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EVALUATION OF MECHANICAL BEHAVIOUR OF BAMBOO/COTTON FABRIC REINFORCED EPOXY COMPOSITES

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ABSTRACT

To Optimize the Mechanical Properties of Hybrid Composite Material. To Manufacture epoxy based composites with different weight % fiber.

Keywords: Environmental damage, Reinforcing material and Creep resistance

1. INTRODUCTION

1.1 DEFINITION OF COMPOSITE

A composite is combination of two materials in which one of the materials, called the reinforcing phase, is in the form of fibers, sheets, or particles, and is embedded in the other materials called the matrix phase. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Composites typically have a fiber or particle phase that is stiffer and stronger than the continuous matrix phase and serve as the principal load carrying members. The matrix acts as a load transfer medium between fibers, and in less ideal cases where the loads are complex, the matrix may even have to bear loads transverse to the fiber axis. The matrix is more ductile than the fibers and thus acts as a source of composite toughness. The matrix also serves to protect the fibers from environmental damage before, during and after composite processing. When designed properly, the new combined material exhibits better strength than would each individual material. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications.

Jartiz stated that “Composites are multifunctional material systems that provide characteristics not obtainable from any discrete material. They are cohesive structures made by physically combining two or more compatible materials, different in composition and characteristics and sometimes in form”. Kelly very clearly stresses that the composites should not be regarded simple as a combination of two materials. In the broader significance; the combination has its own distinctive properties. In terms of strength to resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them. Beghezan defines as “The composites are compound materials which differ from alloys by the fact that the individual components retain their characteristics but are so incorporated into the composite as to take advantage only of their attributes and not of their short comings”, in order to obtain improved materials. Van Suchetclan explains composite materials as heterogeneous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can be also considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property.

The following are some of the reasons why composites are selected for certain applications:

High strength to weight ratio (low density high tensile strength)

High creep resistance

High tensile strength at elevated temperatures

High toughness

1.2 HYBRID COMPOSITE

Hybrid composites are more advanced composites as compared to conventional FRP composites. Hybrids can have more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing and multiple matrix phases. They have better flexibility as compared to other fiber reinforced composites. Normally it contains a high modulus fiber with low modulus fiber.The high-modulus fiber provides the stiffness and load bearing qualities, whereas the low-modulus fiber makes the composite more damage tolerant and keeps the material cost low. The mechanical properties of a hybrid composite can be varied by changing volume ratio and stacking sequence of different plies.

1.3 NATURAL FIBER REINFORCED COMPOSITES

The interest in natural fiber-reinforced polymer composite materials 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, kenaf, pineapple, ramie, bamboo, banana, etc., as well as wood, used from time immemorial as a source of lignocellulosic fibers, are more and more often applied as the reinforcement of composites. Their availability, renewability, low density, and price as well as satisfactory mechanical properties make them an attractive ecological alternative to glass, carbon and man-made fibers used for the manufacturing of composites.

2. LITERATURE REVIEW

Andressa Cecilia Milanese et al (2012) [1**]** had used fiber as Woven sisal fibre and resin as Synthetic Phenolic Resin (cascophen) under gone tests likeTensile test, Flexural test . He concluded that Woven sisal fabric was submitted to heat treatment before mouldings and the influence of moisture content of fiber on the composites were removed. It is treated with thermal treatment for 72 hrs at 60ºC.Experimentally the result shows that tensile strength of 25MPa and flexural strength of 11Mpa.

Athijayamani et al (2010) [2] Sisal fiber, Roselle fiber glass fiber and resinas Polyester and test were Tensile test ,Impact test and Flexural test and finally conclusion are Length of the fiber 50-150mm.Composite were prepared by varying fiber loading (10-30 wt%) .The Length of glass fiber - 50mm .Tensile, impact and Flexural strength of glass/polyester composite with10%wt and 50mm length having better mechanical properties .Hybrid composite having Weight fraction 30%wt and 150mm length of Tensile and Flexural strength is higher value .Impact value of Roselle/sisal hybrid composite 10wt%-100mm is having better value.

