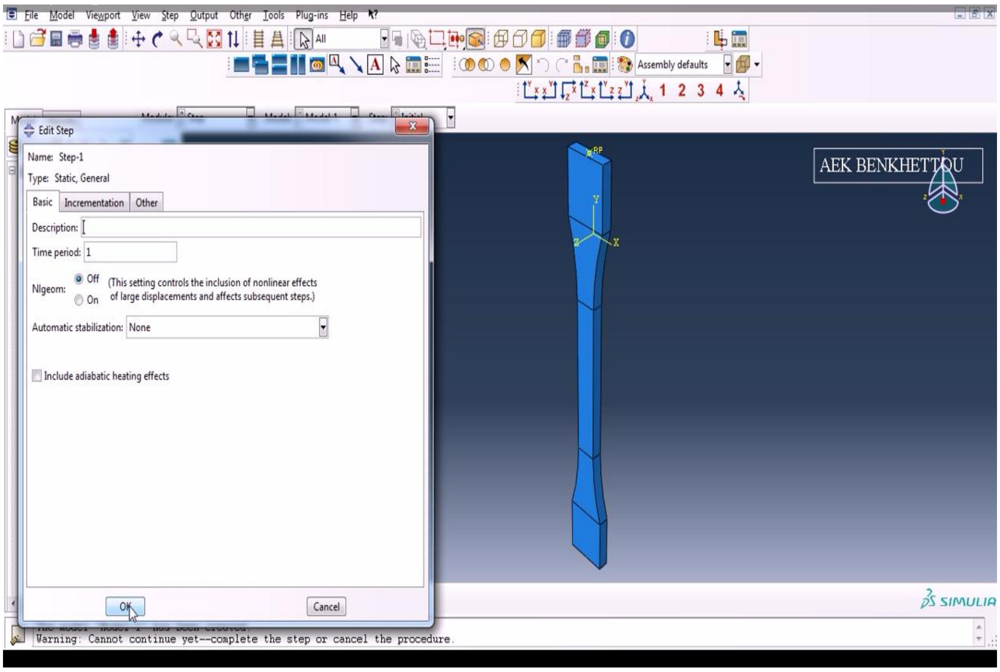


Figure5.3. *Applying the load*

Step-5:

Meshing

In this we can select the part-1, and then one dialog box will come, in this we can select the approximate global size-3.4.

And then by fraction of google size-0.1. And then click the ok button. The total object is select for the meshing and then click ok button

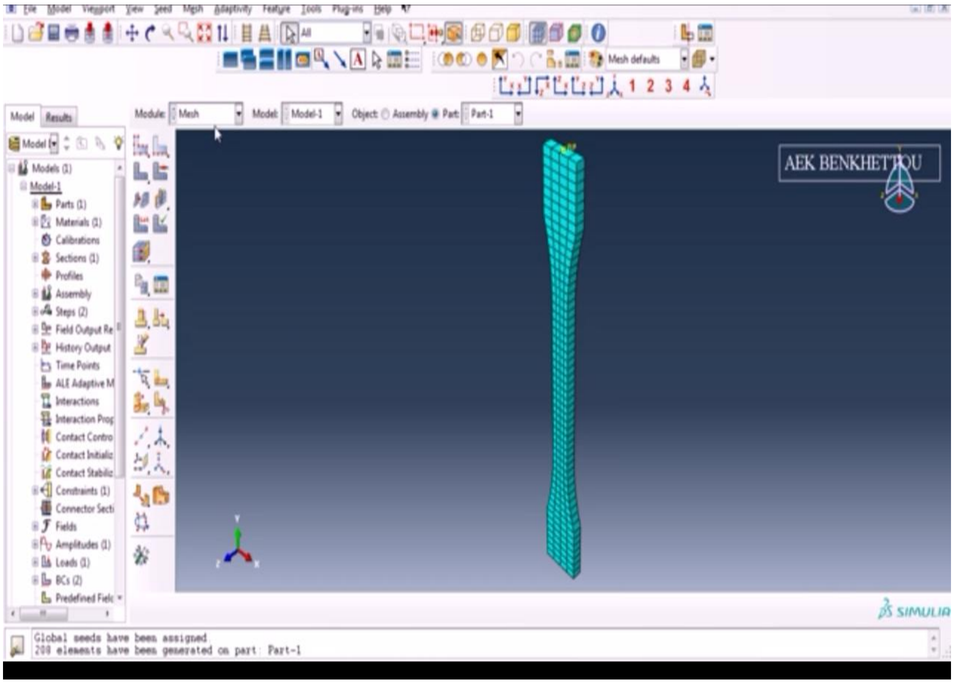


Figure5.4. *Meshing*

Step-6:

