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Investigations on Mechanical Properties of Kenaf/Banana/E-glass Fiber Reinforced Polymer Matrix Composites

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Abstract: Natural materials are one of the prominent and cost effective options for alternating the synthetic fibers reinforced composites. The availability of the natural material and ease of manufacturing attracts the researchers to try the locally available inexpensive fibers and to study their feasibility in reinforcing in to polymers. Accordingly extensive studies on preparation and properties of polymer matrix composite (PMC) replacing the synthetic fiber with natural fiber like Jute, Sisal, Pineapple, Bamboo and Kenaf were carried out. These plant fibers have many advantages over glass fiber or carbon fiber like renewable, environmental friendly, low cost, lightweight, high specific mechanical performance.

The present research work has been under taken with an objective to prepare the hybrid nano composite. It is also planned to use these nanofiller as reinforcing material in polymer composite. The low modulus of glass fiber composites has limited their use in applications where buckling stability or high natural frequency is the criteria. It is also known that natural fibers composite possess much lower mechanical strength properties than synthetic fiber reinforced composite.

Hence the use of natural fiber alone in polymer composite is inadequate in satisfactorily tackling all the technical needs of a fiber reinforced composite. It is reported that if natural fiber is hybridized with a synthetic fiber in the same matrix the properties of natural fiber could be improved by taking the advantage of both the fibers. In this work an attempt has also been made to fabricate the hybrid nano composite filled with and without nanofiller. The different types of hybrid laminates with Wt % of graphene as nano filler are fabricated by using kenaf, banana(natural fiber) and glass fiber(man made fiber) as reinforcing materials with epoxy resin by keeping the thickness 4mm by using the manual hand lay technique. Tensile, compression and hardness test will be conducted..

Keywords: Kenaf, Banana,Glass fiber, Grapene .

I. INTRODUCTION

Composite materials are among the most punctual and furthermore the most recent of underlying materials. Despite the fact that the essential ideas of composite materials were known from antiquated occasions and a few materials were utilized before, the improvement of cutting edge composite materials, for example, boron epoxy, Kevlar epoxy, glass epoxy, carbon epoxy, and so on, appropriate for current designing applications, gotten consideration just in ongoing past. These fiber supported plastics (FRPs, here after alluded to as ordinary composites) are acquiring ubiquity as essential and optional primary materials in aviation, marine, car, common development applications, sports industry, protection, sustainable power areas, material ventures and different regions in view of their intrinsic mechanical properties, like low thickness, high solidarity to-weight proportion, high firmness to-weight proportion, phenomenal sturdiness, dimensional steadiness, non destructive nature, great warm and electrical protection properties and simplicity of creation. Likewise, anisotropic nature of composites made them simple to embrace its properties relying on plan prerequisites. Besides, numerous FRPs gangs better inner damping which prompts high effect energy retention inside the material and results in decreased transmission of commotion and vibration to adjoining structures. These are a portion of the fundamental explanations behind the fame and achievement of regular composites in underlying and nonstructural applications.

The polymer composites containing vegetable strands have gotten impressive consideration both in the writing and in industry. The interest in regular fiber built up polymer composites is becoming quickly because of the superior in mechanical properties, critical handling benefits, minimal expense and low thickness. Normal filaments are sustainable assets in many non-industrial nations of the world. They are less expensive, represent no wellbeing dangers lastly, give an answer for ecological contamination by discovering new uses for squander materials. Moreover, regular fiber

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supported polymer composites structure another class of materials which appear to have great potential in the future as a substitute for scant wood and wood based materials in primary applications.

Non-ordinary filaments like jute, sisal, coir, banana, palm strands and so forth, are separated from stem/leaf/product of plants. Among this load of filaments, jute and sisal enjoy an upper hand over other fiber. Jute is accessible both in fiber/strand and mat structure, and sisal filaments are accessible in the fiber structure. These filaments gangs moderate strength and solidness. Simple accessibility of these supported materials, a developing pattern in the use of these composites and accessibility of a couple of physical, mechanical properties of these strands prompted the interest and interest to take up this work

Presently a-days, exploration and designing interest have been moving from customary engineered fiber composite to lignocellulosic regular fiber composite because of their benefits like high solidarity to weight proportion, non-cancer-causing and bio-degradability. Other than the accessibility of normal strands and simple of assembling have enticed scientists to attempt locally accessible modest fiber and to concentrate on their possibility of support reason and how much they fulfill the necessary determinations of good built up polymer composite for various applications. With minimal expense and high explicit mechanical properties, regular fiber addresses a decent inexhaustible and biodegradable option in contrast to the most well-known engineered support, for example glass fiber.

