Mechanical Characterization of E-Glass Mat, Kenaf Mat and Flax Mat Reinforced Hybrid Composite Materials

[*]Snehlata Pandey, [#]Atul kumar Tiwari

[*]Student, [#]Associate Professor, [*,#]Sagar Institute of Technology and Management, Barabanki U.P, India, [*]sneh1710.pandey@gmail.com, [#]smsatulkumar@gmail.com

Abstract—In present scenario, natural fiber reinforced composites have raised more attention for the growth of biodegradable material and are somewhat replacing presently used artificial fibers. Natural fibers able to replace the synthetic fibers that it has the eminent benefits of like low density, small manufacturing cost, its availability, ease of manufacture, low development energy, non-abrasive, worthy acoustic property, biodegradability, reasonable mechanical strength, renewability. composite were made-up by hand lay-up method with the bidirectional natural fibers and epoxy resin in a mould and cured under gradual pressure. In this research paper mechanical behavior such as tensile, impact, indentation capacity and water absorption test of E-Glass and kenaf/flax mat reinforced hybrid composite materials (GKFHC)studied. The purpose of this work to investigate the mechanical characterization of the hybrid composite material. Sample was prepared and tested accordance to the ASTM standards.

Keywords—ASTM Standard, Bidirectional, Charcterization, GKFHC, Hand-layup, Indentation.

I. INTRODUCTION

Synthetic fiber based composite is replaced by the bio based composite because the synthetic based composite consists of the gasoline built artificial fibers and resins, it causes major biological, conservational and universal energy disaster[1]. The natural fiber is more unfailing and abundantly obtainable substitute to exclusive and non-reliable artificial fibers[2],[3]. At the present scenario there is high awareness about the environmental rules and regulation therefore the synthetic fibers are exchange with the decomposable fibers[4]. The synthetic fiber is like glass, carbon, aramid and the natural fibers are flax, hemp, jute, kapok, kenaf, henequen, sun hemp, begaasse etc[5].When two or more materials which having different properties are coalescing collected to form a composite material. Composite materials are consisting with two parts, first one is reinforcement and another one is matrix. The reinforcement having large load carrying capacity while the matrix is weaker. Matrix are used for transferring the stress in between the reinforcing particle while the presence of particles or fibers in the composite materials are increasing the mechanical properties (tensile strength, flexural strength, hardness, impact strength etc.). Composite consist of two distinct phase in which one is continuous and next one is discontinuous. The hybrid composite materials are formed due to discontinuous phase is implanted into the continuous phase. Reinforcing phase occur in the two forms either fibrous or non-fibrous. [6]. Natural fiber reinforced polymer composite also known as fibrous composite consist of the matrix and fiber as a reinforcement. In the present scenario these hybrid composite has found tha application in the different field like marine, sports equipment, aerospace, automotive etc. due to their specific strength and stiffness. Usually, fiber used as reinforcement which help to fulfill the required condition and allocate strength into the matrix component, impelling and improving their preferred properties. Fiber is categorized by its length which is greater than its b cross sectional magnitudes. Matrix effected the properties of the fibers. [7]

The strength of the natural fiber reinforced hybrid composite depend upon the chemical stability, fiber strength, bonding between the matrix and reinforced material to permit stress transfer, fiber strength.[8]. The natural fiber has some limitations like it have the low mechanical properties comparatively synthetic fiber composite, poor resistive to the water absorption. Henceforth, natural fiber with polymer matrix provide the adequate mechanical properties. [9].

II. MATERIAL

A. Kenaf Mat

It belong to the Hibiscus cannabinus family L. family Malvacea.It is obtained by the bast. It implants in the month of May to December grown up from 6-8 month achieve height of 5-6 m quickly at the 20-27^0 C temperature. It is harvested by hand and machine both. Its retting process is same as jute fiber. Plant stem is

 DOI : 10.35291/2454-9150.2019.0025

immersed into water for 7-14 days after that wash out with fresh water and dried out. Retting is the method of take out the fiber from stem or bast of the plant. When the kenaf stem is retted, the stem is collected in bundles and punched with wooden hammer to prepare the fiber loose from the kenaf core. The fiber is washed away with water and press the dehydration. kenaf have good tensile strength, It is purchased by the Viruska Composite, vijaybada.

