iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** XII **Month of publication:** December 2017

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 5 Issue XII December 2017- Available at www.ijraset.com

Investigation on Mechanical Properties of Composite Material with Different Material Configuration by using FEM Analysis

Navin Kumar[1], Kunal Dewangan[2]
[1]*Student of Production Engineering* S.S.I.T.M Bhilai, India
[2]*Assistant professor Mechanical engineering department* S.S.I.T.M Bhilai, India

Abstract: Extensive literature review has been carried out in the field of Composite vibration. This work is concerned with the comparison of experimental and simulation analysis and enhancement of mechanical properties of composite material like (jute abaca glass fiber). The finite Element method has been used computational by means of ANSYS 15.0 a main reason for adopting ANSYS 15.0 is that there is no analytical model has been develop for Composite structure in presence of singularities i.e. total deformation and shear stress. Following analysis has been carried out for dogbane shape structure and we have taken the dimensions & boundary condition from the base paper [26]. (i.e. simply supported shear strength of laminated composite).
Keywords: Composite material, Finite element method (FEM), Total deformation, shear stress.

I. INTRODUCTION

A. Definition

A composite material is a material in which two or more distinct materials are combined together but remain uniquely identifiable in the mixture. The most common example is, perhaps, fiberglass, in which glass fibers are mixed with a polymeric resin.

B. Is it possible to design a composite material?

Obviously the answer to that question is “Yes”! First, we must identify the numerous materials related variables that contribute to the mechanical and physical properties of the composite material. Secondly, the appropriate physical and mathematical models that describe how the properties of the individual components of the composite are combined to produce the properties of the composite material itself must be derived. So, “Yes”, it is possible to design a composite material such that it has the attributes desired for a specific application. Those attributes might be as simple has having a specified stiffness and strength, a desired thermal conductivity, or have a minimum specified stiffness at the cheapest possible cost per unit volume. Whatever the specifications it should be possible to design a suitable composite material. As in all design processes, it may not be possible to meet all the specifications exactly and compromise and tradeoffs will be required, but by understanding the physical origin of the required properties and developing an appropriate mathematical description, a suitable composite can be designed. We should also keep in mind that there may be an existing conventional material that is more suitable for the application than a composite. So the composite must offer a specific advantage in terms of cost or performance than conventional alternatives. It is one of the goals of this resource to show you the logical steps needed to implement the design process.

C. How do we get started?

Perhaps the easiest way to demonstrate how the design process required to develop a composite material is implemented is to start with a familiar composite material and examine just what factors control its properties. So I will start by asking a simple question, "How strong is a piece of fiberglass?” As you should be aware, there is no single answer to that question and one might be tempted to reply, "How strong do you want it to be?”

The amount of load that it takes to break a piece of fiber glass depends on the size of the piece of fiberglass, its thickness, width and length, whether we are simply pulling it in tension, compressing it, or bending it. It also depends on what the fiberglass is made of. There are many types of glass and many different polymeric resins that are used to make fiberglass. There are also many different ways in which the glass can be combined into the resin, for example, are the fiber all aligned in the same direction, are the fiber woven into a cloth, what type of cloth, are the fiber aligned at random, are the fiber long or short? Then, if the fiber are oriented, at what angle relative to the fiber, is the fiberglass being loaded? Finally, just what is the ratio of fiber to resin and is that by volume or by weight?

By looking at the range of fiberglass products available and by seeking clarification on the structure and composition of the fiberglass we have begun to identify the micro structural variables that will control the properties of the composite. These may be summarized as

1) The properties of the fiber reinforcement
2) The properties of the matrix in which the reinforcement is placed
3) The amount of reinforcement in the matrix.
4) The orientation of the reinforcement
5) *The size and shape of the reinforcement.*

II LITERATURE SURVEY

It has been found that when the fiber orientation increases from 0° to 90°, the resistance to delamination fracture increases by a factor of two [1].

The wear rate of the composite is minimum when the orientation of the fibers is normal to the direction of the sliding movement [2,3].

The presence of glass fibers tends to increase the erosive wear rate of the composite. The effect of fiber orientation on the erosive wear rate is more pronounced at lower impact angles (30°) and there is no significant difference at higher angles. Experiments show that during tensile loading, composites sustain greater loads as the angle between the fiber orientation and the load direction increases [4, 5].

FRP can be used to strengthen the structural members even after they have been severely damaged. Fibers provide toughness, impact resistance, and energy absorption to the composite [6].

The modulus of elasticity can be increased by increasing the volume of fiber in the composite. But, this leads to the decrease of ultimate tensile strength. The usage of natural fibers has resulted in a cost reduction of 20% and weight reduction of 23% in curved pipes [7,8].

Abaca fibers have better bonding with the matrix when compared to cellulose fibers and this is attributed to their rough surface [9].

Liu et al. [10] stressed the importance of the fibers location in the fiber stem. In the experiments they conducted, the tensile properties of the abaca fiber increased with increase in the fragment height in the fiber stem (FHFS) up to a height of 1 m and then began to decrease.

The chemically treated natural fibers have better mechanical properties and also provide better fiber–matrix adhesion [11].

The abaca fibers treated with natural enzyme showed better chemical resistance in acid and base medium. The moisture absorption was also reduced by 40% and the tensile and flexural strengths showed a significant increase of 5–45% and 10–35% respectively [12].

The impact properties of the composite depend on the type of fiber, resin, their volume fraction and their production method. The flexural properties of abaca reinforced polypropylene compos- ite increases linearly with the increase in fiber content up to 50% by weight. The flexural properties can be further increased by adding a melted polypropylene coupling agent, which enables better stress transfer from the matrix to the fiber. These composites can replace conventional materials in low impact strength applications [13,14].

Abaca fibers increase the flexural strength of the composite, when compared to the non-reinforced composite with the same matrix [15].

The mechanical and chemical properties of the composite vary according to the cellulosic content of the natural fiber. The major disadvantage of natural fiber is its hydrophilic nature which affects the mechanical properties of the composites [16,17].

Composites based on agricultural residue have densities lower than conventional glass composite fibers. Jute fiber finds use in sophisticated fields like decorative and furnishing materials such as lamp shades, wall covers, curtains, and upholsteries. Today it is the least expensive fiber of mass consumption, at only a fraction of the cost of glass fibers. In terms of volume, jute is now the sec- on most important fiber in the world, next to cotton [18,19].

