NOVATEUR PUBLICATIONS
International Journal of Innovations in Engineering Research and Technology [IJIERT], ISSN: 2394-3696
Conference Proceedings of i - Mechanical Engineering Students Conference 2018 (i – MESCON 18)
28th December, 2018

PAPER ID –D05

COCONUT FIBER COMPOSITES: A REVIEW

Shubham Bankar
Dept. of Mechanical Engineering, Indira College of Engineering and Managemen Pune, India
bankarshubham1@gmail.com
Ganesh Raut
dept.of mechanical engineering, Indira College Of Engineering and Management, Pune, India
ganeshraut1169@gmail.com
Akash Galande
dept.of mechanical engineering, Indira College Of Engineering and Management, Pune, India akashgalande05@gmail.com
Rnjitsinh Mule
dept.of mechanical engineering, Indira College Of Engineering and Management, Pune, India muleranjitsinh7323@gmail.com
Prof. S. B. Chopade
Asst. Professor, Dept.of Mechanical Engineering, Indira College of Engineering and Management Pune, India
sushchopade607515@gmail.com

Abstract—

Over the last three decades, plastics, ceramics and composite materials have been the dominant emerging materials. The number of applications of composite materials have been increased continuously, powerfully and conquering new markets persistently. Modern composite materials constitute a substantial proportion of the engineering materials, market ranging from everyday products to sophisticated niche applications. While it have been already proven that composites are weight saving materials. In today's scenario challenge to researcher is to make composites cost effective. This review paper discuss about natural coconut fibersits applications. Also, this paper concentrates on Mechanical properties of coconut fiber composites.

Keywords—coconut fibers, composite, mechanical properties

I. INTRODUCTION

The composite material has been used from centuries ago, and it all started with natural fibers. Natural fibers have become one of the important items in the economy and in fact, they have turn out to be a significant source of jobs for developing countries. Today, naturalfibersare assessed as an environmentally correct material due to their biodegradability and renewable characteristics. Natural fibers like sisal, jute, coir, oil palm fiber have all been proved to be good reinforcement in thermo set and thermoplastic matrices. The cumulative interest in automotive, cosmetic etc. application has heightened the need of natural fibers reinforced composites in these regimes as it offers an economic and environmental advantage over traditional inorganic reinforcements. [1]Therefore, many industrial companies are looking for new composites material which has good and specific properties like mechanical, chemical and dynamic characteristic. In searching for such new material, a study has been made where coconut fiber (also known as coir fiber) is compounded with composite material. Coir is the natural fiber of the coconut husk where it is a thick and coarse but durable fiber. It is relatively water-proof and has resistant to damage by salt water and microbial degradation.[2]

This paper gives a review on coconut fiber composites with different epoxy resins and focuses on the mechanical properties of coconut fibers.

II. LITERATURE REVIEW

P N E Naveen and M Yasaswi[2] measured a mechanical properties of coconut fiber composites First the steel mould of size 210 x 210 x 210 mm was fabricated. Mechanical properties of material such as strength, toughness, elastic modulus and ductility are measured by result from tensile test on specimen. The 5 sample were tested using universal testing machine. Stress strain diagram was made. The mechanical properties of coir fiber composites depends on content or volume fraction of fiber. Tensile strength and young's modulus decreased as increasing fiber volume fraction. The tensile strength of composite decreases with increasing fiber volume. The failure strain increases 3.4% to 5.8% when the volume percentage in fiber 5 to 12.5%. The fiber length also have effect on mechanical properties on composites. It was found that increase in fiber length increase the tensile strength and flexural strength in composite.

S.Stephano, V.G.Thurbius Galdius[3]focusedon use of more environmental friendly products. Natural fiber reinforced composites materials are used to replace the synthetic materials. They used the coconut fiber as natural fiber. Coconut fiber was chemically treated with diluted sodium hydroxide before using it as a composite material. After the alkaline treatment with sodium hydroxide it was found that the tensile strength was increased by 33%, flexural strength was increased with 35% and impact strength was doubled. It was concluded that the mechanical properties enhanced after chemical treatment and improved the formation of chemical bonds between the coir epoxy resins with the coupling agent.