Table 1: Chemical properties of kenaf fiber [10]

Cellulose	45–57 %
Hemicellulose	21.5 %
Lignin	8-13 %
Pectin	5-8 %

Figure 1:kenaf mat(00 / 900 orientation)

B. Glass Mat

It is low alkali glass which contain 54 wt.% of silicon oxide ,14 wt.% of aluminum oxide, 22 wt.% of calcium and magnesium oxide, 10 wt.% of boron oxide and less than 2 wt.% of sodium and potassium oxide.it is also known as alumina calcium borosilicate It is manufactures by the melt spinning technique. It is manufactured by the extrusion of thin silica gel with small diameter into various fiber. Due to its weight properties it is more favorable than the metals. Glass mat is produced by machine. E glass fiber have good dimensional stability, moisture resistance, specific properties, thermal properties, high tensile strength, good electric insulator. It is not effected by the organic solvent. It is opaque and transmission property ultra- violent towards violet transmission. Woven glass contains very fine fibers of the glass. Glass mat is bought through the Viruska Composite, Vijaybada.

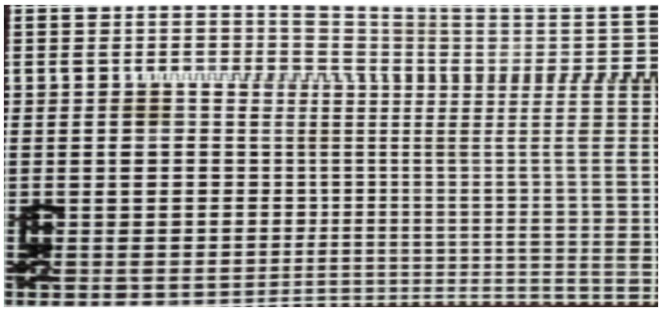

Figure 2:E-Glass Mat(00 / 900 orientation)

C. Flax Mat

It is sown in month of march & April. Flax fiber is grown up in very short time period about in 100 days. It contains small branches and long fibers. The different steps are involved for the processing of the flax fiber like cultivation, harvesting, ripping, retting, scotching and hackling. It is procured by the Viruska Composite, vijaybada.

Table 2: Chemical properties of flax fiber [10]

Cellulose	71%
Hemicellulose	18.6–20.6 %
Lignin	2-3%
Pectin	2.3%

Figure 3:Flax Mat(00 / 900 orientation)

D. Epoxy Resin

Epoxy is procured by the Singhal Traders, Merrut. It is the part of thermosetting resin. Araldite LY 556 epoxy manufactured by the Huntsman Advanced Materials which follow the certain properties which is used by the matrix materials

1) Insulating capacity
2) Easy to access
3) Prolonged open time.
4) Chemical resistive
5) Provide good dimensional stability

For epoxy hardener as a preserving agent. Hardener work as a catalyst when combine with resin. It hardens the material due to evolution of heat by the exothermic reaction. The Mixing of epoxy with hardener provide the good characteristics for the environment. HY951 is used as a hardener in this experiment.it contain the 10-20MPa viscosity with 25^0C.

