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Preparation and Mechanical Optimization of Composite Pipes

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Abstract: Composite materials reinforced with synthetic fibers such as glass, carbon, and aramid provide a Advantages of high stiffness and strength to weight ratio as compared to conventional construction materials, i.e. wood, concrete, and steel. But replace of synthetic fiber of composite Material to natural fibers like Kenaf, cotton, jute, etc and improve the properties of natural and compare to other synthetic fiber as well as now used material and prepared for Kenaf, cotton and jute fiber and e-glass fiber compare the properties as tensile test and water absorption and pressure test and manufacturing of composite pipes of Kenaf ,jute and cotton and composite pipe of E-Glass are finding the best properties of composite material will be compare, check and also find out the result in ANSYS(Work Bench) and develop the real applications composite pipes and check the all failure condition of composite pipes due to ASTM specification to PVC pipes compare with composite pipes and their improve the properties and design model with help up mechanical tool and design calculation of a different type of composite pipes and prove the best model of natural composite model (pipe) .

***Keywords: kenaf, jute, cotton, E-*Glass**

I. INTRODUCTION

Composite is defined as the combination of any two or more materials i.e. metal, polymer and ceramics. The interest in natural fiber-reinforced polymer composite materials/Bio composites is rapidly growing both in terms of their industrial applications and fundamental research. They are renewable, cheap, completely or partially recyclable, and biodegradable. Plants such as flax, cotton, hemp, jute, sisal, century, Kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocelluloses fibers, are more and more often applied as the reinforcement of composites.

Composite materials are made from two or more constituents materials with significantly different physical or chemical properties which remain separate and distinct on a macroscopic level within the finished structure. Composites are made up of individual materials referred to as constituent materials. There are two categories of constituent materials referred: Matrix and reinforcement. At least one portion of the each type is required. The matrix materials surround and support the reinforcement materials by maintaining their relative positions. The reinforcement impacts their special mechanical and physical properties to enhance the matrix properties.

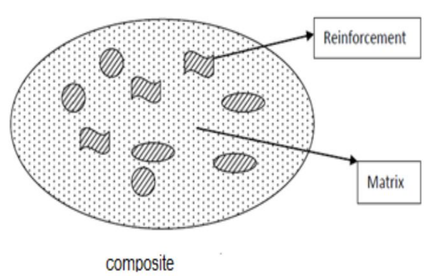

Fig 1: Structure of Composite

II. PREPARATION OF COMPOSITE PIPES

Filament winding is the process of impregnating glass fiber reinforcement with resin, then applying the wetted fibers onto a mandrel in a prescribed pattern. Fillers, if used, are added during the winding process. Chopped glass roving may be used as supplemental reinforcement. Repeated application of wetted fibers, with or without filler, results in a multilayered structural wall construction of there quired thickness. After curing, the pipe may undergo one or more auxiliary operations such as joint preparation. The inside diameter (ID) of the finished pipes fixed by the mandrel outside diameter (OD). The OD of the finished pipe is variable and is determined by the pipe wall thickness. The concepts of the filament winding as shown in fig .2

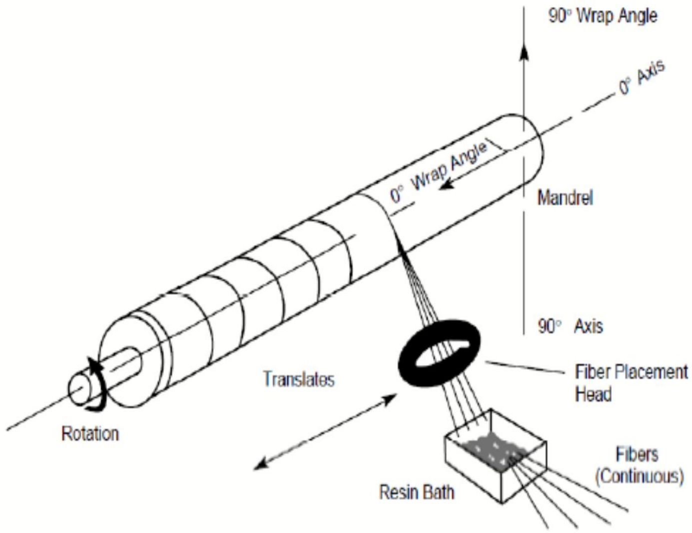

Fig 2: Filament Winding Process

Resin can be applied by resin or spray, though developments in Resin technology and mandrel equipment have combined to markedly increase the use of resin bath application methods. Whichever application method is chosen, it is important to use a Resin from the Cryptic range, specially formulated with the correct theology for that method.