Mulinari D.R et al.[4]Given the information regarding the importance of using natural composites. Coconut fiber were extracted from exocarp and dried for 24 hours. Soluble extractives were removed by pretreatment of coconut fiber with alkaline solution. Characteristics of coconut fiber like surface morphology was tested by Scanning Electron Microscopy(SEM). The chemical structure of coconut fiber were evaluated by fourier transform infrared spectroscopy. The composites were manufactured in a glass mould of size 250x250 mm. composites were prepared manually by mixing polyester resin and treated coconut fiber. The component were prepared and mechanical test were founded by using servo-hydraul MTS model 810.233M. The form and dimensions of

the sample tension and tension fatigue were carried out according to the ASTM standards D3039.
By examining the surface with SEM it was found that untreated fiber showed large amount of debris adhering to surface because the coating of non cellulose materials. It was observed that the alkaline treatment removed the wax, pectin, lignin and hemicellulose on the coconut fiber surface. This caused the increase in roughness of fibers and maximized the adhesion between the fiber and matrix.

C.R.Rajeesh, K.K.Saju[5] have given review on coir fiber based composite boards and its flammability characteristics as it is under study still, increased demand of natural fiber composites needs more study of characteristics and properties of materials. Unconventional building materials like natural fiber reinforced composites have become economical due to their renewability and ease of renewability. Medium density coir boards, coir faced block boards, coir veneer boards and coir hard boards are produced with use synthetic resins like phenol formaldehyde binder by applying heat and pressure for a required time. The combination of different types of fire retardants with different proportions are used to produce additive effect. Phosphorus based fire retardants, nitrogen based fire retardants, halogen based fire retardants, and inorganic based fire retardants are used to avoid flammability behavior. To apply the fire retardants pressure impregnation process, full cell process, empty cell process is used. In pressure impregnation process the application of pressure to force fire retardant into the material by using pressurized cylinder is the efficient and easy way to obtain good absorption values. It is found that combination of phosphorous and nitrogen provides the good opposition to the flammability nature of coir composites or cellulose materials. More research is going on to develop fire retardant coir composites with self-extinguishing characteristics.

Rahul Shrivastavaet.al[6] have explained about alkaline treatment on natural fibers composite. According to them naturalfiber composites contains cellulose, pectin, lignin and hemicellulose which is the reason of the hydrophilic nature of natural composites. Cellulose contain affects the mechanical properties of composites. Alkaline treatment is done on the fibers and then different batches of fibers are treated with dicumyl peroxide treatment, sodium hypochlorite treatment, acrylic acid treatment. These treatment changes the surface properties of fiber, it removes the wax and non cellulose materials causing the weight change in fiber and making it rougher. It upsurges the adhesion between the fiber and matrix. It was found that the increase in fiber content in dry atmosphere greater the tensile strength and flexural stiffness compared to moist environment.
Coir fiber and woven E glass fiber were used as reinforcement materials and thermosetting polymer epoxy as a binder. Coir fiber undergone through alkaline treatment and then dried. Mould of 150mm x140mm x40 mm is used to fabricate composite. ASTM D3039 standards are used for tensile testing performed on universal testing machine. After testing it was found that the length and amount of fiber affects the tensile strength. Tensile strength reduces for the longer fiber placed longitudinally due to its wavy nature which causes the improper alignment of fiber.10 mm coir fiber shows the tensile strength of 40.7 Mpa and 15mm shows the tensile strength of 32.52 Mpa.

TP Sathishkumar et.al[7] reported Mechanical Properties and absorption capability of the natural fiber composites. In this they have used natural fibers of various types like coconut fiber, sisal fiber, agave fiber, roselle fiber, bamboo etc. the fibers were immersed in the water for some days and then dried. The dried natural fiber was chopped in different length. The length, diameter and cross sectional area composites was measured by using scanning electron microscopy. After this it was found that the natural fiber contains cellulose macro-fibrils in an amorphous matrix. The low content of wax and cellulose improves the properties of composites materials. The crystalline index of the coconut fibers were determined by x-ray diffraction. Thermo gravimetric analysis reported that weight loss in fibers may be associated with the loss of water content. The raw fibers had high moisture content. After alkaline treatment the moisture content was reduced and thermal stability was increased. The mechanical properties were measured based on the ASTM D 3822-01 by applying various loads. To form the composite, short coir fibers were mixed in material consisting unsaturated polyester resin, cobalt octoate accelerator and mythy ethyl ketone peroxide in a ratio of 1:0.015. Composite sheet was formed by using mould of dimensions of 300mm x 150mm x 3mm. the properties of untreated natural fiber composites were found to be less than the treated natural fiber composites.