The expression "regular fiber" covers an expansive scope of vegetable, creature and mineral strands. Notwithstanding the interest and ecological allure of regular strands, their utilization is restricted to non-bearing applications because of their lower strength contrasted and manufactured fiber built up polymer composite. The solidness and strength inadequacies of bio composites can be overwhelmed by primary designs and better game plan one might say of setting the filaments in explicit areas for most elevated strength execution. In like manner, broad examinations on planning and properties of PMC supplanting the manufactured fiber with regular fiber like Jute, Sisal, Pineapple, Bamboo and Kenaf were completed. These plant filaments enjoy numerous upper hands over glass fiber or carbon fiber like sustainable, ecological agreeable, minimal expense, lightweight, high explicit mechanical execution.
Increased technical innovation, identification of new applications, continuing political and environmental pressure and government investments in new methods for fiber harvesting and processing are leading to projections of continued growth in the use of natural fibers in composites, use of 150,000 tonnes bio composites (using 80,000 tonnes of wood and natural fibers) in the automotive sector in 2012 could expand to over 600,000 tonnes of bio composites in 2020, using 150,000 tonnes of wood and natural fibers each along with some recycled cotton. The easy availability of natural fibers and manufacturing have motivated researchers worldwide recently to try locally available inexpensive fibers and to study their feasibility of reinforcement purposes and to what extent they satisfy the required specifications of good reinforced polymer composite for tribological applications.
There are many natural resources which India has in abundance. Most of it comes from the forest and agriculture. However, in most cases residues from traditional crops such as rice husk or sugarcane, bagasse or from the usual processing operations of timber industries do not meet the requisites of being long fibers. This biomass left over are abundant, and their use as a particulate reinforcement in resin matrix composite is strongly considered as a future possibility.
It is really clear that kenaf, banana fiber is reinforced with different fibers and glass fiber are reinforced with many other natural fibers, though the properties are determined in earlier research. Nevertheless, the nanofiller filled kenaf, banana and glass reinforced epoxy composites are not constructed so far and its attributes are not experienced. Hence in this research work, it is asserted to investigate the possible utilization of glass to the kenaf, banana in epoxy matrix composites with and without the reinforcement of nanofiller and the effect of nanofiller to the kenaf/glass and banana/glass content on the physical and mechanical characterization will be examined.

II. MATERIALS AND METHOD

A. Material used

- **Graphene**

Graphene is a crystalline allotrope of carbon with 2-dimensional properties. Its carbon atoms are densely packed in a regular atomic-scale chicken wire (hexagonal) pattern. Each atom has four bonds, one σ bond with each of its three neighbours and one π- bond that is oriented out of plane. The atoms are about 1.42 Å apart. Graphene's hexagonal lattice can be regarded as two interleaving triangular lattices. This perspective was successfully used to calculate the band structure for a single graphite layer using a tight-binding approximation.

- **Kenaf fiber**

The kenaf fiber derived from the outer fibrous bark is also known as bast fibre. Kenaf bast fiber has superior flexural strength combined with its excellent tensile strength that makes it the material of choice for a wide range of extruded,

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moulded and non- woven products. Kenaf fiber could be utilized as reinforcement material for polymeric composites as an alternative to glass fiber.

- **Banana fiber**

Banana fiber a ligno-cellulosic fiber obtained from the pseudo-stem of banana plant (Musa sepientum) is a bast fiber with relatively good mechanical properties are shown in the table 4.4. In the recent past, banana fiber as shown in fig had a very limited application and was primarily used for making items like ropes, mats, and some other composite materials.

- **Glass fiber**

Glass or electrical grade glass was originally developed for standoff insulators for electrical wiring. It was later found to have excellent fiber forming capabilities and is now used almost exclusively as the reinforcing phase in the material commonly known as fiber glass. Glass fibers shown in fig are generally produced using melt spinning techniques. These involve melting the glass composition into a platinum crown which has small holes for the molten glass to flow.

- **Epoxy resin**

The epoxide group can be referred to as a glycidyl group. The resins are adaptable in nature, especially in erosion to opposition, high quality to weight proportion, adhesion properties and dimensional dependability. They are the polymers that are normally made up by methods for gathering epichlorhydrin with bisphenol A. The resins are shaped at temperatures in the locale of 50-100ºC because of the way that the consistency is high, so that because of this, they disintegrate in a inert solvent dissolvable to limit the thickness with the goal that cover at encompassing temperature is conceivable.

