Evaluation on Buckling Properties of Laminated Banana Fabric Polyester Composites

Naveen Kumar.V[1], Mr. Janardhana.K[2]
[1, 2] Department of Mechanical Engineering
[1, 2] Sir MVIT

Abstract- *In this present work, the banana fiber reinforced with epoxy polymer was fabricated and their Buckling properties were investigated experimentally. The composite were prepared by using 17 layers of banana and is placed in between the mat. Laminates, were prepared by the hand layup technique of size 130*120*3.7 mm³. Epoxy LY556 and Hardener HY951 been used as a resin and hardener for the fabrication of composite laminate. Buckling properties of the composite were studied.*

*In this paper, the buckling of rectangular plates of 130*120*3.7 mm³ is made of laminated banana fabric polyester composite plates with and without cutouts. Composite plates with cutouts are circular, rectangular and square. The effects of fabric orientation angle, the cutout shapes on buckling strength are evaluated. For the 0^0 fabric orientation angle, the buckling strength will be maximum and for the 30^0 or 60^0 fabric orientation angle, the buckling strength will be minimum. The buckling strength which is given by buckling test decreases as the fabric orientation angle increases. The rectangular composite plates with circular cutouts will have maximum value when it is compared with the composite plate of rectangular and the square cutout.*

Keywords- Composites, Banana Fabric, Epoxy Resin, Hand Layup, Buckling

I. INTRODUCTION

Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker materials (known as matrix). Reinforcement provides strength and rigidity, helping to support structural load. The matrix or binder (organic or inorganic) maintains the position, orientation of the reinforcement and transfers the external load to the reinforcement. Significantly, constituents of the composites retain their individual, physical and chemical properties.

Composite laminated plates when loaded in compression are subjected to a type of behavior known as buckling as long as the load on the plate is relatively small, then any increase in the load results only in an axial shortening of the plate. However once a certain critical load is reach, the plate suddenly bows out sideways. This bending gives rise to large deformations, which cause the plate collapse. The load at which buckling occurs is thus a design criterion for compression plate. Plates with circular and other holes are extensively used as structural members in aircraft design. The buckling behavior of such plate has always received much concentration by investigators. The main purpose of the work is to study the effect of fibre orientation [0^0, 30^0 and 60^0] on buckling behavior in composite plate.

Description of Hand Layup technique:

Matrixes/Resins are impregnated by hand into fibers which are in the form of chopped strand mat woven, knitted, stitched or bonded fabrics. This is usually accomplished by rollers or brushes, with an increasing use of nip-roller type impregnators for forcing resin into the fabrics by means of rotating rollers and a bath of resin. Laminates are left to cure under standard atmospheric conditions.

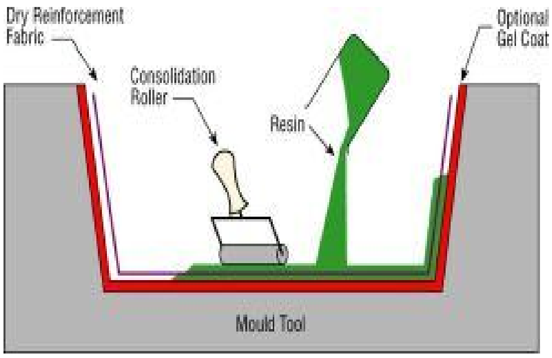

Figure 1. Hand layup technique

II. LITRATYRE REVIEW

The chapter outlines some of the recent reports published in literature on buckling behavior of banana fibers based polymer composites with special emphasis on banana fiber reinforced epoxy composites.