Athijayamania et al (2009) [3] were used Roselle fiber, Sisal fiber and resin as Polyester and under gone test are Tensile test, Flexural test, Impact test and conclusion made by them are Dry and wet conduction Roselle and sisal polyester at a ratio of 1:1. The various weight (10-30wt%) and length (50-150mm). The composite specimen to be used for moisture absorption test were first dried in an oven at 50°C. Then these conditioned composite specimens were immersed in distilled water at 30°C for about 5days. The maximum percentage of strength reductions in tensile and flexural strength (length- 150mm&30%wt). The impact strength reduced in (length-150mm&20%wt).

Bulent ozturk et al (2010) [4] had used fiber as Jute Fiber, Rockwool Fiber and resin as Phenol formaldehyde and had undergone test like Tensile test, Flexural test and Impact test. By using this fiber and resin he observed that Jute and Rockwool Fiber Reinforced phenol formaldehyde composite were fabricated with varying fiber loading (16, 25, 34,42,50,60 Vol%) .The tensile and flexural strength of jute/PF and rock wool/PF composites improved by increasing fiber load up to 42vol% .Maximum impact strength occurs at fiber loading of 50 vol% .The jute &Rockwool Hybrid composite were manufactured at various Ratios of jute Rockwool fiber Such as(1:0, 0.92:0.8, 0.82:0.18, 0.70:0.30, 0.54:0.46, 0.28:0.72, 0:1). The tensile ,flexural, impact strength of Hybrid composite having better mechanical properties at ratio of 0.82:0.18. The maximum hardness value at 0.28:0.72.

3. PROBLEM IDENTIFICATION

Based on the literature presented in the previous chapter; It is found that some research is carried out on hybrid cotton/bamboo woven fabric, they found out only mechanical properties of fiber. There is a lot of scope to characterize the mechanical behavior of hybrid cotton/bamboo woven fabric composites. So it is decided to carry out research if the above topic and analyses the following mechanical properties like.

Tensile Test
Flexural Test
Impact Test

4. MATERIALS AND METHODS

4.1 INTRODUCTION

This chapter explains in detail the materials used, various methods followed to perform the experimental works and the use of different chemicals/agents in the process of fiber preparations surface treatment processes of composite materials during this research and also discusses the detailed specification of machining properties and testing methods.

4.2 REINFORCEMENT MATERIALS

3.2.1 Bamboo fiber

Bamboo is from a group of woody perennial evergreen plant in the true grass family poacoae and sub family bambusuae and it is one of the fastest growing plants in the world. Generally, bamboo has two patterns during growth namely clumping and running. The clumping bamboo species tends to grow and spread slowly as the pattern of the rhizhomes is to simply expand the root mass gradually similar to ornamental grass while the running bamboo needs care even during cultivation due to its potential and aggressive behaviour.

Figure: 1Bamboo steam

Bamboo fiber is pure cellulose, biodegradable, called "green" and environmentally friendly. Recycled bamboo fiber is obtained from bamboo plants, which is a cheap and abundant natural resource. Bamboo is very common in Asian countries, and bamboo fiber is used for textile applications.

3.2.2 Cotton fiber

The fiber king cotton is a single-cell fiber obtained from the seeds of cotton plants belonging to the Malvaceae family. Cotton is the backbone of textile applications. Cotton is a soft white fibrous substance and is a natural fibre known for its comfort and durability. Leaf and best fibres are very important but they can't be compared with textile fibres, seed fibres and cotton. As cotton has some unique structure, it can absorb water up to 2.7 times of its weight. India stand second in producing cotton after china. Out of the total cultivated area, cotton grown area occupies 3% in the world. India has its own unique position in producing cotton and is also one of the main exports of cotton yarn and garments. cotton plaut has flowers in white and the flowers turn purple after two days of blooming while its length ranges from 3/8" to 2"

