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Effect of Date Seed Granules on the Mechanical Properties of Glass Fibre Reinforced Epoxy Composite

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Abstract

In this study, Date Seed Granulated Powder (DSGP) was used as a reinforcement material for Glass Fibre Reinforced Epoxy resin (GFRE) composite. Specifically, the DSGP was prepared and added to Glass fibre reinforced Epoxy composite using the hand lay-up method. The DSGP reinforced GFRE was produced in different weight ratios of 0 %, 10 %, 20 %, 30 %, 40 % and 50 % wt. The mechanical properties of the developed specimens of the DSGP reinforced GFRE composite were investigated using the universal INSTRON tensile machine, flexural testing equipment, Izod impact testing machine (ASTM D256 standard) and Rockwell Hardness testing machine for hardness test. Results of the tests showed maximum values of tensile strength, flexural strength and Hardness Number as 271 MPa, 241 MPa and 97 HRB for the 50, 40, 30, 20 and 10 % wt. GDS samples respectively. Energy absorption capacity (U in Joules) of the samples were also determined. From the results obtained, the best variation of the reinforcement of Glass Fibre Reinforced Epoxy with Date seed granules is the GFR-40 % wt. GDS composition. This study therefore proves that Glass fibre –Date seed reinforced composites are good alternatives to Glass fibre composites, since they gave higher mechanical properties at lower cost.

Keywords: Date Seed Granules, Mechanical Properties, Glass Fibre, Reinforced Epoxy Composite

Introduction

Glass fiber reinforced Epoxy (GFR-E) have been proposed for various manufacturing technology and are widely used for various applications. GFR-E is characterized by having excellent properties like light weight, high strength and specific stiffness–weight ratios. These properties are important and makes them attractive for automotive and

aerospace applications *(Lopez F. A. et al., 2012).* Moreover, GFR-E has an optimal property that make them a suitable material for other products and other different applications in industry *(Basavarajaa S. et al, 2009).*

There are very many situations in engineering where no single material will be suitable to meet a particular design requirement. However, two materials in combination may possess a feasible solution to the materials selection problem. A typical composite material is a system of materials comprising of two or more materials mixed and bonded together. For example, concrete is made up of cement, sand, stones and water. If the composition occurs on a microscopic scale (molecular level)*(Karnaniet. al 1997),* the new material is called an alloy for metals or a polymer for plastics. Types of composites are fiber reinforced composites, metal matrix composites, polymer matrix composites, and ceramic matrix composites.

Generally, a composite material is composed of reinforcements. These reinforcements are generally classified into two; synthetic and natural. Synthetic reinforcements include glass, carbon and aramid fibers. Mass production of glass strands was discovered in 1932 when James Slayter, a researcher at Owens-Illinois accidentally directed a jet of compressed air at a stream of molten glass and produced fibers *(Mohd et. al, 2007).*

Natural fibre-reinforced composites have been increasingly utilized in quite widespread applications. Natural fibres are obtained from different parts of the plants, to name a few, for example jute, flax, kenaf, coconut, hemp, ukam, sisal, banana, pineapple fibres from the leaf; cotton and kapok from seed; coir and coconut from the fruit.

The Date fruits (Phoenix dactylifera L.) are one of the oldest plants cultivated, from the earliest records of *Predynastic*Egypt. Cultivation of Date palms in Egypt goes back thousands of years *(Al-Khayri J. et al. 2015).* The Date seed is found as a waste of a bio-mass due to the existing high amount of plant, so its use is considered as an economical value filler. Composites filled with Date seed (DS) are the proposed materials; these are low weight, and easy in manufacturing *(Ibrahem R. A. 2015).* Due to the rising realization about environmental impact and new regulations, considerable work has been done for replacing polluting and hazard fillers with those derived from bio-sources such as eggshells (*Iyer K. and Torkelson J. 2014).* In this study, Date-seed granulated powder (DSGP) will be used as a filler reinforcement material for Glass fibre reinforced Epoxy (GFR-E) composite, since it is non-brittle application of this material will solve a great problem.

Engineering materials selection poses a great influence in the operational life and effectiveness of structures and machine components. Locally sourcing of engineering materials that will stand the test of time when compared to synthetic materials is a growing interest. These engineering materials must possess mechanical properties that will make them compete favorably with the underlying environmental and operating conditions. It is proven that ceramics has high strength and hardness with a very low percentage of ductility, and other mechanical properties, but with the production of DS reinforced fibre glass, the ductility percentage is highly increased.

In this study, the effect of date seed particles on the mechanical properties of Glassfibre reinforced Epoxy (GFR-E) composite will be investigated to see how it solves the above underlying problems.

LITERATURE REVIEW

Date Fruit

Phoenixdactylifera, commonly known as date or date palm is a flowering plant species in the palm family *(Arecaceae*) cultivated for its edible sweet fruit. Although its exact place of origin is uncertain because of long cultivation. It probably originated from the Fertile Crescent region straddling Egypt and Mesopotamia *(Krueger and Robert R. 2018).* The species is widely cultivated across Northern Africa, the Middle East, the Horn of Africa and South Asia, and is naturalized in many tropical and subtropical regions worldwide *(Kenoyer et al. 2005).*



Fig. 1 Date Palm
Source: en.m.wikipedia.org/wiki/ Date_palm

Description and Uses

Date seeds are traditionally used for animal feed. They can also be used as a source of oil (which has antioxidant properties valuable in cosmetics), as a coffee substitute, as a raw material for activated carbon or as an adsorbent for dye-containing waters *(Lecheb, 2010; Banat et al., 2003; Barreveld, 1993)*. Date by-products are usually fed to animals during winter, though they can be used at any time of the year *(Genin et al., 2004).*

Date seeds are the by-product of date stoning, either for the production of pitted dates or for the manufacture of date paste *(Ecocrop, 2011; Barreveld, 1993).* The date seed is a hard coated seed, usually oblong, ventrally grooved, with a small embryo. Date pits weigh 0.5 g to 4 g and represent 6 to 20% of the fruit weight depending on maturity, variety and grade (Ecocrop, 2011; Daghir, 2008; Zaid et al., 2002; Barreveld, 1993; Göhl, 1982).



