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IMPACT STRENGTH ANALYSIS OF LAKE TANA PAPYRUS/GLASS FIBER HYBRID COMPOSITES

Peddinti Nehemiah
Faculty of Mechanical & Industrial Engineering, Bahir Dar Institute of Technology, Bahir Dar University, Ethiopia.

Abstract

The advantages of composite materials are numerous and well documented. Currently all over the world composite materials have a great role in any kind of manufacturing because of high strength to weight ratio, dimensional stability etc. Many studies were conducted to investigate the impact behaviour of fiber reinforced composites due to the increasing demand of these materials in the automotive, maritime, aviation, infrastructure, military, sport sectors and petroleum. However, in order to obtain new properties, in this study, Papyrus and Glass fibers are hybridized as reinforced materials. Composite materials are often used in environments in which they will suffer impact damage. Impact test is the process applying hammering effect on the work materials, which determines how much mechanical energy is required for the failure. The ability to quantify this property is a great advantage in product liability and safety. The main objective of this research is to find out enhanced hybrid composite material for impact strength of Lake Tana papyrus and glass fiber with polyester Resin. There are different methods to investigate the hybrid composite impact strength. The present research is done by varying the percentage content of the natural fiber for papyrus composite (30%/70%), (20%/80%) and for PGFHC (15%/15%/70%) and (10%/10%/70%) with 70% fixed value of polyester. The other method is by changing the arrangement of the fiber glass and papyrus fibers in unidirectional, woven and random/Chopped/ manner. The Papyrus/Glass fiber hybrid composite is prepared manually by hand lay-up method. Twelve samples were fabricated for each lamina and percentage content. After the samples are manufactured the test pieces are cut according to ASTM E-23 standard. Tests are conducted on IZOD impact testing machine for low velocity. In addition to experimental work, samples were analyzed for equivalent stress with ANSYS. The maximum impact strength is observed for composite with 15 wt% Papyrus fiber loading and unidirectional fiber orientations that is 28.53 kJ/m^2 with Equivalent Von-

Mises stress 45.403 MPa. Minimum values of impact strength were observed in chopped 30%/70%, which is 18.27 kJ/m^2 with Equivalent Von-Mises stress 317.88 MPa.