Figure .2 Cotton plant

3.3 EPOXY RESIN AND HARDENER

In this present work Epoxy resin is used as matrix material (Araldite LY 556). Epoxy or polyepoxide is a thermosetting peroxide polymer that cures (polymers and cross links) when mixed with a catalyzing agent or "hardener". Most common epoxy resin is produced from a reaction between epichlorohydrin and Biphenyl-A. The reaction product is high in viscosity and can either undergo further reaction process to yield a lower viscosity resin. Epoxy resin is often modified using other product to improve some measured property of the final product such as toughness or sensibleness. Epoxy resin and additives contribute to the viscosity of the system and to the shrinking character tics. The amount of the fillers and diluents will impact both the physical and handling properties of the resin system. Epoxy resin are part of a two component thermo-set plastic that requires an epoxy hardener to determine the majority of the handling and physical properties of the base. The use of several variations of unmodified and modified epoxy resin with the same epoxy hardener will produce some variations in their property; however, the epoxy hardener is the primary factor in the base property. Epoxy adhesives are a major part of the class of adhesives called "structural adhesives" (which also includes polyurethane, acylic, cyanoacrylate, and other chemistries.) these high performance adhesives are used in the construction of aircraft, automobiles, bicycle, golf clubs, skis, snow boards, and other applications where high strength bonds are required. Epoxy adhesives can be developed that meet almost any applications. They are exceptional adhesives are wood, metal, glass stone, and some plastics. They can be made flexible or rigid, transport or opaque/color, fast setting or extremely slow. Epoxy adhesives are almost unmatched in heat and chemical resistance among common adhesives. In general, epoxy adhesive curved with heat will be more heat and chemical resistant than when cured at room temperature. Epoxies are sold in hardware stores, typically two components kits. They are also sold in boat shops as repair resins for marine application. Epoxies typically are not used in the outer layer of a boat because they are deteriorated by exposure to UV light. They are often used during boat repair and assembly, and then over coated with conventional or two pot polyurethane paint or marine varnishes that provide UV protection.

3.4 FABRICATION OF COMPOSITES

Plain woven fabric and resin were taken separately in correct proportion and the harder and epoxy resins were mixed in a jar using glass stirring rod. So that it can be mixed without air bubbles and pore in the mixture. Before starting the fabrication process, the top and the bottom surface were cleaned and waxed. The plain woven fabric was stacked on the bottom die surface and using Hydraulic Operated Compression Moulding Machine (HCMM), the pressure was applied between moulded plates upto 110bar.The mould plates were then opened at room temperature under atmospheric air condition. Further, the temperature was gradually increased to 80º c and it was kept for 30 minutes. The photographic representations of fabrication using HCMM and the fabric in five different structures are given in Table 3.1 with efficient combination, and different fiber loading conditions i.e. 70:30, 65:35, 60:40, 55:45 and 50:50, fabrication was carried out have to pictures of fabrics and composite laminates.