Figure 4: Eproxy and Hardner

III. FABRICATION

Hand layup method is used for formulating hybrid composite material as shown in figure 5. Natural fiber is used as reinforcement and epoxy is used as matrix. To fabricate the mould of the dimension (600x300x10mm)

 DOI : 10.35291/2454-9150.2019.0025

with marble. Brush is used for cleaning the inner surfaces and other impurities.Initially, a release gel (wax) is scattered on the mould surface to evade the stabbing of epoxy on the surface Two wooden frame is prepared of having dimensions(420x240x5mm). Accumulate the mats of the glass, kenaf and flax and placed it on the mould longitudinally. Mats are cut in the according to the mould size. Epoxy –hardener mixer is poured onto the surface of the mat which is located in the mould. One fiber mat is placed over the other surface of the mat. This process is continual after each layer of epoxy and mat until unless essential layer is stacked. C clamp is used with the mild pressure for removing any air stuck as well as additional epoxy remaining. After that fixed load is applied through the C-clamp and leave for the 48 hours Fabricated composite part is taken out from the mould at 55% humidity at room temperature.[11]

Figure 5: Frame

Figure 6: Mould

Finally, the hybrid composite sheet is prepared having a dimension of (300×200×6) mm. It is characterized by the different mechanical parameters like tensile,impact, hardeness and water absorption test. It is cut by the diamond tip hand cutter.

Figure 7: Final composite sheet

Figure 8: Side view of the final composite

IV. TESTING AND RESULT

A. Tensile Testing

Tensile test deals with the maximum amount of the stress sustain by the material before the fracture. Specimen are cut as per the ASTM 3039 [12]. The testing was carried out on ASI Sales Pvt. Ltd**.** universal testing machine Model No-ASI 40 having capacity 400 KN. Through this testing the the ultimate tensile strength, modulus value and strain determined. The specien is hold by the grip and load applied until the failure occurs.Figure 9(a)& 9(b) shows the digital UTM machine before and after holding the specimen in the jaw.

Figure 9(a): Digital UTM

 DOI : 10.35291/2454-9150.2019.0025

Figure 9(b): Specimen fixed hinged job

Figure 10(a) & 10(b) shows the tensile test of the specimen before and after fracture respectively. It shows that breaking obtained at the neck points.

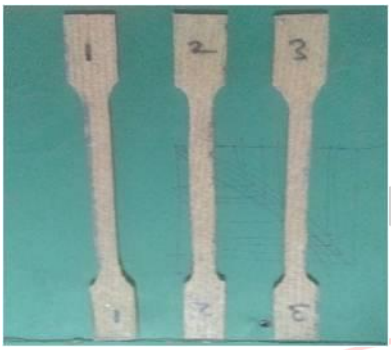

Figure 10(a): Tensile Specimen before Fracture

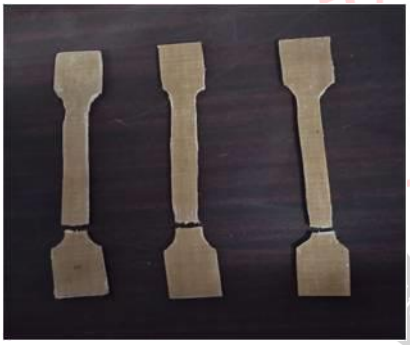

Figure 10(b) :Tensile Specimen after Fracture

Figure 11 shows the stress strain curve of the hybrid composite material , which indicate the 27MPa is the ultimate tensile strength and 330MPa is the young modulous. 52.37% elongation is obtained.

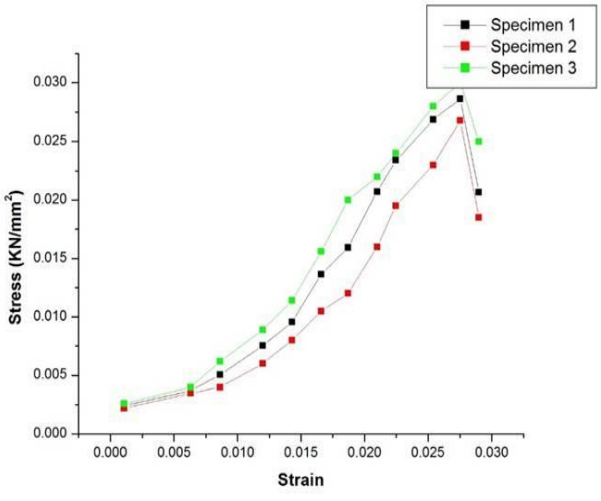

Figure 11:Stress strain curve of GKFHC

B. Impact Test

The Pendulum Impact Tester Model AI - IT 30 was designed for conducting Izodtest. This machine was used for impact testing.Specimen are designed as per the ASTM D256 [13]. Izod test provide the impact strength of the material. With the help of this experiment the impact strength is 63.33 J/m which have better strength than other hybrid composite material. The figure 13(a) and 13(b) shows the impact strength before and after the impact testing.