Fig. 2: Date seed
Source: feedipedia.org

Date trees typically reach about 21–23 metres (69–75 ft) in height growing singly or forming a clump with several stems from a single root system. Date fruits (dates) are oval-cylindrical, 3 to 7 centimetres (1 to 3 in) long, and about 2.5 centimetres (1 in) in diameter, ranging from bright red to bright yellow in colour, depending on variety. Containing 61–68 percent sugar by mass when dried, dates are a very sweet fruit.

FLEXURAL, THERMAL AND DYNAMIC MECHANICAL PROPERTIES OF DATE PALM FIBRES REINFORCED EPOXY COMPOSITES

Mohamed H. G. et al. (2019) presented a study to improve the flexural, thermal stability and dynamic mechanical properties of epoxy composites by reinforcing Date palm fibres (DPF) at different loading (40%, 50% and 60% by wt.) and to evaluate the best loading through hand lay-up technique. Three point bending dynamic properties in terms of storage modulus (E), loss modulus (E) damping factor, Cole–Cole plot and thermal properties were analyzed by dynamic mechanical and *thermogravimetric (*TGA) analyser respectively. The flexural test results of the study showed that loading of 50% DPF increases both the flexural strength and modulus of pure epoxy composites from 26.15 MPa to 32.64 MPa and 2.26 GPa to 3.28 GPa, respectively. The TGA results revealed that reinforcement of DPF in epoxy composites also improves the thermal stability and residual content. The residual content of epoxy (9.58%), 40% DPF/epoxy (12.51%), 50% DPF/epoxy (19.8%) and for 60% DPF/epoxy composites (15.2%) was noted, revealing that 50% DPF/epoxy composites confers the best result. Incorporation of DPF into epoxy also improves the E and E but 50% DPF show more remarkable improvement compared to 40% and 60% DPF loading. Moreover, damping factor decreases considerably by the reinforcement of DPF and are found lowest for 50% DPF/epoxy composites among all composites. The research concluded that 50% DPF loading is the ideal loading to enhanced flexural, thermal stability and dynamic properties of epoxy composites.

ECO-FRIENDLY DATE-SEED NANOFILLERS FOR POLYETHYLENE TEREPHTHALATE COMPOSITE REINFORCEMENT

HebalElkhouly et al. (2020) used Date seed nanofillersto reinforce Polyethylene Teraphthalate. In the study, Micro-particle fillers were typically added as reinforcement materials to improve the characteristics of these composites. In the work, organic nanoparticles of date seeds were added as a filler for polyethylene terephthalate (PET) to produce enhanced polymer nanocomposites. A date-seed nanofiller (DSN) was prepared and examined with x-ray diffraction measurements, and then added to PET by hot compression. The characteristics of the PET-DSN composite were experimentally investigated through tests of mass loss, compressive strength, and Vickers micro-hardness. The PET-DSN microstructure was inspected using a scanning electron microscope and Fourier-transform infrared spectroscopy. The results showed chemical stability of the PET-DSN composite. Moreover, key mechanical properties of the composite, namely hardness, compressive strength and wear resistance, were improved and optimized with a DSN reinforcement of 0.75 wt%.

DATE PALM SEED AS SUITABLE FILLER MATERIAL IN GLASS–EPOXY COMPOSITES

The aim of this work conducted by *Heba I. E. et al. (2018)* was to study the mechanical characteristics of glass fiber (G–E) filled with date seed (DS) as potential polymer filler. DS was produced during the processing of fruit plant *(Phoenix dactylifera L.).* G–E hybrid composite was then reinforced with DS powder by applying the semi-automatic technique (SAT). The effects of DS filler on wear rate and impact energy at different efficient parameters were investigated.

MATERIALS AND METHODS

MATERIALS

In this study, all the materials used were sourced locally. These materials include:

a. Date Seed: Date seeds are the by-product of date stoning, either for the production of pitted dates or for the manufacture of date paste (Ecocrop, 2011; Barreveld, 1993). The date seed is a hard coated seed, usually oblong, ventrally grooved, with a small embryo. The date seed to be used in this study will be sourced locally.

b. Glass fibre: Glass fibers are materials consisting of numerous and extremely fine fibers of glass. Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. The Glass fibre was obtained from Kenyatta building materials market at Enugu.

c. Epoxy: The Epoxy resin to be used in this study is Accelerator. Accelerator is a fast setting and strong adhesive which will be used to bond the Glass fibre. The Epoxy resin and hardener were obtained from henry biochem Epoxy Resin / Hardener, ariaria.

d. Hardner: Hardner HY951 is a hardener which is used with the epoxy resin for the encapsulation or coating of low voltage and electronic components such as Glass fibre. Hardner HY951 has good mechanical strength, good resistance to the atmosphere and chemical degradation.

Date Seed Extraction and Preparation

In this study, the Date fruits were purchased locally from kwara state where the plant grows abundantly in nature. The Date seed filler was prepared as follows:

1. The DS surface layers were eliminated locally with knife and hard brush.
2. The Date seed was then washed with distilled water and dried in air for 24 hrs.
3. The moisture content of the DS was eliminated using an oven at 70 °C for 8 hrs.
4. The DS was then crushed and milled, using ball mill and sieve(Iyer K. and Torkelson J., 2014).

Glass Fibre Reinforced Epoxy Preparation

The E-glass fiber (woven roving mat, plain weave 900GSM) was obtained commercially from Ebenchem Epoxy Resin / Hardener, Abuja. The Epoxy (Araldite (LY556)) and Hardener (HY951) was used as a resin. The mixing ratio by weight of fiber to resin and resin to hardener was maintained at 2:1 and 10:1, respectively.

Material Preparation

The production of the composite of the Glass fibre reinforced (GFR) epoxy and Date seed granulated (DSG) powder was done in the following proportion:

1. 100% GFR Epoxy
2. 50% GFR Epoxy and 50% DSG powder
3. 60% GFR Epoxy and 40% DSG powder
4. 70% GFR Epoxy and 30% DSG powder
5. 80% GFR Epoxy and 20% DSG powder

6. 90% GFR Epoxy and 10% DSG powder

The mold sizes of each test piece for the different variations listed above are the same.