Fig 3: Preparation of composite pipes

For optimum performance, it is important to control the Resin thickness to 0.4mm - 0.5mm and as a guide, 450g-600g/m^2 of Resin mixture will give the required thickness. If the Resin is too thin it may not cure fully and the pattern of the reinforcing fibre may show through from the backing composite.

Fig 4: Preparation of composite pipes

Thin Resin are also prone to solvent attack from the resin used in the backing composite pipes and this can result in Resin wrinkling. If the Resin is too thick, it may crack or craze and will be more sensitive to impact damage, particularly from the reverse side of the pipe.

A Resin of uneven thickness will cure at different rates over its surface. This causes stresses to be set up in the resin which may lead to crazing or, in the case of,resin transfer approaches methods.

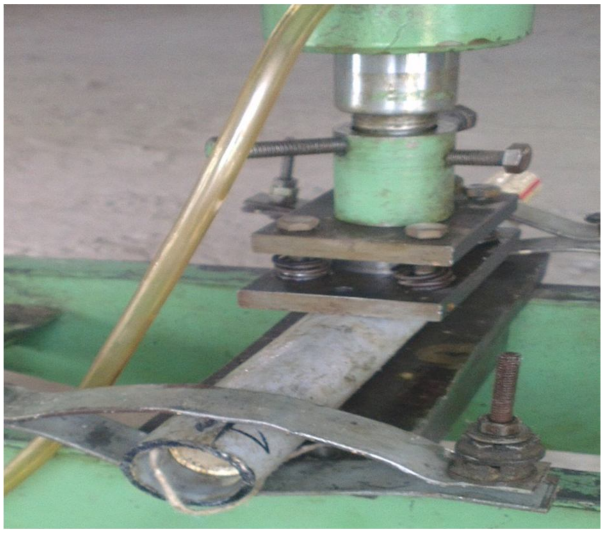

Fig 5: compression moulding on pipes

The reinforcement will then conform readily to the contours of the mould. Once the first layer of mat is fully impregnated, further resin can be added, if necessary, before applying subsequent layers of reinforcement. It is important that the first layer is as free of air bubbles as possible, as any air trapped immediately behind the Resin could lead to blistering, should the moulding be exposed to heat or water during its working life. Impregnation of the reinforcement can be carried out using a brush ring, or a mohair or polyester roller.

As per ASTM schedule 40D standard pipe specimens of same thickness are cut from the same size composite pipe using compressive moulding and filament winding process to maintain good surface finish as shown in below **.**

Fig 6: Jute pipe model

III. MODELLING IN ANSYS (WORK BENCH)

The finite element simulation was done by FEA/FEM package known as ANSYS. The FEA- software package offerings include time-tested, industry-leading applications for structural, thermal, mechanical, computational fluid dynamics, and electromagnetic analyses, as well as solutions for transient impact analysis. ANSYS software solves for the combined effects of multiple forces, accurately modeling combined behaviors resulting from "multiphysics" interactions.

This is used to perform the modeling of the ASTM stranded specimen and find the result of stress and strain with relevant mode shapes. This is used to simulate both the linear & nonlinear effects of structural models in a static or dynamic environment also includes the ANSYS WORKBENCH for building and controlling user-defined parametric and customized models.

The purpose of the finite element package was utilized to model the Fiber reinforced polymer (FRP) Shell (3D 4 node181). This package enables the user to investigate the physical and mechanical behavior of the composite pipe.