Jute fiber (30% by weight) reinforced composites had the optimum set of mechanical properties. Jute fiber composites post-treated with Urotropine yields better mechanical properties. The bonding between the polypropylene matrix and Urotropine treated jute fiber can be improved to have better mechanical properties at higher fiber content [20].
It is found that the abaca–jute hybrid composite has better properties than the abaca fiber alone in tensile and shear. However, the abaca composite is superior to hybrid composite in flexural and impact strength [21,22].

III. METHODOLOGY

A. Aligned Continuous Fiber

If the composite material is to stay in equilibrium then the force we apply to the composite as a whole, F, must be balanced by an equal and opposite force in the fiber, F_f and the matrix F_m.

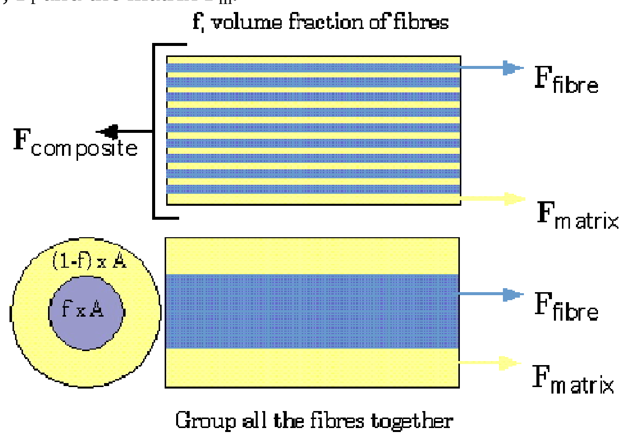


Fig: 1.1 Aligned Continuous Fibers

When considering 'Strength of Materials' problems we usually work in terms of stress (force per unit area) rather than force itself. So the force on the fiber is simply the stress on the fiber multiplied by the cross-sectional area of the fiber lying perpendicular to the stress. The cross sectional area of the composite occupied by the fiber is just f, the volume fraction of the fiber multiplied by the cross-sectional area of the composite itself - we'll call that "A" - i.e. f x A. Similarly the force on the matrix is just the stress in the matrix multiplied the cross-sectional area of the matrix in the composite, i.e. (1-f) x A. Since the cross-sectional area of the composite itself, A, is in each term on both sides of the equation we can cancel it out. So the stress in the composite is just the sum of the stresses in the fiber and the matrix multiplied by their relative cross-sectional areas.

$$F = F_m + F_f$$

$$\sigma A = \sigma_m (1-f) A + \sigma_f f A$$

$$\sigma = \sigma_m (1-f) + \sigma_f f$$

We can now use Hooke's Law, which states that the stress (or Force) experienced by a material is proportional to the strain (or deflection). This applies as long as the stresses are low (below the elastic limit - we'll come to that soon) and the material in question is linear elastic - which is true for metals, ceramics, graphite and many polymers but not so for elastomers (rubbers).

$$\sigma = E\varepsilon$$

Where E is the elastic modulus; the bigger this numbers the stiffer the material. For compatibility, the strain must be the same in both the fiber and the matrix otherwise holes would appear in the ends of the composite as we stretched it. This is known as the Isostrain rule.

$$E\varepsilon = (1-f)E_m\varepsilon + fE_f\varepsilon$$

$$E = (1-f)E_m + fE_f$$

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 5 Issue XII December 2017- Available at www.ijraset.com

Since the fiber and matrix often have quite different elastic moduli then the stress in each must be different - in fact the stress is higher in the material with the higher elastic modulus (usually the fiber). In fiberglass, the elastic modulus of the glass (~75GPa) is much greater than that of the polyester matrix (~5GPa) so as the volume fraction of fiber is increased, the elastic modulus of the composite (measured parallel to the fiber) increases linearly.

Natural fibers are replacing synthetic fibers in many applications due to their advantages like low weight, low cost and biodegradeability. Thermoplastics and thermoset plastics can be used as resin matrices combined with a suitable hardener. Due to the high cost of material and fabrication, applications of synthetic fiber composites are limited to aeronautical and defense applications. Natural fiber reinforced composites are best suited to any design that demands weight savings, finite tolerances, precision engineering and simplified production and operations. Bi woven fabrics provide greater damage tolerance and increased popularity in different applications. The present investigation carried on epoxy resin bi woven glass fiber (238 gsm), the matrix materials are epoxy resin YD128 and hardener HY140 mixed in appropriate ratio with room temperature curing cycle of 48 hours duration.

B. Model the Geometry

Follow bottom up modeling and create the geometry

Set preferences. (Structural) Define constant material properties. Properties of material are tabulated below.

C. Materials used

Jute is a highly biodegradable and affordable fiber. Jute fiber can be spun into coarse, strong threads which make it ideal for many industrial applications. These fibers are 1–4 m long and off fade from brown to white. Abaca fiber is classified as hard fiber and it primarily consists of cellulose, lignin and pectin. Its applications extend from rope making to specialized paper products. Glass fiber is one of the most commonly used polymeric composites. In hybrid composites, it is added as the top and bottom layer to improve the tensile strength and surface finish. The required interfacial adhesion and bonding between various layers of fiber is achieved by using Epoxy resin (LY556) and Hardener (HY951) mixed in a ratio of 10:1.

Properties of fibers

Some of the properties of fibers are given below.