Percentage Composition Analysis

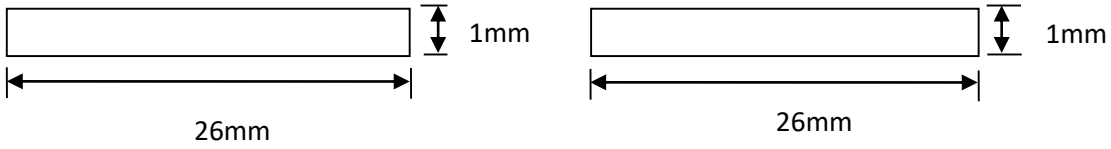


Fig. 3: Percentage composition of composites

a). Density

I. Glass fibre reinforced polyester resin = 1100 kg/m^3

II. Date Seed Density = 1180 kg/m^3

b). Volume

Volume = length x breadth x width

3.1

Volume of test piece/specimen = 0.2 X 0.08 X 0.05 = 0.0008 m^3

c). Mass/Weight of the variations

From the density, mass and volume relation,

Density = Mass(m) /Volume(V)

3.2

Mass = Density X Volume

3.3

Table 1: Weight Variation of each Test Piece

	GFR Epoxy Content	GDS Powder Content	Volume of GFR Epoxy m^3	Volume of GDS powder m^3	Weight of GFR Epoxy Kg	Weight of GDS Powder Kg	Total Weight of composite kg
1	100% GFR	_	0.0008	_	0.88	_	0.88
2	90% GFR	10% GDS	0.00072	0.00008	0.792	0.094	0.886
3	80% GFR	20% GDS	0.00064	0.00016	0.704	0.189	0.893
4	70% GFR	30% GDS	0.00056	0.00024	0.616	0.283	0.899
5	60% GFR	40% GDS	0.00048	0.00032	0.528	0.378	0.906
6	50% GFR	50% GDS	0.0004	0.0004	0.44	0.472	0.912

A. Total weight of Glass fibre reinforced epoxy needed

GFR needed = (0.880X4)+(0.792X4)+(0.704X4)+(0.616X4)+(0.528X4) +(0.440X4)

= 15.84 kg

B. Total weight of granulated date seed needed

GDS needed = (0.094X4)+(0.189X4)+(0.283X4)+(0.378X4)+(0.472X4)

= 5.66kg

METHODS

The following methods and techniques were applied in the manufacturing and testing of the Date seed reinforced Glass fibre composite.

Lignocellulose characterization of the date seed powder was done in order to allow for a proper fibre to matrix orientation between the granulated Date seed and the Glass fibre reinforced epoxy resin composite. The following processes were used in the lignocellulose characterization of the date seed powder:

A. Sample Defatting (Extractives)

50g of sample was weighed into a 1000ml flat bottom flask. Sample was weighed using electronic weighing balance. Some quantity of n-hexane was introduced into the sample and shacked vigorously until the sample was completely submerged. The mixture was covered using masking using masking foil and masking tape as well. It was allowed to stand for 48 hours for complete fat extraction. The n-hexane which has the oil dissolved in it was gradually decanted from the sample and sample allowed to dry at ambient temperature.

$$Fat\ (\%) = \frac{\text{initial sample wt.} - \text{final sample wt.}}{\text{initial sample wt.}}\ (100) \qquad 3.4$$

B. Bleaching (Lignin removal)

The de-fated sample was introduced into a three neck round bottom flask. 500ml of 7.5% weight by volume (w/v) aqueous hydrogen peroxide solution was introduced into the weighed sample. A reflux condenser was fitted into the middle neck of the flask. The whole solution contained in the flask fitted with the condenser was refluxed at 90^0c for 2 hours for complete lignin extraction. While heating, cold water is at the outer jacket of the reflux condenser. The solution was allowed to cool and filtered using a vacuum pump. It was also washed with hot water to neutralize the residue and it was allowed to dry at ambient temperature.

$$Lignin\ (\%) = \frac{\text{initial sample wt.} - \text{final sample wt.}}{\text{initial sample wt.}}\ (100) \qquad 3.5$$

C. Sodium hydroxide treatment (Hemicellulose treatment)

The bleached sample was introduced into a flat bottom round flask. 500ml of 18% NaOH solution was introduced into it and stirred at room temperature for 30 minutes. During stirring, the flask was covered using aluminum foil. After this, the solution was filtered using a vacuum pump. It was washed with 500ml of 20% acetic acid in hot water. The solution was washed again with hot distilled water to neutralize the residue. The filtrate was tested with a pH meter to confirm the neutrality of the residue. The residue was allowed to dry. The percentage hemicellulose and other extractives was given as:

$$Hemicellulose\ (\%) = \frac{\text{initial sample wt.} - \text{final sample wt.}}{\text{initial sample wt.}}\ (100) \qquad 3.6$$

D. Total Ash

The ash content was determined from the total loss in weight that occurs during the incineration of the sample in the presence of oxygen at temperature high enough to allow all

organic matter to be burnt off without allowing appreciable decomposition of the ash content or loss by volatilization. It is the inorganic residue remaining after the organic matter has been burned away.

An empty clean porcelain crucible (w_1) was weighed. 2g of sample (w_2) was weighed into the crucible and heated in a bunsen burner at 600^{o}c for three hours. It was allowed to cool in desiccator and weighed (w_3).

$$Ash\ (\%) = \frac{\text{initial sample wt.} - \text{final sample wt.}}{\text{initial sample wt.}}(100) \quad 3.7$$

$$\text{Cellulose}\ (\%) = 100 - \{\text{fat}(\%) + \text{lignin}(\%) + \text{hemicellulose}(\%) + \text{ash}(\%)\} \quad 3.8$$

Composite Manufacturing Method

The samples of composites were made by using the hand lay-up method. This method is used because of its simplicity and availability of the items. The laminating mixture of the Epoxy resin and the granulated Date seed powder was applied by pouring in the prepared mould and using a paint roller to properly dress the surface to fit in. Then the glass fibres were applied on the poured resin using the woven-roven method. FRP rollers (paint rollers) were used to consolidate the laminate, thoroughly wetting the reinforcement and removing entrapped air. Subsequent layers of Glass fibre reinforcements laminate mixture of Epoxy resin and granulated Date seedwere added to build the required composite thickness as indicated in Section 3.1.3.