A. Stress, Strain and Total Deformation Models of Composite Pipes

1) Maximum principal stress for Kenaf composite pipe model

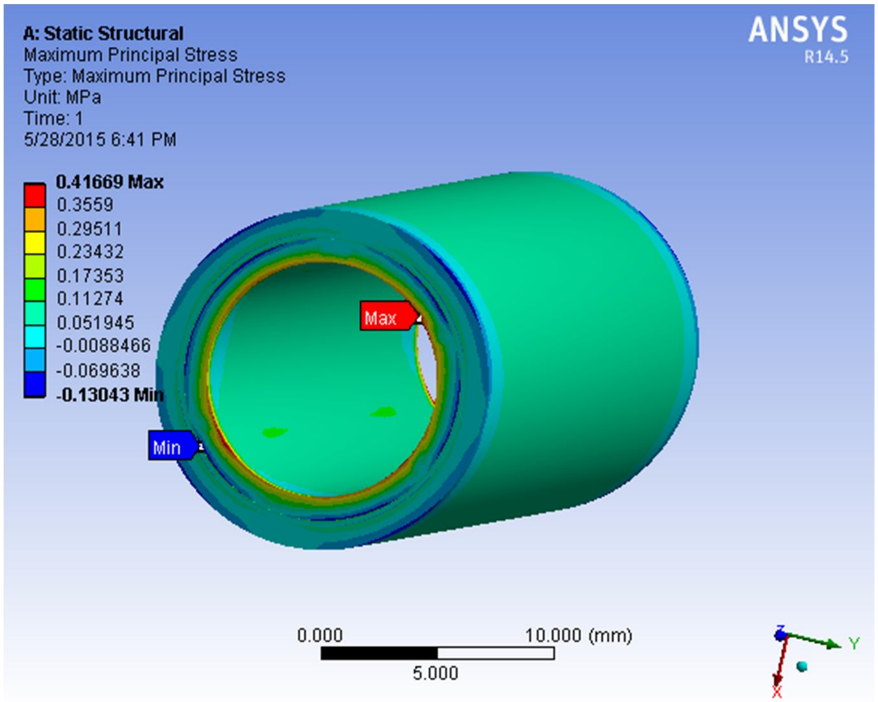

Fig 7 Maximum principal stress for Kenaf composite pipe model

Maximum principal stress for Kenaf composite pipe model is 0.41669 N/mm^2

2) Maximum Principal Elastic Strain for Kenaf Composite Pipe Model

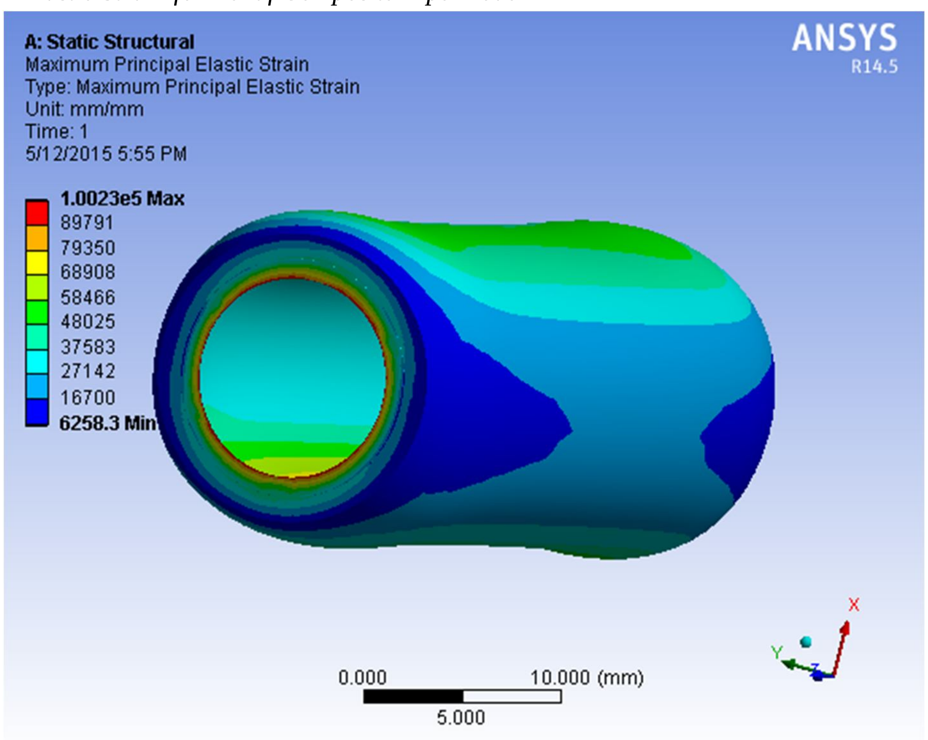

Fig 8. Maximum principal strain for Kenaf composite pipe model

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Maximum Principal Elastic Strain Kenaf is $1.0023e^5$