Particulars	Plain woven fabric
Warp	Cotton
Weft	Bamboo

Figure 3. Hydraulic operated Compression Moulding Machine

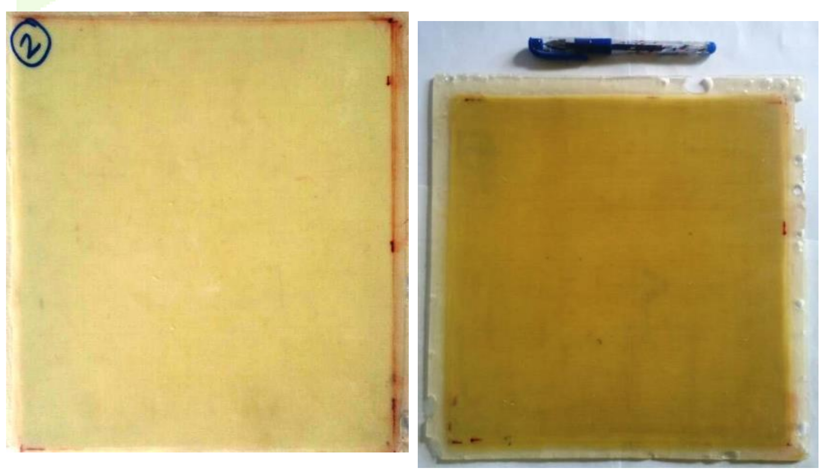

Figure 4 woven fabric Composite laminates

4. RESULTS AND DISCUSSIONS

4.1 PHYSICAL PROPERTIES OF YARN

The single yarn was tested for strength, elongation, and tenacity in SITRA Coimbatore. Test method and imperfection U % were tested as per ASTM D 1425 using USTER Tenso rapid – 4 testing machine the results were reordered

Blend ratio	100 % Cotton	70:30 % Cotton / Bamboo	50:50 % Cotton / Bamboo	30:70 % Cotton / Bamboo	100% Bamboo
Diameter mm	0.291	0.283	0.275	0.261	0.245
Tenacity RKM (g/tex)	18.93	14.68	13.51	14.45	14.76
Elongation at break %	6.44	6.50	6.20	6.58	15.03
Elongation at cv %	4.76	5.62	6.54	6.67	6.74
Thin Place /Km (-50 %)	0.90	0	0	0	0
Thick Place / km (+50%)	18	4	5	6	13
Mean (U%)	9.35	8.18	7.48	8.43	8.27
Mean CVm%	11.85	11.56	10.99	10.66	10.44
Single Yarn strength(g)	494.7	446.2	422.4	478.8	512.1

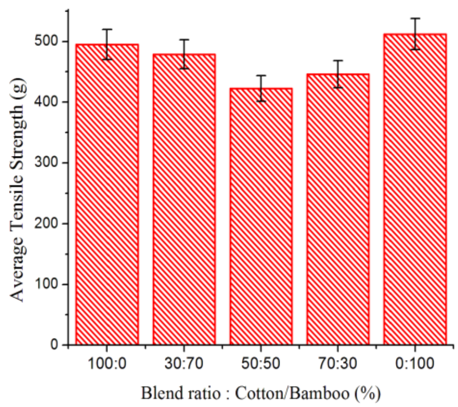

Figure .5 Single Yarn Tensile Strength

It is observed that as the amount of bamboo increases with yarn count, the diameter of yarn reduces. Compared to the cotton yarn, bamboo yarn is closely packed. The bamboo yarn is packed in better way because it has lower bending and torsion rigidity (Majumdar et al. 2011). From the result, it is evident that the warp direction bamboo yarn is the main body in the spinning triangle process and thus the hairiness decreases with increasing yarn quality. 50:50 cotton-bamboo yarn is the weakest of all the tested yarns, because cotton and bamboo yarn have different breaking elongation (Prakash et al. 2015). Since the cotton yarn has much lower breaking elongation than the bamboo yarn, cotton yarn ruptures earlier and the remaining proportion of bamboo collapses and it cannot withstand the applied load (Pan and Postle 1995 & Cheng et al. 1975) Bamboo has smaller diameter and it has good air permeability. The 30:70 ratio of cotton/bamboo blended yarn is compared with the effects of 100% cotton yarn. The 30:70 cotton/bamboo mixed yarn displays all the properties very close to 100% cotton yarn but lower than 100% bamboo yarn. The number of thick places increases with increase in bamboo percentage, irrespective of the linear density of the yarn. The number of thin places increases as the amount of bamboo content increases, and this does not depend on the linear density of the yarn. The main objective of the blended yarn is to reduce the cost of the yarn and utilization of cotton with bamboo. The properties of the blended yarn when compared with all the blended samples fall within the acceptable limit.