Merlini et al. [1] have studied the effect surface treatment on the chemical properties of banana fiber and reported that treated banana fiber give higher shear interfacial stress and tensile strength when compared with the untreated fiber. Pothan et al. [2] have investigated on the influence of fiber content and length on short banana fiber reinforced polyester composite material. Laban et al. [3] has studied on the physical and mechanical behavior of banana fiber reinforced polymer composite and noticed that kraft mashed banana fiber material has better flexural strength. The tensile strength is detected maximum at 30 mm fiber length whereas the impact strength is noticed maximum at 40 mm length of fiber. Consolidation of 40% untreated banana fibers gives 20% rise in the tensile strength and 34% rise in impact strength. Joseph et al. [4] studied and compared the mechanical behavior of phenol formaldehyde composites which was reinforced with glass fiber and banana fiber. Laly et al [5] have investigated in dynamic mechanical analysis, banana fiber reinforced polyester composites and found that the optimum content of banana fiber is 40%. Corbiere-Nicollier et al [6] have studied the Mechanical properties of banana-fiber-cement composites were investigated physically and mechanically. Pothan et al [7] have reported that Kraft pulped banana fiber composite has good flexural strength. In addition to that short banana fiber reinforced polyester composite was studied. Ghannadpour et al [8] found out that plates that have a cutout can buckle at higher buckling load compare to plates without cutout. Kremer et al [9] studied the influence of the shape of optimized cutouts on the buckling behaviour. Tercan et al [10] have studied the cutout shape effect on buckling behaviour. Eryigit et al [11] investigate the effect of hole diameter and its location on the lateral buckling behavior (woven fabric). Komur et al [12] studied the buckling analysis with circular/elliptical hole, numerically (woven glass polyester). Kumar et al [13] observed that the cutout shape has considerable effect on the buckling and post buckling behavior (quasi-isotropic laminate) with large size cutout. Ameen et al [14] determine the critical buckling load of E-glass reinforced polyester plastic material experimentally.

III. EXPERIMENTAL DETAILS

1. Materials:

In this work for preparing laminated banana fabric polyester composite, Banana fabric is used as a reinforced material and Epoxy resin is used as a matrix material.

a) Banana Fabric:

Banana fiber is environmentally friendly like jute fiber. It has large export demand from many countries like Japan, Australia, Germany and many. Fiber can be obtained from whole banana plant. After the fruit is obtained, the plant is thrown away giving rise to increase in waste. The proper disposal of this plant is another problem. By using a good fiber extractor machine, a large amount of fibre can be obtained which will give rise to additional income. Banana fiber is a best fibre with relatively good mechanical properties due to its high alpha cellulose and low lignin percentage.

Applications of Banana Fabric:

1) Banana fiber has great potentialities for paper making specially demand of handmade papers.
2) Even in some countries it is used for making currency paper.
3) It is used for making rope, mats and other composite materials.
4) Banana fiber has recognized for apparels and home furnishings.
5) Composite material of banana fiber is used in building boards and fire resistance boards.
6) Polypropylene reinforced with banana fiber is used by automobile companies for making under floor protection panels in luxurious cars like Mercedes.
7) Banana fiber mostly used in making handicrafts and home decorative.

Table 1 shows mechanical properties of banana fibers, by which we use fibers as reinforcement for a good mechanical properties of composite materials.

Table 1. Mechanical properties of banana fibers

Tensile Strength (Mpa)	529 - 914
Specific Tensile Strength	392 - 677
Young's Modulus	27 - 32
Specific Young's Modulu (Gpa)	20 - 24
Failure Strain (%)	1 - 3
Density (Kg/m3)	950 - 750
Source	3

b) Epoxy Resin:

The materials used for matrix are epoxy, unsaturated polyester and vinyl ester. Epoxy resins are the most common matrices for high performance advanced polymer composites, but they are also inherently brittle because of their high degree of cross linking. The densely cross linked structures are the basis of superior mechanical properties such as high modulus, high fracture strength, and solvent resistance. However, these materials are irreversibly damaged by high stresses due to the formation and propagation of cracks. These lead to dangerous loss in the load-carrying capacity of polymeric structural engineering materials. Currently the unsaturated polyesters are the most widely used polymer in construction.