Figure 12: Impact Machine

Figure 13(a): Impact Specimen Before Fracture

Figure 13(b): Impact Specimen Before Fracture

C. Hardness Test

Digitally hardness testing machine measure the indentation capacity of the material. This machine has model RBHT, M scale which having specification are 100 Kgf load carrying capacity, M scale, 1/4'' ball indenter. The GKFHC shows the 62.33 (mean value) which is more harden the other natural fiber composite.

 DOI : 10.35291/2454-9150.2019.0025

Figure 14(a):Digital Hardness Tester

Figure 14(b): Hardness Test Reading on M scale

D. Density of GKFHC

Three hybrid composites specimens were cut as per test standards which is square shape with dimension 60x40x5 mm. The volume was calculated from the measured dimension. The all hybrid composites specimens' density was then recorded. Density was measured by using ASTM D 1895 standard [14]. The density of hybrid composites – 0.806 gm/cm^3.

E. Water Absorption Test

The water absorption test conducted in chemistry lab of the sagar institute of technology and management at 22◦C & 55% humidity. Experiment was carried out for 48 hours. A rectangular piece (60mm×40mm×6mm) was immersed in beaker of 250ml water for 48 hours. The water used for testing is brought by the Harsh aqua Tech india,lucknow. 500ml water was supplied by the company.Figure 15(a),15(b),15(c) shows the water absorption tet of the specimen.

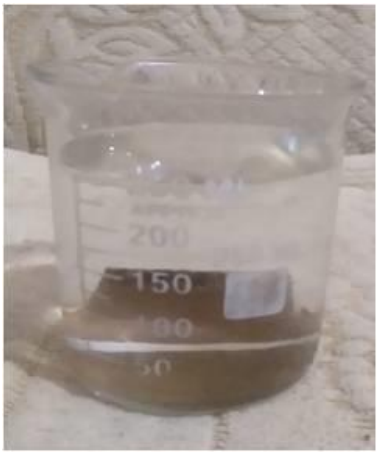

Figure 15(a): Sea Water

Figure 15(b): Distilled Water

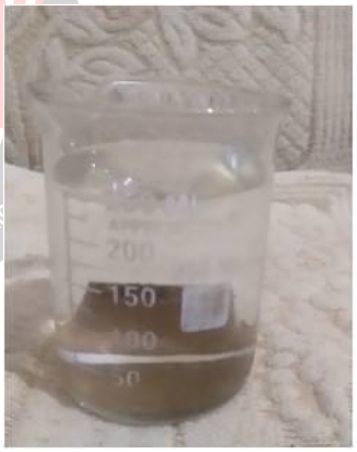

Figure 15(c): Borewell Water

 DOI : 10.35291/2454-9150.2019.0025

The weighing balance is used for measuring the weight which is manufactured by the Ohaus, China.This test is performed as per the ASTM D570 standarads [15],[16] Its least count is 0.01g. initial weight of the specimen was 8g. After 4 hrs. the weight of the work piece measured. The figure 17 show the water absorption curve in the change in weight percentage and time.

Figure 16: Weighing balance

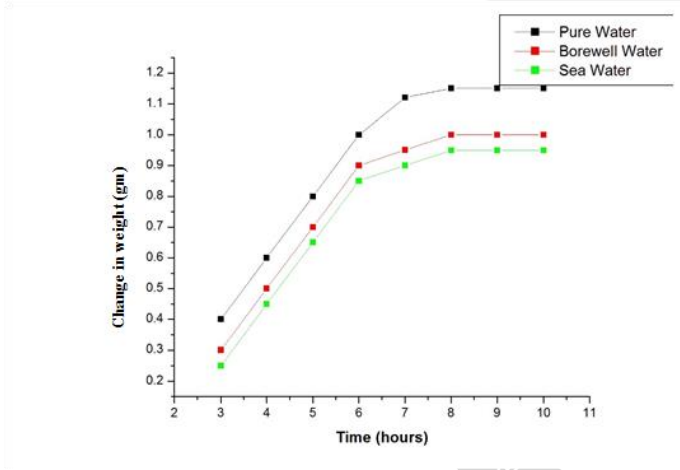

Figure 17:Weight Absorbtion Test

V. CONCLUSIONS

The present investigation a hybrid composite (GKFHC) is made with polymer matrix (Epoxy Resin). Various mechanical tests are performed as per ASTM standards.

1) There is 22.48% increase in Ultimate tensile strength of GKFHC Composite(27MPa) by adding kenaf and flaxfibre with glass in comparison to Banana and jute with the glass fibre natural hybrid composite and 13.7% greator than the jute/sisal/glass.[17],[18]

2) The impact strength of the GKFHC(63.33J/m) is 85.78% increase than the jute/banana with the glass fiber[19].

3) The maximum amount of water absorbed by the puerwater.The hybrid composite material GKFHC have low water absorption rate than the individually woven composite material. The water absorption rate dependuponthe cellulosic and hemicellulosic content. The GKFHC composite absorbed water upto its saturation point, after that the absorption of water did not takes place until it immersed in the water for the infinite time period.[20],[21]

4) Density of GKFHC composite is 0.8067 gm/cm^3 which is very less then other glass fibre composite

5) There is improvement (25.12%) in hardness of GKFHC Composite(62.33) in comparison to Bagasse and coconut coir glass fibre natural hybrid composite.

VI. APPLICATION

The various application of the hybrid composite materials are in Construction industry, Automobile interior, Railway coach, Everyday application, smart structure, Packaging industry.

ACKNOWLEDGMENT

The author would like to thank **Dr. Shimant,** Director , **Mr Atul Shukla** Head of Department (HOD) of Mechanical Engineering, Sagar Institute of technology & Management and **Mr. A. K. Srivastava,** Head of Department (HOD) of Mechanical Engineering, Ansal Technical Campus, Lucknow-226030, U.P, India.

REFERENCES

[1] T.P. Sathishkumar, P. Navaneethakrishnan, Shankar. “characterization of natural fiber and composite-a review”. J ReinfPlast Camp 32:1446-1465, 2013.

[2] A.K. Srivastava, R. Shukla, “To develop and evaluate impact behaviour of Jute fibre reinforced composite” International journal of Mechanical and Industrial engineering (IJMIE).ISSNNo. 2231 – 6477, Vol-3, Iss.-2, pp. 31-34, 2016

[3] Alavudeen, N. Venkateshwaran, ” Review of natural fibre reinforced woven composite” Rev. Adv. Material Science, Volume number 27, 146-150, 2011.

[4] K.L. Pickering, M.G. AruanEfendy, T.M. Le, “A review of recent development in natural fiber composites and their mechanical performance”. ELESVIER, Part A 83, 98-112, 2016.

[5] Jawaid M and Abdul Khalil HPS. “Cellulosic/synthetic fiber reinforced polymer hybrid composite”. Carbohydrate Polym , 86;1-18, 2011.

[6] N. Venkateshwaran, A. Elayaperumal, G.K. Sathiya, “Prediction of tensile properties of hybrid-natural fiber composites” elesvier, Part B 43, 793–796, 2012.

[7] M. Muthuvel, G. Ranganath, K. Srinivasan, characterization of the jute and glass fiber einforced hybrid composite material” International journal of engineering research and technology ISSN;2278-0181, 2016.