4.2. TENSILE PROPERTIES OF FABRICS

The growth of textile industries mainly focuses on the physical and mechanical properties of yarn and fabric. The types of weave structure and spin yarn properties are influencing the linear density of warp and weft direction of fabric. The influence of weaving conditions relies on weaving speed, weft up force, insertion rate, tension warp and weft way of shed opening and number of threads used in reed etc. The aerial density of the fabric i.e. mass per unit area (g/m^2) was measured and fabric thickness readings were recorded at 5 different parts of each fabric with the help of a thickness tester.

S.No	Woven fabric properties	Cotton / Bamboo (CB)
1	Warp Strength (N)	581.73
2	Warp Elongation (%)	18.13
3	Weft Strength (N)	492.16
4	Weft Elongation (%)	14.28
5	End/inch	69
6	Pick/inch	54
7	Thickness (mm)	0.37
8	Aerial density (g/m^2)	168

It is observed that cotton/bamboo fabric has better strength in warp and weft direction when compared to other weaving structure. The weaving structure is the important factor that influences warp strength. Addition of bamboo yarn in weft direction is to enhance the fabric strength in warp direction (Sajn Gorjanc D & Zupin 2017). The bamboo yarn in weft direction with cotton yarn enhances the mechanical properties of fabric. The maximum tensile strength 581.73 N is achieved for cotton/bamboo fabric in warp direction and 492.16 N in weft direction because plain woven fabric has higher number of inter locking points. Therefore, high tensile strength is achieved in weft direction.

4.3 EVALUATION OF MECHANICAL PROPERTIES OF COTTON/BAMBOO FABRIC EPOXY COMPOSITE.

4.3.1 TENSILE TEST

Tensile testing of specimen prepared according to ASTM D 3039 type IV sample was carried out, using electronic tensile testing machine with cross head speed of 2mm/min and a gauge length of 150 mm. The tensile modulus and elongation at beak of the composites were calculated from the stress strain curve. Four specimens were tested for each set of samples and mean values were reported. The tensile strength of plain woven fabric reinforced composites mainly relies on various factors namely fiber orientation, length of fiber, strength, fiber content, fillers, bonding between fiber and matrix and weave style. After critical point, the matrix material is insufficient for effective bonding between fiber and matrix. Fig 4.2. Shows the cotton bamboo composite experiences increase in tensile strength of 85 Map at 45 wt. % of fiber loading since the bamboo fiber has higher load carrying capacity than cotton fiber; the result of difference in tensile strength shows cotton bamboo composite has enhanced property. A bonding between fiber matrixes has vital role in identifying properties of composite laminates and high strength is achieved by maximum usage of fiber and adequate stress transfer between fiber and matrix. Cotton bamboo composite has less fiber pullout, torn fiber and good bonding between fiber and matrix.