***Keywords**: Hybrid Composite, Papyrus fiber, Glass fiber, Polymer, Impact Strength.*

1. Introduction

The most common form in which fibre-reinforced composites are used in structural applications is called a laminate, which is made by stacking a number of thin layers of fibers and matrix and consolidating them into the desired thickness. Fiber orientation in each layer as well as the stacking sequence of various layers in a composite laminate can be controlled to generate a wide range of physical and mechanical properties for the composite laminate [1]. Researchers [2] concluded from their study that the addition of a very small amount of nanoparticle into a matrix can improve both thermal and mechanical properties significantly without compromising the weight or process ability of the composite. Hybridization [3] is a process of incorporating of two reinforcements either synthetic fibers/ Nano fillers/natural/ or metallic fibers in order to yield better properties such as (high mechanical strength, compressive strength, stiffness, thermal stability and lowered water absorption properties) which cannot be realized in conventional composite materials. Hybrid materials are very advanced composites materials [4] consisting of two or more different constituents at the molecular or nanometer level.. Cyprus Papyrus is the largest member of the family. It has the capacity of growing very quickly, but needs fairly specific conditions. Temperature limits its range to tropical and sub-tropical regions, and it will not tolerate any shortage or irregularity in the supply of water (sensitive to water stress). Essentially it grows in slow flowing rivers, and lakes of low salinity, with stable water levels and shallow banks. It is native to Africa (parts) and Palestine [5]. Many studies were conducted to investigate the impact behaviour of fiber reinforced hybrid composites due to the increasing demand of these materials in the automotive, maritime, aviation, infrastructure, military, sport sector and petroleum.However, in order to obtain new properties, several researchers [6] studied on hybridizing fibers into polymer matrix. Impact resistant materials remain a concern to all types of military and civilian equipment manufacturers. The light weight fiber-reinforced composites have the capability to replace metals and traditional composites for high impact strength and vibration damping while providing good in-plane stiffness [7]. The study of various composite materials subjected to impact loading has not been given enough attention even though it should be a major design factor. The few published results on impact behaviour were obtained with a standard Charpy impact machine without any attempt to study the phenomena of impact. For a fiber reinforced plastic material, it is likely that the impact behaviour will be time dependent, i.e., dependent on the velocity of the hammer when striking the specimen. It has been shown that for a glass fiber reinforced plastic matrix, the ultimate strength increases as a function of the rate of loading in the fiber direction. Thus, in this impact study [8], the rate of loading during impact was used as one of the primary variables. It is naturally convenient to study [9] together the composites that have the same strengthening mechanism, which in-turn depends on the geometry of the reinforcement. The behaviour of hybrid composites is a considered sum of the individual components in which there is a more favourable balance between the inherent advantages and disadvantages. Also, using a hybrid composite that contains two or more types of fibers, the advantages of one type of fiber could complement with what are lacking in the other. As a consequence, a balance in cost and performance could be achieved through proper material design [10]. The impact strength of the hybrid composites increased with the addition of glass fibers. Addition of Kevlar fiber to glass fiber has improved the load carrying capability, energy absorbed [11]. Sisal fibers obtained from local sources and the chopped strand mat of glass fibers were used for the present study. Unsaturated polyester resin obtained as the matrix. An alkoxy [12] silane has been used as the coupling agent in order to enhance the adhesion characteristics between the fiber and the matrix. The sisal fibers were treated with a 2% solution of NaOH into a glass tray and the fibers were allowed to soak in the solution for 1 h. Preparation of Composites is done by hand lay-up and castings of different thickness were made from resin. In order to make the test specimens, the matrix system is poured into a mould made of glass plates. Unsaturated polyester and styrene are mixed in the ratio 100: 25 parts by weight respectively. Later, 1wt % methyl ethyl ketone peroxide and 1wt % cobalt naphthenate were added and mixed thoroughly. The impact specimens were cut as per ASTM D 256 specifications and the Izod impact tester was used. It is observed that the impact strength has been improved with increased glass fiber content and the total fiber content in the hybrid composite. In the study by Maneesh Tewari et.al [13] the properties of Palmyra/glass fiber composites at 55 wt. % fibers are investigated. Composites are prepared by varying both glass fiber and Palmyra fiber content by keeping the overall fiber content constant. The impact strength of Palmyra fiber composite is 30.50 kJ/m^2 which is comparable with results of other natural fiber composites. Increase in fiber content results in increase in fiber-to-fiber contact and hence matrix breakage becomes predominant failure mechanism. When the glass fiber is added to the Palmyra fiber the impact resistance is increased considerably. Evaluation of Mechanical Properties of Bagasse-Glass Fiber Reinforced Composite, in their research work natural fiber a bagasse-glass fiber reinforced composite material is developed, with 15 wt%, 20 wt%, 25 wt% and 30 wt% of bagasse fiber with 5 wt% glass fiber mixed in resin. The research was therefore initiated with the objective of studying the feasibility of manufacturing composite boards from a mix of fibrous bagasse particles with glass fiber by means of a flat press process and to show bagasse content, and pressure effect on selected board properties tensile and impact strength. Epoxy resin (CY230), hardener (HY951), bagasse fiber and glass fiber with different weight percentage were used. Different weight percentage (wt %) of bagasse fiber (15, 20, 25, 30 wt %), glass fiber (5 wt %) and epoxy resin were mixed by mechanical stirring at 3000 rpm. Finally, the investigation showed an improvement in the impact strength that has been observed due to addition of bagasse fibers. An increase of impact strength from 22.07 Nm to 27.01 Nm has been noticed due to addition of 30 wt% bagasse to the epoxy composite. From these observations it can be concluded that bagasse fiber improves the impact strength when added as filler material. Addition of fiber increases the modulus of elasticity of the epoxy. Mixing of bagasse with glass fiber also improves the modulus of elasticity. Bagasse and bagasse-glass fibers improve the impact strength of epoxy materials due to high elasticity properties of fiber as compared to pure resin. M. R. Sanjay and B. Yogesha, [14] conducted Study on Mechanical Properties of Jute/E-Glass Fiber Reinforced Epoxy Hybrid Composites, this paper deals with the hybrid effect of composites made of jute/E-Glass fibers. S. Mishra et.al, [15] Studied on mechanical performance of bio-fiber /glass reinforced polyester hybrid composites, the degree of mechanical reinforcement that could be obtained by the introduction of glass fibers in bio-fiber (pineapple leaf fiber/ sisal fiber) reinforced polyester composites has been assessed experimentally. Vithal Rao Chavan et.al, [16] evaluated the influence of fiber orientation and filler Content on Tensile, Hardness, and Impact Strength of Hybrid Laminated Composite. The values of different composites under consideration developed with ±90° oriented E-glass fiber reinforced and 6wt% of Fe_2O filled and polyester resin matrix shows more Impact Strength compared to other composites.