D. Jute

Density (g/cm3): 1.3–1.49
Diameter (mm): 25–250
Tensile strength (MPa): 393–800
Young modulus (GPa): 13–26.5
Elongation at break load (%): 1.16–1.5

E. Abaca

Density (g/cm3): 1.5
Diameter (mm): 10–30
Tensile strength (MPa): 430–813
Young modulus (GPa): 31.1–33.6
Elongation at break load (%): 2.9

F. E-Glass

Density (g/cm3): 2.55
Diameter (mm): 15–25
Tensile strength (MPa): 2000–3500
Young modulus (GPa): 70–73
Elongation at break load (%): 2.5–3.7

G. Apply Boundary Conditions

1) Apply constraints to the model i.e. force IN ONE DIRECTION 5860 N
2) Convergences

3) Define element type. i.e. shell 3D
4) Mesh. i.e. Mapped mesh

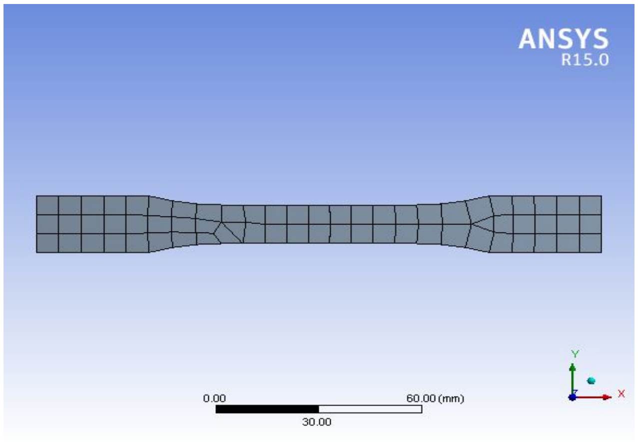


Figure 1 Mesh file

A 20-node three-dimensional structural solid element was selected to model the beam. The Laminated plate was discretized into 558 elements with 325 nodes. Plate boundary conditions can also be modeled by constraining all degrees of freedoms of the nodes located on the left end of the beam.

H. Obtain Solution
5 Specify analysis types and options
6 Solve

IV. RESULTS AND DISCUSSIONS

A. Validation
The governing equations of the problem were solved, numerically, using an Element method, and finite element Analysis (FEA) used in order to calculate the characteristics of a Composite structure. As a result of this simulation, the value of deformation (i.e. Displacement at break load (mm)) and shear stress is to be evaluated and compared with the experimental method which is found to be in good agreement with the practical sample structure.

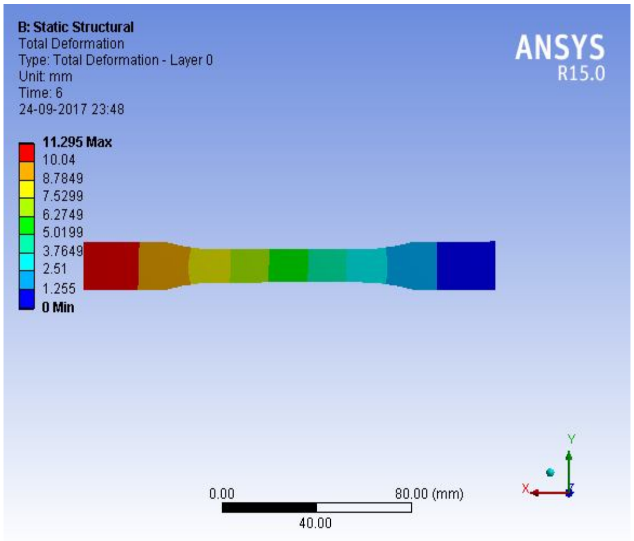


Figure 2 total deformation

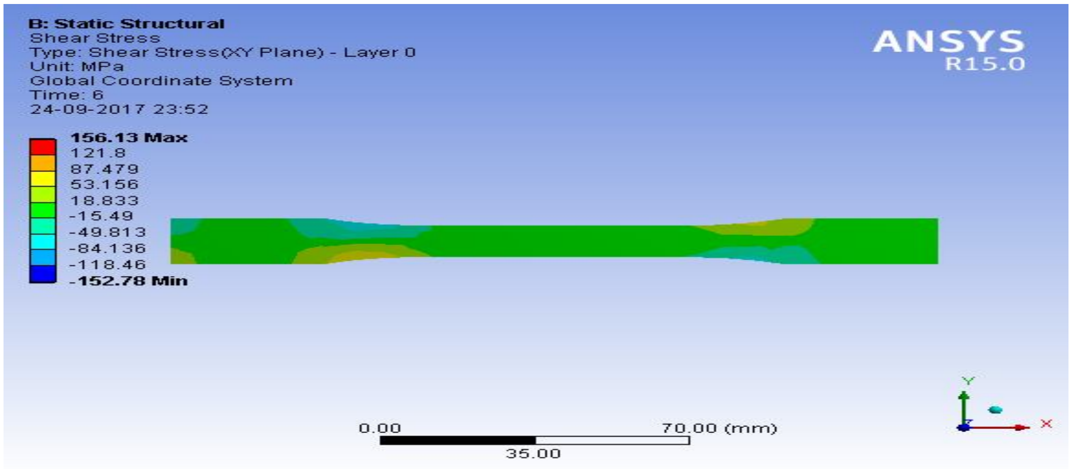


Figure 3 shear stress

Table 1: Validation with deformation and tensile strength of composite material

Composite specimen	Displacement at break load (mm)	Ultimate tensile strength (MPa)
Sample 1	11.31	39.82
My Present ANSYS work	11.29	156.13 (with factor of safety =3)

B. Effect on shear stress and deformation for different composite materials for stacking sequence 0-45-90-135-180

When composite materials are designed, the reinforcements are always oriented in the load direction. Effect on shear stress and deformation for different composite materials for stacking sequence 0-45-90-135-180 in which we select three new composite like honeycomb Carbone uni-direction, Carbone woven fiber were prepared under the same conditions as discussed earlier.