3) Total Deformation for Kenaf Composite Pipe Model

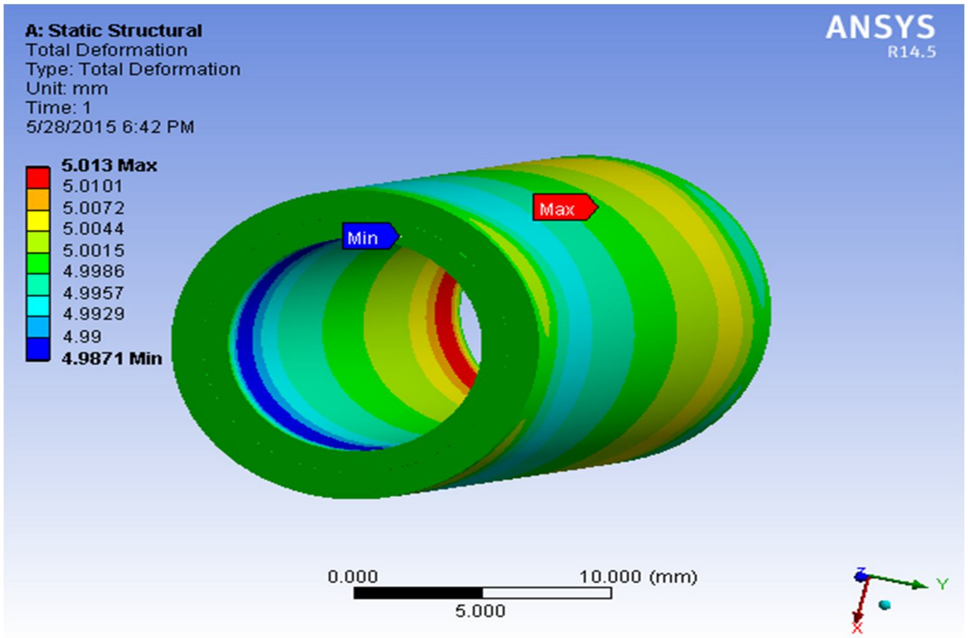

Fig 9. Total Deformation for Kenaf composite pipe model

Total Deformation for Kenaf composite pipe model is 5.013 mm

4) Maximum Principal Stress for Jute Composite Pipe Model

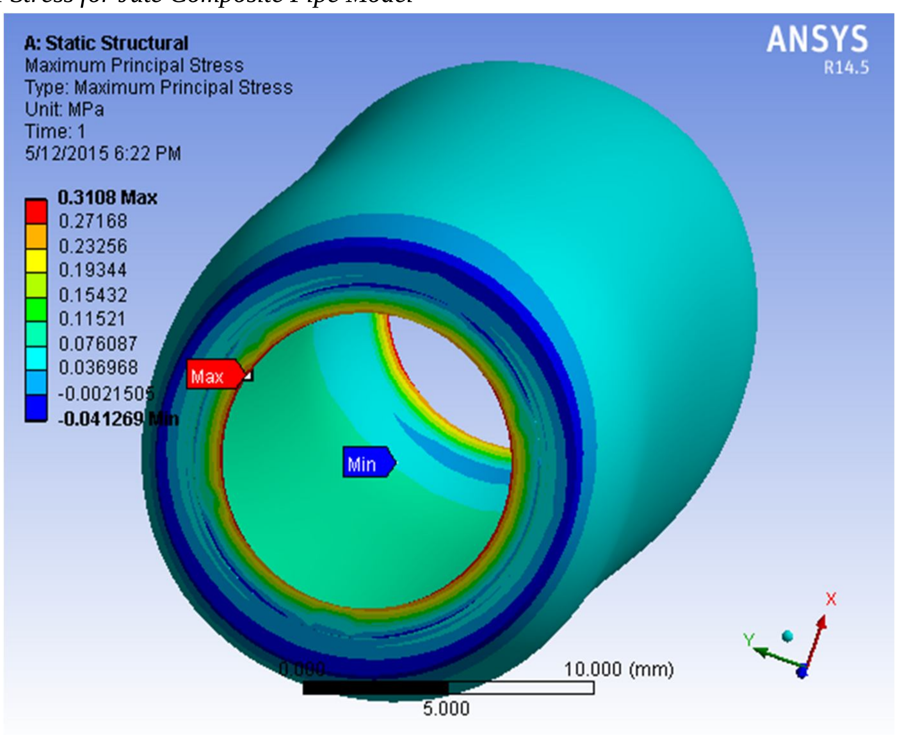

Fig 10 Maximum principal stress for jute composite pipe model

Maximum principal stress for jute composite pipe model is 0.3108 N/mm^2

5) Maximum Principal Elastic Strain for Jute Composite Pipe Model

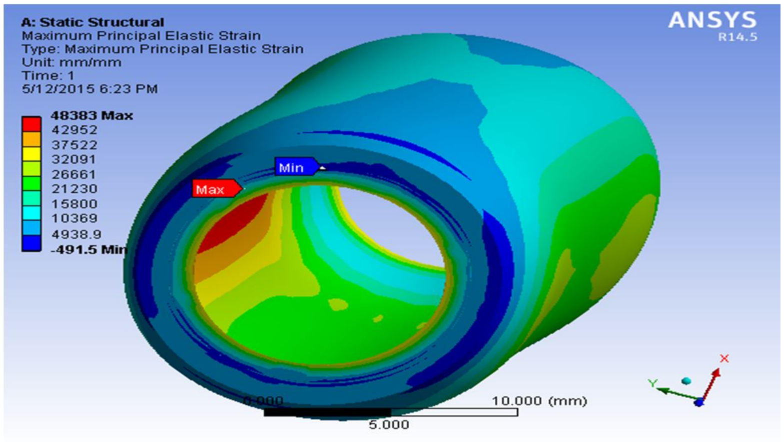

Fig 11. Maximum principal strain for jute composite pipe model

