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Investigation on fiber coating and treatment on mechanical properties of fiber composites

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***Abstract*---**The purpose of this project is to investigate on mechanical properties of fibre coated reinforced composites. Tensile properties of the coated flax fabrics tested at different resin treatment. The tensile test is to evaluate the effect of the epoxy coating on the strength of the flax fiber and to predict the behavior of the coating how influence the mechanical properties of the composites. The results show that the epoxy-coated flax fiber considerably higher tensile properties compared with the non-coated flax fiber reinforced composite materials. The tensile strength of the reference sample, i.e., flax fiber without coating is 18.7 MPa is compared low to the value of the coated fiber value of 19.3 MPa. It is important to consider, that there is a large number of factors affecting mechanical properties of coated fiber, for curing temperature, resin combination, fiber arrangement etc. Consequently, it is not possible to compare accurately the achieved values with the literature. To the best of authors' knowledge there is no previously published work on effect of fiber coating on flax fiber using high modulus. So, this latter assumption should be checked in a separate study. Tensile strength of the epoxy coated flax fiber at room temperature is more than twice as high as of the reference sample. At the same time, the strength depends on the resin that used for the coating apart matrix is very important.

***Keywords*---**Flax fiber, Polyster Resin, Epoxy.

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1. Introduction

Flax fiber is obtained from the inner bark of the stem of a plant grown in temperate and subtropical regions of the world. It is a natural, cellulosic, multi-cellular bast fiber. Flax fiber is 10–100 cm in length. The use of flax fibres as reinforcement in composites has gained popularity due to an increasing requirement for developing sustainable materials. Flax fibres are cost-effective and offer specific mechanical properties comparable to those of glass fibres Environmental awareness is a most important concern nowadays.
economic advantages, has resulted in increased attention in developing novel natural fiber reinforced composites.

Figure 1: Brown Flax Fiber

Figure 2: Natural Flax Fiber

Flax Fibres

The diameter of the flax stem is in the range of 1–2 mm, with a height of about 80 cm. It can be seen from that there are three layers—bark, bundle and xylem—in the flax stem. The outer layer of bark functions as a protective cover from external attacks except for the penetration of water and other nutrients.

Figure 4: Origin of Flax Fibre

1.1 Flax natural fiber – an important bast fiber

Flax fiber is considered the most important member of the bast family for composite reinforcement due to its unique properties.7 The bast fibers are collected from the fibrous bundles situated in the inner bark of a plant stem. The inherent high strength and stiffness of flax fiber and low elongation to failure are the important characteristics of this fiber that make it particularly interesting in composite research. Flax (Linumusitatissimum) is typically grown moderate climate region. Charlet et al.

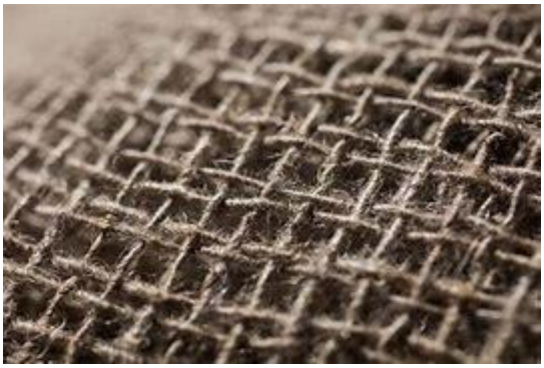


Figure 5: Flax Fiber

1.2 Structure and composition of flax fiber

A flax stem has the constituents of bark, phloem, xylem, and a void at the center. The fibers are located as fiber bundles in the outer surface of the plant stem as shown in Figure 2. The flax plants can grow to heights of 80 to 150 cm in less than 110 days since the plants are fast-growing by nature. The bundles are between 60 and 140 cm long and their diameter ranges from 40 to 80 lm. A flax stem contains 20–50 bundles in its cross section. Each bundle consists of 10–40 spindle-shaped single (elementary) fibers 1–12cm long and 15–30 lm in diameter.23 Charlet et al.24 reported that the elementary fiber diameters are different if taken from the bottom, the middle, and the top part of the flax stems. The mean fiber diameter was found to decrease from the bottom to the top of the stems. The elementary fiber (Figure 3) denotes a single cell in the flax plant. Each elementary fiber is composed of concentric cell walls that are different from each other in terms of thickness and the arrangement of their constituents.