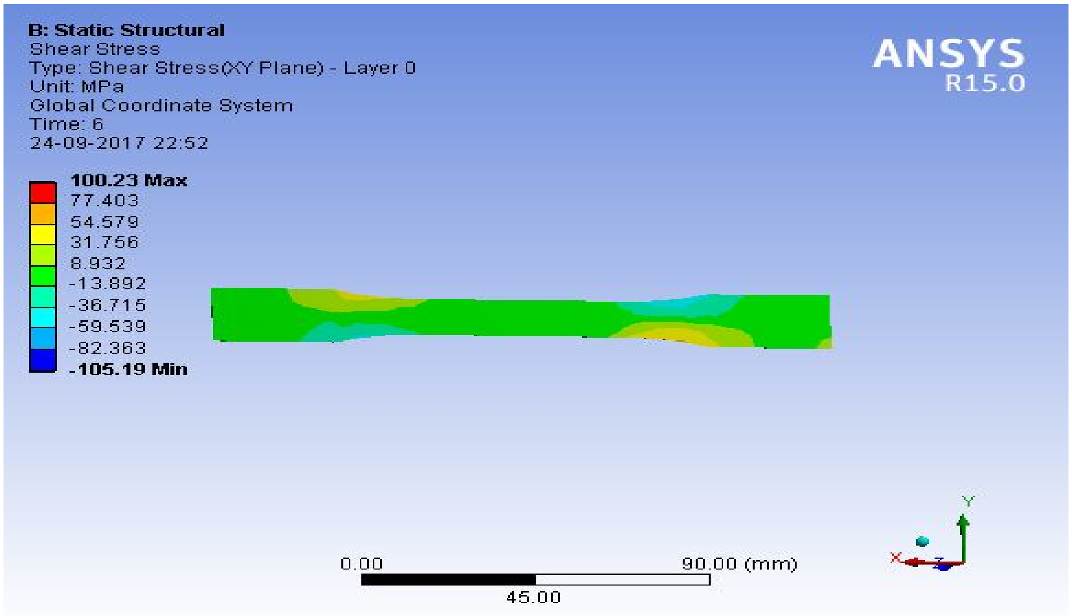


Figure 5.3 Result of shear stress for composite material glass fiber-abaca-Carbone UD-abaca-glass fiber for stacking sequence 0-45-90-135-180.

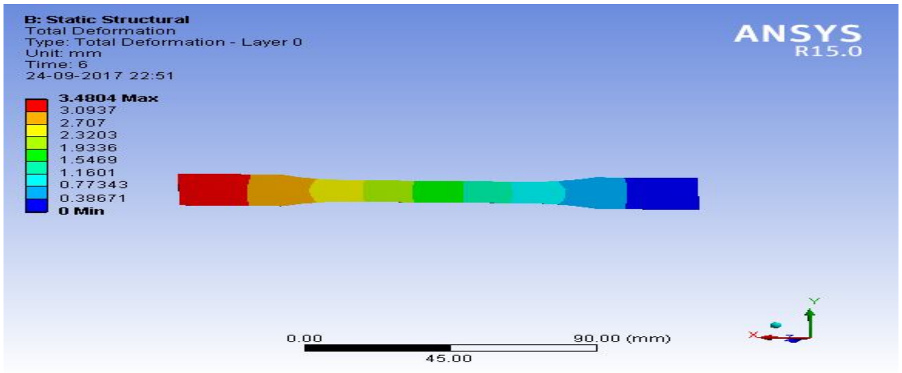


Figure 5.4 Result of deformation for composite material glass fiber-abaca-Carbone UD-abaca-glass fiber for stacking sequence 0-45-90-135-180.

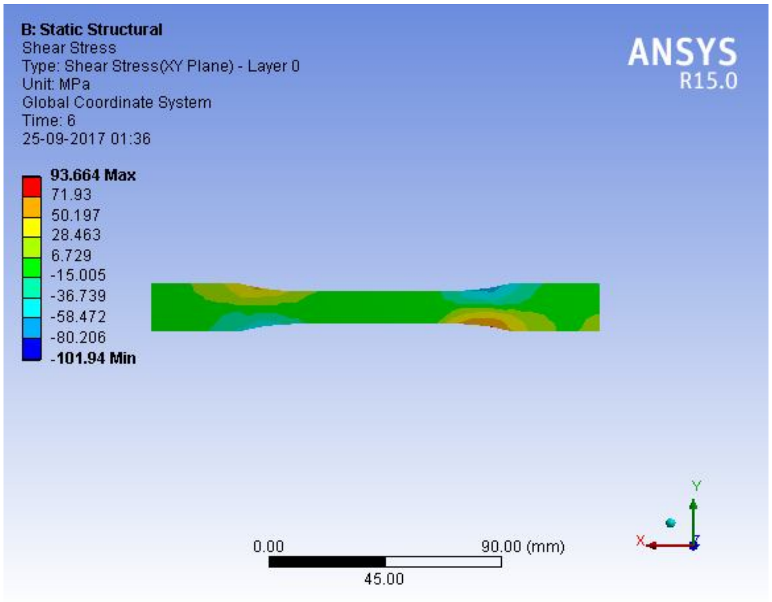


Figure 5.5 Result of shear stress for composite material glass fiber-jute-Carbone UD-jute-glass fiber for stacking sequence 0-45-90-135-180.

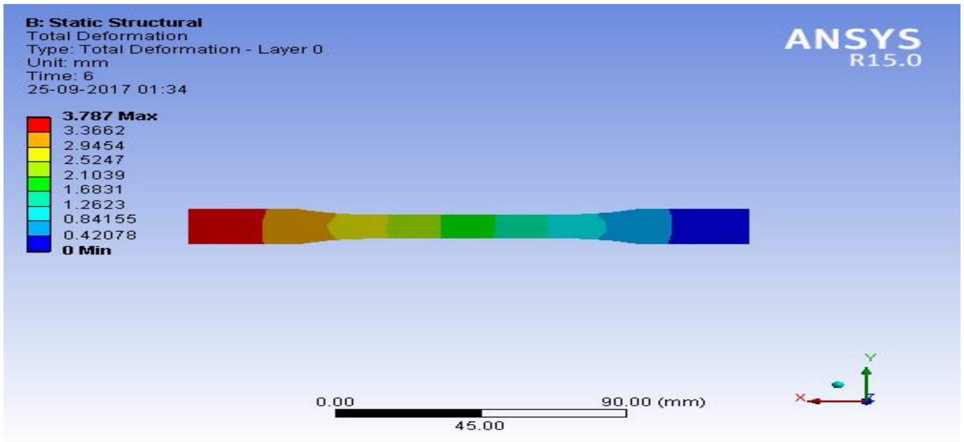


Figure 5.6 Result of deformation for composite material glass fiber-jute-Carbone UD-jute-glass fiber for stacking sequence 0-45-90-135-180.