Maximum Principal Elastic Strain for jute composite pipe model is 48383

6) Total Deformation for Jute Composite Pipe Model

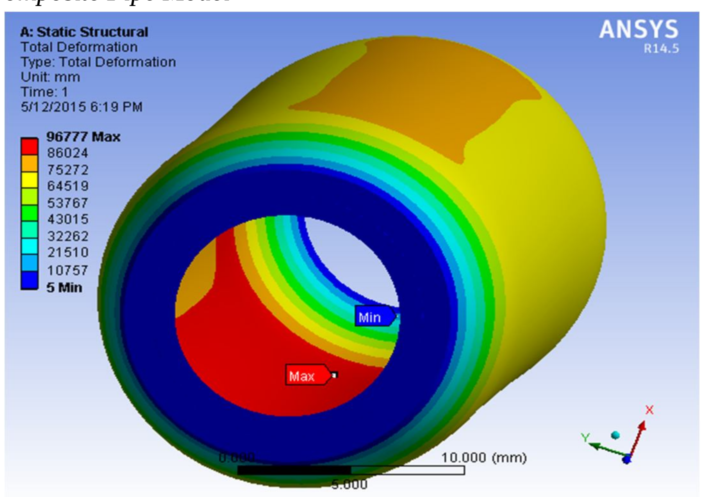

Fig 12. Total Deformation for jute composite pipe model

Total Deformation for jute composite pipe model is 96777 mm

7) Maximum Principal Stress for Cotton Pipe Model

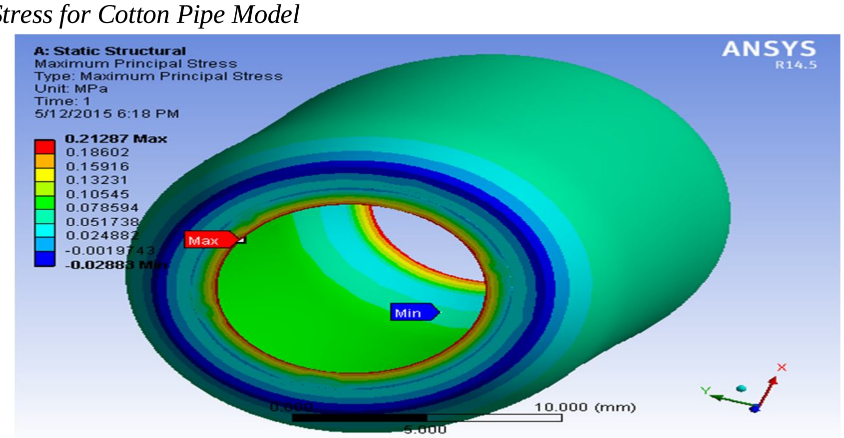

Fig 13. Maximum principal stress for cotton composite pipe model

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Maximum Principal Stress for cotton pipe Model is 0.21287 N/mm^2.