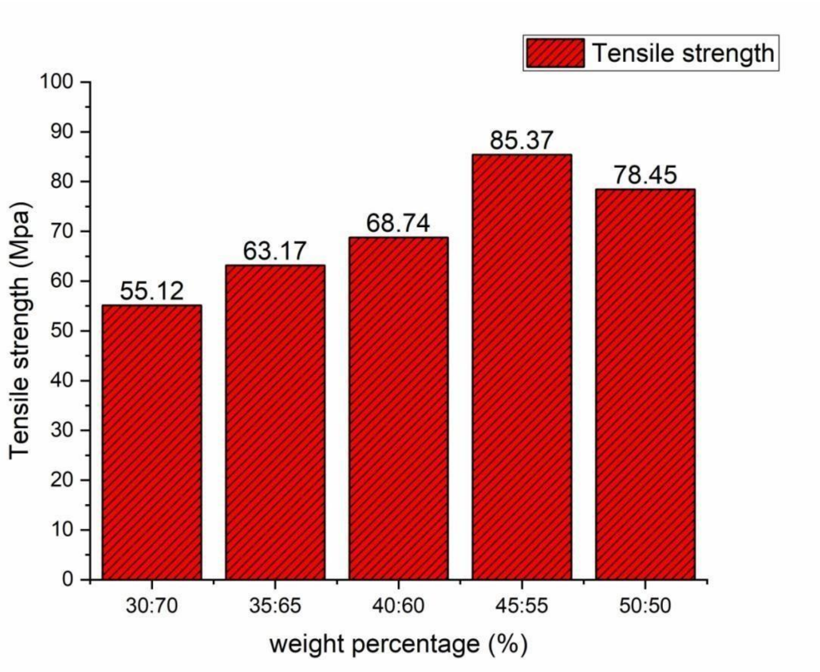

Figure: 6 Tensile strength of cotton & bamboo epoxy composite

4.3.2 FLEXURAL TEST

The flexural test was performed by the three-point bending method according to ASTM D 790, and cross head speed of 1 mm/min. Four specimens were tested, and the average was calculated. The specimen was freely supported by a beam, the maximum load was applied in the middle of the specimen, and the flexural modules is calculated from the slope of the initial portion of the load deflection curve. The three-point flexural test analyses the bending nature of the composite. The bending strength of composite laminate is mainly due to sequence of compression and shear strength. Nate gets increased as a result of increasing amount of fiber loading. When increasing the amount of fiber loading, the density of the fiber and fiber distribution enhances with elevated strength properties but, beyond 45 wt. % at 82.08 Map, the fiber loading result decreases because of insufficient effect in bonding between fiber and matrix. As such, flexural strength has enhanced with increase in fiber loading up to a critical point of 45 wt. %. But, it starts to decrease when there is increase in fiber loading since the flexural strength of the composite is also influenced by the strength of the fiber. The cotton/bamboo exhibited higher flexural strength at 107.02 Map at 45 wt%. In plain weaving pattern, the effect of cotton yarn (warp direction) and bamboo yarn (weft direction) constitutes an interlocking structure. The result indicates that yarns in warp and weft direction are noted with higher bending load capacity. The flexural properties of cotton/bamboo composite are mainly because of arranging high strength fiber in proper direction. It is noted that fiber pullout, voids and fiber dislocation are identified due to improper ratio between fiber and matrix. The cotton/bamboo composite has good bonding between fiber and matrix and this is due to proper ratio between fiber and matrix which results in high flexural strength .so the flexural strength of the cotton &bamboo composite is high in 45 wt%.