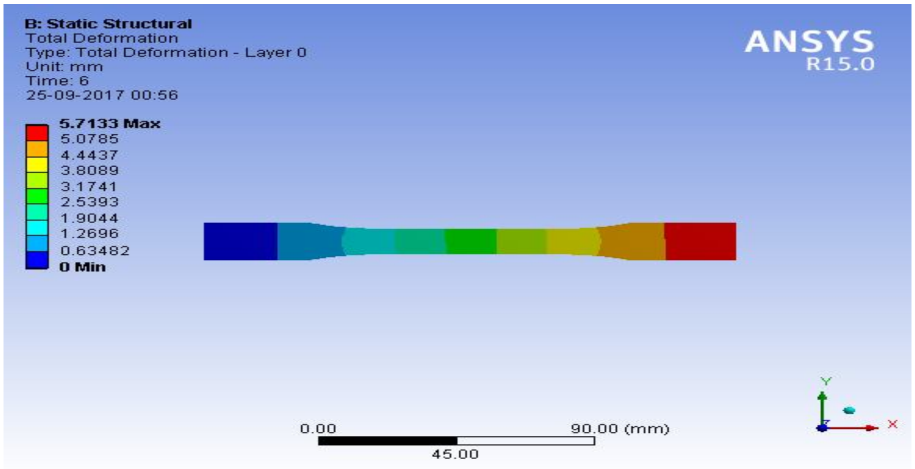


Figure 5.7 Result of deformation for composite material glass fiber-abaca-Carbone woven fiber -abaca-glass fiber for stacking sequence 0-45-90-135-180.

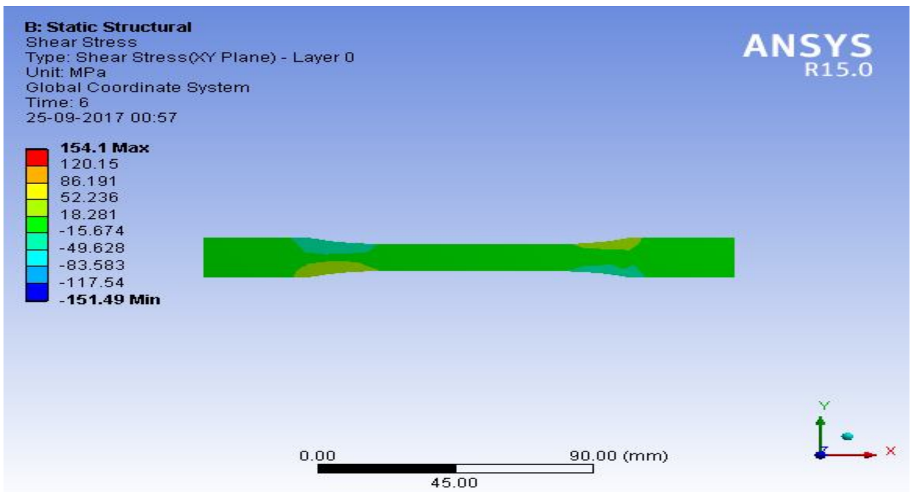


Figure 5.8 Result of shear stress for composite material glass fiber-abaca-Carbone woven fiber -abaca-glass fiber for stacking sequence 0-45-90-135-180.

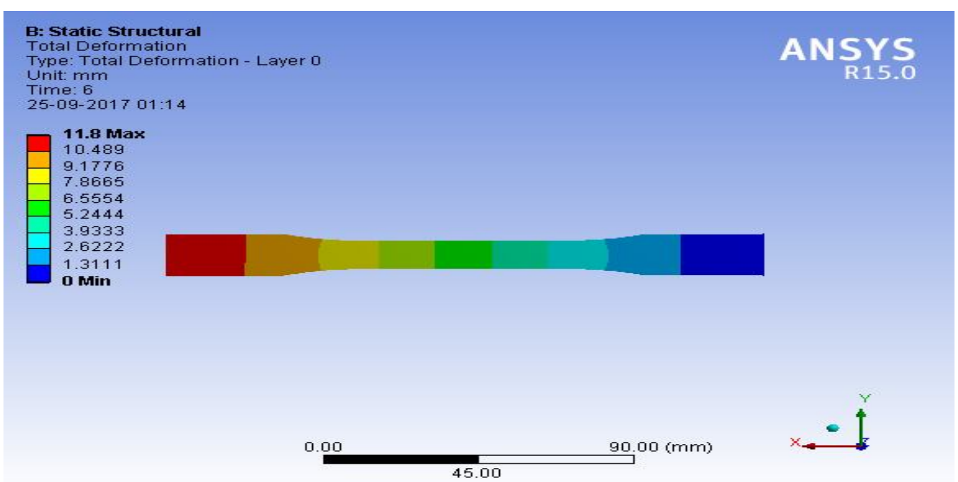


Figure 5.9 Result of deformation for composite material glass fiber-abaca- honeycomb -abaca-glass fiber for stacking sequence 0-45-90-135-180.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor :6.887
Volume 5 Issue XII December 2017- Available at www.ijraset.com

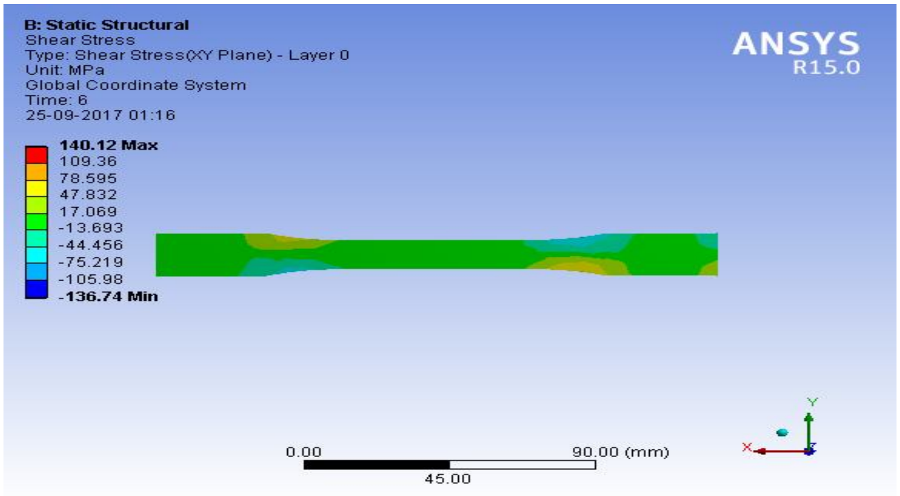


Figure 5.10 Result of shear stress for composite material glass fiber-abaca- honeycomb -abaca-glass fiber for stacking sequence 0-45-90-135-180.