8) Maximum Principal Elastic Strain for Cotton Pipe Model

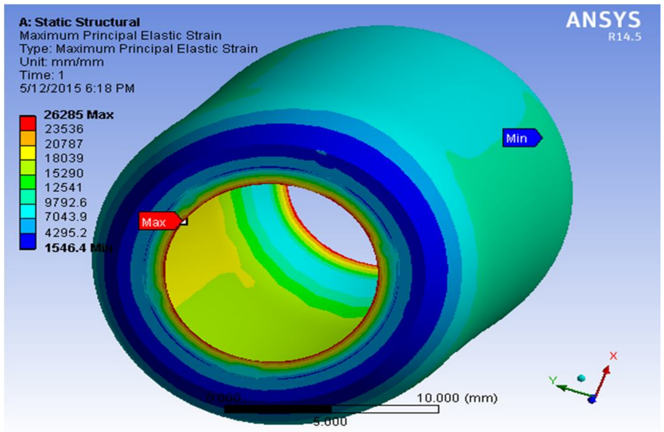

Fig 14. Maximum principal strain for cotton composite pipe model

Maximum Principal Elastic Strain for cotton pipe Model is 26285.
Maximum Principal Elastic Strain for cotton pipe Model is 26285.

9) Total Deformation for Cotton Pipe Model

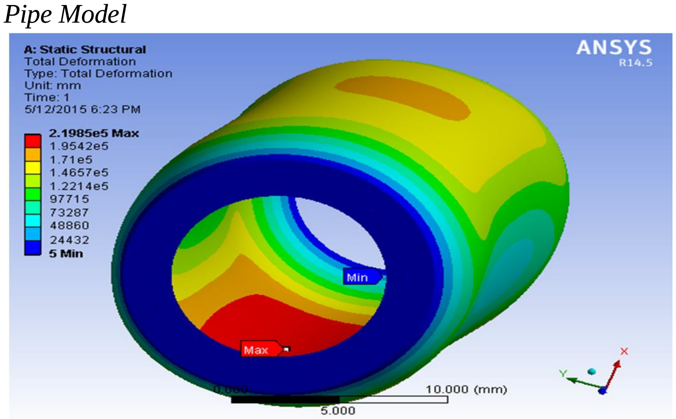

Fig 15. Total Deformation for cotton composite pipe model

Total Deformation for cotton pipe Model is 2.1985e^5 mm.