Result-1:

In this we can see result or deformed shape of the composite material. The deformed shape of natural fiber is shown in bellow image

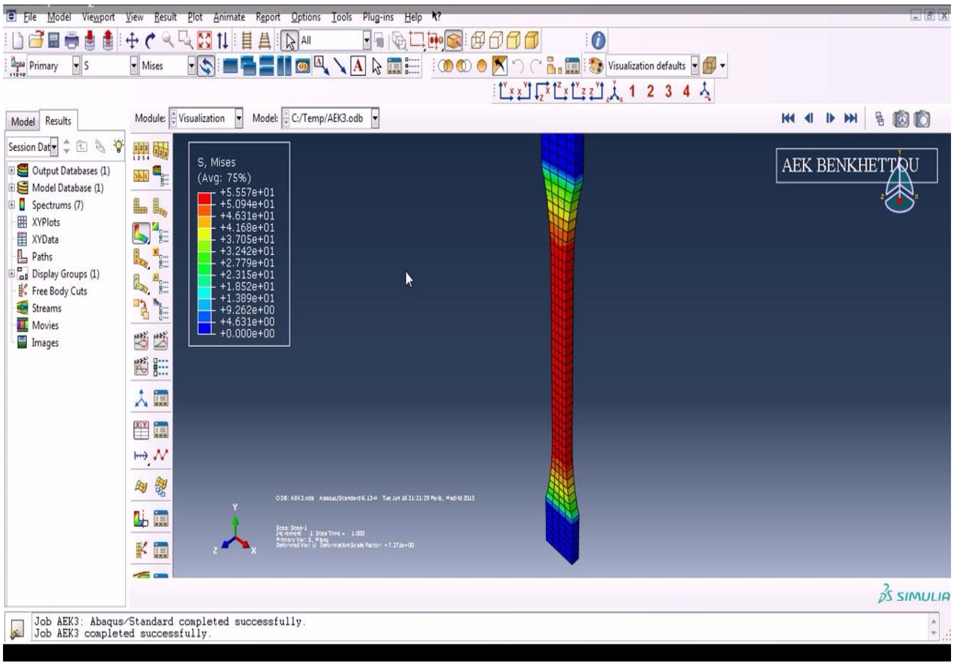


Figure5.5. *Deformed shape of the palm fiber*

Result-2:

Same process is done for the both two composite materials, only properties is change, so the properties are