Both cobalt Ammine-based accelerator and catalyst and hardener (HY951) were employed as curing agents for theEpoxy (Araldite LY556) resin. These chemical components were uniformly and thoroughly mixed before introducing the Date seed granules. After the composite manufacturing process, the composite system was allowed to cure for two hours, after which it was demolded.

Experimental Procedure for manufacturing the Laminate

The following procedures were applied to produce the required test piece of 10mm x 50mm x 100mm by the hand lay-up method.

Reinforcement of Glass fibre Reinforced Epoxy with 0% wt of Granulated Date Seed

(1) Using ply wood, we furniture a mould of the required size 50mm x 80mm x 100mm.
(2) The internal section of the mold was lined with polyethylene to ensure the epoxy composite do not stick to the mold.
(3) A release agent (Vaseline) was applied on the surface of the polyethylene in order to allow for easy demolding.
(4) For 1 liter of the Epoxy (Araldite LY556) resin, 20 cm^3 of Cobalt Ammine was added and stirred.
(5) 10 cm^3 of the hardener was added to the mixture.
(6) The mixture was stirred appropriately for proper reaction.

(7) A hand brush was used to apply the laminate mixture of the granulated Date seed and Epoxy resin in the mold, the reinforcement (Glass fibre) was quickly laid in the mold by a woven roving method. A roller was used to ensure that the resin resin laminate spread across the fibre mat so as to enhance uniform fibre orientation across the specimen.Cellophane was then used to compress the first layer. This was done to remove the air bubbles present.

(8) The hand lay-up method was repeated continuously until the thickness of 50 mm was achieved.

(9) When the laminate gelled, excess reinforcements around the edges of the mold were trimmed off with a pair of scissors.

(10) As the specimen solidified, it was demolded and set aside to cure for two hours at room temperature. Curing occurs when the heat of reaction has been given off (exothermic reaction) – a situation initiated by the presence of the catalyst.
The fibre reinforced plastic specimen so formed was smoothened with a sand paper.

Reinforcement of Glass fibre Reinforced Epoxy with 50% wt, 40% wt, 30% wt, 20% wt and 10% wt of Granulated Date Seed

The composites were developed by blending the materials in predetermined proportions as stated in the composite percentage analysis in Table 3.1.The internal section of the mold was lined with polyethylene to ensure the epoxy composite do not stick to the mold. A release agent (Vaseline) was applied on the surface of the polyethylene in order to allow for easy demolding. For 1 liter of the Epoxy (Araldite LY556) resin, 20 cm^3 of Cobalt Ammine was added and stirred. 10 cm^3 of the hardener (HY951) was added to the mixture and stirred appropriately for proper reaction. A hand brush was then used to apply the laminate mixture of the granulated Date seed and Epoxy resin in the mold. The reinforcement (Glass fibre) was quickly laid in the mold by a woven roving method. A roller was used to ensure that the resin laminate spread across the fibre mat so as to enhance uniform fibre orientation across the specimen. Cellophane was then used to compress the first layer. This was done to remove the air bubbles present. The hand lay-up method was repeated continuously until the thickness of 10 mm for each composite was achieved. When the laminate gelled, excess reinforcements around the edges of the mold were trimmed off with a pair of scissors.

As the specimen solidified, it was demolded and set aside to cure for two hours at room temperature. The fibre reinforced plastic specimens formed was smoothened with a sand paper.

Specimen Preparation

The pure Glass fibre reinforced Epoxy resin and the composite samples (GDS-GFR) developed were tested in various machines for compressive, tensile, hardness, and impact tests as well as metallographic examination of the fractured surfaces.



Fig. 4: The final preparation of the Glass fibre reinforced Epoxy resin composite specimen for mechanical test

MECHANICAL TESTS

The manufactured Date seed - Glass fibre reinforced epoxy composite samples developed were tested in various machines for tensile, compressive, hardness, and impact tests as well as metallographic examination of the fractured surfaces.

Tensile Test

The tensile test of each sample was carried out using Instron Universal testing machine which has a 100 KN load frame, that requires specimen configuration that has wedge grips fixtures at both ends, it also contain several strain gauge extensometers and a Merlin software which was loaded into the machine for data collections and analysis features.

The specimen was mounted in between the jaws and it was then subjected under tension. The test sample was loaded in the direction of fiber length, until fracture occurred. At the same time the reading was noted as a function of increase in length. The measurement of the tensile strength values were taken parallel to fiber length. The results obtained were very precision result of the tension test. The procedure was repeated three times with the same test samples. Samples were tested in triplicates.



Fig. 5: The Instron Universal testing machine (for compressive and tensile test)

Bending Test

Three-point bending tests were performed using a testing machine in accordance to ASTM D 790 standards. For the bending test, samples with dimensions of 100 mm × 50 mm ×20 mm were used. The bending strength test was carried out on the tensometer with its attachment fixed properly

Experimental setup for the bending and fatigue test

The bending tests on the six specimens were conducted on an Electro Puls with the speed set to 2 mm/min. According to the ATSM D790-2003 standard, the tests were performed for a span-to-thickness ratio of 20:1. The distance between the two supports was 180 mm, and the test loading size is shown in Fig. 5



Fig. 6: Experimental setup of the flexural bending test

The flexural test of the manufactured specimen was carried out under the ASTM B 790-03 standards. The test specimen was placed in between two supports and it was loaded at its center until the composite specimen failed by bending. The results of flexural strength was recorded. Samples were tested in triplicates and finally mean value is reported.

Impact Test

The developed composites were machined to impact test specimen with a notch at the

middle. The samples were tested using the impact testing machine by applying sudden energy so as to break the sample.

The prepared sample was placed on Izod impact testing machine. Then the pendulum was allows to strike the specimen which was loaded in the tester. The test result in the function of energy which is required to break the specimen was recorded. This energy absorbed is used to measure the yield properties of fiber reinforced polymer composites. The samples were tested in triplicates.



