iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** IV **Month of publication:** April 2019

DOI: https://doi.org/10.22214/ijraset.2019.4329

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

An Investigation on Fracture Toughness of Glass Fiber Composite with Banana Fiber Composite

Girija. M[1], Dr. R. Thanigaivelan[2]
[1]M.E –Manufacturing Engineering, Department Of Mechanical Engineering, Mahendra Engineering College, Namakkal-637503.
[2] M.Tech., Ph. D Head of the Department, Professor, Department Of Mechanical Engineering, Mahendra Engineering College, Namakkal-637503.

Abstract: Now a day, Fiber-Reinforced Polymer (FRP) has been widely accepted and implemented in various fields of engineering, these materials also used in various technical applications; here the material need high strength and stiffness and weight of component should be low. Among various available natural fibers, banana fiber is an essential because of its characteristics such as high tensile strength, high tensile modulus, and low elongation at break beside, low cost and eases of accessibility. In addition now day global warming is an big issue due to use of plastics and other non decomposable products, our product material banana is eco friendly and it does not create any pollution. Hence this article analyze banana fiber and glass fiber reinforced polyster resin composites manufacturing using hand layup approach. Experiments are conducted to compare both fiber and to find the effect of fiber volume fraction on mode I fracture toughness of both composites.
Keywords: Banana fiber, glass fiber, fiber reinforced polymer, tensile strength and fracture toughness.

I. INTRODUCTION

In the previous decade, natural fibers with thermoplastic and thermoset grids have been grasped via vehicle producers and providers for door panels, seat backs, main events, package trays, dashboards, and inside parts. Prior FRP's are utilized in automotives for their less weight, high solidness and strong quality for various applications. Because of the foundation of disposal techniques for glass fiber unbreakable plastics and their reusing laws are imperative contemporary subjects in light of the fact that numerous condition issues have showed up and intensified all through the world. Because of a worldwide temperature alteration and other ecological impact, the look for the option and earth well disposed material is a head.

The usage of natural fiber resistant plastics indicates alluring and reasonable techniques for supplanting the synthetic fibers. Natural fibers are light and inexhaustible; they are minimal amount and high explicit quality resource. Among different common fibers, banana fiber is exceptionally compelling in that its composites have high elasticity quality, high pliable modulus, and low lengthening at break close to its minimal amount and facilitates of accessibility. Despite the fact that the data on the banana fiber is constrained in exiting literature, this work establishes in the field of banana fiber strengthened polymer composites with exceptional references to the structure, physical and mechanical properties of the composites and investigation the crack durability of banana fiber composites.

Natural fibers are cheaper, bio–degradable and no health hazard. Furthermore natural fiber reinforced fibers are seen to have good potential in the future as a substitute. Natural fibers are extracted from various part of the plant such as bast, leaf, seed, wood and grass stem.

Advantages of natural fiber are

1) Natural fibers are renewable resources.
2) Lower pollution level during production.
3) Energy necessary for fiber production is lower than that of glass.
4) CO_2 neutral: amount of CO_2 neutralized during fiber plant.
5) Growth is comparable with that emitted during processing.
6) Lower cost.
7) Less abrasive to the processing equipment.
8) Low density is the main point why NFC is interesting in automotive sector.
9) Using biodegradable polymers as matrix, we can have totally recyclable materials.

A. Glass Fiber

Glass fibers are presumably the most well-known of all strengthening fibers for polymeric matrix composites. The significant kind of glass fiber is E-glass, which is a borosilicate glass with a little antacid present in its organization. E-glass represents to one of the most reduced expenses of all commercially accessible reinforcing synthetic fibers, which is the significant explanation behind its boundless use in the fiber fortified composites industry.

In general, the key points of interest of glass fibers incorporate high elasticity, high synthetic resistance and great protecting attributes. Then again, the impediments are low modulus contrasted with other superior strands, for example, carbon and Kevlar fibers, moderately high explicit gravity (among the business fibers), more expense (contrasted with common fibers), sensitivity to abrasion area with dealing which often diminishes rigidity, low weakness obstruction and high hardness.

B. Banana Fiber

The extraction of the common fiber from the plant required certain consideration to maintain a strategic distance from harm. In the present tests, at first the banana plant areas were cut from the primary stem of the plant and after that moved delicately to expel the abundance dampness. Contaminations in the rolled strands, for example, colors, Broken fiber, covering of cellulose and so on were evacuated physically by methods of a brush, and after that the fiber were cleaned and dried. This mechanical and manual extraction of banana filaments was monotonous, tedious, and made harm the fiber. Thus, this sort of strategy can't be suggested for mechanical application. This was trailed by cleaning and drying of the fiber in a chamber at 20˚C for three hours. The fiber were then named and prepared for cover process. The mechanical properties of these filaments were additionally tried and observed to be extraordinarily affected by the state of the fiber, regardless of whether the fiber was new or dried, and upon the some portion of the plant from which the fiber had been evacuated.

II. LITERATURE SURVEY

K.G.Satyanarayana et.al, presents the advancement of new materials which improve ideal usage of common assets, and especially, of sustainable assets. Common filaments, for example, jute, coir and sisal have a place with this class. This paper depicts precise work did so far on the structure property relationship of these strands including break modes. Endeavors to join them in polymers and portrayal of these new composites, with and without exposing them to natural conditions, are accounted for. Issues emerging out of preparing of the composites and endeavors made to limit these issues are likewise depicted. Endeavors to manufacture a couple of segments and assessment of their execution in genuine use are displayed. Recommendations for future work are additionally given.

Kuruvilla Joseph et.al, discusses the different engineered materials that have been investigated and pushed, polymer composites guarantee a significant investment as building materials. There has been a developing enthusiasm for using characteristic strands as support in polymer composite for making minimal effort development materials as of late.

Characteristic strands are planned fortifying materials and their utilization as of recently has been more conventional than specialized.

They have since a long time ago filled numerous helpful needs however the use of the material innovation for the use of characteristic filaments as support in polymer grid occurred in similarly late years. Financial and other related factors in many creating nations where regular strands are copious, request that researchers and designers apply suitable innovation to use these characteristic filaments as viably and monetarily as conceivable to deliver great quality fiber strengthened polymer composites for lodging and different needs.

Among the different common strands, sisal is of specific enthusiasm for that its composites have high effect quality other than having moderate malleable and flexural properties contrasted with other lingo cellulosic strands. The present paper overviews the exploration work distributed in the field of sisal fiber fortified polymer composites with extraordinary reference to the structure furthermore, properties of sisal fiber, preparing systems, and the physical and mechanical properties of the composites.

P. S. Mukherjee and K. G. Satyanarayana, discusses the pressure strain bend for sisal filaments has been tentatively decided. Extreme rigidity (UTS), introductory modulus (YM), normal modulus (AM) and percent extension at break of strands have been estimated as capacity of fiber breadth, test length and test speed. UTS, YM, AM and percent extension lie in the range 530 to 630 MN m^{-2}, 17 to 22 GN m^{-2}, 9.8 to 16.5 GN m^{-2} and 3.64 to 5.12 individually for filaments of widths going somewhere in the range of 100 and 300μm. No critical variety of mechanical properties with change in width of the filaments was watched. Notwithstanding, with increment in test length of the strands, the UTS and percent stretching are found to diminish while YM and AM expanded in the test length extending from 15 to 65 mm. With the expansion in speed of testing from 1 to 50 mm min^{-1}, YM and UTS are found to increment while percent lengthening and AM don't demonstrate any huge variety. At a test speed of 500 mm min−1 the UTS esteem diminishes forcefully. The above outcomes are clarified as far as the inside structure of the fiber, for example, the cell structure, micro fibrillar point, abandons, and so forth. Examining electron magnifying lens (SEM) investigations of the cracked tips of the sisal filaments uncover that the disappointment of the fiber is because of the uncoiling of micro fibrils joined by decohesion lastly tearing of cell dividers.

The propensity of uncoiling appears to diminish with expanding pace of testing.

J. Giridhar et.al, presents a relative contemplate was made between the dampness ingestion practices of sisal also, jute fiber composites in an epoxy grid under inundation conditions. Sisal strands, in show disdain toward of having more minimized structure than jute strands, displayed higher dampness absorption levels in their composite frame, opposite to desires. This propensity was credited to the high cellulose content also, a conceivable interfacial impact in the previous.

III. PROPOSED SYSTEM

Composite materials are essentially hybrid materials constructed of different materials so as to use their individual structural compensation in a single structural material. Different logical definitions for composite materials can be expresses. The word composite in the term composite material implies that at least two materials are joined on a plainly visible scale to frame a valuable third material.

In professional practice, the modem composite materials have significantly affected the innovation of structure and development. It is a typical rule that at least two components might be joined together to be customized propelled composite materials, which are lighter, stiffer and more grounded than some other basic material that may some way or another have been utilized.

Fibers are the real constituent in a fiber - reinforced composite material as far as volume division and load-bearing limit. In auxiliary applications, fibers possess vast volume parts in a composite overlay and offer the major portion of the load on a composite structure.

As indicated by business and residential use, fibers are extensively named as natural fibers and synthetic (man-made) fibers. Natural fibers are plant, creature or mineral items. It is intriguing to take note of those natural fibers, for example, jute, coir, banana, sisal, and so forth, are bounteously accessible in creating nations.

A. Banana Fiber

Most of tropical region produces banana plants in high ration. It represents tree like appearance and trunk like stalk and it can grow from 3.0m to 9.0m and it does not contain any woody materials. The stalk, which runs in measurement from 200 mm to 370 mm, comprises of layers of covering leafstalk encompassing an empty center. Toward the finish of each stalk is a dim green elongated leaf, estimating around 3600 mm by 600 mm. The stalk contains long multi-celled strands expanding length-wise through the thick tissues of long leaves or leaf-stems.

Banana strands are acquired from the pseudo stem of the banana plant. The pseudo stem is called stalk, and is encompassed and bolstered by leaf sheaths which contain numerous fibers. A typical stalk is 1.8 m to 3.0 w long and 0.2 m to 0.3 m wide, and each leaf contains filaments in the external layers. The procedures of acquiring banana fiber regularly include manual or mechanical scratching.

1) *Materials Used:* Banana fiber composite
   a) Banana fiber
   b) Polyester Resin
   c) Methyl ethyl ketone (Accelerator)
   d) Cobalt (Catalyst)
   e) Polyvinyl (Separator)

i) *Composition and Structure of The Banana Fiber:* Under close examination, the banana stalk uncovers fibers broadening longitudinally along the whole length of the leaf, strengthening the leaf structure and keeping it unbending. The fibers are implanted in the mash tissue of the leaf and are appropriated all through the leaf cross area. Banana fibers are various celled structures. The long fiber is made out of a package offine hair-like strands (fibrils) established together with the regular sticky materials of the plant tissue. In general, the fibers are made out of carbohydrate cellulose with the related sticky binding and encrusting materials. The sticky binding materials, assigned the pectic substances, are related with the fats and wax inborn to the plant. The woody tissue contains the lignin. The cell is essentially cellulose and the related carbohydrate xylan.

Properties	Banana Fiber
Cellulose %	63–64
Hemicellulose %	19
Lignin %	5
Moisture content %	10-11
Density (kg/m^3)	1350
Flexural modulus (GPa)	2-5
Microfibrillar angle	11
Lumen size (mm)	5
Tensile strength (MPa)	54
Young's modulus (GPa)	3.4878

Table 1: Major chemical constituents of the banana fiber

Initial modulus(GN/m^2)	20-51
Ultimate tensile strength (MPa)	520-750
Torsional rigidity(GN/m^2)	0.3-1.2
Flextural rigidity(GN/m^2)	2-5

Table 2: Mechanical properties of banana fibers

B. Glass Fiber

1) Materials Used
2) Glass fibre Composite
a) E-glass fibre
b) Polyester Resin
c) Methyl ethyl ketone (Accelerator)
d) Cobalt (Catalyst)
e) Polyvinyl (Separator)

i) The Composition of Glass Fiber: Glass fibers are undefined (non crystalline) materials. Their metal structure comprises of a three dimensional long system of silicon, oxygen, and different atoms arranged in an arbitrary manner. They have no particular micro structure. The primary constituent in all glass fibers is silica (SiOi). Different oxides, for example, B2O3 and AI2O3, are added to adjust the system structure of Si02 just as to enhance its. The E-glass is named because of its electrical properties. It is based on the eutectic in the ternary system CaO - AI2O3 - Si02 with some B2O3 substituting for Si02 and some MgO for CaO. The main chemical composition of E-glass and S-glass is shown below.

Glass fiber type	Oxides in weight fraction (%)				
	SiO_2	Al_2O_3	CaO	B_2O_3	MgO
E-glass	54	14	18	9	5
S-glass	65	25	-	-	10

Table 3 Typical chemical composition of E-glass and S-glass (Matthews and Rowlings)

ii) *General Properties of Glass Fibres:* Glass fibre properties are not strongly dependent on the chemical composition of fibre. The mechanical properties are isotropic. Processing parameters during fibre forming have a significant effect on fibre properties. Furthermore, fibres of the same composition and same diameter but made under different forming conditions show differences in properties.

Properties	E-glass	S-glass
Diameter (µm)	7	7
Specific gravity	2.54	2.49
Tensile modulus (GPa)	70	88
Tensile strength (GPa)	1.7	4.6
Strain to failure (%)	2.2	5.2
Density (g/cm^3)	2.56	2.49

Table 4 shows some properties of the E-glass fibre and S-glass fibre.

C. *Experimental Analysis*

The banana fiber utilized in the examination is 10 mm slashed banana fiber. The banana stalk was provided from ROPE Internationals, Chennai. Banana fibers were gotten from the pseudo stem of the banana plant. The pseudo stem, which is encompassed and upheld by leaf sheathes, is known as the stalk. The leaves were isolated from the pseudo stem and cut into 10mm length. The extraction of the fiber from the stripped leaf sheath (cleaned well) was finished by hand scratching utilizing a delicate wooden board. The essence was then expelled ceaselessly until the point when the filaments seemed clean.

Figure 1: Extracted Banana Fibers

Banana plant gives the flavorful natural product as well as gives material fiber, Banana fiber. It develops effortlessly as it sets out youthful shoots and is most ordinarily found in hot tropical atmospheres. All assortments of banana plants have fibers in bounty. These filaments are acquired after the natural product is reaped and fall in the gathering of bast fibers. This plant has for quite some time been a decent hotspot for fantastic materials in numerous parts of the world.

1) *Polyester Resin:* Polyesters are one of the minimum costly pitch. Polyester has the benefit of being incredibly modest when contrasted and other thermoset resins for example vinylesters and epoxies. On the off chance that the upside is cheap estimating, the drawback incorporates poor bonds, high water assimilation, and high shrinkage. Polyester resins are just good with fiberglass fibers. Polyester is most appropriate for applications obtuse to weight and don't require high attachment or break durability.

D. *Fabrication Of Composite And Test Specimen*

1) As per volume fraction of fiber, banana fibers are weighed.
2) Those banana fibers are chopped into various lengths 10mm.
3) Then 3 aluminium plates are taken at a dimension of 400*400*3mm.
4) In that 1 plate is made as a spacer (a hollow part space at the middle portion of aluminum plate).
5) The next step is the chemical reaction process
6) The chemicals are mixed into the certain compositions.

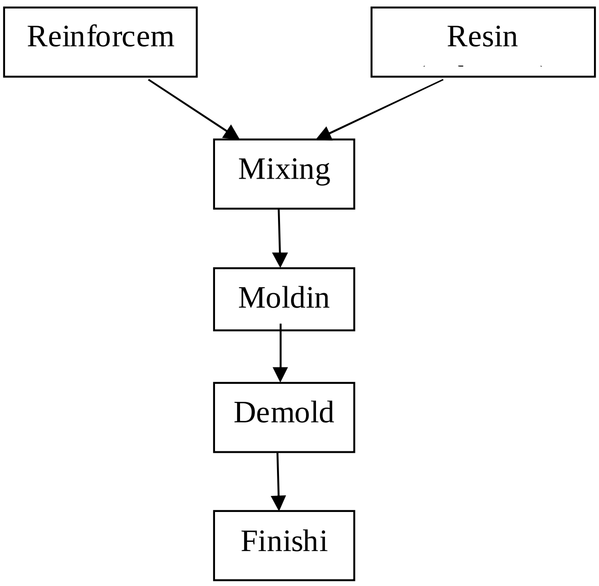
International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

The used chemicals are

Matrix	- Polyester Resin	(As per volume fraction)
Accelerator	- Methyl ethyl ketone	(2% for each composite)
Catalyst	- Cobalt	(1% for each composite)
Separator	- Polyvinyl	(2% for each composite)

a) After mixing these chemicals stir it properly for 5-10 minutes.
b) Then the fabrication process is done in the compression molding machine.
c) First keep the aluminum plate on the machine, and then keep the spacer above that aluminum plate.
d) Pour the chemical solution inside the spacer and spread the chopped banana fiber in that and mix it properly.
e) Apply some wax all over the aluminum sheets to remove the fabricated job easily.
f) Then cover the upper part with polythene sheet and keep the other aluminum sheet on it.
g) Then start the machine and press the aluminum sheet at a pressure of 1-1.5 Pascal.
h) The temperature should be at 70 degrees during the fabrication process.
i) After 4 hours switch off the machine and remove the aluminum plate from the machine.

Remove the fabricated banana fiber from the spacer by ramming those aluminum sheets.
Follow the same procedure for fabrication of Glass fiber composites.



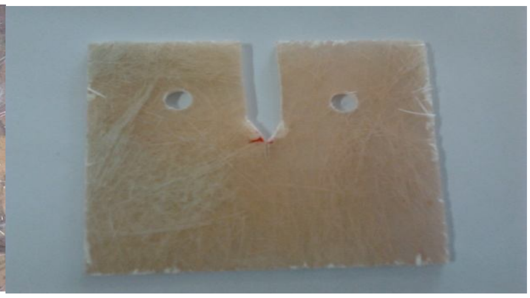
Aluminum mould

Composite fabrication in compression machine


Fabricated banana fiber composite


Fabricated BFRPC CT test specimen


Fabricated glass fiber composite


Fabricated GFRPC CT test specimen

E. *Calculation*

1) *Fraction Volume Calculation:* Volume fraction is defined as the ratio between volume of fiber to the volume of composite.

$$V_f = \frac{V_{fi}}{V_c}$$

V_{fi}- Volume of fiber

V_c- Volume of composite

2) *Formula Used To Calculate Fracture Toughness*

a) *Stress Intensity Factor:* Stress intensity factor K can be considered as a estimate of fracture toughness.

It depends on the

i) Load
ii) Flow depth
iii) geometry

Critical stress intensity factor for mode 1

$$K_{ic} = \frac{P}{B\sqrt{W}}\left\{F\left(\frac{A}{W}\right)\right\} \longrightarrow \text{(1)}$$

IV. RESULT AND DISCUSSION

From the load obtained from the each composite the average load is calculated. This is utilized to calculate fracture toughness value of composite. The average loads are tabulated below.

BANANA FIBER COMPOSITE				
VOLUME FRACTION IN %	LOAD IN NEWTON			AVERAGE LOAD IN NEWTON
	SPECIMEN			
	1	2	3	
13	16.53	18.66	22.4	16.56
17	18.4	18.6	18.8	18.66
20	22.2	22.7	22.5	22.46

Table 5: average Load for banana fiber composite

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

For the same glass fiber composite three test specimens such as specimen1, specimen 2 and specimen 3 were tested in the global agreed machine. The variations in load for the similar glass fiber composite were tabulated below.

GLASS FIBER COMPOSITE				
VOLUME FRACTION IN %	LOAD IN NEWTON			AVERAGE LOAD IN NEWTON
	SPECIMEN			
	1	2	3	
13	19.8	19.2	19.5	19.3
17	22.2	21.9	22.4	22.15
20	25.3	25.6	25.7	25.5

Table 6: average Load for glass fiber composite

Then average load is calculated from the loads obtained from the each composite. The average load is used for calculating fracture toughness value of composite. The average loads are tabulated above.

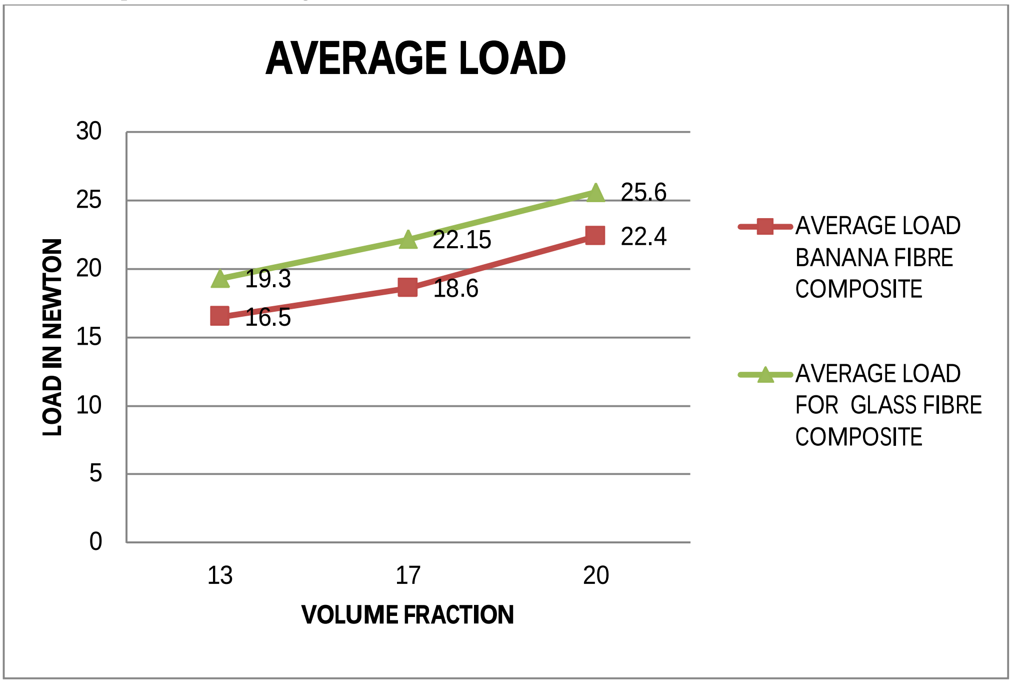


Figure 2: Average load of GFRPC

The fracture toughness variation is calculated as a function of relative change in volume fraction for banana fiber composite is shown. The volume fraction of banana and glass fiber increases will increases fracture toughness.

COMPOSITE	Fiber Length (mm)	Volume Fraction %	Experimental Fracture Toughness (Kic)
Glass fiber composite	10	13 17 20	4.75 5.4 6.8
Banana fiber composite	10	13 17 20	4.07 4.59 5.53

Table-7: Experimental Fracture value comparison

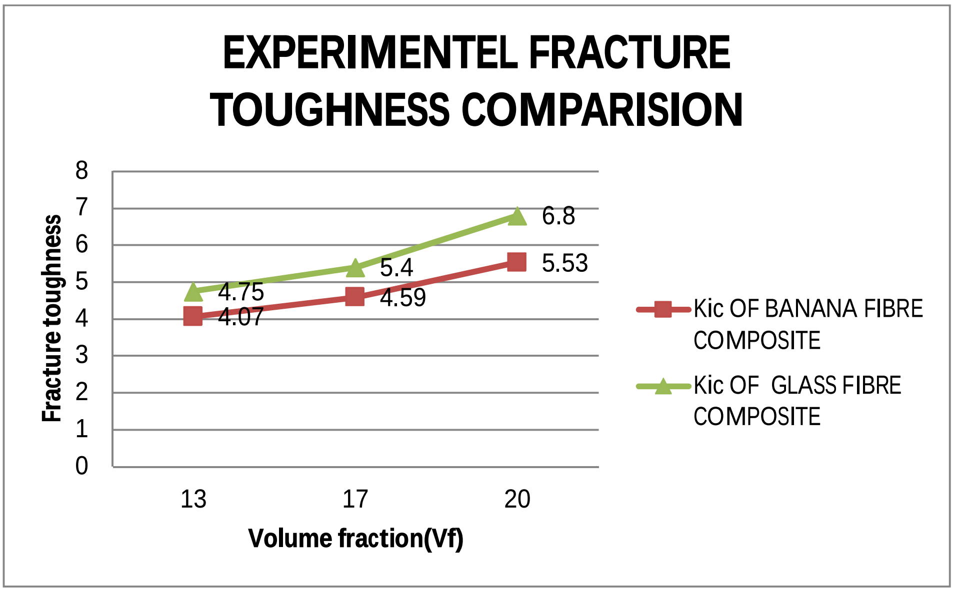


Figure 3: Compare the experimental fracture toughness of glass and banana fiber composite BFRPC

The estimations of break strength for composites with various fibers content got tentatively appeared in figure. It very well may be seen that the outcomes got from both concur with one another, where the expanding fiber substance will enhance the crack durability of both banana and glass fiber composites.

V. CONCLUSION

Banana fiber and its composites can be further attractive if a suitable cost–effective design method of fiber separation and its composite production may increases its application to a greater extent. Composites based on banana fibers have very good potential use in the various sectors like construction, automotive, machinery etc. Fracture toughness tests were performed on GFRP, BFRP composites with fiber fraction volume percentages of 13%, 17%, 20% Vf. It can be concluded that fracture toughness is improved with the reinforcement of glass fiber as well as banana fiber. When compare the glass fiber composite with banana fiber composite, fracture toughness of glass fiber composites are better than the banana fiber composites. More over fracture toughness of banana fiber composite is near to the glass fiber composite. Banana fibers are eco friendly so it is better for replace glass fiber instead of natural fiber for better environment.

REFERENCES

[1] K.G.Satyanarayana, K,Sukumaran, Kulkarni,A.G, Pillai S.G.K and Rohatgi (1984), "Performance of banana fabric –polyester composites" in proceedings of Second international conference on Composite Structure 13-16 Sep 1983,ed.I.H.Marshall,Applied Science publishers, London :535-537.
[2] K.G.Satyanarayana, K. Sukumaran, P.S.Mukherjee, C. Pavithran and S.G.KPillai, (1990)" natural Fiber-Polymer Composites", Journal of Cement & Concrete Composites, v 12: 117-136.
[3] Lightsey.G.R (1983),"Polymer application of renewable resource materials", Characteristic of banana fiber, New York: Plenum Press.
[4] Kuruvilla Joseph,Romildo Dias Toledo Filho, Beena James, Sabu Thomas and Laura Heker(1999)," A review on banana fiber reinforced polymer composites", R.Bras.Eng.Agric. Ambiental, Campina Grande, v3:367-379
[5] J.Gridhar, Kishore and R.M.V.G.K.Rao, "Moisture Absorption Characteristics of Natural fiber composites", Journal of Reinforced Plastics and Composites v5, 1986 141 -150.
[6] Paul Wambua, Jan Ivens, Ignaas Verpoest, (2003), "Natural fibers: can they replace glass in fiber reinforce plastics?" Journal of Composite Science and technology, 63, 2003, 1259-1264.
[7] Mukherjee, K.G, Satyanrayana.K.G, (1984)," Structure and properties of some vegetable fibers", Journal of Material Sciences v19: 3925-3934.
[8] Diether H.Muller, Andreas Krobjilowski, (2003),"New Discovery in the properties of composite reinforced with natural fibers", Journal of Industrial textiles, v33, 111-130.
[9] S.V.Joshi, L.T.Drza, A.K.Mohanty, S.Arora, (2004), "Are natural fibers composites are environmentally superior to glass fiber reinforced composites", Composts Part A: v35: 371-376.
[10] Shakila Umair, (2006),"Environmental effect of fiber composite materials-Study of Life cycle assessment of materials used for ship structure", M.S Thesis Dissertation, Royal Institute of Technology, Stockholm.