Fig 1: a) Graphene powder, b) Kenaf fabric mat, c) Banana fabric mat, d) Glass fabric mat, e) Epoxy resin.

B. Fabrication Technique

Hand lay-up technique is basically an open moulding that is suited for fabricating from small to large varitey of composites. Through it is lesser in terms of production volume per mould, it is possible to make up the composites in large quantites using multiple stamps. The hand lay technique is the most basic type of fabrication which ia sample in the process, offers varying ranges of sizes and also provides tooling at low price, however skilled operators are needed to obtain the consistency in quality and good production rates. The changes in design can be made at the spot with a minimum share for the equipment.

Fig 2: Hand lay-up technique process

III. EXPERIMENTATION

A. Tensile Test

Tensile testing is on a very basic level a materials science test where in which a laminate is subjected to a strain until crack. In the present study, the tensometer as shown in fig.4.11 is used for tensile test for the hybrid composited and hybrid nano composites samples as shown in fig.4.12. All the specimens are examined as per ASTM D3039 standard (sample dimension is 250x25x4mm3) to know the tensile force, tensile modulus and percentage of elongation.

Fig 3: Before Tensile Test specimens.

Fig 4: After Tensile Test specimens

B. Compression test

Unlike metals, properties of composites in tension and compression are not same in general. Compression testing is one of the most difficult tests which can be performed on composites. A number of test methods together with specimen designs have been proposed to avoid the specimen buckling or global instability under a compressive load.

C. Hardness Test

The hardness of the composites is determined by using Rockwell hardness tester as shown in fig 4.21. The indicating dial has 100 divisions. Considering the B scale with a weight of 100kgf, using 1/4" mm ball indenter.

IV. RESULTS

A. Tensile test

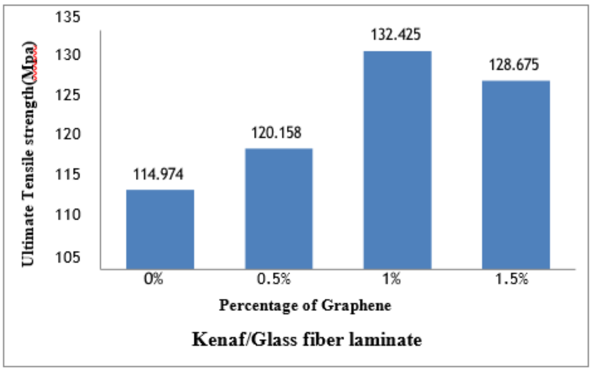
The tensile test is generally performed on flat specimens. The standard test method as per ASTM D 3039 has been used. The tensile test is performed in tensometer at the test speed 5mm/min. For each test composite laminate of five samples were tested and average value was taken for analysis.

- **Kenaf/Glass Hybrid Nano composites**

The effect of nano filler addition (0.5, 1 and 1.5 wt.%) on the tensile strength of the kenaf/glass hybrid composite has been carried. The experimental results for tensile strength are presented in table 1

Table 1 Tensile Test Results for Kenaf/Glass Hybrid Nano composites

Composite Laminate	wt% of Graphene	Max. load (N)	Max. Displacement (mm)	UTS (MPa)
Kenaf/Glass	0	11199.2	13.119	114.974
	0.5	11905.2	13.425	120.158
	1.0	12885.9	15.735	132.425
	1.5	12944.7	14.409	128.675



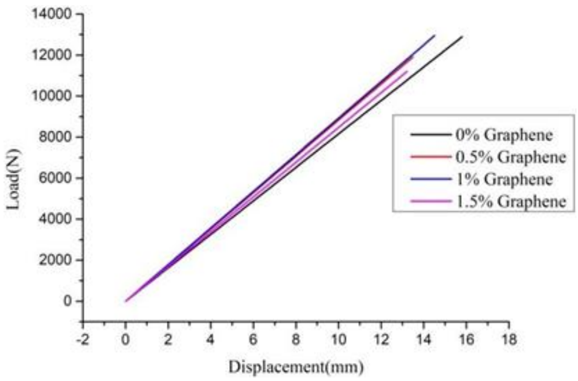


Fig 5: UTS for Kenaf/Glass Hybrid Nano composites
Fig 6: Load vs Displacement for kenaf/glass hybrid nano composites

- **Banana/Glass Hybrid Nano composites**

The variation tensile strength, Maximum load and Maximum displacement of banana/glass hybrid composites for different weight percentage graphene are tabulated in table 2

Table 2 Tensile Test Results for Banana/Glass Hybrid Nano composites

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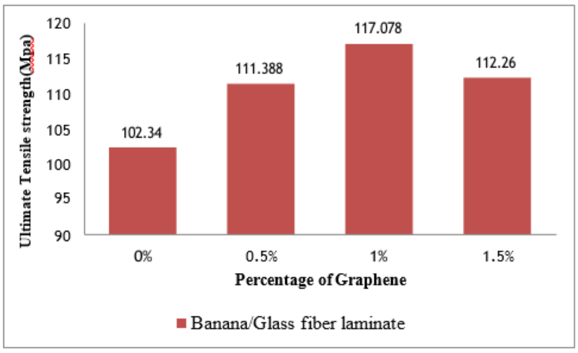
Composite Laminate	wt% of Graphene	Max. load (N)	Max. Displacement (mm)	UTS (MPa)
Banana/Glass	0	10581.3	11.931	102.340
	0.5	10619.5	12.381	111.388
	1.0	11218.8	14.070	117.078
	1.5	11209.0	13.255	112.260



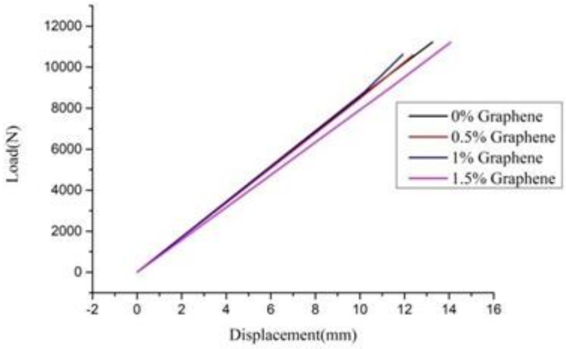


Fig 7: UTS for Banana/Glass Hybrid Nano composites
Fig 8: Load vs Displacement for banana/glass hybrid nano composites

B. Compression test

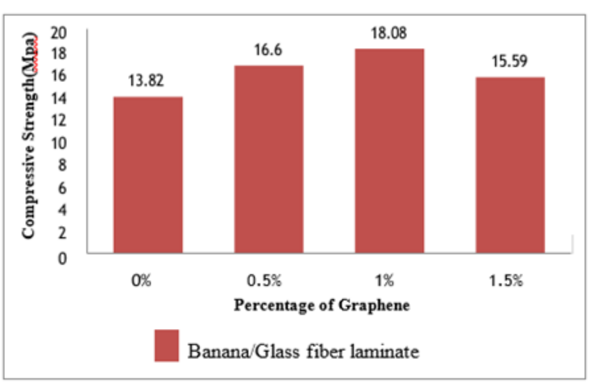
The method of adding weight percentage of graphene have a great influence on the properties of the composites.

- **Kenaf/Glass Hybrid Nano composites**

The different weight percentages of graphene (0.5, 1 and 1.5 wt.%) are added to the kenaf/glass hybrid composites and tested for the compression properties as per ASTM standards. The table 5.3 shows the test results.

Table 3 Compression Test Results for Kenaf/Glass Hybrid Nano composites

Composite Laminate	wt% of Graphene	Max. load (N)	Max. Displacement (mm)	Compression Strength(MPa)
Banana/Glass	0	529.60	1.086	13.82
	0.5	637.40	1.256	16.60
	1.0	627.84	1.10	18.08
	1.5	686.50	1.392	15.59



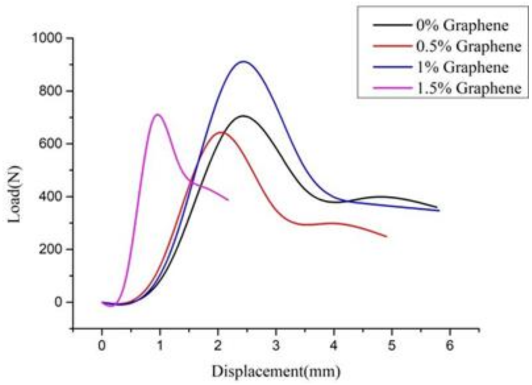


Fig 9: Compressive strength for Banana/Glass Hybrid Nano composites Fig 10: Load vs Displacement for banana/glass hybrid nano composites

- **Banana/Glass Hybrid Nano composites**

From the Fig.5.10 It is observed that the compression strength for the composite with 1% graphene is higher than the other percentage of graphene for kenaf hybrid composites and for with 1% graphene is higher than the other percentage

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of graphene for banana hybrid composites. The maximum compression strength of 28.95MPa is obtained for 1% of graphene kenaf hybrid composites. However, the compressive strength increases when 1wt% graphene is added into the composite system. Adding graphene more than 1% decreases the compression strength of hybrid composites due to non-uniform distribution of graphene and the formation of agglomeration in epoxy resin. In these composites there is a considerable increase of compression strength as the percentage of reinforcement increases. The increase of compression strength is due to the increased area of bonding at the interfacial region of the matrix and the reinforcement.

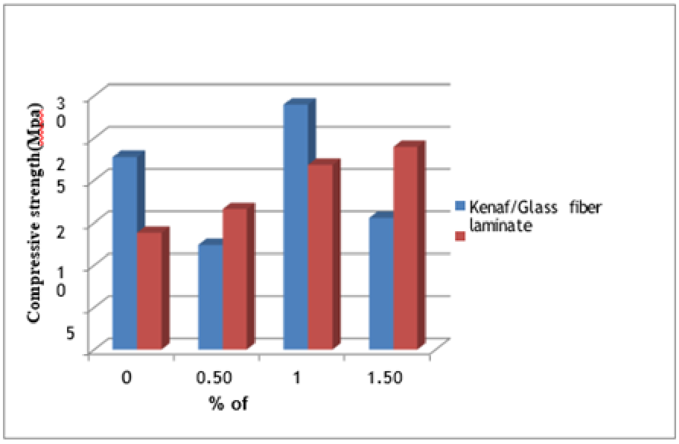

Fig 11: Comparison of Compressive Strength for Hybrid Nano composites

C. Hardness Test

Hardness test was conducted on Kenaf and Banana hybrid nanocomposite by using Rockwell hardness and results are shown in table 4

Table 4 Rockwell Hardness Test Results

Composite laminates	Wt % percentage of Graphene	Major load (kg)	Minor load (kg)	RHN			Avg. BHN
				Trail 1	Trail 2	Trail 3	
Kenaf/Glass	0	100	10	58	50.1	47.6	51.9
	0.5	100	10	75.2	78.3	80.2	77.9
	1	100	10	79.2	83.5	81.2	81.3
	1.5	100	10	65	71	70.4	68.8
Banana/Glass	0	100	10	56.5	54	47.9	52.8
	0.5	100	10	79.5	82.3	82.1	81.3
	1	100	10	88.2	92.1	88.8	89.7
	1.5	100	10	75.3	80.1	73.5	76.3

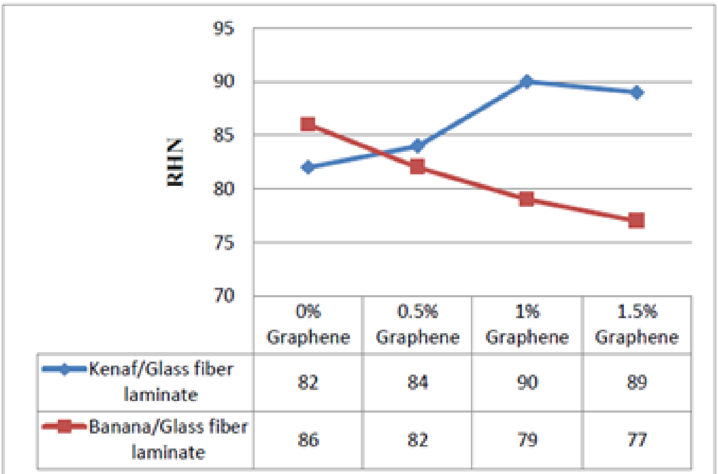

Fig 12: RHN of Hybrid Nano composites

The hardness number of kenaf hybrid nano composite is compared with banana hybrid nano composites as show in Fig.. The hardness number is maximum for kenaf/Glass laminate of 90 RHN for 1% of graphene than other laminates. The variation in the hardness reading is caused by the difference in the hardness between resin and filler materials.

V. CONCLUSION

From the experiments conducted to study the effect on adding different weight percentage of Graphene to the hybrid composites for the properties.
The following conclusions can be drawn

- Fabrication of Kenaf/glass and Banana/glass fiber hybrid polymer composites with different percentage of graphene were prepared successfully by hand lay- up process.
- The hybridization of polymer composites gives better mechanical properties.
- It is found that tensile, compression and bending strength is maximum for 1% of graphene for kenaf/glass nano composites then the banana/glass nano composites.
- The hardness number is maximum for kenaf/glass laminate of 90 RHN for 1% of graphene than other laminates. The variation in the hardness reading is caused by the difference in the hardness between resin and filler materials.
- It is noticed that the kenaf/glass laminates is manifesting high amount of voids having 4.376%. This is because the kenaf has a large number of hydroxyl group making them to be hydrophilic in nature..

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