1.3 Flax fiberre inforced composites

Elementaryflaxfibersareprocessedintotheformofmats, rovings, fabrics, and yarns to use in the manufacturing of composites. After selecting asuitable manufacturing technique, these are combined into several layers withthe matrix material of some form of a resin to manufacture composites.

1.4 Motivationnaturalfiberapplicationsinpolymercomposites

Due to the exponential growth of human population on Earth we face environmental problem smoreandmore. Now, in21stcentury, itisclearthatwearepayingforadvancedtechnologywithecologicaltroublesandevendisa sterssometimes. Anditisinourintereststolookforsolution.

2. Literature Review

[1]. A new special coating/fiber element for analyzing effect of interface on thermal conductivity of composites. The effects of interface or interphase on micro- and macro-thermal behaviors of square pattern unidirectional fiber- reinforced composites are investigated. The interfacial phase is modeled by a thin layer coated on the surface of the fiber to resist radial and circumferential thermal expansion of the fiber. The numerical results demonstrated that the proposed special coating/fiber element is promising and efficient for the analysis of a coated circular fiber model of fiber-reinforced composites. It was concluded from the numerical results that changes in the interface thickness have more influence than changes of thermal conductivity of the interface on the effective thermal conductivity of the composite by Hui Wanga, b, Qing- Hua Qinb.

[2]. Enhanced mechanical properties of short carbon fiber reinforced polyether sulfone composites by grapheme oxide coating. Polyether sulphone (PES) is an important special engineering plastic. In order to broaden its applications in automobile and sports fields etc., its mechanical properties have to be enhanced. This paper reports the effectively enhanced tensile and flexural properties of injection molded graphene oxide (GO)- coated short carbon fiber reinforced PES composites by GO coating. The GO content varies in a range of 0.0e1.0 wt%. First, the GO is employed as surface sizing agent to treat short carbon fibers (SCFs) by a facile physical absorption method by Fei Li a, b , Yu Liu a , Cheng-Bing Qu a , Hong-Mei Xiao a , Yang Hua a , Guo-Xin Sui c , Shao-Yun Fu a,

[3]. Coating applications to natural fiber composites to improve their physical, surface and water absorption characters. Natural (organic) fibers are used in reinforced composites and natural fiber composites (NFCs). These fibers have advantages over synthetic fiber composites such as high mechanical properties, lower densities and biodegradability. However, one major disadvantage of NFCs is their hydrophilicity

[4] A novel Bio composites where both natural fiber and matrix are derived from underutilized parts of sugar palm tree was successfully developed. This 100% green materials can lead to solve depletion and non-degradable polymer waste disposal problems. Unfortunately, since moisture absorption is a matter of

concern in bio composites, the effect of water absorption on mechanical properties of sugar palm fiber reinforced sugar palm starch (SPF/SPS) composites has been studied. Natural fiber such as kenaf, hemp, flax and ramie demonstrated several advantages which include high specific strength and stiffness, low density, biodegradable, abundance and low production cost.4 Thus, natural fiber are the potential sources of reinforcement for the development of new green materials associated with polymer matrix. Bakhtaran et al.5 carried out a study on properties of sugar palm fibre reinforced high impact polystyrene (HIPS) composites while the research of Ishak et al.6 and Sahari et al.78 dealt with sugar palm fibre reinforced unsaturated polyester composites.