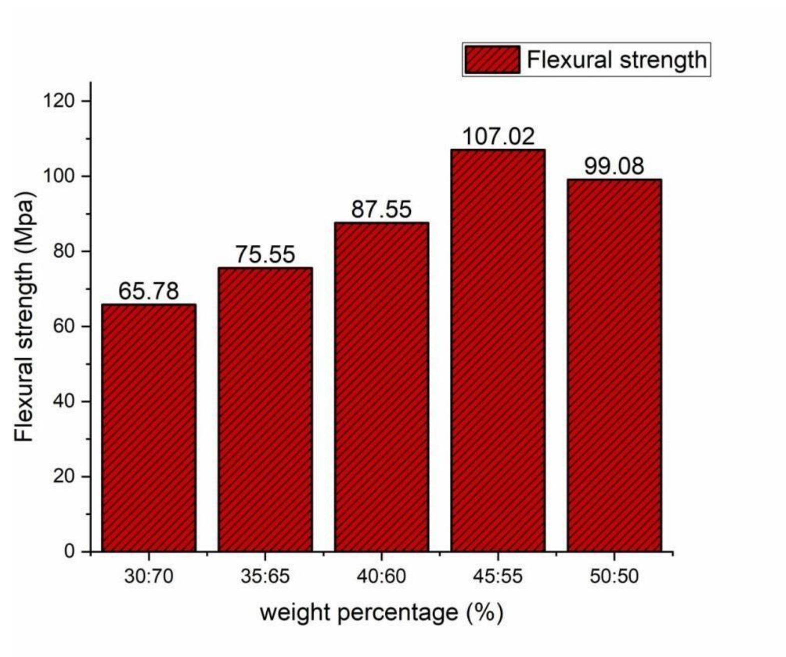

Figure 7. Flexural strength of cotton & bamboo epoxy composite

4.3.3 IMPACT TEST

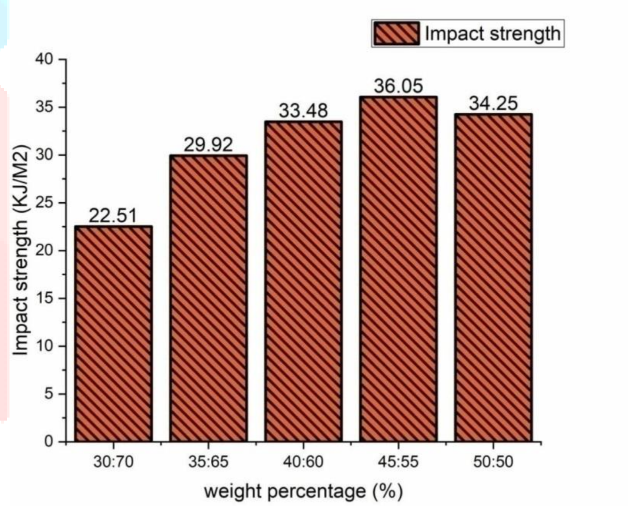

Figure. 8 Impact strength of cotton & bamboo epoxy composite

The capability of material to resist fracture under the sudden applied load at same velocity (or) speed is called impact strength. The impact properties of laminated composites are based on the factors like fracture toughness, fiber pull out on friction force, inter laminar and interfacial strength between fiber and matrix. The cotton/bamboo composite laminate strength increases up to 45 wt. % as 32.3 KJ/m^2. In the woven pattern, the impact strength of laminates with different types of fiber influences parameter interface between fiber, matrix and dimension of composite laminates. The strength and structure of individual fiber plays a key roal in the strength of laminates and bamboo yarn has high strength compared to cotton yarn. Hence, it is observed that impact strength is owing to properties of the individual fiber used during hybridization in the polymer matrix system rather thanusing other parameter. The surface voids, crack fiber pullout and poor bonding thatexist between fiber and matrix are the main causes of low impact strength of composite material. The weak bonding between fiber and matrix occurred due to fiber pullout and voids in the composite laminates. The presents of enriched resin around the fiber restricts the sliding motion of fiber by shearing action at the interface .so the impact strength of cotton bamboo composite at the wt% of 45 is high.

4.3.4 COMPRESSION STRENGTH

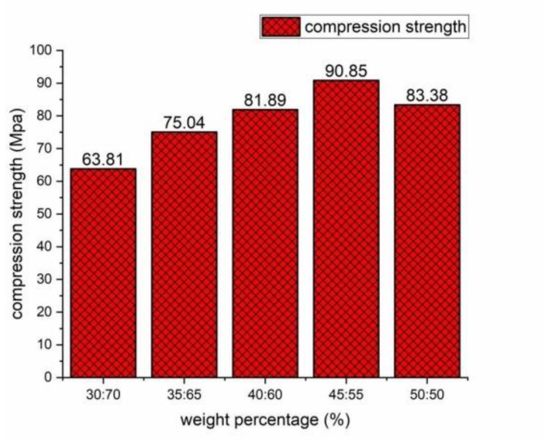

Fig. 9 Compression strength cotton & bamboo epoxy composite

The compressive strength values for cotton/bamboo composites. In this observation, the maximum compressive strength occurs when cotton/bamboo composite has 90.85 Map at 45 wt% has shown in fig 4.5 and this is due to homogeneity of fibers and good bonding between fiber and matrix. In this state, the stress is equally distributed among the fibers and at this conditions, the maximum compressive strength is achieved. At reduced fiber loading condition, less fiber content causes decrease in load transfer capacity among the fibers.