Epoxy resins are available in liquid and solid forms and are cured into the finished plastics by a catalyst. They are cured at room temperatures as well as elevated temperatures of about 275^{0}C. The erosion resin of grade LY-556 was used of density 1.1-1.2gm/cc at 298K. It having the following outstanding properties has been used as the matrix material.

a) Excellent adhesion to different materials.
b) High resistance to chemical and atmospheric attack, high dimensional stability.
c) Free from internal stresses.
d) Excellent mechanical and electrical properties such as Odorless, tasteless and completely nontoxic, negligible shrinkage.

Properties of Epoxy resin

Table 2. Properties of Epoxy Resin

Glass Transition Temperature (Tg)	120 – 130º c
Tensile Strength	85 N/mm²
Tensile modulus	10,500 N/mm²
Elongation at break	0.8%
Flexural strength	112 N/mm²
Flexural Modulus	10,000 N/mm²
Compressive Strength	190 N/mm²
Co-Efficient of Linear Thermal Expansion	34*10E-6
Water Absorption – 24 hrs at 23º c	5-10 mg

c) Hardener

A substance of mixture added to a plastic composition to take part in and promote or control the curing action, also a substance added to control the degree of hardness of the cured film. See also curing agents, catalyst and cross-linking [6]. All working times (pot life) are based upon an optimum working temperature of about 80 degrees F. temperatures variations will greatly affect curing times, and when below 65F can sometimes double curing times. Other factors that affect epoxy curing can be moisture and humidity, as well as the thickness of lamination.

2. Methodology

Specimen Preparation Method

The banana fiber is obtained from banana plant, which has been collected from local sources. The extracted banana fiber were subsequently sun dried for eight hours then dried in oven for 24 hours at 105° C to remove free water present in the fiber. The dried fiber were subsequently cut into required lengths. The epoxy resins and hardener are procured from Ciba Geigy India Ltd. The banana fiber based epoxy composite is fabricated by using hand lay-up process. The moulds have been prepared with dimensions of 130×120×3.7 mm³. The banana fiber of different length has been mixed with matrix mixture with their respective values by simple mechanical stirring and mixture is slowly poured into the different moulds, keeping the characterization standards and view on testing condition. The releasing agent has been use on mould sheet which give easy to composites removal from the mould after curing the composites. A sliding roller has been used to remove the trapped air from the uncured composite and mould has been closed at temperature 30° C duration 24 hour. The constant load is applied on the mould in which the mixture of the banana, epoxy resin and hardener has been poured. After curing, the specimen has been taken out from the mould. The composite material has been cut in suitable dimensions with help of zig saw for mechanical tests as per the ASTM standards. The fabricated banana fiber based epoxy composite is shown in Figure.

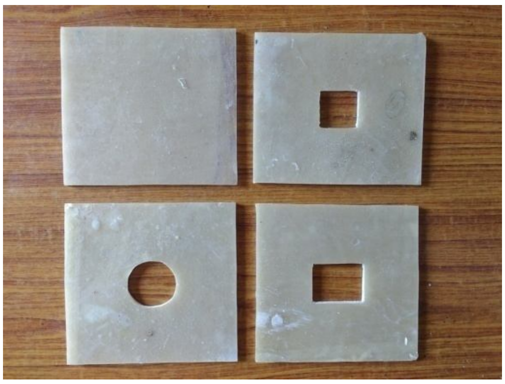

Figure 2. Composite specimens without cutout, with square cutout, circular cutout and rectangular cutouts

The composite plate having a circular cutout of 40 mm diameter, the composite plate having a square cutout of 35 mm X 35 mm and the composite plate having a rectangular cutout of 40 mm X 30mm.