Papyrus is one of the ecological materials for which it has many distinct characteristics such as: It reaches its maximum strength in just few months; It is renewable material; Has simple production process; Has fairly good mechanical properties; High specific strength, non-abrasive, eco-friendly and bio-degradability characteristics; Has low cost and weight etc. Papyrus fiber has been selected in this study for the hybridization with glass fiber. Even though this natural plant has the aforementioned characteristics, in the previous years, sufficient studies have not been made on papyrus fibers as reinforcement hybrid composite materials. The main trouble for the application of papyrus as a reinforcement, still is the lack of sufficient information about its interaction with other synthetic fibers. This study tried to fill this gap and presents the results of experimental study carried out and a concise summary of the information about the impact strength of papyrus and glass-fiber composite. As Automotive industry is growing in Ethiopia, the industry may need some martials that help to replace steel. This research tries to fill these needs by conducting software analysis and experimental test on impact strength of papyrus/glass fiber hybrid composite. This research mainly deals with the impact strength of papyrus/fiberglass hybrid composites using IZOD impact test machine and FEA analysis using analysis software ANSYS. Rationale for the Study in this research work, within reinforcing materials, glass fibers are the most frequently used in structural constructions because of their specific strength properties; Finding composite material having a good impact strength mechanical property; Glass fiber composite can be used for much more purpose by replacing metals and carbon fiber; Papyrus is natural, renewable, less cost; Papyrus is useful in replacing other natural fibers; Knowing the mechanical property of this Papyrus/glass fiber hybrid composite material will be useful for engineers and scientist for their work to use as alternative material.

From the above surveyed scientific literature, it is understood that nobody has carried out research on Papyrus which is abundantly available in Lake Tana, Bahir Dar, Ethiopia. This Papyrus Fiber along with Glass fiber and Polyester resin are used to prepare the specimen. Determining the Impact strength of the composite material made of the above materials is taken up as main study in the present work.

2. MATERIALS AND METHODOLOGY

2.1 Materials: The raw materials in this research work, E-glass fibers, polyester resin with its hardener material are utilized directly for composite preparation. Lake Tana Papyrus fibre is extracted from papyrus stem taking from Lake Tana, which is then processed in AG FIBER factory, Bahir Dar, Ethiopia, finally the test was performed in Debre Tabor University.

2.1.1 Papyrus

In Lake Tana Papyrus was a weed that grew wildly along the banks more than 3000 km^2 of the lake. Currently the peoples live around like Tana used papyrus to make baskets, sandals, mats, rope, blankets, tables, chairs, mattresses, and small boats called (Denkel). Truly, papyrus is important "gift of the lake Tana".

Figure 1. Typical view of Papyrus plant

Figure 2. a) Socked papyrus stem b) Manual extraction of fiber c) Extracted papyrus fiber

Table 1 Properties of papyrus fiber

Fiber	**Papyrus Fiber**
Density (g/cm^3)	1.46
Elastic Modulus (E) GPa	4.2
Poisson’s Ratio	0.029
Typical Diameter (μm)	70

Source: (Nishino,Takashi/Hirao, Koichi/Kotera, Masaru, 2007

2.1.2 Glass fiber: Glass fiber is a material consisting of numerous extremely fine fibers of glass. Glass fiber is commonly used as an insulating material. It is also used as a reinforcing agent for many polymer products to form a very strong and light fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), popularly known as "fiberglass". Glass fiber has roughly comparable properties to other fibers such as polymers and carbon fiber. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle (Patil Deogonda1 et.al, 2013).

