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# Study on Flexural and ILSS Properties of Kenaf and E-Glass Fiber Reinforced Polymer Matrix Composites

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**ABSTRACT**

Natural fibers are extensively being used for the production of hybrid composites. Hybrid Nano composites can be developed by combining natural fiber/synthetic fibers with epoxy resin and nano filler. Nano particles are considered as high potential filler materials for the improvement of mechanical and physical properties of polymer composites. As the nano scale filler materials are usually free of defects, hence, their applications in the field of polymer composites area set up new trends of prospect.

In this study an effort has been made to produce new type of polymer matrix composite with epoxy as the matrix with graphene as the Nano filler and kenaf and glass fiber as the reinforcing material. The objective of this research work is to investigate the possible utilization of glass to the Kenaf, in Epoxy matrix composites with and without the reinforcement of nano filler and the effect of Nano filler to the kenaf and glass content on the physical and mechanical characterization will be examined. Therefore the hybrid nano composite, specimen with different weight percentage of graphene like 0%, 0.5%, 1% and 1.5% graphene with kenaf/e-glass fibers are prepared and used to characterize Flexural and ILSS properties. The combination yielded good result with graphene Nano filler. The scanning electron microscopy (SEM) is utilized for the morphological investigation of the hybrid nano composite material.

**Keywords** : Nano particle, Kenaf, Flexural, ILSS(Inter laminar shear strength),SEM

## I. INTRODUCTION

A composite material is characterized as the blend of at least two constituent materials, which are basically insoluble into one another to such an extent that the properties of the mixed combination are superior to the amount of the properties of every constituent taken independently. The objective of this mix is to determine the most desirable characteristics of the constituent materials. There are two classes of constituent materials matrix material encompasses and supports the reinforcement materials with their relative positions. The reinforcement gives their exceptional mechanical and physical properties to improve the matrix properties.

The most commonly used matrix materials are polymer matrix materials. The polymer material has high molecular weight. This material has different processing methods which in turn has versatility inproperties. This versatility in properties of polymer makes them attractive matrix material for many applications. A very large number of polymeric materials, thermosetting and thermoplastic, are being used as matrix materials for the composites. The polymer matrices are selected on the basis of adhesive strength, fatigue resistance, heat resistance, chemical and moisture resistance.

Fibers are the reinforcement and the main source of strength while matrix glues all the fibers together in shape and transfers stresses between the reinforcing fibers. The fibers carry the loads along their longitudinal directions. Common fiber reinforcing agents include asbestos, carbon/graphite fibers, beryllium, beryllium carbide, beryllium oxide, Similarly common matrix materials include epoxy, phenolic, polyester, polyurethane, poly ether ketone, vinyl ester etc,.

The natural fiber reinforced composites have attracted considerable importance as a potential structural material. The attractive features of the natural fibers like jute, sisal, coir and banana have been their low cost, light weight, high specific modulus, renewability and biodegradability. Composites reinforced with such natural fibers have thus been a subject of intense study for low strength, low cost application in contrast to the synthetic fiber reinforced composites. These fiber reinforced plastics(FRP), are getting popularity as primary and secondary structural materials in aerospace, automobile, civil construction applications, marine, sports industry, textile industries, renewable energy sectors, defense, and other areas due to their inherent mechanical properties, such as low density, high strength-to-weight ratio, excellent durability, high stiffness-to-weight ratio, non corrosive nature, dimensional stability, good thermal and electrical insulation properties and ease of fabrication. . Furthermore, natural fiber reinforced polymer composites form a new class of materials which seem to have good potential in the future as a substitute for scarce wood and wood based materials in structural applications. Hybrid composites can be developed by combining natural fibers/natural fiber and natural fibers/synthetic fibers with epoxy, polyester, phenolic, poly vinyl ester, poly urethane resins, etc., new composites with addition of more than one reinforcement from natural resources, such as natural fiber/natural fiber or natural fiber/nanofiller from organic sources as an alternative to synthetic fibers. Hybridization involving the combination of nanofiller and natural fiber in the matrix results reduction of water absorption properties and increased in mechanical properties. Natural fiber/nanofiller-based hybrid composites can be used in building and construction materials, transportation (automobiles, railway coaches, aerospace) packaging, consumer products, etc., and also could be possible to produce acoustic insulator and extremely thermally stable materials.