IV. RESULTS AND DISCUSSIONS:

Buckling test:

Buckling test can be defined as bowing, swelling, bending of a member when it is subjected to a axial compression load. Buckling is a instability that leads to a failure mode. When a structure is subjected to compressive stress, buckling may occur. Buckling is characterized by a sudden sideways deflection of a structural member. This may occur even though the stresses that develop in the structure are well below those needed to cause failure of the material of which the structure is composed. As an applied load is increased on a member, such as a column, it will ultimately become large enough to cause the member to become unstable and it is said to have buckled. Further loading will cause significant and somewhat unpredictable deformations, possibly leading to complete loss of the member's load-carrying capacity. If the deformations that occur after buckling do not cause the complete collapse of that member, the member will continue to support the load that caused it to buckle. If the buckled member is part of a larger assemblage of components such as a building, any load applied to the buckled part of the structure beyond that which caused the member to buckle will be redistributed within the structure. The specimens which are placed in Universal testing machine are shown and during the buckling test how the specimen is buckled is also shown in the following figures.

Figure 3. Specimen before buckling

Figure 4. Specimen after buckling

During Buckling test, the composite plates of dimensions 130*120*3.7 mm³ are used, where the two sides of the specimen are free and the remaining two sides are clamped in the universal testing machine. It is subjected to an axial compression load. The upper and lower sides of the composite plates are fixed against translation and rotating by using the clamping screws. The composite plate is placed between the two cross heads. During the test, the upper machine cross head is moved downwards through the servo hydraulic cylinders and the lower cross head rigidly fixed. A constant cross head speed of 0.6 mm/min is maintained throughout the test. A peak load is generated at the point where the composite specimen is buckled.

The experimental results obtained from the Buckling test of the laminated banana fabric polyester composites for each samples are tabulated in the tabular column below.

Table 3. Buckling strength of laminated banana fiber based hybrid composite

Sample number	Sample name	Buckling Strength in MPa
1	Without cutout and 0º orientation	3.6
2		6.45
3		5.68
4	With Circular cutout	4.20
5		3.37
6	With Square cutout	3.34
7		2.48
8	With Rectangular cutout	1.65
9		5.10
10	Without cutout and	4.69

	30º orientation	
11	Without cutout and 60º orientation	3.19

The Buckling strength as a maximum of 6.45 N/mm² for composite without cutout for 0º orientation and the Buckling strength as minimum of 1.65 N/mm² for composite with Rectangular cutout. The value of buckling strength mainly depends on epoxy resin and fabric used and the thickness of the composite plates,. The Buckling strength as a maximum of 6.45 N/mm² for composite without cutout for 0º orientation, this is because of improper curing and delamination failure. The Buckling strength as minimum of 1.65 N/mm² for composite with Rectangular cutout. This is because of the distribution of the epoxy resin and hardener may varies and improper curing after the fabrication process.

V. CONCLUSIONS

The following conclusions have made from the results obtained from the experimental study for the laminated banana fiber based hybrid composites.

- The materials used for fabrication of laminated banana fiber reinforced epoxy hybrid composite are Banana fabric, epoxy resin and the hardener.
- The fabrication was successfully carried out by using the Hand layup technique.
- In Buckling test, For orientation angles without cutout the

1) Buckling strength has a maximum of 6.45 N/mm² for the composite without cutout of 0º orientation, when compared to the 30º and the 60º orientation.
2) Buckling strength has a minimum of 3.19 N/mm² for the composite without cutout of 60º orientation, when compared to the 0º and the 30º orientation.

- In Buckling test, for cutouts

1) Buckling strength has a maximum of 4.20 N/mm² for composite plate having circular cutout.

REFERENCES

[1] Merlini C., Soldi V., Barra G. M. O., “Influence of Fiber Surface Treatment and Length on Physico-Chemical Properties of Short Random Banana Fiber-Reinforced Castor Oil Polyurethane Composites”, Polymer Testing, 30 (2011), pp. 833–840.

[2] Pothan L. A, Thomas S., Neelakantan N. R., “Short Banana Fiber Reinforced Polyester Composites: Mechanical, Failure and Aging Characteristics”, Journal of Reinforced Plastics and Composites, 16(1997), pp. 744-765.