Fiber glass materials usually have laminate structure with different fibers orientations in the reinforcing glass layers. Various glass fibers orientations result of the material properties in the plane parallel to the laminates. E-glass fibers are, by far, the most common types found in composites. These types have good combinations of chemical resistance, mechanical and insulating properties. Furthermore, E-glass offers the more attractive economics (Deborah D.L Chung, 2010).

Fiber is the reinforcing phase of a composite material. The present research work, E-glass fiber is taken as the reinforcement in the polyester resin to fabricate composites samples. These fibers are high-performance reinforcement widely used in hand lay-up and robot processes for the production of boats, vessels, plane and automotive parts, furniture and sports facilities. It is relatively low cost, the most common form of reinforcing fiber used in polymer matrix composites. “E” glass produced fibers are considered as predominant reinforcement for polymer matrix composites due to their: E-glass fiber has good electrical insulator characteristic, Low susceptibility to moisture, E-glass fiber has higher mechanical strength than other glass fiber types and, E-glass is low susceptibility to moisture (resists attacks from water), E-glass fiber is cheap in price. Due to the above promising characteristic and is widely adopted in AG fiber industry, E- glass fiber has been taken as papyrus fiber reinforcement for this study. The type of E- glass fiber which is used in this study is listed below.

E-glass fibers are usually exist in three Common forms: Unidirectional glass fiber, Chopped (random) glass fiber and woven glass fiber.

2.1.3 Unidirectional glass fiber

It is basically known as continuous glass fibres strand, or collection of individual fibres also known as a tow. The strands may be brought together to form an untwisted bundle of fibres called a roving. Both strands and roving can be woven into a variety of cloths.

Figure 5. Continuous E-Glass fiber

2.1.4 Chopped (random) glass fiber

Chopped strands are formed by cutting continuous strands into short lengths. Their length ranges from 3.2 *mm* to 12.7 *mm.* Chopped strand mat is manufactured from chopped strands, which are bonded together in a randomly oriented two-dimensional manner. This type of reinforcement is considerably cheaper than woven fabric when measured on a weight basis and is typically used as a reinforcing material in a laminate by itself or in conjunction with a woven fabric.

Figure 6. Chopped (Random) arrangement E-Glass fiber

2.1.5 Woven glass fiber

Glass fibers are also available in woven form. Woven roving is a coarse fabric and used in moldings and laminates to produce highly directional strength characteristics. A layer of woven roving is sometimes bonded with a layer of chopped strand mat to produce a woven roving mat. The woven forms are suitable for hand lay-up moldings *(Mallick 1988)*.

Figure 7. Woven Arrangement E-Glass fiber

Table 2 Properties of E-Glass fiber

Fiber	**E-glass**
Typical Diameter (μm)	10
Density (g/cm^3)	2.54
Elastic Modulus (E) GPa	72.4
Tensile Strength GPa	3.45
Strain-to-Failure (%)	4.8
Poisson's Ratio	0.2

Source: (P.K Mallick, 2007)

2.1.6 Polyester Resin and its Catalyst: The resin used for this study is Unsaturated Polyester with brand name of OCPOL 711 GP REISN manufactured by ORGI CHEMIE FZ-LLC Development Corporation. Which has low viscosity for fast wet-out, high thixotropic index to prevent draining on vertical surfaces. General Purpose (GP) resin exhibits good mechanical and electrical properties together with good chemical resistance (herakovich, 1998). Polyester resins are quite easily accessible, cheap and find use in a wide range of fields. Liquid polyesters are stored at room temperature for months, sometimes for years and the mere addition of a catalyst can cure the matrix material within a short time. Figure (8) shows a General-Purpose polyester resin

Catalyst (Hardener): Polyester resin is cured by adding a catalyst, which causes a chemical reaction without changing its own composition. The catalyst initiates the chemical reaction of the unsaturated polyester and monomer ingredient from liquid to a solid state. When used as a curing agent, catalysts are referred to as catalytic hardeners.

The cured polyester is usually rigid or flexible as the case may be and transparent. Polyesters withstand the variations of environment and stable against chemicals. Depending on the formulation of the resin or service requirement of application, they can be used up to about 75ºC or higher. The ratio of Polyester resin to hardener used for this study was based on their masses. In general ratio, it is calculated based on manufacturer guide lines and that was 27% hardener for 100% Polyester. According to manufacturer guide lines, better mechanical properties of composites after curing process are attained if & only if the above-mentioned ratio is correctly applied irrespective of any environmentally determined conditions.