Fig. 7: The Izod impact testing machine

Hardness Test

The hardness test on the fabricated fiber composites was carried out using the Rockwell hardness number under the ASTM 2210-86 standards. The L scale tester was used to measure hardness value of composite specimen under the applied load of 60 kg with 0.25'' ball indenter. The test samples were placed on moving jaw and it was then subjected to loading for 10s in an ambient conditions. Finally, the load was released gradually and corresponding reading was taken. The samples were tested in triplicates. The mean value of the results was then considered as the exact hardness number.



Fig. 8: The Hardness testing machine

Physical characterization

Bulk density

Bulk density was determined using 50ml density bottle (pycometer). The empty pycometer was initially weighed (w_1). The test sample was filled to the neck of the pycometer and tapered consistently until the pycometer could no longer take more sample and weighed (w_2).

$$\text{Bulk density} = \frac{\text{Mass}}{\text{Volume}} = \frac{w_2 - w_1}{\text{volume}}$$

Particle density

Introduce distilled water into a cylindrical measuring cylinder to the 50ml mark. 10g of soil sample was introduced into the measuring cylinder. Note the volume of displaced water was noted.

$$\text{Particle density (g cm}^{-3}) = \frac{\text{Mass}}{\text{Volume}}$$

3.5.3 Total porosity

$$\text{Total porousity (\%)} = \left(1 - \frac{\text{bulk density}}{\text{Particle density}}\right) 100$$

RESULTS AND DISCUSSION

RESULTS

The Glass fibre reinforced Epoxy resin and the granulated Date seed reinforced Glass fibre reinforced Epoxy resin composites was manufactured according to the specifications in section 3.2.4 above. In order to determine if the reinforced Glass fibre reinforced Epoxy composite will have an improved mechanical property than the un-reinforced Glass fibre reinforced Epoxy composite, and to determine which proportion of Date seed should be best used to reinforce Glass fibre reinforced Epoxy resin that will yield an enhanced mechanical property, the specimens were subjected to series of mechanical tests. Each mechanical test was conducted on three (3) intervals and then the mean of the result was taken as the actual value of test result.

DISCUSSION

The results of the mechanical tests conducted on the Glass fibre reinforced Epxoy resin composite and the various composition of granulated Date seed are discussed below based on the type of test conducted.

Tensile Test Result

Table 2: Tensile Strength Result

S/N	Designation	E_1(MPa)	E_2(MPa)	E_3(MPa)	Mean E (MPa)
1	GFR Epoxy	231	241	225	232
2	GFR-50% wt. GDS	220	224	220	221
3	GFR-40% wt. GDS	274	270	270	271

4	GFR -30% wt. GDS	241	243	241	242
5	GFR -20% wt. GDS	247	251	243	247
6	GFR -10% wt. GDS	258	261	265	261

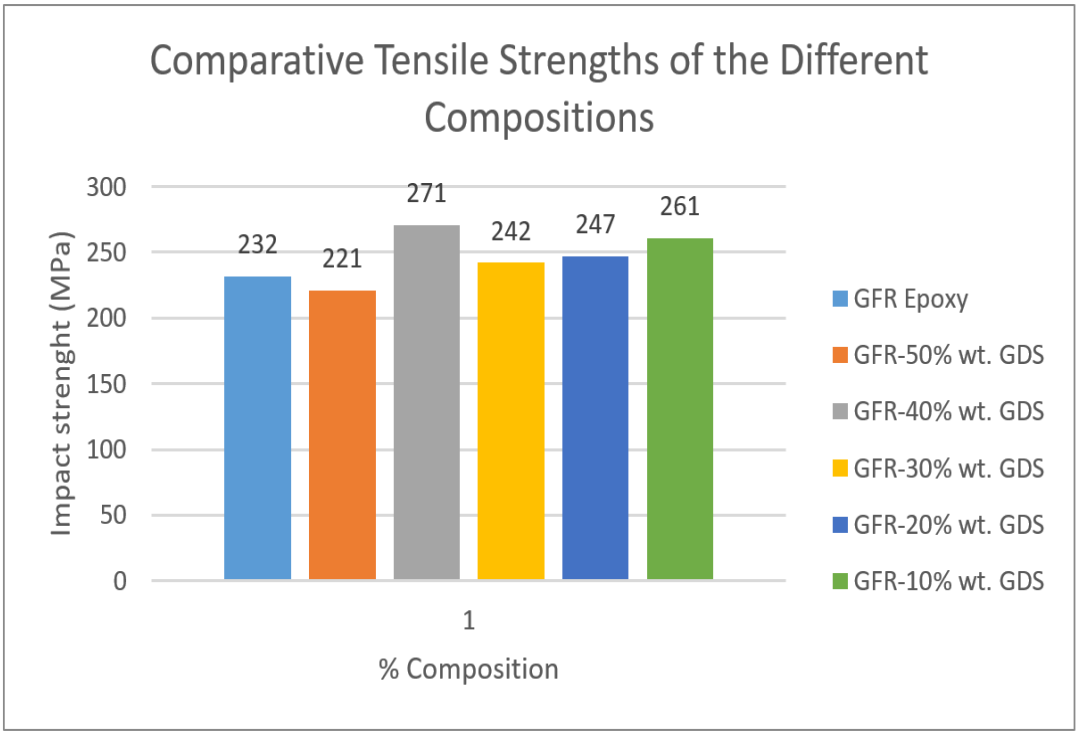


Fig. 9: Comparative Tensile strengths of the different compositions

On the application of a compressive force of 2000 N, it is apparent that the unreinforced Glass fibre reinforced Epoxy resin composite has a tensile strength lower than the reinforced Glass fibre reinforced Epoxy resin with granulated Date seed. Fig. 9 also shows that the tensile strength of the reinforced Glass fibre reinforced Epoxy resin decreased as the percentage composition of the Date seed granules decreased.