10) Maximum Principal Stress for E-Glass Pipe Model

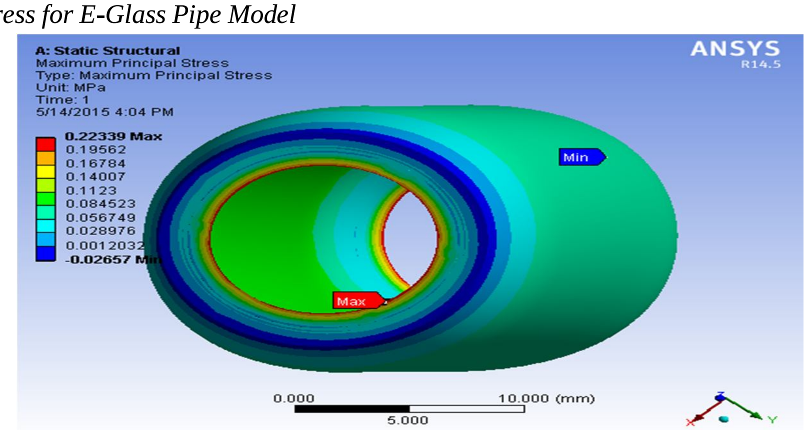

Fig 16.Maximum principal stress for E-Glass composite pipe model

Maximum Principal Stress for E-Glass pipe Model is 0.22339 N/mm

11) Maximum Principal Elastic Strain for E-Glass Pipe Model

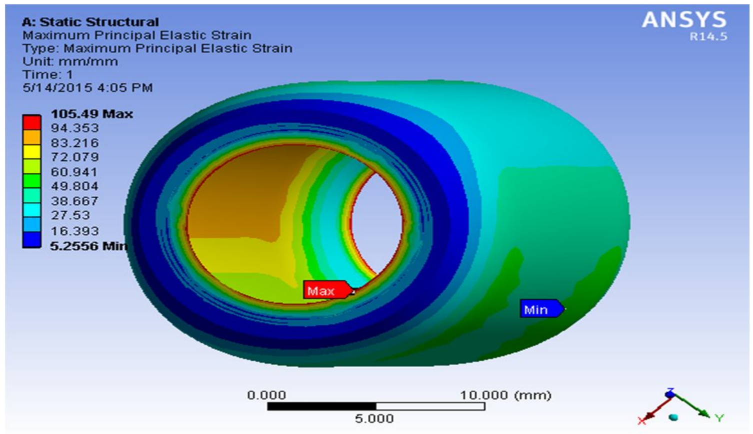

Fig 17. Maximum principal strain for cotton E-Glass pipe model

Maximum Principal Elastic Strain for E-Glass pipe model is 105.49

3.1.12 Total Deformation for E-Glass pipe model

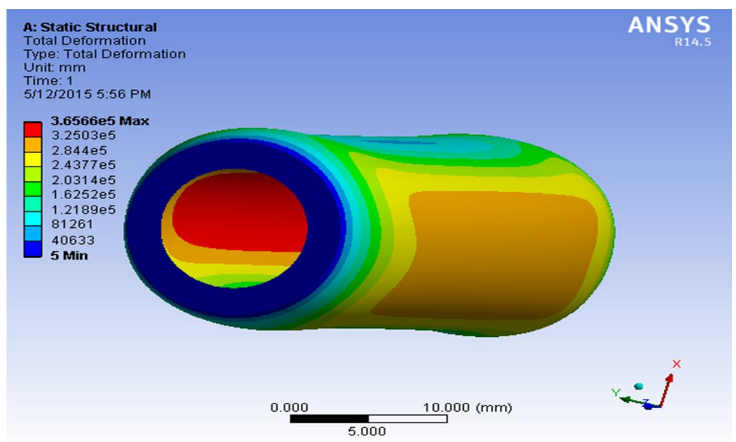

Fig 18. Total Deformation for E-Glass pipe model

Total Deformation for E-Glass pipe model 3.6566e^5 mm

IV. ANSYS (WORK BENCH) STRESS-STRAIN RESULTS

Jute	
σ	€
0.310	4838
0.271	4295
0.232	3752
0.193	3709
0.154	2666
0.115	2123
0.076	1580

Kenaf	
σ	€
4.166	100230
3.559	97910
2.951	79350
2.343	68908
1.731	58460
1.112	48020
0.519	37580

Table 1. stress-strain result values for kenaf and jute

E-Glass	
σ	€
0.212	105.49
0.186	94.353
0.159	83.216
0.132	72.079
0.105	60.941
0.078	49.804
0.051	38.667

cotton	
σ	€
0.223	26285
0.195	23536
0.167	20787
0.140	18039
0.112	15290
0.08	12541
0.05	9792

Table 2. stress-strain result values for cotton,E-Glass

A. Analytical stress –strain curves

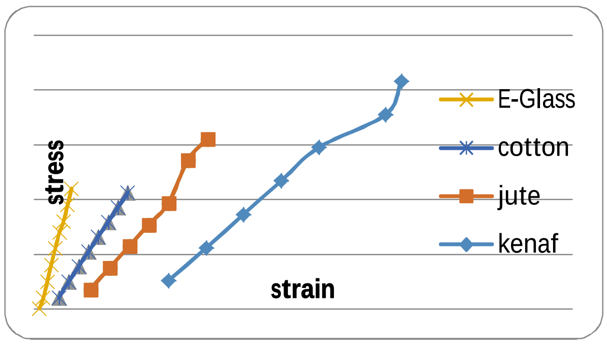

Fig 19. stress –strain curves

From above graph it shows that stress-strain values for kenaf, jute, cotton, and E-Glass among all these four materials kenaf fiber gives better stress-strain results as compare with other composite materials

V. CONCLUSION

In the present work, one artificial and three natural fibers are used. The materials selected were fully characterized in terms of their mechanical properties. The data obtained on the single lamina prepared with that natural fibers (i.e Kenaf fiber) has good properties, when compared to the other fibers (Jute, Cotton and E-glass). Experiments were conducted on the prototype model by simulating the real working conditions of Pressure test, tensile test & Water absorption test confirmed that kenaf Fiber only can withstand the real working conditions. Stress-strain and deformation results are obtained by mechanical tool i.e ANSYS WORK BENCH. Which are correlated with the experimental results.