5. CONCLUSION

In this work, mechanical property of cotton / bamboo woven fabric hybrid epoxy composites were investigated. The tensile, flexural impact and compression properties of the composites as a function of fiber content were analysised. The single yarn strength, tenacity, and elongation of (100%) cotton yarn are low but (100%) bamboo yarn has more and at the same time, blended yarns have low strength, tenacity, and elongation. The cotton/bamboo (30:70) yarn properties are close to cotton yarn. But the cotton/bamboo (70:30) blended yarns have higher properties when compared to all blended yarns. The breaking force of the plain weave fabric in the vertical direction is higher than the breaking force in the horizontal direction as the number of yarns per unit area in the vertical direction is higher than the number of yarns in the horizontal direction. Therefore, the horizontal direction only has higher strength. The tensile, flexural and compression strength of cotton & bamboo woven fabric /epoxy composite improved by increasing fiber loading up to 45wt.% and deceased by higher loading. The Impact strength of cotton & bamboo woven fabric /epoxy composite improved by increasing fiber loading up to 45wt.% and deceased by higher loading. Addition of bamboo fiber in weft direction increasing the mechanical properties of composites.

6. REFERENCE

1. Andressa Cecilia; Cioffi, Maria Odila Hilario; Voorwald, Herman Jacobus Cornelis, (2012) "Thermal and mechanical behaviour of sisal/phenolic composites", Composites: Part B, Vol.43, pp 2843–2850.
2. Andressa Cecilia; Cioffi, Maria Odila Hilario; Voorwald, Herman Jacobus Cornelis, (2012) "Thermal and mechanical behaviour of sisal/phenolic composites", Composites: Part B, Vol.43, pp 2843–2850.
3. Athijayamani,A, Mani Thiruchitrambalam, Manikandan Vairavan and B. Pazhanivel, (2010) "Mechanical Properties of Natural Fibers Reinforced Polyester Hybrid Composite". International Journal of Plastics Technology, Vol. 14(1), pp.104-116.
4. Athijayamani,A, Mani Thiruchitrambalam, Manikandan Vairavan and B. Pazhanivel,(2009) "Effect of Moisture Absorption on the Mechanical Properties of randomly Oriented Natural Fibers/Polyester Hybrid composite", Materials Science and Engineering,A.517,pp344–353.

5. Bulent ozturk (2010) et al, “Hybrid Effect in Mechanical Properties of Jute and Rockwool Hybrid fiber Reinforced Phenol Formaldehyde Composites”,Fiber and polymers,Vol.11,No.3,pp464-473.

6. Chandramohan,D. and Kavithamani Marimuthu, (2011) “Tensile and Hardness Tests on Natural Fiber Reinforced Polymer Composite Material”, International journal of advanced engineering sciences and technologies Vol.6, issue no. 1, pp 097 – 104.

7. Elaine C.Ramires, and Elisabete Frollini, (2012) “Tannin–phenolic resins: Synthesis, characterization, and application as matrix in bio based composites reinforced with sisal fibers”, Composites: Part B Vol.43, pp2851–2860.

8. Jamal Mirbagheri, Mehdi Tajvidi, John C Hermanson and John C Hermanson Ismaeil Ghasemi, (2007) “Tensile properties of wood flour/kenaf fiber polypropylene hybried composites”, Journal of Applied polymer science Vol.105,pp 3054-3059.

9. Maries Idicula, S.K. Malhotra and Kuruvilla Joseph,(2005) “Dynamic mechanical analysis of randomly oriented intimately mixed short banana/sisal hybrid fiber reinforced polyester composites ”,Composites Science and Technology Vol.65, pp1077–1087.

10. Maya Jaco, Sabu Thomas and K. T. Varughese,(2004)., “Mechanical properties of sisal /oil palm hybrid fiber reinforced natural Rubber composites”, composites science and technology Vol.64, pp 955-965.