[3] Laban B. G., Corbiere-Nicollier T., Leterrier Y., Lundquist L., Manson J. -A. E., Jolliet O., “Life Cycle Assessment of Biofibers Replacing Glass Fibers as Reinforcement in plastics”, Resources Convertion and Recycling, 33(2001), pp. 267-287.

[4] Joseph S., Sreekala M. S., Oommena Z., Koshy P., Thomas S., “A Comparison of the Mechanical Properties of Phenol Formaldehyde”, Composites Reinforced with Banana Fibres and Glass Fibres, Composites Science and Technology, 62 (2002), pp. 1857–1868.

[5] Laly A. Pothana, Zachariah Oommenb, and Thomas S, “Dynamic Mechanical Analysis of Banana Fiber Reinforced Polyester Composites”, Composites Science and Technology, 63(2), 2003, pp. 283-29

[6] Corbiere-Nicollier T, Laban B.G, Lundquist L, Leterrier Y,. Manson J.A.E and Jolliet O, “Life Cycle Assessment of Biofibers Replacing Glass Fibers as Reinforcement in plastics”, Resources Convertion and Recycling, 33(4), pp. 267-287.

[7] Pothan L.A, Thomas S and Neelakantan, “Short Banana Fiber Reinforced Polyester Composites: Mechanical, Failure and Aging Characteristics”, Journal of Reinforced Plastics and Composites, 16(8), pp. 744-765.

[8] Ghannadpour, Najafid, Moammadi, “On the buckling behaviour of cross-ply laminated composite plates due to circular/elliptical cutouts”, Jr Composite Structures, Vol.75, 2006.

[9] Kremer, Schurmann, “Buckling of tension loaded thin walled composite plates with cutouts”, Jr composite Science and Technology, Vol. 68, 2008.

[10] Tercan,Aktas,”Buckling behaviour of 1_1 rib kitting laminated plate with cutouts”, Jr Composite Structures, Vol.89, 2009.

[11] Eryigit, Zor, Arman, “Hole effect on lateral buckling of laminated cantilever beams”, Jr Composite: Part B, Vol.40, 2009.

[12] Komor, Sonmez, “Elastic buckling of rectangular plateunder linear varying in-plane normal load with

circular cutouts", Jr. Mechanics Research Communications, Vol.35, 2008.

[13] Kumar, Singh, "Effect on boundary conditions on buckling and post buckling responses of composite laminates with various shaped cutouts", Jr Composite Structures, Vol.92, 2010.

[14] Ameen, "Buckling Analysis of composite Laminated plate with cutouts", Engg. And Tech. Jr., Vol.27, No.8, 2009.

[15] Suhaib A Sheikh*, N.P.Awate, "A Review paper on Design and Development of Banana fiber extraction machine", International journal of engineering sciences & research technology, ISSN: 2277-9655, March 2016

[16] Ravi Bhatnagar, Gourav Gupta, Sachin Yadav, "A Review on Composition and Properties of Banana Fibers", International Journal of Scientific & Engineering Research, Volume 6, Issue 5, May-2015

[17] R.Sakthivel and D.Rajendran, "Experimental Investigation and Analysis a Mechanical Properties of Hybrid Polymer Composite Plates", International Journal of Engineering Trends and Technology (IJETT) – Volume 9 Number 8 - Mar 2014, page no. 8

[18] Sujeet Kumar, "Study on Mechanical behaviour of Banana Fiber Reinforced Epoxy Composites", National Institute of Technology, Rourkela, May 2014

[19] P.Shashi Shankar, Dr.K.Thirupathi Reddy and V.Chandra Sekhar, Mechanical Performance and Analysis of Banana Fiber Reinforced Epoxy Composites, International Journal of Recent Trends in Mechanical Engineering (IJRTME) Vol. 1, Issue. 4, Nov. 2013

[20] Satyanarayana, K. G, K. Sukumaran, A. G. Kulkarni, S. G. K. Pillai, and P. K. Rohatgi, (1986),Fabrication and Properties of Natural Fiber-Reinforced Polyester Composites, J. Composites, 17(4) pp.329–333