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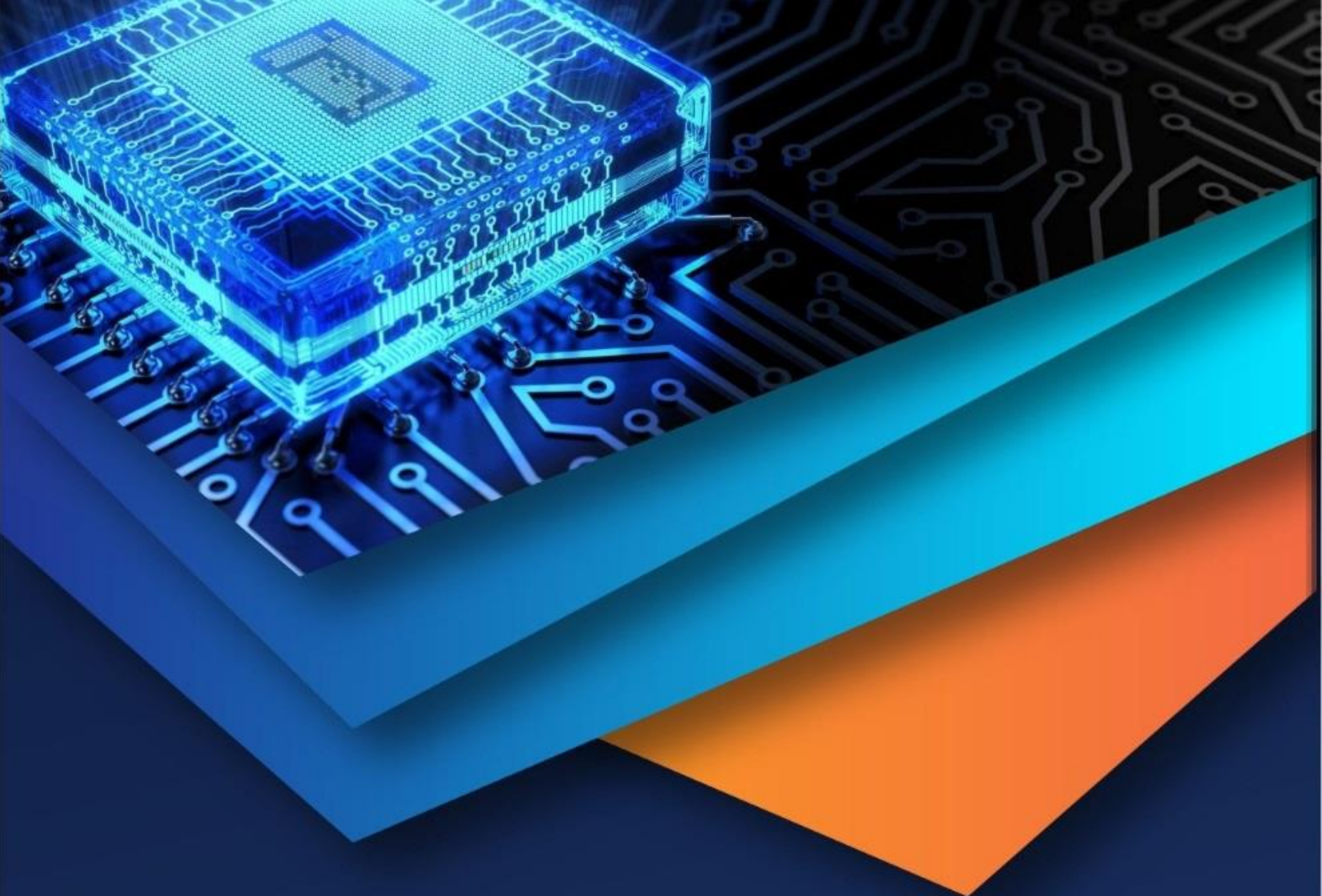

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