Table 3 Properties of polyester Resin

	Elastic modulus E (GPa)	Density (g/cm3)	Poisson ratio
Polyester Resin	4.9	1.399	0.38

Source: (P.K Mallick, 2007)

2.2 Methodology

2.2.1 Fiber and matrix volume content of the composite

Fabrication and analysis of composite materials, the first and critical task is the determination of ingredient percentages such as fiber and matrix (resin) fraction presence in laminate. The ratio of the resin to the laminate can be determined through experience. It may be based on the volume ratio or weight ratio. The ratio was made on the base of their weight and then it was converted into volume ratio. The formula used to calculate the weight fraction and volume fraction of fiber and matrix was discussed below according to (Hei-lam et.el, 2016.) .These components are microstructural elements of the composite laminate in which composites strength and properties are determined and limited by these values. In general, result obtained from the equations presented below are mandatory for: Composite laminate preparation, In order to use ASTM standard. To determine size of laminates that meets the ASTM requirements, Finite element analysis purpose. The improvement of fabricated laminate for the future by varying these values. These values can be used as a design manual in collaboration of composite laminate's different experimental results which are fabricated by these contents, etc.

The composite weight Wc is the multiplication of the composite volume Vc and ρc

$Wc = Vc * \rho c$

Glass fiber weight Wg: $Wg = Wc * wg$

Papyrus fiber weight Wp: $Wp = Wc * wp$…

Where: wg: the weight fraction of glass wp: the weight fraction of Papyrus fibers wm: the weight fraction of matrix vg: the volume fraction of glass fibers vp; the volume fraction of Papyrus fibers vm: the volume fraction of matrix ρg: the density of glass fiber (g/cm^3) ρp: the density of Papyrus fiber (g/cm^3) ρm: the density of polyester resin (g/cm^3) Wp: weight of Papyrus Fibre (g) Wm: weight of Matrix (g) Wg: weight of glass (g) Vp: Volume of Papyrus fibres, (cm^3) Vg: Volume of Glass fibres, (cm^3) Vm: Volume of Matrix, (cm^3

) Wc: weight of composite specimen (g) Vc: Volume of Composite specimen (cm^3)

Here, total fiber is the sum of Papyrus fibers and glass fibers.

In this research, preliminary data from manufacturers' for E-glass fiber and Polyester are taken. by using the above aforementioned equations, these values were Calculated as follows; As measured composite mass for Composition of 30% Papyrus and 70% Polyester composites weight and volume fraction shown below;

As measured composite mass for Composition of 30% Papyrus and 70% Polyestercomposites weight and volume fraction shown below;

W*p* = 250g*0.3 = 75g W*m* =250g *0.7 = 175g

Wp + Wm = Wc 75g + 175g = 250g

Then the sum of weight fraction of the composite is become one as mentioned above inequation (3.5)

$w_p + w_m = 1$

$0.3 + 0.7 = 1$

Table 4: Density values of materials

Parameters	**Value**
Papyrus fiber density (ρp)	1.46 g/cm^3
Glass fiber density (ρg)	2.54 g/cm^3
Matrix Density (ρm)	1.399 g/cm^3

Table 5 The values in composites obtained from the above equation Composition of 30%Papyrus and 70% Polyester

Sample ID	**Wc (g)**	**Wp (g)**	**Wg (g)**	**Wm (g)**	**Vp (cm^3)**	**Vg (cm^3)**	**Vm (cm^3)**	**Vc (cm^3)**	***vp* (%)**	***vg* (%)**	***vm* (%)**

A1, A3 and A5	250	75	…	175	51.3	…	125.08	176.38	29.08	…	70.91

Table 6 The values in composites obtained from the above equation

Composition of 20%Papyrus and 80% Polyester

Sample ID	**Wc (g)**	**Wp (g)**	**Wg (g)**	**Wm (g)**	**Vp (cm^3)**	**Vg (cm^3)**	**Vm (cm^3)**	**Vc (cm^3)**	***vp* (%)**	***vg* (%)**	***vm* (%)**
A2, A4 and A6	250	50	…	200	34.25	….	142.96	177.21	19.33	…..	80.67

Table 7 The values in hybrid composites obtained from the above equation

Compositionof 15% Papyrus, 15% Glass and 70% Polyester

Sample ID	**Wc (g)**	**Wp (g)**	**Wg (g)**	**Wm (g)**	**Vp (cm^3)**	**Vg (cm^3)**	**Vm (cm^3)**	**Vc (cm^3)**	***vp* (%)**	***vg* (%)**	***vm* (%)**
B1, B3 and B5	260.4	39.06	39.06	182.3	26.7	15.37	130.3	172.4	15.51	8.91	75.57

Table 8 The values in hybrid composites obtained from the above equation

Compositionof 10% Papyrus, 20% Glass and 70% Polyester

Sample ID	**Wc (g)**	**Wp (g)**	**Wg (g)**	**Wm (g)**	**Vp (cm^3)**	**Vg (cm^3)**	**Vm (cm^3)**	**Vc (cm^3)**	***vp* (%)**	***vg* (%)**	***vm* (%)**
B2, B4 and B6	260.4	26.04	52.08	182.8	17.83	20.5	130.7	168.99	10.55	12.13	77.3

Composite Manufacturing method

There are two types of manufacturing method for composite materials. Curing and lay up process. There are different types of lay-up process: hand lay-up/wet lay-up, spray lay-up, filament winding. Vacuum Bagging, Resin Transfer Moulding (RTM), Autoclave, Pultrusion are grouped under curing process (MILTON, 2004). In this research the manufacturing method used is manual hand lay-up method. This method is a reliable process, it is by nature very slow and labor-intensive.

Fabrication process of composite samples: The proportion of reinforcement and matrix, the fabrication process undertaken in this research are presented in the section below. Composite laminates are formed by assembling different plies with different fiber constraints and orientations. In this work the impact test was performed according to the ASTM E23 and Standardspecimen size of the hybrid composite were manufactured with the method manual hand lay-up method. Two types of samples were prepared, Papyrus fiber with polyester and Papyrus fiber/glass fiber hybrid composite. The two samples have different calculated wt% ratio, it shows below in table (9) and (10)

For Papyrus composite

Table 9 Percentage composition for papyrus composite

Arrangement of fiber	Sample ID	Papyrus fiber %	Polyester resin %
Unidirectional	A1	30%	70%
	A2	20%	80%
Woven	A3	30%	70%
	A4	20%	80%
Chopped	A5	30%	70%
	A6	20%	80%

For papyrus/glass fiber hybrid composite

Table 10 Percentage papyrus/glass fiber hybrid composite

Arrangement of fiber	Sample ID	Papyrus fiber %	Glass fibre %	Polyester resin %
Unidirectional	B1	15%	15%	70%
	B2	10%	20%	70%
Woven	B3	15%	15%	70%
	B4	10%	20%	70%
Chopped	B5	15%	15%	70%
	B6	10%	20%	70%

Then calculated value of the various ratios were;

For Papyrus composite

Table 11 Calculated amount of the various ratios for papyrus composite

Percentage % (Papyrus/polyester respectively)	Sample ID	Weight of Papyrus (gm.)	Weight of polyester (gm.)
30%/70%	A1, A3and A5	63	147
20%/80%	A2, A4 and A6	42	168

For papyrus/glass fiber hybrid composite

Table 12 Calculated amount of the various ratios for papyrus/glass fiber hybrid composite

Percentage % (Papyrus/polyester/ glass respectively)	Sample ID	Weight of Papyrus 30% (gm)	Weight of Glass fiber (gm)	Weight of polyester 30% (gm)
15%/15%/70%	B1,B3 and B5	31.5	31.5	147
10%/20%/70%	B1, B3 and B5	21	42	147

Simulation Method

In this work, ANSYS version 15 software is used to calculate the flexural strength of Papyrus/Glass fiber hybrid polyester composite of different angle arrangement of fibres. For this material, the nine independent elastic constants are Exx, Eyy, Ezz, Gxy, Gxz, Gyz, *v*xy, *v*xz and *vyz* required to characterize material property as inputs for ANSYS program and then the results are obtained for the given data.

3.RESULTS and DISCUSSION

3.1 **EXPERIMENTAL RESULTS :** PGHPC was fabricated with different percentage fiber volume fraction and matrix volumefraction in three ways, which are unidirectional, woven and chopped (random) lamina orientation. Regarding the Papyrus composite and Papyrus/E-glass fibers hybrid composites, four different ratios [30%/70%], [20%/80%], [15%/15%/70%] and [10%/20%/70%] which is Papyrus/glass/polyester respectively based on volume has undertaken. A total of twelve samples made, and three specimens were used for each sample it become totally 36 specimens for the experiment. The variation of recorded testresult among the three specimens for each samples taken the average result.

3.1.1. Impact test: This test is performed according to (ASTM E23) at room temperature. Izod impact tests are used to testing absorbed energy, it is pointed by a slave friction pointer mounted on thedial after fracturing the test piece. In this test, the calculation of the ***Impact strength*** depended on the absorbed energy for fracture. It was Measured and recorded for (3) specimens for each samples of papyrus composite and hybrid composite. The calculationsdone as follows based on the absorbed energy;

Papyrus composite : In these composite only papyrus and polyester used to fabricate and the impact test result is shown and discussed below;

- **For 30% papyrus and 70% polyester experimental result (absorbed energy)**

Table 13 30% papyrus and 70% polyester experimental result (absorbed energy)

Lamina	Sample ID	Test 1 (U_c) (J)	Test 2 (U_c)(J)	Test 3 (U_c) (J)
Unidirectional	A1	17.2	16.9	17.3
Woven	A3	14.7	14.4	13.8
Chopped	A5	13.5	13.8	13.8

All Impact strength values for 30% papyrus and 70% polyester experimental resultcalculated and summarized below in the table and the average value is also done.

Table 14 30% papyrus and 70% polyester calculated result (impact energy)

Lamina	Sample ID	Specimen Area (m^2)	Test 1 (G_c) (kJ/m^2)	Test 2 (G_c) (km^2)	Test 3 (G_c) (kJ/m^2)	Average value (G_c) (kJ/m^2)
Unidirectional	A1	0.00075	22.93	22.53	23.06	22.84
Woven	A3	0.00075	19.60	19.20	18.40	19.47
Chopped	A5	0.00075	18.00	18.40	18.40	18.27

Papyrus/Glass fiber Hybrid composite

For Papyrus/Glass fiber hybrid composite Experimental result and calculated value isshown and discussed below;

❖ **For 15% Papyrus, 15% Glass fiber and 70% Polyester Hybrid compositeExperimental result**

Table 17 Experimental result 15% Papyrus, 15% Glass fiber and 70% Polyester Hybridcomposite (Absorbed Energy)

Lamina	**Sample ID**	**Test 1** (U_c) **(J)**	**Test 2** (U_c) **(J)**	**Test 3** (U_c) **(J)**
Unidirectional	B1	21	21.6	21.6
Woven	B3	19.8	19.5	18.8
chopped	B5	18.8	19.8	18.3

Table 15: Calculated result 15% Papyrus, 15% Glass fiber and 70% Polyester Hybrid composite (Impact Energy)

Lamina	**Sample ID**	**Specimen Area** (m^2)	**Test 1** (G_c) (kJ/m^2)	**Test 2** (G_c) (kJ/m^2)	**Test 3** (G_c) (kJ/m^2)	**Average value** (G_c) (kJ/m^2)
Unidirectional	B1	0.00075	28	28.80	28.80	28.53
Woven	B3	0.00075	26.40	26	25.07	25.82
chopped	B5	0.00075	25	26.40	24.40	25.29

Discussion on Experimental Results : From the Experimental results, Izod impact tests are used to testing absorbed energy pointed by a slave friction pointer mounted on the dial after fracturing the test piece. Absorbed energy has been recorded and these values used to calculate the impact energy. In this case the test is carried out with the sample of 3 for each type and the average valueis taken among the three specimen for each samples of papyrus composite and hybrid composite. From Figure 25 It has been observed that the average Impact strength value is high in the case of unidirectional lamina with 30 %/70% Papyrus composite compared to the other lamina it has the value of 22.84KJ/m^2. And also from Papyrus composite composition 30%/70% has greater value than 20%/80% in all lamina.From figure 28 also the result observed that the average Impact strength value is high in the case of unidirectional lamina with 15 %/15 %/70% Hybrid composite compared to theother lamina it has the value of 28.53KJ/m^2. And also from hybrid composite composition10%/10 %/70% has greater value than 10%/20%/70%

in all lamina.The impact tested composite specimen with unidirectional 15%/15%/70% did not break completely and showed the broken specimen like a hinge. Many fibers pull-outs can be seen on the fracture surface of the specimen. The higher impact strength of the compositeswith unidirectional 15%/15%/70% might be, a result of the fibers pulled out as well as bothfibers have equal Wt% that is 15% papyrus fiber and 15% Glass fiber. On the other hand, the other composites specimen broke completely into two pieces. Debonding occurred between a Papyrus fiber and Polyester resin, which showed the low impact strength. As a result, the Papyrus fiber/Glass fiber hybrid Polyester composites wereable to absorb higher impact energy during fracture propagation than Papyrus fiber with Polyester resin composites. The maximum impact strength is observed for composite with 15 wt% Papyrus fiber, 15 wt% Glass fiber loading and unidirectional lamina that is 28.53kJ/m^2. And minimum impact strength is observed for Papyrus composite with 30 wt% Papyrus fiber loading for chopped fiber orientations that is 18.27kJ/m^2.

3.2. Simulation Result: In this section, it is just concentrated on two main aspects modelling the specimen and simulate using ANSYS Explicit Dynamic Workbench. A 3D Finite Element model was created to simulate Impact test in ANSYS. For the impacttest simulation taking consider the shape and geometry of the sample process, the shape and geometry of the hammer. During simulation solving process material properties and test conditions in a practical test is used.

Simulation result for unidirectional and random chopped composites

Table 16. Simulation Equivalent Von Mises result for unidirectional and random choppedcomposites

Equivalent (von-Mises) stress (MPa)	Unidirectional Lamina	Random/Chopped lamina
30%/70%	142.55	317.88
20%/80%	168.68	254.17
15%/15%/70%	45.403	62.772
10%/20%/70%	82.885	91.417

3.3. Discussion on Simulation Results: Here the ANSYS simulation software is used for the simulation of the design to know theEquivalent von-Mises stress of specimens in unidirectional and random/chopped/ laminasmade of Papyrus/Glass fiber Hybrid composite when subjected to impact load. Random oriented fibre composite ideally assumes to have a property of an isotropic material the examination of stress, From ANSYS simulation result the following things have been observed. From Papyrus composite in the simulation unidirectional lamina 30%/70% has minimum equivalent von-Mises stress than 20%/80% which is 142.55MPa and 168.68MPa respectively but when it comes to random oriented lamina the equivalent von-Mises stress is become vice versa, 317.88MPa and 254.17MPa. From hybrid composite unidirectional lamina 15%/15%/70% has minimum equivalent von-Mises stress which is 45.403MPa and 15%/15%/70% randomoriented lamina also has small equivalent stress relative to other specimen, 62.772 MPa. Unidirectional lamina and Random oriented lamina in 10%/20%/70% Wt% concentration has minimum equivalent stress than both 30%/70% and 20%/80% Wt% concentration. The maximum Equivalent von-Mises stress is observed at Random lamina ofPapyrus composite among the other lamina relatively which is 317.88 MPa.

4.CONCLUSIONS AND RECOMMENDATION: The impact strength of the composites with unidirectional was significantly higherthan those of the composites with woven and chopped. This trend was confirmed by the fracture types of the tested specimens. Two different composites were made Papyrus composite and hybrid composite. It was tested and seen that the impact strength of the hybrid composites increases withthe addition of glass fiber content. And in this thesis the maximum impact strengthis achieved when Papyrus and Glass fiber become equal wt% which is 15%. The existence of void content in the composites significantly reduces the impact strength of the composites. Within the limitations of this present study, 15% papyrus and 15% glass fiber composition in Papyrus fiber composite was observed to have the maximum impactstrength, hence it is the critical composition needed for effective load transfer in this research work.

4.1. Future scope of the work: Study other mechanical properties of PGFHC like Tensile test, Compressivestrength test, Flexural test, Fracture and fatigue analysis.

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