## II. METHODS AND MATERIAL

In this study, an effort has been made to produce new type of polymer matrix composite with epoxy as the matrix with nanofiller graphene as the filler, kenaf (organic fiber) and glass (inorganic fiber) as the reinforcing material.

**Fabrication method:**

**Handlay-up method**: is basically an open molding technique that is suited for fabricating from small to large variety of composites. Production volume per mold is low, however it is possible to make up the composites in large quantities using multiple stamps. The hand lay technique is the most basic type of fabrication which is simple 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 below shows the simple hand lay up process.

**Simple hand layup method for hybrid and hybrid Nano composites**

The maintained volume fraction for the matrix and reinforcement is 40:60. The resin to hardener ratio is100:10

1) Initially a discharge operator (wax) is showered totally on the mould surface to maintain a strategic distance from the adhering of polymer to the surface.
2) Then thin plastic sheets are set at the best end and base end of the shape plate with a specific end goal to acquire a decent surface complete of the composite laminate.
3) The fortification as woven mates are cut according to the span of the form and are put at the surface of shape after Perspex sheet.
4) Then the Nano filler (graphene) of different weight percentage of 0.5, 1, 1.5 is blended to the epoxy resin in appropriate extent alongside a hardener at the evaluated speed of 400-500rpm and poured onto the surface of tangle which is now set in the mould.
5) The epoxy resin is consistently spread by methods for brush.
6) Second layer of mat is then set on the surface of the polymer.
7) A roller is proceeded onward the mat-polymer layer so as to expel any kind of air caught and crush out the abundance polymer that is followed on the fortification.
8) The process is rehashed for each layer of polymer and mat till the required layers are stacked to accomplish the thickness.
9) After setting the plastic sheet, the release agent is showered on the inward surface of the best shape plate which is then kept on the stacked layers and the weight is connected. The restoring happens at room temperature for about 48hours.
10) Then shape is opened and the created composites part is taken out and additionally handled in a oven at 100˚C for polymerization to stay away from the development of voids.

The same method is carried out without the addition of nano filler Graphene for the fabrication of hybrid composites. During the fabrication of laminates, the alternate layer of kenaf and glass are added until thickness of 4mm is obtained.

| Composites Laminates | Nano filler | Fiber orientation | Thickness | Fiber Layer Compositions |
|---|---|---|---|---|
| Kenaf/Glass | 0.5 wt % | Bi-directional | 4mm | G+K+G+K+G+K+G+K+G+K+G |
| | 1wt % | | | G+K+G+K+G+K+G+K+G+K+G |
| | 1.5 wt % | | | G+K+G+K+G+K+G+K+G+K+G |

***Materials used***

The materials used are the epoxy resin, graphene nanofiller, kenaf fiber and glass fiber. These materials fabricated using hand layup technique to frame a hybrid composite and hybrid nano composites. Utilizing these two types of composites, they are described to examine the scanning electron microscope other mechanical properties like flexural test, interlaminar shear quality

**Epoxy resin**: the resin used is epoxy resin LY 556 and hardener HY 951 is used in fabrication. The epoxide group can be referred to as a glycidyl group. They are the polymers that are normally made up by methods for gathering epichlorhydrin with biphenyl. By carefully selecting of hardener the curing rate can be controlled according to process demands.

**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.

**Kenaf fiber:** The kenaf fiber derived from the outer fibrous bark is also known as bast fibre. Kenafbast fiber has superior flexural strength. Kenaf fiber can be utilized as reinforcement material for polymeric composites as an alternative to glass fiber.

Mechanical properties of kenaf fiber

| Properties | Units | Kenaffiber |
|---|---|---|
| Density | (g/cm3) | 1.4 |
| Tensile Strength | Mpa | 930 |
| Flexural Strength | Mpa | 98000 |
| Specific Strength | KN.m/Kg | 61 |
| Young's Modulus | Mpa | 53000 |
| Flexural Modulus | Mpa | 7300 |

**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 being used exclusively as the reinforcing material commonly known as fiber glass, they can be used in continues fiber form or short fiber form.

## III. RESULTS AND DISCUSSION

In the present work mechanical properties like flexural strength and interlaminar shear strength of kenaf/e-glass fiber reinforced hybrid composites as well as kenaf/e-glass reinforced graphene nanofilled hybrid nano composites are studied and tests are conducted as per ASTM standards.

**Flexural test**

Flexural strength is determined by ASTM D790 standard test method. In this test, a composite beam specimen of rectangular cross-section is loaded in three-point mode. Sample is cut into flat shape of size (12.5x100x4mm$^3$), in accordance with ASTM standards D3410 as shown in fig a) and fig b) before and after flexural test. Flexural test: The flexural test for different hybrid nano composites are performed as per the ASTM standards at the test speed of 5mm/min.

**Inter laminar shear strength:**

Inter laminar shear test was led as per ASTM D2344-84. The information recorded during the three-point twist test was utilized to assess the inter laminar shear strength (ILSS). The test was led utilizing the equivalent tensometer utilized for flexural test with twist test installation. For various weight level of graphene filler, four indistinguishable examples were tried, and normal outcome was discovered. ILSS was determined by using the following equation

$ILSS = (3F_{max})/4bt$

Where, F= the maximum load in(N)

b=width of the specimen (mm)

t=Thickness of the specimen (mm)


Fig:a

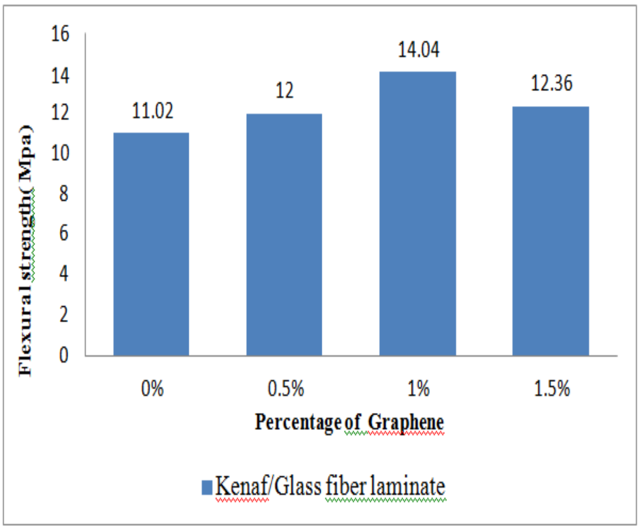
Fig:b

Fig: a)Flexural samples as per ASTM standards

Fig: b)Flexural samples after test

**Flexural Test Results** for Kenaf/Glass Hybrid Nano composites

| Composite Laminate | wt% of Graphene | Max. load (N) | Max. Displacement (mm) | Flexural Strength(MPa) |
|---|---|---|---|---|
| Kenaf/Glass | 0 | 515.8 | 8.164 | 11.02 |
| | 0.5 | 742.4 | 7.34 | 12.00 |
| | 1.0 | 632.5 | 6.297 | 14.04 |
| | 1.5 | 477.6 | 5.864 | 12.36 |



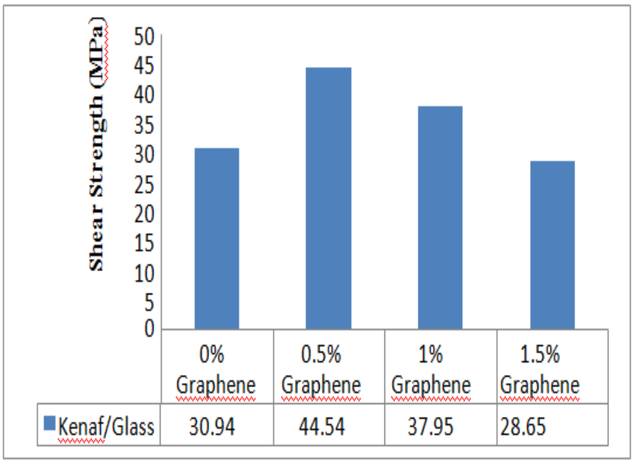

The maximum and minimum flexural strength of 14.04Mpa and 11.02MPa were recorded for 1% and 0% of graphene filler laminates respectively as shown in fig. The flexural strength decreases after 1% of graphene due to the poor dispersion of nanofillers this may result in poor strength. It is observed 1% graphene filler laminate could withstand higher flexural strength than other laminates. The laminate of 1% of graphene can withstand the maximum load of 632.5N

**Inter laminar Shear Strength Test**

The ILSS test are carried out for kenaf and glass hybrid composites with different weight percentage of graphene as per ASTM D2344 standards and answers are presented in the following table

**ILSS Test Results**

| Composites Laminates | Wt% of Graphene | Shear Strength(MPa) |
|---|---|---|
| Kenaf/Glass | 0 | 30.94 |
| | 0.5 | 44.54 |
| | 1 | 37.95 |
| | 1.5 | 28.65 |




Shear Strength of Kenaf/Glass hybrid composites

The results indicate that kenaf, glass hybrid composites depends on the matrix material and only less contribution of fibers in taking place. Thus it is affirmed that the kenaf/Glass hybrid composites with 0.5% of graphene shows better results than the other character of composite laminates tested.

**Characterization by Scanning Electron Microscope (SEM)**

The scanning electron microscopy is utilized for the morphological investigation of the composite material. The surface perspective of the kenaf and Glass hybrid composite will be dissected for better derivation of the explanations behind failure and diminished in quality through the pictures that are exhibited in the figure beneath. Laminate are at first covered with gold sputtering directing material before observing the surface through SEM. The fiber diffusing, cleft and internal structure of the separated surface of the composites laminates are doubtlessly detectable from photos showed up through the scanning electron microscopy.

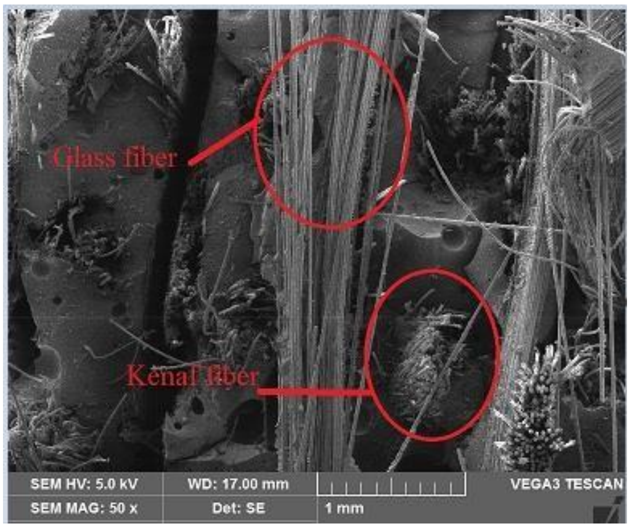



Fig: SEM images of Kenaf/Glass fiber composites

Above figure Demonstrates The breakage of Kenaf/Glass fiber present along epoxy resin.

## IV. CONCLUSION

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

Fabrication of Kenaf/glass fiber hybrid polymer composites with different weight percentage of graphene were prepared successfully by hand lay-up process.

It is found that flexural strength is maximum for 1% of graphene for kenaf/glass nano composites.

The inter laminar shear stress properties for kenaf/glass hybrid composites with 0.5% of graphene having 44.54Mpa is better results than the other character of composite laminates tested.

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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