 DOI : 10.35291/2454-9150.2019.0025

[8] Subhanalijog, Muhammad Moazambaloch, Alidadchandio, Iftikhar Ahmedmemon, and Ghulam Sarwar Chandio, "Evaluation of Impact Strength of Epoxy Based Hybrid Composites Reinforced with E-Glass/Kevlar 49" . HAL Id: hal-01705594, 2017

[9] Ji riMilitky ,abuljabbar, " comparative evaluation of fiber treatments on the creep behavior of the jute/green epoxy composite". Published by Elsevier Ltd. composite part B 80, 361e368, 2015.

[10] R. SasiKumar,V. S. Dharun, R. Prabhu, "Flexural Response of Advanced Hybrid Composites" Proceeding of National Conference on Advances in Mechanical Engineering (NME'2015) held on 30.04.2015 at Regional Office, Anna University Tirunelveli Region, Tirunelveli – 627 007, 2015.

[11] H.M. Akil, M.F. Omar, A.A.M. Mazuki, S. Safiee, Z.A.M. Ishak, A. Abu Bakar, "Kenaf fiber reinforced composites: A review"Materials and Design 32 ,4107–4121, 2011.

[12] G. Velmurugan, S. P. Venkatesan, P. V. Prakash, N. Sathishkumar, N. Vijayakumar, "Mechanical Testing of Hybrid Composite Material (Sisal and Coir)" International Journal of Scientific and Research Publications, Volume 4, Issue 7, ISSN 2250-3153, 2014.

[13] Asif Ahmed .A, Dr. Keerthiprasad K. S, "Development and Characterization of Natural Hybrid Composite using Basalt and Bamboo Fibers" International Research Journal of Engineering and Technology (IRJET) Volume: 05 Issue: 12 | Dec 2018.

[14] M. Jawaid, " Hybrid composites of oil palm empty fruit bunches/woven jute fiber: chemical resistance, physical and impact properties" Journal of Composite Materials 2011 45: 2515 originally published online 10 May 2011.

[15] Camilla Medeiros Dantas ,Raimundo Carlos Silverio Freire Júnior, "Influence of the Quantity of Water Absorption in the Mechanical Properties of Jute Fiber and Glass Fiber Composites" Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 24 May 2018.

[16] A B Maslinda, M S Abdul Majid , M J M Ridzuan and AR.A. Syayuthi, "Water absorption behaviour of hybrid interwoven cellulosic fibre composites" ournal of Physics: Conf. Series 908 (2017) 01 2015.

[17] P. Parandaman and M. Jayaraman, "Experimental Investigation on the Mechanical Properties of Jute/Sisal/Glass and Jute/Banana/Glass Hybrid Composite Materials" European Journal of Applied Sciences 7 (3): 138-144, 2015.

[18] M. Harikrishna, K.Ajeeth, S,Ranganatha and C.Thiagarajan. " fabrication and mechanical properties of hybrid natural fiber composites (Jute/Banana/Glass)" International Journal of Pure and Applied Mathematics Volume 119 No. 15, 685-696, 2018.

[19] P. B. Lokar , S. K. Ghola, N. K. Gavade, "To Develop and Evaluate Impact Behaviour of Natural Fibre Reinforced Composite-Review" International Journal For Engineering Applications and Technology [143-147]

[20] Sanjay M. R. , B. Yogesha " Study on Water Absorption Behaviour of Jute and Kenaf Fabric Reinforced Epoxy Composites: Hybridization Effect of E-Glass Fabric" International Journal of Composite Materials, 6(2): 55-62, 2016.

[21] Girisha. C, murthy, Gunti Ranga Srinivas , "Sisal/Coconut Coir Natural Fibers Epoxy Composites: WaterAbsorption and Mechanical Properties" . International Journal of Engineering and Innovative Technology (IJEIT), Volume 2,Issue 3, September 2012 .

 DOI : 10.35291/2454-9150.2019.0025