Fairuz I. Romli et.al[8] explained that the natural fiber composites has a potential to become future replacement of many plastic and polymer product applications. Natural fiber composites have properties like low density, low cost, high toughness and a reasonable strength. Coconut fiber and coconut husk are used in various applications like building materials and household applications, and for aerospace applications. Epoxy and hardener were mixed at 4:1 ratio to form the matrix. To clean by the mould fabrication. The curing time, coir fiber volume fraction and the applied compression load were varied through the testing. The mild steel plate of thickness 6mm and width 80mm were used to fabricate the sheet. As per the ASTM D638 Standard the sheet was cut into the dog-bone type. After the testing it was found that for 24hr curing time the tensile strength increase with increase in coir fiber volume and compression load but after 48hr curing time it started to decrease. The tensile strength data was then entered into MATLAB for analysis.

Celso Pires et.al[9] according to them, unripe coconut husk contains high amount of lignin and cellulose which can act as a natural binder under suitable conditions of pressure and temperature.
Unripe coconut husk was processed to separate the pith and fiber. Then it was washed and dried for 5days under the sun. To prepare fiberboards white coir pith and fiber where mixed in 7:3 proportion. Mixture was evenly distributed in the mould of size 110 x 110 mm. The densities of fiberboards were determined by taking ratio of mass and volume. Mechanical characterization was carried out with sample of 110 x 15 x 5 mm. The white coir fiber contains 38.7% of lignin, 24% hemicellulose, 27% alpha cellulose 8.2% moisture, 2.3% ash, 3.7% extractives. The factors like age of the fruit, variety and the environment affect the chemical composition improving mechanical properties. Presence of xylose increases swelling of fiberboards. Boards were made by pressing white coir fiber

and pith at 220°C with different pressure. The boards were made at different temperature; the board made at 210°C contains the highest modulus of elasticity. Auto-cross linking of wood polymers increase the modulus of elasticity but reduces tensile strength. The use of appropriate temperature of improves the cure of lignin and cellulose while higher temperature may result in damage and stress points on surface of board.

Layth Mohammed et.al[10] according to them natural fiber polymer composites contains polymer matrix combined with natural fiber. The combination of natural fiber and polymer matrix results as a difference in chemical structure between them; this can cause ineffective stress transfer so chemical treatment on natural fiber is necessary. Natural fiber has hydroxyl group which causes hydrophilic nature of fiber which can cause weak mechanical and physical properties. Orientation of fiber, strength of fiber, physical properties of fiber, interfacial adhesion property of fiber, volume fraction are the factors which affects the performance of composite. Addition of polyactic acid increases tensile strength whereas addition of flax fiber reduces tensile strength of composite 16%. The bonding strength between fiber and polymer matrix is a major factor to obtain good properties. Chemical modification is done to reduce the hydrophilic nature of composite. The chemical treatment reduces the extractives on fiber. Every material has some wear and friction properties they degrade with the time so tribological loadings are important in design. Studies on different kinds of tribological analysis have been conducted on fibers like kenaf, betelnut fiber, sugarcane etc. friction and wear features were found under different conditions like dry contact condition with varying parameters and applied load.

N Rajini et.al[11] had worked on naturally woven coconut sheath. It is used as new type of reinforcement. The hybrid composites are developed with the combination of coconut sheath / nanoclay using unsaturated polyester matrix and the effect of nanoclay on the mechanical free vibration behavior is studied. The addition of nanoclay improved the mechanical and damping properties of the composite. In addition the effect of alkali and silane treatments on fibers and different stacking sequence were investigated. Alkali treatment of fibers improved the mechanical properties of composites when cellulose fiber was present. Thefabrication of coconut sheath reinforced intra ply hybrid composites was carried out in two steps. In the first step, the 2 weight percentage of nanoclay was taken with unsaturated isophthalic polyester resin and the above mixture was mechanically stirred with the mixer. In the second step, the nanoclay mixture was mixed with curing agent and spread over the fiber mat, which were placed inside the closed mold of size 300x125x3 mm3 by keeping one over another up to six layers. Tensile and flexural tests were conducted in a universal testing machine (Instron, Series-3382) according to the ASTM-D638 and ASTM-D790. Alkali-treated coconut sheath/MMT clay reinforced hybrid composite shows 40% of increased flexural strength than pristine polyester (65 MPa).

Girisha.C, Sanjeevamurthy, Gunti Ranga Srinivas[12]had studied about hydrophilic nature of coconut fiber reinforced composite. Hydrophilic nature can reduce adhesion in polymer matrices composite. Moisture diffusion depends on volume fraction of fiber, voids, viscosity, humidity and temperature. Epoxy resin of grade LM-556 and hardener HY-951 was mixed at ratio 10:1. Coir contains lignin, wax and cellulose. Coir was soaked in the NaOH solution for 10 hours. The prepared mixture and coir was mixed in epoxy and poured in mould layer by layer and was left for 24 hour by applying pressure. The prepared specimens were weighed. Then specimen was immersed in water at room temperature for different time periods. The specimen was weighed from 24 to 67 hours at each 24 hours. The moisture content was calculated by difference in weight. Then specimen was tested to measure tensile strength on universal testing machine with ASTM D-638 standard. After testing it was found that tensile strength of wet sample was less than the dry sample. For flexural strength it was found that flexural strength of composite increased with the fiber content at wet condition. The effect of moisture absorption on mechanical properties of coconut coir composite was compared with composite containing dried coconut fiber.