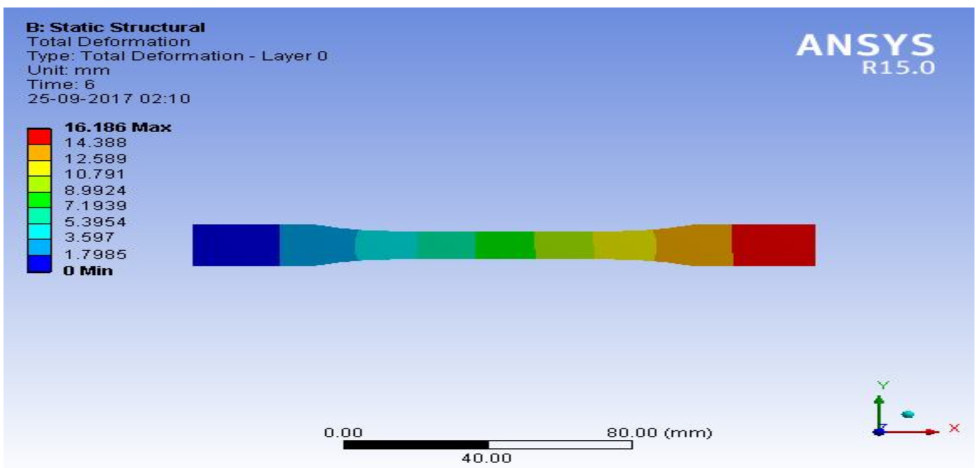


Figure 5.11 Result of deformation for composite material glass fiber-jute- honeycomb -jute-glass fiber for stacking sequence 0-45-90-135-180.

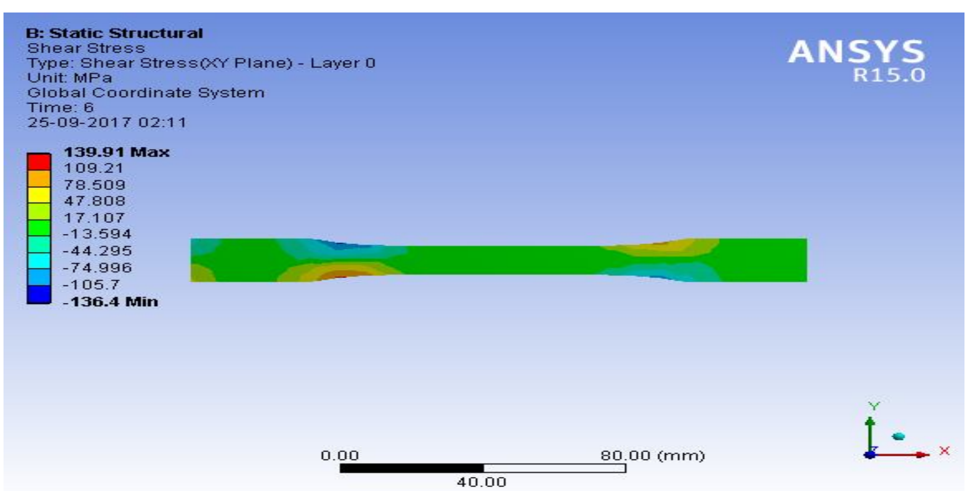


Figure 5.12 Result of shear stress for composite material glass fiber-jute- honeycomb -jute-glass fiber for stacking sequence 0-45-90-135-180.

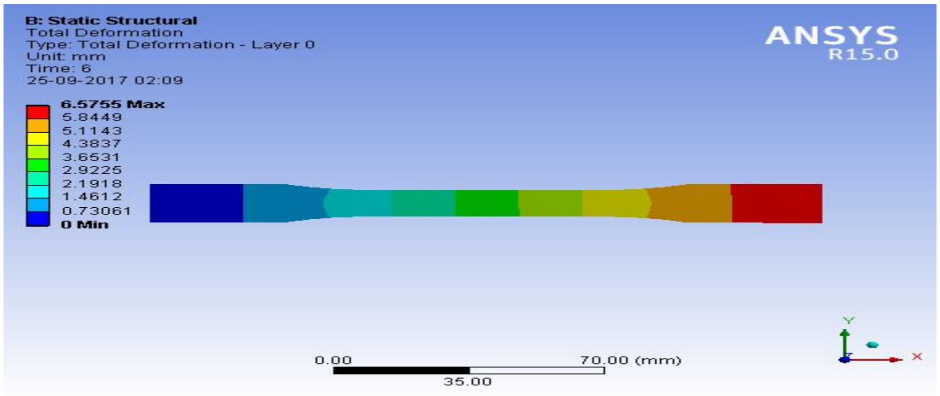


Figure 5.13 Result of deformation for composite material glass fiber- jute- carbon woven fiber -jute-glass fiber for stacking sequence 0-45-90-135-180.

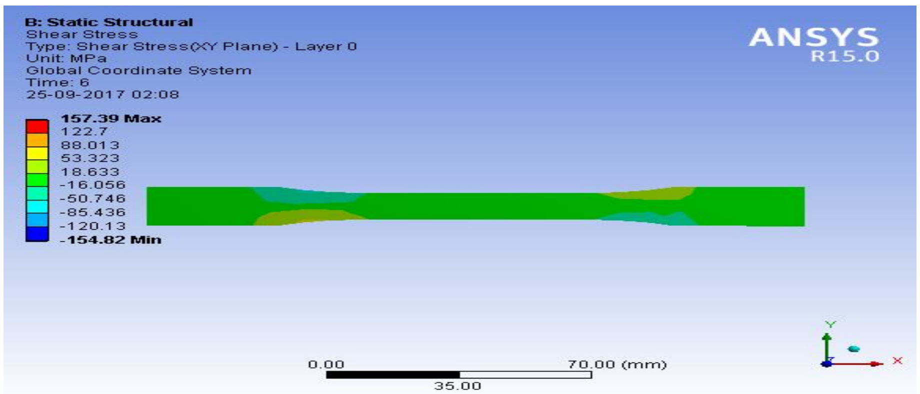


Figure 5.14 Result of shear stress for composite material glass fiber- jute- carbon woven fiber -jute-glass fiber for stacking sequence 0-45-90-135-180.

The all above results are summarized in form of table in as below.