Flexural Test Result

Table 3: Bending test Analysis

S/N	Designation	B_1(MPa)	B_2(MPa)	B_3(MPa)	Mean B (MPa)
1	GFR Epoxy	201	202	195	199
2	GFR-50% wt. GDS	181	180	184	182
3	GFR-40% wt. GDS	246	240	237	241
4	GFR -30% wt. GDS	193	194	197	195
5	GFR -20% wt. GDS	205	210	209	208
6	GFR -10% wt. GDS	225	231	233	230

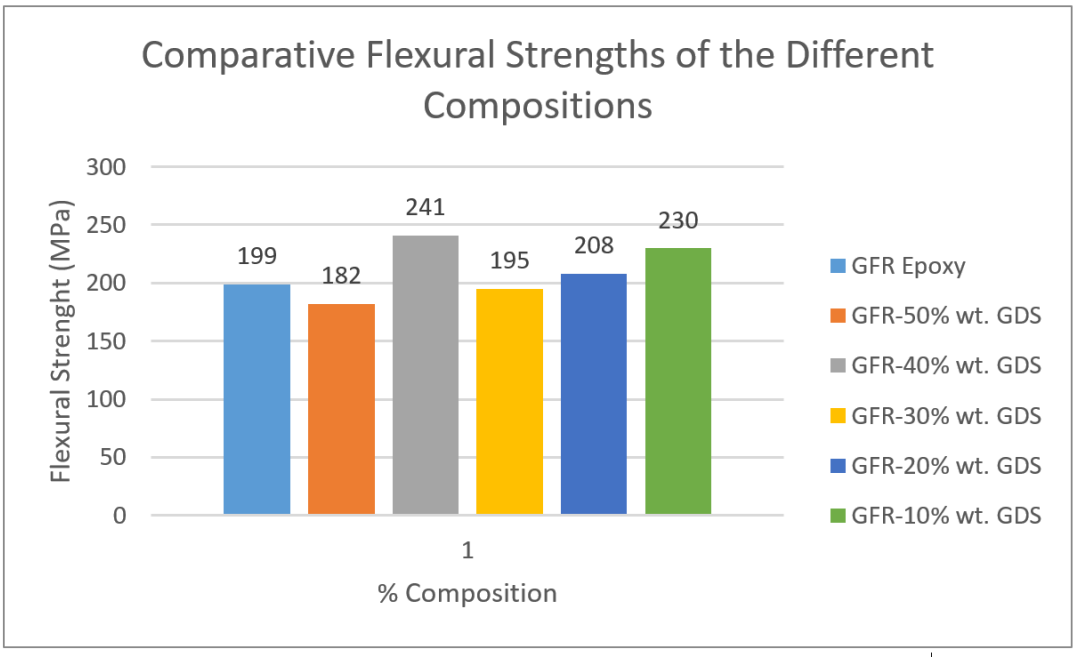


Fig. 10: Comparative Flexural strengths of the different compositions

The flexural tests conducted on the specimens depicts that at a stress levels of 80%, 90% and 100% up to the failure of the specimens, the GFR-40% wt. GDS has a maximum bending strength of 241 MPa as shown in Table 3 and Fig. 10. This shows that at this composite mixture ratio, the composition will withstand maximum bending due to flexural loading.

Impact Test Result

From the Izod Impact test conducted on the specimens, the following are the results:
Result of the impact test

A. Volume of specimen

V = Length x width x thickness (4.1)

$= 0.2 \times 0.08 \times 0.05$ m

$= 8 \times 10^{-4} m^3$

B. Energy absorption capacity of the material

$U = (\sigma_{max})^2 \times L_o/E$ (4.2)

Where L_o = original length of specimen = 0.3 m

E = mean young modulus of elasticity calculated from the compression test

σ_{max} = maximum breaking stress measured on impact

Table 4: Impact strength (J/mm^2)

S/N	Designation	σ_1 (J/mm^2)	σ_2(J/mm^2)	σ_3(J/mm^2)	Mean σ (J/mm^2)
1	GFR Epoxy	2.68	2.56	2.50	2.58
2	GFR-50% wt. GDS	2.73	2.69	2.70	2.75
3	GFR-40% wt. GDS	2.20	2.16	2.21	2.76
4	GFR -30% wt. GDS	2.69	2.68	2.73	2.7
5	GFR -20% wt. GDS	2.50	2.55	2.57	2.54
6	GFR -10% wt. GDS	2.42	2.40	2.45	2.42

Table 5: Impact analysis of the various compositions on impact

Specimen	GFR Epoxy Resin	50% wt. GDS powder	40% wt. GDS powder	30% wt. GDS powder	20% wt. GDS powder	10% wt. GDS powder
Max. Breaking Stress σ_{max} (MPa)	91.38	104.48	98.3	95.6	93.78	92.46
Energy Absorption Capacity U (Joules)	2.58	2.74	2.76	2.70	2.54	2.42

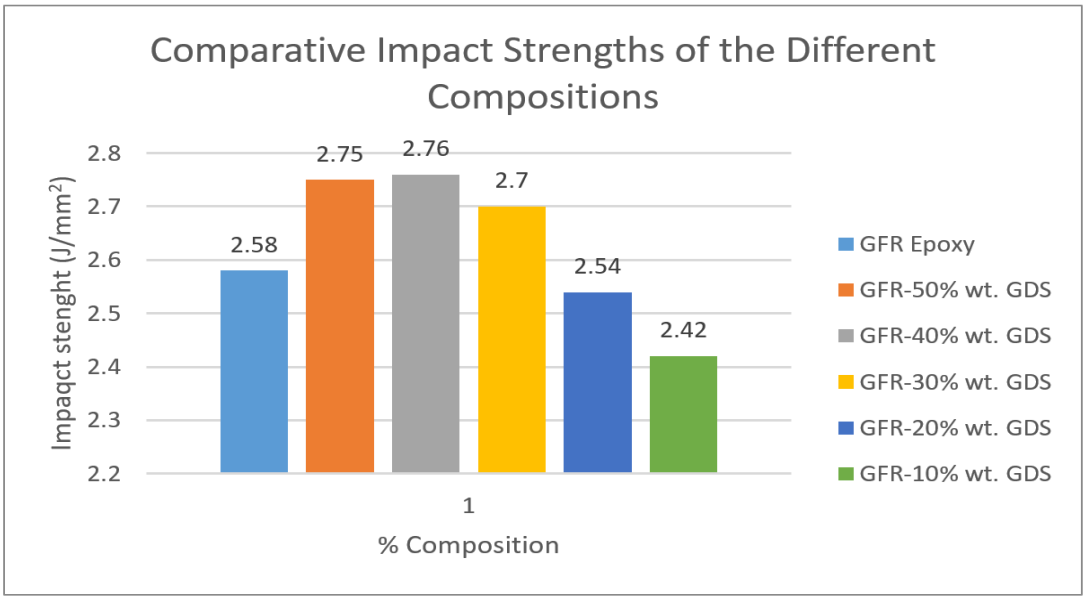


Fig. 11: Comparative impact strengths of the different compositions

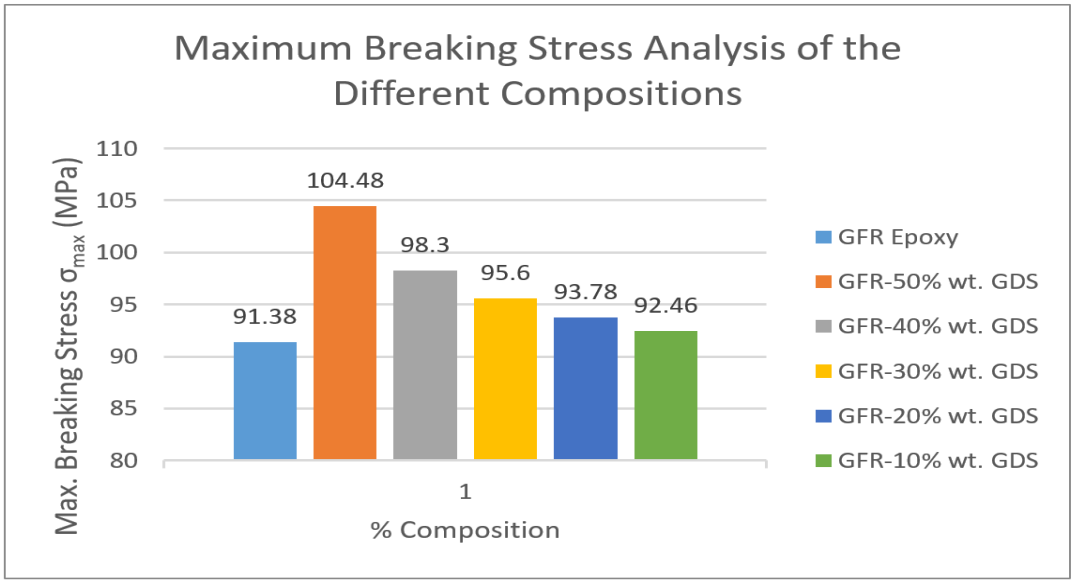


Fig. 12: Comparative Maximum breaking stress analysis of the different Compositions

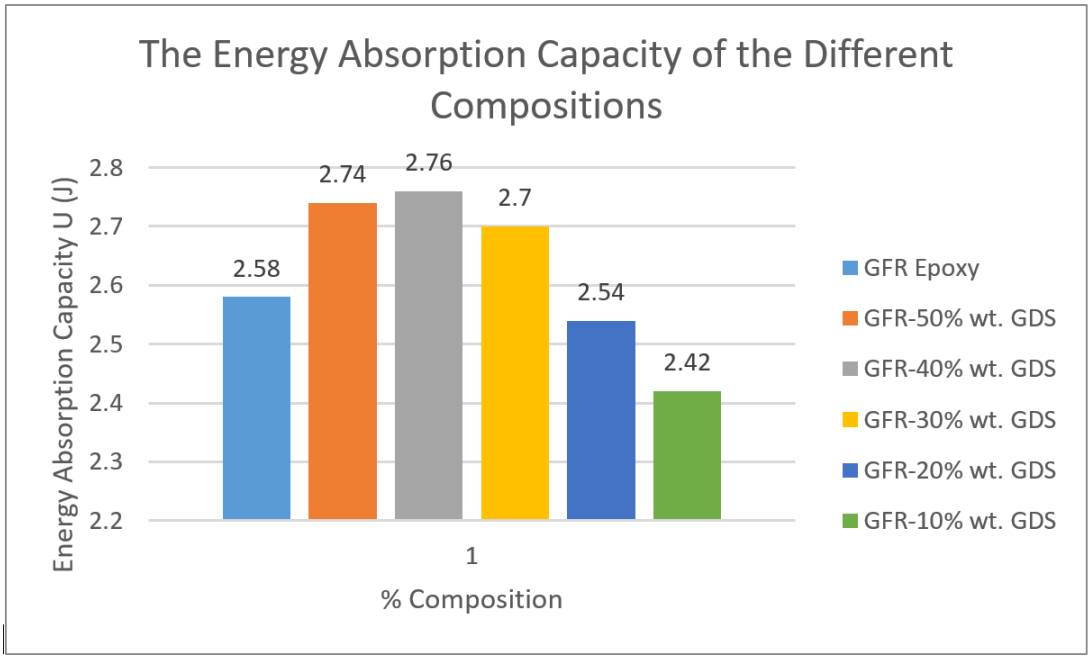


Fig. 13: Energy Absorption capacity of the different compositions

The impact strength of the specimen depends on its thickness, Young modulus of elasticity of the material and the impact force on the specimen. As shown in Fig. 13, the energy absorption capacity (U in Joules) of the Glass fibre reinforced Epoxy resin composite was determined as 2.58 Joules at a maximum breaking stress of 91.38 MPa, that of GFR-50% wt. GDS was determined as 2.74 Joules at a maximum stress of 104.48 MPa, that of GFR-40% wt. GDS was determined as 2.76 Joules at a maximum stress of 98.3 MPa, that of GFR-30% wt. GDS was determined as 2.70 Joules at a maximum stress of 95.6 MPa, that of GFR-20% wt. GDS was determined as 2.54 Joules at a maximum stress of 93.78 MPa while that of GFR-10% wt. GDS was determined as 2.42 Joules at a maximum stress of 92.46 MPa.