Young's modulus = 4.2e69

Poisson ratio = 0.62

Deformed shape of cotton fiber is as shown in bellow figure

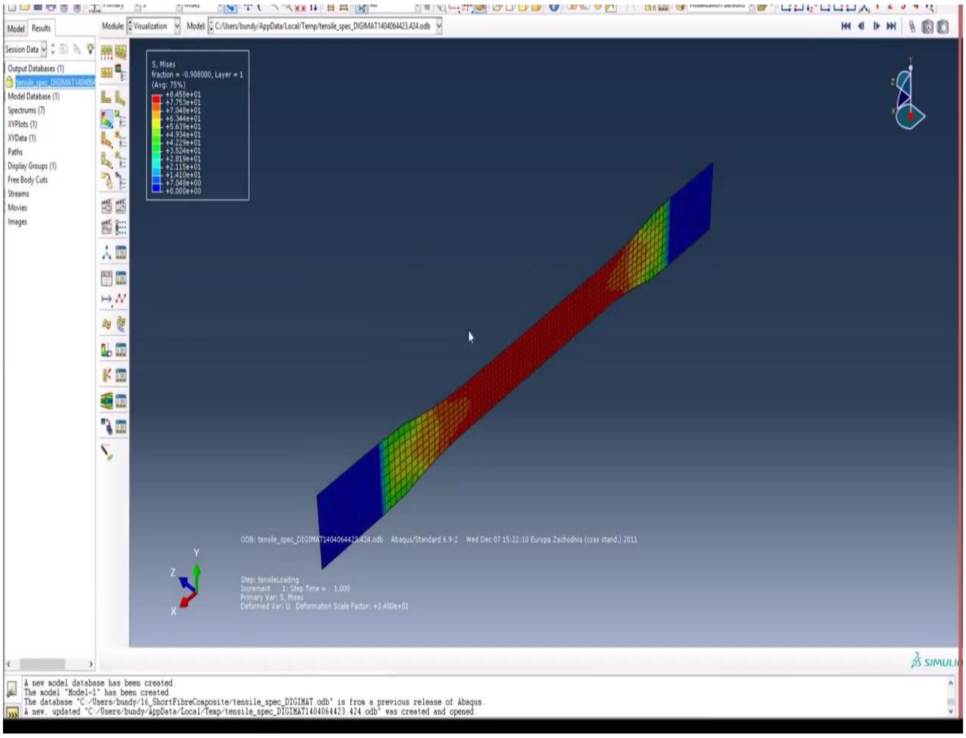


Figure5.7. *Deformed shape of the cotton fiber*

Stress-Strain Diagram

We can draw the stress-strain diagram by using above values in Microsoft excel

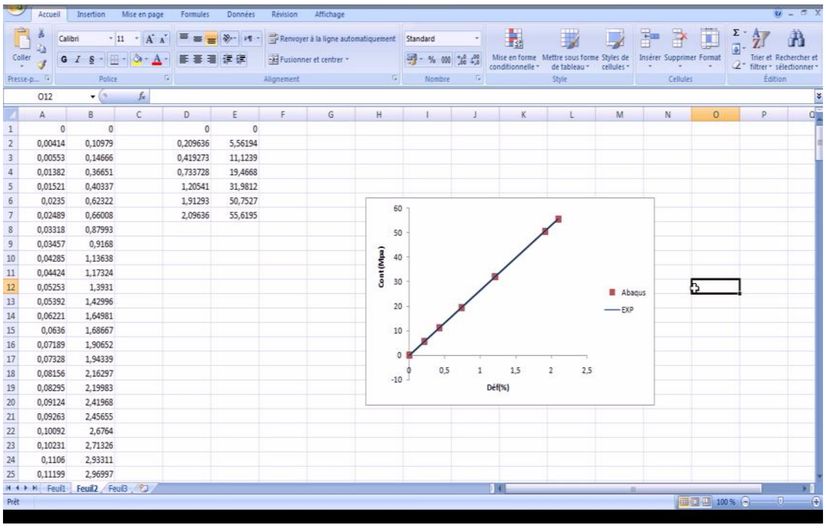


Figure5.8. *Stress-strain diagram for natural palm fiber*

CONCLUSION

Effects of cotton fiber on mechanical properties of developed composite sample were examined. Tensile test for both cotton and polyester resin were conducted separately. There was significant overall improvement in tensile strength and modulus of elasticity of developed composite material It was observed that tensile strength was 19.78% and modulus of elasticity was 24.81% improved. Reduction in tensile elongation of 6.29% was also detected in composite material. During the hardness test it was examined that developed composite material was of a ductile nature as its hardness decreased up to 2.6% as compared with polyester material reference specimen.

This study shows that preparation of date palm fabric fiber and coconut shell particle filler hybrid reinforced epoxy composite is possible by hand lay-up technique.

1- Mechanical characterization of the composites reveals that hybrid fillers had significant effect as compared with each composite that denoted in this study.

2- Natural fillers such as date palm fabric fiber and coconut shell particle filler can be used effectively as reinforcing materials for epoxy composites. It can be said that com-posites prepared from these fillers can replace synthetic fillers in some applications where high strength and stiff-ness is not the major concern.

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