[5] The hybridization effect of bamboo (B) and kenaf (K) fibers at different weight ratio were studied at B:K:70:30, and B:K:30:70 while maintaining total fiber loading of 40% by weight. The dimensional stability were strongly influence by the fiber orientation where all composites shows prominent expansion in the transverse fibers direction but relatively low expansion in longitudinal fibers direction. Dynamic mechanical properties in term of complex modulus (E*), storage modulus (E'), loss modulus (E''), Tan delta and Cole-Cole plot were studied. DMA results reveal that B:K 50:50 hybrid composite possess the highest complex modulus due to the strong fiber/matrix interfacial bonding which supported by the coefficient of effectiveness and Cole-Cole plot. Hence, it is concluded that 50:50 weight ratio of bamboo and kenaf fibers is the optimum mixing ratio to enhance both dimensional and dynamic mechanical properties of hybrid composites, and it can be utilized for automotive or building materials applications which demand high dimensional stability and dynamic mechanical properties Keywords: A. Hybrid; B. Thermomechanical; C. Thermal analysis; D. Thermosetting resin.

[6] An Epoxy piece and Jute fiber-epoxy composite is prepared using hand lay-up technique. For this purpose, an open type mold made of mild steel plate has been used. It is revealed that the jute epoxy composite exhibited better tensile and compressive strength. Bundle strength of fibers decreases with increase in number of fibers in a Bundle. Tensile and compressive strength increases with Jute fiber reinforcement. Due to environmentally friendly, bio degradability and sustainability, natural fiber composites are preferred as compared to conventional synthetic fiber-based composites. They are used in diversified domains [1-5] like building materials [4-6], structural purpose, aerospace industry, automotive industry and many other applications [2-5]. Due to environmentally friendly, bio degradability and sustainability, natural fiber composites are preferred as compared to conventional synthetic fiber-based composites. They are used in diversified domains [1-5] like building materials [4-6], structural purpose, aerospace industry, automotive industry and many other applications.

[7] From flexural test, it is concluded that hybrid fiber shows more advantage than the available composite. Similarly, hardness test represents that the composite can be utilized for high strength to low weight applications. Thus the prepared composite is eco-friendly in nature with low cost. Bindu et al. [3] investigated the influence of tensile strength and flexural properties of short fiber composites and concluded that the increase in fiber volume increases the mechanical properties of the composites. Dabade B. M. et al. [1] developed hemp

and Palmyra fiber on polyester matrix by varying the ratio of fiber lengths and weight. The variation of fiber length and weight accounts for improvement of different properties. Chabba et al. [4] analyzed the modified cross linking of soy flour with glutaraldehyde and reported that, tensile and thermal properties are sufficient for indoor structural applications of biodegradable green composites. Mishra et al.

[8] Three different processes methodologies were adopted to mix the jute fiber homogeneously in the mortar matrix. By optimizing the processing Conditions and fiber loading; the cold crushing strength and flexural strength, flexural toughness and the toughness index of the mortar has significantly been increased. Based on the Fourier transformed infrared spectroscopy and thermo-gravimetric analyses a plausible mechanism of the effect of jute reinforcement controlling the physical and mechanical properties of cement mortar have been proposed. Natural fibers such as Roselle, sisal, coconut, sugar-cane bagasse, hemp, and jute are reported to yield improved compressive and tensile strength of the cement based composites [3–8]. Thus Is mail [8] has investigated the effect of Roselle fiber in improving the compressive and tensile strengths of cement matrix. The chopped natural fiber reinforcement improves the energy absorption capability of the cement matrix to transform a brittle material into a pseudo-ductile one.

[9]. The bamboo fibers were prepared through chemical treatment by sodium hydroxide (Na OH) followed by physical milling method. The thermal characteristics of the bamboo fiber and its polymer composite were analyzed using a thermogravimetric analysis and differential scanning calorimetric. The functional groups and crystallinity of the fiber were analyzed with Fourier transform infrared and x-ray diffraction spectroscopy. Meanwhile, the fiber morphology was examined using a scanning electron microscope. The tensile and flexural properties of all the BFRCs were found to be directly proportional to the fiber volume fractions. It was found that the bamboo fiber reinforced epoxy composite (BFREC) with 40 % fiber volume fraction exhibited the highest tensile and flexural strength compared to polyester and vinyl ester composites. The method of bamboo fiber composite preparation in this work may serve as a useful guide to produce a strong BFRC for external strengthening of buildings and structures.

Table 1: Bast Fibre: Compositions, Physical and Mechanical properties

Bast fibers	Cellulose	Hemicellulose	Lignin	Pectin	Wax	Density (gm/cc)	Young's modulus (GPa)	Tensile strength (MPa)	Elongation at break (%)
Flax	60-81	14-20.6	2-3	1.8-5	1.7	1.5	27.6	345-1500	2.7-3.2
Hemp	70-92	17.9-22.4	3-5.7	0.9	0.8	1.4-1.5	17-70	368-800	1.6-4
Jute	51-84	12-20.4	5-13	0.2	0.5	1.3-1.4	10-30	393-773	1.2-1.5
Kenaf	31-57	13.6-21	5.9-19	2	-	1.2	14-53	240-930	1.6
Ramie	68.6-76.2	13-16.7	0.6-1	1.9-2	-	1.5-1.56	27-128	400-1000	1.2-3.8
Banana	60-65	6-19	5-10	3-5	-	1.3-1.35	27-32	529-914	1-3

3. Expreimental Analysis

This included the appliance of fiber treatments to improve durability, fire Retardance and biodegradation resistance. Again various (different) strategies were adopted and investigated by KU Leuven, IVW and SHR. KU Leuven focused on the durability increase by strengthening the internal structure of the flax fibers. Research strategies were developed and attempted to increase the internal interphase strength of flax fibers by treating the fibers with specific cross-linking chemical agents. The idea behind this technique is that hydrophilic molecules that are inherently exposed within the reinforcing flax fibers are prevented from interacting with water molecules in the atmosphere by covalently binding them to chemical precursors.

3.1 Fabrication of Composites Laminates

A thin film is a layer of material ranging from fractions of a nanometer (monolayer) to several micrometers in thickness. The controlled synthesis of materials as thin films (a process referred to as deposition) is a fundamental step in many applications. A familiar example is the household mirror, which typically has a thin metal coating on the back of a sheet of glass to form a reflective interface. The process of silvering was once commonly used to produce mirrors, while more recently the metal layer is deposited using techniques such as sputtering. Advances in thin film deposition techniques during the 20th century have enabled a wide range of Technological breakthroughs in areas such as magnetic recording media, electronic semiconductor devices, Integratedpassive devices, (such as antireflective coatings), hard coatings on cutting tools, and for both energy generation (e.g. thin-film solar cells) and storage (thin-film batteries). It is also being applied to pharmaceuticals, via thin-film drug delivery. A stack of thin films is called a multilayer.

Figure3.2.1ThinFilm Figure3.2.2VacuumBagging

A suction tape is stuck around the composite so that a plastic film is placed so that the composite can be isolated from the atmosphere.

Figure3.2.3 Fabrication of Flax fiber coated composite laminate

Figure3.2.4 Vacuuming in composite laminates

Once the plastic film is stuck accurately the vaccum tube is inserted inside so that the air traped inside can be sucked outside. After doing the above procedure correctly then curing process is started. The curing process is done for around 4-5 hours. After that a panel is created once the curing process is finished. After the panel is cut into pieces. It is then sent to the lab so that different experiments can be conducted over the composite and the accurate results can be found.

Specimen Preparation

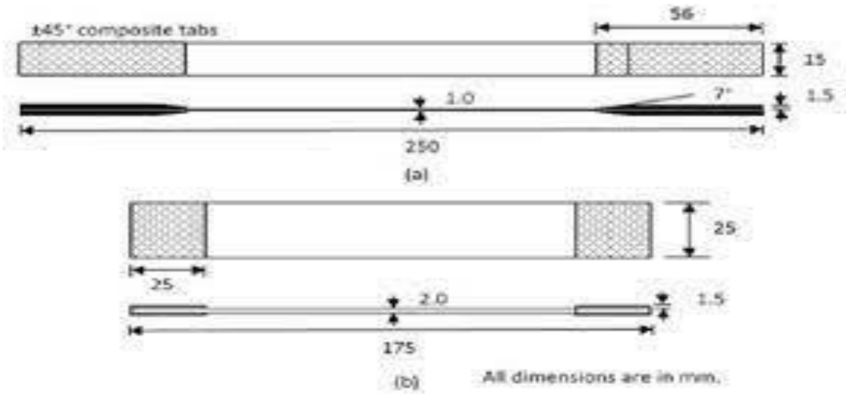
It quickly turned out that although pure water jet cutting is ideal for soft materials with a maximum of medium hardness, materials such as steel, ceramics, glass and stone are left out. Attempts to improve water jet cutting with an abrasive were finally crowned with success in the early 1980s. Ingersoll-Rand added abrasive water jet cutting to its product range in 1984. At the end of the 1990s, the manufacturer Flow optimised the process again. The so-called Dynamic water jet offers even higher precision and the possibility of cutting even very thick workpieces.

Figure 3.3.1: Water Jet Cutting

3.2 Tensile Specimen Test (ASTM)

Tensile testing is most often carried out at a material testing laboratory. The ASTM D638 is among the most common tensile testing protocols. The ASTM D638 measures plastics tensile properties including ultimate tensile strength, yield strength, elongation and Poisson’s ratio. The most common testing machine used in tensile testing is the universal testing machine. This type of machine has two crossheads; one is adjusted for the length of the specimen and the other is driven to apply tension to the test specimen. There are two types: hydraulic powered and electromagnetically powered machines.

The strain measurements are most commonly measured with an extensometer, but strain gauges are also frequently used on small test specimen or when Poisson's ratio is being measured. Newer test machines have digital time, force, and elongation measurement systems consisting of electronic sensors connected to a data collection device (often a computer) and software to manipulate and output the data. However, analog machines continue to meet and exceed ASTM, NIST, and ASM metal tensile testing accuracy requirements, continuing to be used today.



Tensile Test Composites Specimen

Result and Discussion

4.1 Tensile Strength of Fabrics

Tensile properties of the coated flax fabrics tested at different resin treatment. The tensile test is to evaluate the effect of the epoxy coating on the strength of the flax fiber and to predict the behavior of the coating how influence the mechanical properties of the composites Figure 3.2.3. The results show that the epoxy-coated flax fiber considerably higher tensile properties compared with the non-coated flax fiber reinforced composite materials. The tensile strength of the reference sample, i.e., flax fiber without coating is 18.7 MPa is compared low to the value of the coated fiber value of 19.3 MPa.

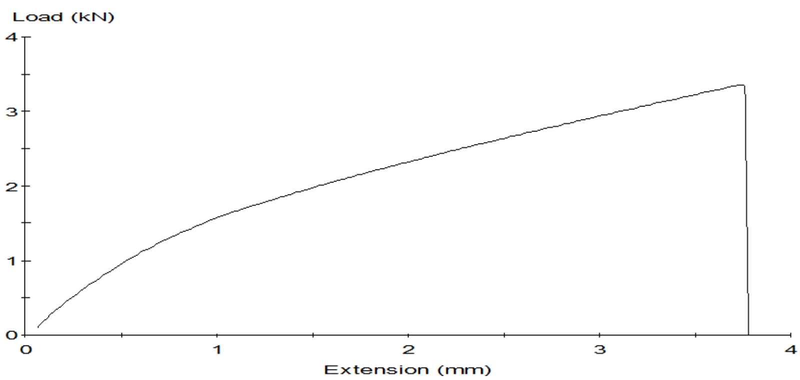


Figure 4.1Resin Coated Flax Fiber Reinforced Composites load vs Displacement

Figure 4.2 Resin Coated Flax Fiber Reinforced Composites stressstain curve

4.2 Charpy Imppact Test

Name	Value	Units
Thickness	7.300	mm
Width	23.780	mm
PeakLoad	3.351	kN
PeakStress	19.3	MPa

The Charpy impact test, also known as the Charpy V-notch test, is a high strain-rate test that involves striking a standard notched specimen with a controlled weight pendulum swung from a set height. The impact test helps measure the amount of energy absorbed by the specimen during fracture.

The Charpy Impact Test entails striking a notched impact specimen with a swinging weight or a "tup" attached to a swinging pendulum. The specimen breaks at its notched cross-section upon impact, and the upward swing of the pendulum is used to determine the amount of energy absorbed (notch toughness) in the process.

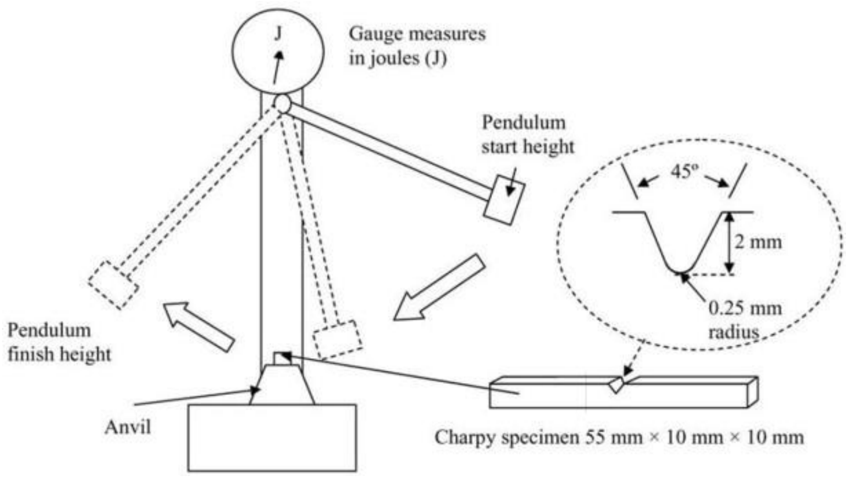


Figure 4.3: Charpy Impact Test

4.3 Flexural test

The most common purpose of a flexure test is to measure flexural strength and flexural modulus. Flexural strength is defined as the maximum stress at the outermost fiber on either the compression or tension side of the specimen. Flexural modulus is calculated from the slope of the stress vs. strain deflection curve.

Sample ID	TESTEDPARAMETER	OBSERVEDVALUES
I1	Charpy Impact Test	3
I2	Charpy Impact Test	3
I3	Charpy Impact Test	3

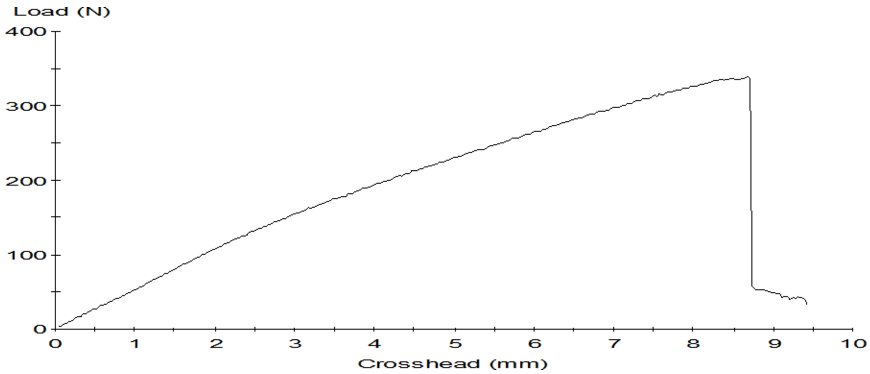


Figure 4.4: Flexural Test

Name	Value	Units
PeakLoad	338.649	N

4.4 Compression Test

Compression tests are used to determine a material's behavior under applied crushing loads, and are typically conducted by applying compressive pressure to a test specimen (usually of either a cuboid or cylindrical geometry) using platens or specialized fixtures on a universal testing machine.

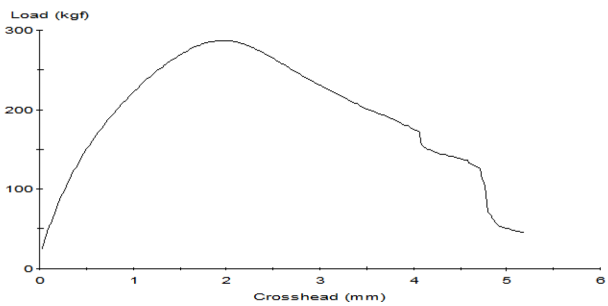


Figure 4.5: Compression Test

Specimen Results:

Name	Value	Units
PeakLoad	2.816	KN

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