Hardness Test Result

Hardness of the composites was determined by using Rockwell hardness testing machine. The machine measures the ability of the sample to resist penetration by measuring the depth of indention. The Six specimens (5) samples – Glass fibre Epoxy resin, reinforced Glass fibre Epoxy resin with 50% wt. GDS, 40% wt. GDS, 30% wt. GDS, 20% wt. GDS and 10% wt. GDS were tested for hardness by determining their various Rockwell hardness number which is based on the depth of the indent.

Specification for the Hardness Test

Scale = B Scale
Indenter material = Steel Sphere
Diameter of indenter = 0.25''
Applied Load = 100 kgf = 981 N

Table 6: indentation values (mm)

S/N	Designation	R_1	R_2	R_3	Mean R
1	GFR Epoxy	30	31	32	31
2	GFR-50% wt. GDS	41	34	39	38
3	GFR-40% wt. GDS	98	99	95	97
4	GFR -30% wt. GDS	55	53	51	53
5	GFR -20% wt. GDS	61	63	63	62
6	GFR -10% wt. GDS	74	83	80	79

Table 7: The Hardness test Result of the various Specimens

Specimen	Indentation (mm)	Harness
GFR Epoxy	31	31 HRB
GFR-50% wt. GDS	38	38 HRB
GFR-40% wt. GDS	97	97 HRB
GFR -30% wt. GDS	53	53 HRB
GFR -20% wt. GDS	62	62 HRB
GFR -10% wt. GDS	79	79 HRB

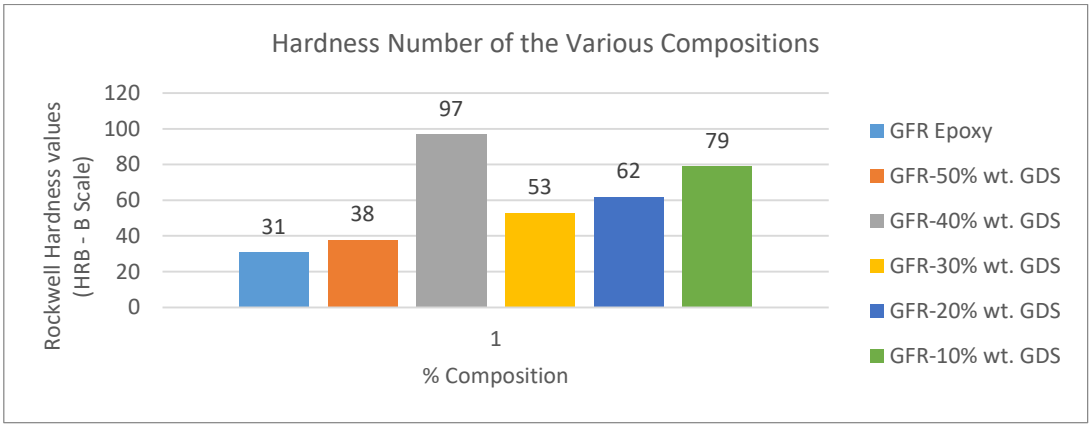


Fig. 14: Comparative Hardness values of the specimen

From Fig. 14, it shows that the granulated Date seed reinforced Glass fibre epoxy resin with 40% wt. GDS has higher hardness value of 97BHN. The chart also shows that the hardness of the reinforcement increased as the percentage composition of the Date seed granule reduced but with an exception at the 60-40% wt. ratio of the reinforcement.

Physical characterization

Bulk density

Bulk density was determined using 50ml density bottle (pycometer). The empty pycometer was initially weighed (w_1). The test sample was filled to the neck of the pycometer and tapered consistently until the pycometer could no longer take more sample and weighed (w_2).

$$\text{Bulk density} = \frac{\text{Mass}}{\text{Volume}} = \frac{w_2 - w_1}{\text{volume}}$$

Particle density

Introduce distilled water into a cylindrical measuring cylinder to the 50ml mark. 10g of soil sample was introduced into the measuring cylinder. Note the volume of displaced water was noted.

$$\text{Particle density (g cm}^{-3}) = \frac{\text{Mass}}{\text{Volume}}$$

4.3.3 Total porosity

$$\text{Total porousity (\%)} = 1 - \left(\frac{\text{bulk density}}{\text{Particle density}}\right) 100$$

Results

Physical characterization

Sample	Bulk density (g/cm^3)	Porosity (%)	Particle density (g/cm^3)
Date palm powder	1.164	64.523	3.281

Particle size distribution

S/N	Sieve size (µm)	Particle distribution (%)
1	> 125	47.74
2	> 75	19.39
3	> 63	11.16
4	> 35	7.22
5	< 35	14.49

CONCLUSION AND RECOMMENDATION

Conclusion

From the analysis of results obtained during this study, the following conclusions were drawn;

- During the mechanical testing/loading of the specimens - the deformation was higher on the Glass fibre reinforced epoxy resin GDS composite compared to GFR epoxy.
- The impact strength of the composite increased as the weight composition of GDS increased.
- The energy absorption capacity of the specimen is higher in the GFR 40 % wt. GDS composite and decreased as the weight composition of GDS decreased.
- With the observations made on the mechanical properties of Glass fibre reinforced epoxy resin reinforced with 50, 40, 30, 20 and 10 % wt. GDS, the best variation of the reinforcement of Glass fibre reinforced epoxy with date seed granules is the GFR-40 % wt. GDS composition. It is therefore worthy to note that at 40 % wt. GDS, the Glass fibre reinforced epoxy composite has the optimum values of: tensile strength (271 MPa), flexural strength (241 MPa), energy absorption capacity (2.76 J) and hardness (97 HRB).

Recommendation

1. Test the composite with varying amounts of date seed granules to see how different ratios affect the strength, flexibility, and durability of the material.
2. Compare the mechanical properties of the composite with those of standard materials used in similar applications to determine if the addition of date seed granules offers any advantages.
3. Conduct long-term tests to evaluate how well the composite holds up over time, especially in different environmental conditions like heat, moisture, or pressure.
4. Identify specific industries or products that could benefit from using this composite material, considering both performance and cost-effectiveness.

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