Table 2 Effect on shear stress for different composite materials for stacking sequence 0-45-90-135-180

Composite material	Shear stress (MPa)
Glass fiber-abaca- honeycomb -abaca-glass fiber	140.12
Glass fiber-abaca-Carbone woven fiber -abaca-glass fiber	154.1
Glass fiber-abaca-Carbone UD-abaca-glass fiber	100.23
Glass fiber-jute- honeycomb -jute-glass fiber	139.91
Glass fiber- jute- carbon woven fiber -jute-glass fiber	157.39
Glass fiber-jute-Carbone UD-jute-glass fiber	93.66

Table 3 Effect on deformation for different composite materials for stacking sequence 0-45-90-135-180

Composite material	Deformation (mm)
Glass fiber-abaca- honeycomb -abaca-glass fiber	11.8
Glass fiber-abaca-Carbone woven fiber -abaca-glass fiber	5.71
Glass fiber-abaca-Carbone UD-abaca-glass fiber	3.48
Glass fiber-jute- honeycomb -jute-glass fiber	16.18
Glass fiber- jute- carbon woven fiber -jute-glass fiber	6.57
Glass fiber-jute-Carbone UD-jute-glass fiber	3.78

The FEM simulation results show that the shear stress and deformation is affected for different composite materials with same stacking sequence significantly as summarized below.
The shear stress is superior in case of Glass fiber- jute- carbon woven fiber -jute-glass fiber for stacking sequence 0-45-90-135-180 and the value is 157.39 MPa.
The deformationis superior in case of Glass fiber-jute- honeycomb -jute-glass fiber for stacking sequence 0-45-90-135-180 and the value is 16.18 mm.

V. CONCLUSION

A. In tensile test, the samples having higher abaca content exhibts better tensile properties. With reference to the orientation of the fibers, the samples fabricated with 45^{o} fiber orientation (Category III) excel well under tensile testing followed by parallel orientation (Category II) and then perpendicular orientation (Category I).

B. Sample 1 under exhibits ultimate tensile strength of 39.82 MPa and displacement at break load (mm) of which is greater than all other samples, which is validated by present ANSYS work. The specimen having 75% abaca content and 25% jute content (Sample 1) under Category III indicates highest tensile strength of 156.13 (with a factor of safety).It was found that in all the conducted tests, Samples made up of higher abaca content displayed better results and found to be superior to other test samplesThe FEM simulation results show that the shear stress and deformation is affected for different composite materials with same stacking sequence significantly as summarized below.

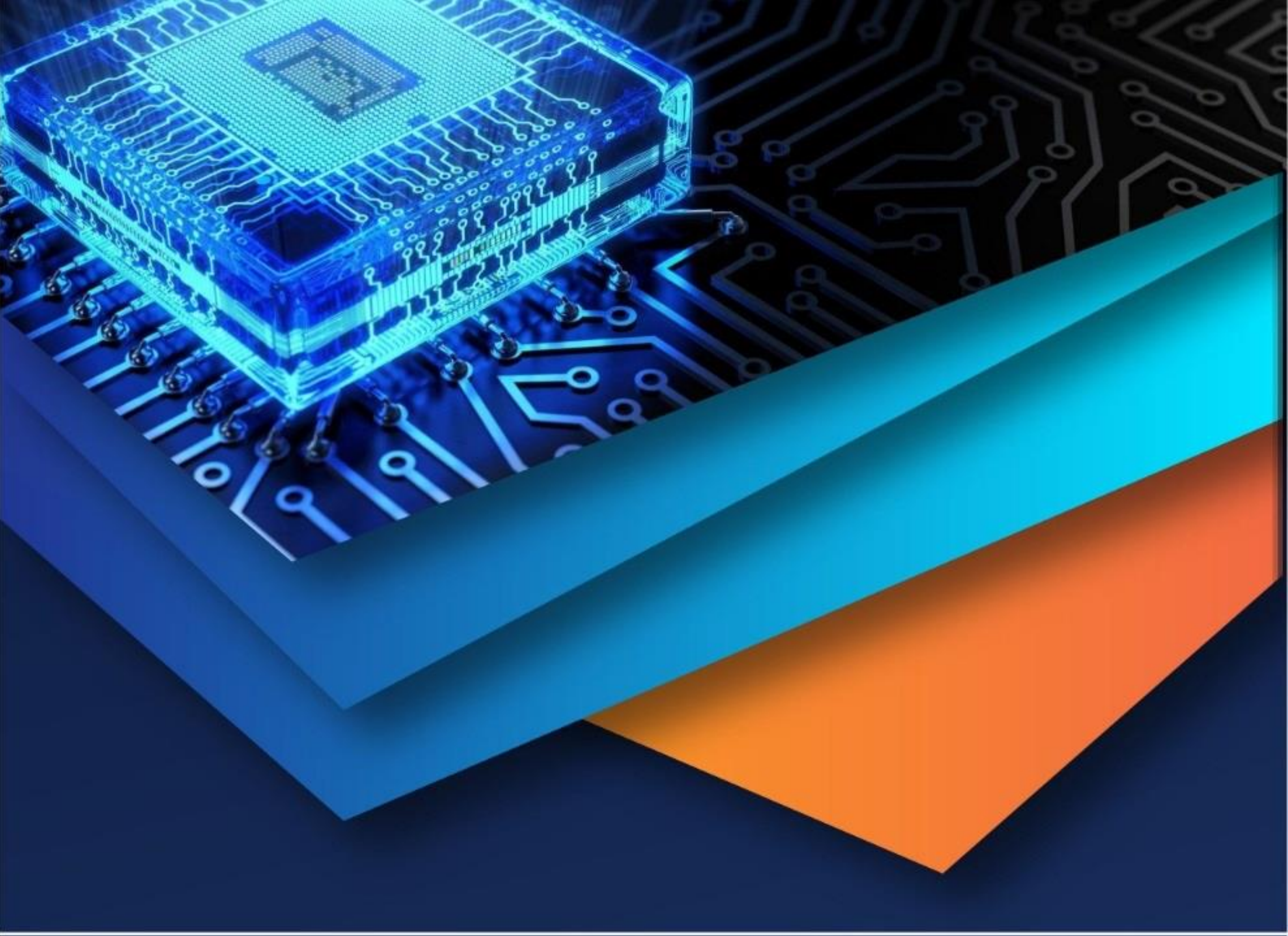
C. The shear stress is superior in case of Glass fiber- jute- carbon woven fiber -jute-glass fiber for stacking sequence 0-45-90-135-180 and the value is 157.39 MPa.