D. Verma et.al[13]studied about coir fiber reinforcement and its application. The increase in use of plastic materials, ceramics has been increased rapidly causing the adverse effect on nature. Composite materials consists many materials which we used daily. This has resulted in development of many methods to improve the properties of composite material. Composite material is combination of two materials which consists fiber and binder. Coconut fibers are easily available and lower in cost. Epoxy resin has advantage like low densities, good corrosion resistance, and low thermal and electrical conductivity. The reinforcement improves the mechanical properties of composite material and resin system. Use of long fiber reduces the number of cracks that might improve reduced the cracks. Chemical composition and adhesive bonding of natural fiber need to be understood for good reinforced composites. The natural fiber includes cellulose, hemicellulose, lignin, pectin, waxes and water soluble substance. Hydrophilic nature of natural fibers reduces low interfacial properties between fiber and polymer matrices. Tensile test was carried out to determine the strength of material, while experimental modal analysis was executed to obtain the dynamic characteristics of the composite material. The acquired results show that the tensile modulus changes with the fiber content. The strength of coconut fiber reinforced composites tends to decrease with the amount of fiber which indicates ineffective stress transfer between the fiber and matrix.

N.Venkateshwaranet al.[14] had done study on banana fiber and explained how length of fiber affects strength of composites. The mould of teak wood of size 300mmx300mmx3mm is used to fabricate specimen. The mould was coated with remover and dried for some time. Fibers of different length are used. Epoxy LY556 and hardener HY951 was used as a binder agents. The tensile strength was determined on universal testing machine with the standard of ASTM D638 and flexural strength was determined by ASTM D 790. The water absorption was studied as per the ASTM D570 standards. Five different sized specimens were used to conduct the tests. For water absorption test the specimen were carried out from water from different time intervals and immediately weighed. The increase in fiber length and weight ratio increases the tensile strength and modulus up to 15mm

fiber length and 12% weight ratio. Use of longer fiber may cause to decrease the properties due to its decrease in adhesion.

Majid Ali[15] had reviewed about the versatility of coconut fibers and it'sin civil engineering as a construction material. Not only the physical, chemical and mechanical properties of coconut fibers are shown; but also properties of composites (cement pastes, mortar and/or concrete etc), in which coconut fibers are used as reinforcement, are discussed. Coconut fibers reinforced composites have been used as cheap and durable non-structural elements.

III. MECHANICAL PROPERTIES OF COCONUT FIBER COMPOSITES

Volume fractions of fibers, fiber aspect ratio, fiber matrix adhesion, stress transfer at the interface are the parameters which affects the mechanical properties of coconut fiber composites. Function of fiber contains, effect of various treatment of fibers and use of external coupling agent are the aspects involve in study of mechanical properties. While improving mechanical properties of composite both the matrix and fiber properties are important. The tensile strength is more sensitive, where as the modulus is dependent on the fiber properties. A strong interface, low stress concentration fiber orientation is required to improve the tensile strength and high fiber aspect ratio determines tensile modulus. For determining fracture properties aspect ratio is very important. In short fiber reinforced composites, there exists a critical fiber length that is required to develop its full stressed condition in the polymer matrix. Fiber length is shorter than this critical length lead to failure due to deboning at the interface at lower load. On the other hand, for fiber length greater than the critical length, the fiber is stressed under applied load and thus results in a higher strength of the composites.

Mechanical properties are also affected by the length of the fiber. The effective length and weight ratio is 15mm and 16% respectively. The increase in fiber length and weight ratio increases the tensile strength and modulus of the coconut fiber composite.

IV. CONCLUSION

After reviewing all these papers, we have concluded that the hydrophilic nature of composite should be reduced to obtain strong adhesion between the fiber and matrix materials. The use of alkaline treatment on natural fibers reduces the amount of cellulose content and natural wax i.e. reduces the hydrophilic nature of composite material and that helps to increase the tensile strength, flexural strength and other mechanical properties. By using different ratios of epoxy and hardener we can get different properties of composites. To get the maximum tensile strength long fiber should be used. It has been noticed that the mechanical properties of the composites such as micro-hardness, tensile strength, flexural strength, impact strength etc. of the composites are also greatly influenced by the fiber lengths. Coconut fibers are reported as most ductile and energy absorbent material.

We have found that the mechanical properties vary by using different length and pattern of the natural fibers. So to get the effective properties we are going to use different lengths and different layering pattern like longitudinal, cross layering, horizontal layering and combing them differently. The use of different epoxy and hardener in different ratios can also has effect on mechanical properties.

To verify the result more accurately we are going to use ANSYS software and going to compare it with the mechanical properties found by the practical experiment.

V. REFERENCES

[1] Rao K M M and Rao K M, "Extraction and Tensile Properties of Natural Fibers: Vakka, Date and Bamboo"," vol. 77, pp. 288-295.

[2] P N E Naveen1 and M Yasaswi, "EXPERIMENTAL ANALYSIS OF COIR-FIBER REINFORCED POLYMER COMPOSITE MATERIALS," *International journal of Mechanical Engineering and robotics Research,* vol. 2, pp. 10-18, 2013.

[3] S.Stephano and V.G.Thurbius Galdius, "FABRICATION OF HYBRID COCONUT FIBRE WITH EPOXY COMPOSITE," *International Journal of Innovative Works in Engineering and Technology,* vol. 3, no. 4, pp. 370-377, 2017.

[4] Mulinari, D.R, Baptista, C.A.R.P, Souza, J. V. C and Voorwald, H.J.C, "Mechanical Properties of Coconut Fibers Reinforced Polyester Composites," *Science direct/Procedia Engineering,* pp. 2074-2079, 2011.

[5] C. R. Rejeesh and K. K. Saju, "Methods and materials for reducing flammability behaviour of coir fibre based Composite Boards: A Review," *Science direct/Materials today,* p. 9399–9407, 2017.

[6] R. Shrivastava, Amit Telang, R. S Rana and Rajesh Purohit, "Mechanical Properties of Coir/ G Lass Fiber Epoxy Resin Hybrid Composite," in *5thInternational Conference of Materials Processing and Characterization (ICMPC 2016)*, 2017.

[7] TP Sathishkumar, P Navaneethakrishnan, S Shankar, R Rajasekar and N Rajini, "Characterization of natural fiber and composites – A review," *Journal of Reinforced Plastics and Composites,* p. 1457–1476, 2013.

[8] Fairuz I. Romli, Ahmad Nizam Alias, Azmin Shakrine Mohd Rafie and Dayang Laila Abang Abdul Majid, "Factorial Study on the Tensile Strength of a Coir Fiber Reinforced Epoxy Composite," in *AASRI Conference on Modelling, Identification and Control*, 2012.

[9] Celso Pires Araújo Junior, Carlos Alberto Cáceres Coaquira, Adriano Lincoln Albuquerque Mattos, Men de Sá Moreira de Souza Filho, Judith Pessoa de Andrade Feitosa, João Paulo Saraiva de Morais and Morsyleide de Freitas Rosa, "Binderless Fiberboards Made from Unripe Coconut Husks," *Waste Biomass Valor,* 2017.

[10] LaythMohammed, M. N. M. Ansari, Grace Pua, Mohammad Jawaid and andM. Saiful Islam, "A Review on Natural Fiber Reinforced Polymer Composite and Its Applications," Hindawi Publishing Corporation.

[11] N Rajini, JT Winowlin Jappes, S Rajakarunakaran and P Jeyaraj, "Mechanical and free vibration properties of

montmorillonite clay dispersed with naturally woven coconut sheath composite," *Journal of Rainforced plastics and composites,* vol. 30, no. 20, p. 1364–1376, 2012.

[12] Girisha.C, Sanjeevamurthy and Gunti Ranga Srinivas, "Sisal/Coconut Coir Natural Fibers – Epoxy Composites: Water Absorption and Mechanical Properties," *International Journal of Engineering and Innovative Technology (IJEIT),* vol. 2, no. 3, pp. 166-170, 2012.

[13] D. Verma, P.C. Gope, A. Shandilya, A. Gupta and M.K. Maheshwari, "Coir Fibre Reinforcement and Application in Polymer Composites: A Review," *JMESCN,* vol. 4, pp. 263-276, 2013.

[14] N. Venkateshwaran , A. ElayaPerumal and M. S. Jagatheeshwaran, "Effect of fiber length and fiber content on mechanical properties of banana fiber/epoxy composite," *Journal of Reinforced Plastics and Composites,* p. 1621–1627, 2011.

[15] "Coconut fibre: A versatile material and its applications in engineering," *Journal of Civil Engineering and Construction Technology,* pp. 189-197, 2011.