D. The deformationis superior in case of Glass fiber-jute- honeycomb -jute-glass fiber for stacking sequence 0-45-90-135-180 and the value is 16.18 mm.

REFERENCES

[1] Lucas James P. Delamination fracture: effect of fiber orientation on fracture of acontinuous fiber composite laminate. Eng Fract Mech 1992;3(42):543–61
[2] Nak-Ho Sung, Suh Nam P. Effect of fiber orientation on friction and wear offiber reinforced polymeric composites. Wear 1979;1(53):129–41
[3] Cirino M, Friedrich K, Pipes RB. The effect of fiber orientation on the abrasivewear behavior of polymer composite materials. Wear 1988;2(121):127–41
[4] Barkoula NM, Karger-Kocsis J. Effects of fiber content and relative fiber-orientation on the solid particle erosion of GF/PP composites. Wear 2002;1–2(252):80–7
[5] Prashanth Banakar, Shivananda HK, Niranjan HB. Influence of fiber orientationand thickness on tensile properties of laminated polymer composites. Int JPure Appl Sci Technol 2012;9(1):61–8
[6] Chandramouli K, Srinivasa Rao P, Pannirselvam N, Seshadri Sekhar T, Sravana P.Strength properties of glass fiber concrete. ARPN J Eng Appl Sci 2010;5(4):1–6
[7] Singh VK, Gope PC, Chauhan Sakshi, Bisht Deepak Singh. Mechanical behaviorof banana fiber based hybrid bio composites. J Mater Environ Sci2012;3(1):185–94
[8] Cicala G, Cristaldi G, Recca G, Ziegmann G, El-Sabbagh A, Dickert M. Propertiesand performances of various hybrid glass/natural fiber composites for curvedpipes. Mater Des 2009;30:2538–42.

[9] Bledzki Andrzej K, Jaszkiewicz Adam, Scherzer Dietrich. Mechanical propertiesof PLA composites with man-made cellulose and abaca fibers. Composites A2009;40:404–12.
[10] Liu Ke, Takagi Hitoshi, Yang Zhimao. Dependence of tensile properties of abacafiber fragments and its unidirectional composites on the fragment height inthe fiber stem. Composites A 2013;45:14–22.
[11] Miah MJ, Khan MA, Khan RA. Fabrication and characterization of jute fiberreinforced low density polyethylene based composites: effects of chemicaltreatment. J Sci Res 2011;3(2):249–59
[12] Bledzki Andrzej K, Mamun Abdullah A, Jaszkiewicz Adam, Erdmann Karsten.Polypropylene composites with enzyme modified abaca fiber. Compos SciTechnol 2010;70:854–60
[13] Kaleemulla KM, Siddeswarappa B. Influence of fiber orientation on the in-plane mechanical properties of laminated hybrid polymer composites. J ReinfPlast Compos 2010;29(12):1900–14
[14] Gironès J, Lopez JP, Vilaseca F, Bayer JR, Herrera-Franco PJ, Mutjé P.Biocomposites from Musa textilis and polypropylene. Evaluation of flexuralproperties and impact strength. Compos Sci Technol 2011;71:122–8
[15] Bledzki Andrzej K, Mamun Abdullah A, Feldmann Maik. Polyoxymethylenecomposites with natural and cellulose fibers: toughness and heat deflectiontemperature. Compos Sci Technol 2012;72:1870–4
[16] Sadeq Noor Sabah. Influence of natural fiber on the mechanical properties ofepoxy composites. Eng Technol J 2013;28(17):5629–36.
[17] Arbelaiz A, Fernandez B, Ramos JA, Retegi A, Llano-Ponte R, Mondragon I.Mechanical properties of short flax fiber bundle/polypropylene composites:Influence of matrix/fiber modification, fiber content, water uptake andrecycling. Compos Sci Technol 2005;65:1582–92.
[18] Nyambo Calistor, Mohanty Amar K, Misra Manjusri. Polylactide-basedrenewable green composites from agricultural residues and their hybrids.Biomacromolecules 2010;11:1654–60
[19] Mohanty AK, Misra M. Studies on jute composites—a literature review. Polym-Plast Technol Eng 1995;34(5):729–92.
[20] Improvement of physico-mechanical properties of jute fiber reinforcedpolypropylene composites by post-treatment. Compos Part A: Appl SciManuf 2008;39(11):1739–47.
[21] Vijaya Ramnath B, Junaid Kokan S, Niranjan Raja R, Sathyanarayanan R,Elanchezhian C, Rajendra Prasad A, et al. Evaluation of mechanical propertiesof abaca–jute–glass fiber reinforced epoxy composite. Mater Des2013;51:357–66.
[22] Niranjan Raja R, Junaid Kokan S, Sathya Narayanan R, Rajesh S,Manickavasagam VM, Vijaya Ramnath B, et al. Fabrication and testing ofabaca fiber reinforced epoxy composites for automotive applications. AdvMater Res 2013(718–720):63–8.
[23] Symington Mark C, Banks William M, West Opukuro David, Pethrick RA.Tensile testing of cellulose based natural fibers for structural compositeapplications. J Compos Mater 2009;43(9):1083–108
[24] Rezaur Rahman Md, Monimul Huque Md, Nazrul Islam Md, Hasan Mahbub.Mechanical properties of polypropylene composites reinforced withchemically treated abaca. Compos Part A: Appl Sci Manuf 2009;40(4):511–7.
[25] Venkateshwaran N, ElayaPerumal A, Alavudeen A, Thiruchitrambalam M.Mechanical and water absorption behavior of banana/sisal reinforced hybridcomposites. Mater Des 2011;32(7):4017–21.
[26] B. Vijaya Ramnath[1] , V.M. Manickavasagam[2] , C. Elanchezhian[3] , C. Vinodh Krishna [5], S. Karthik[6] ,K. Saravanan[7] Determination of mechanical properties of intra-layer abaca–jute–glass fiber reinforced composite. Journal homepage: www.elsevier.com/locate/matdes Materials and Design 60 (2014) 643–652.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY