Experimental investigation of bending characteristics of hybrid composites fabricated by hand layup method

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Abstract. The extensive applications of hybrid composite materials in the field of transportation and structural domeine provide prominent advantages in the order of stiffness, strength even cost. However extend the advantages of hybrid campsites in several field such as aviation and marine even more additional properties should be inculcate in them. During production of such profitable composites poses some problems at time at decompose and processing. It’s better to develop environment friendly and reusable composites, bio hybrid composite materials such of the one. In this paper, focused on development of Eco-friendly hybrid bio composites with the ingredients of drumstick fibers, glass fiber along with polyester resin. This hybrid bio composites subjected to bending test and evaluate the characteristics of bending properties, this research evident that bending characteristics of hybrid composites with longitudinal fiber orientation better than transverse.

Index terms: Drum stick fibers, Hand layup, E glass fiber, Composite materials.

1. Introduction

Composites plays vital role in the field of manufacturing due to its unique characteristics like good compressible, light weight and excellent tensile strength, hence composite find is utilization in various fields of applications. Composite will provide desired properties in material by combing different material have different modulus of elasticity [1]. Composites obtained by combination of properties will exhibits less weight, high strength, good Stiffness, bio-degradable, permeable, good optical, electrical & magnetic characteristics which cannot obtained by monolithic material. These composite materials are customized according to the requirement easily for specific applications [2]. The durability of composite material is longer when compared to any other materials. Today the industries are dependent on the composite materials due to its wide applications and advanced technology of manufacturing [3].

Composite materials are classified into metal, ceramics and polymer matrix with wide variety of reinforcement. Since the demand surged in the market for requirement of the unique property materials, a lot of research are under process on composite materials to find out the solution to solve complex
problems in manufacturing industries [4]. Composites are widely used in diverse field of applications for its excellent properties which has grown steadily and advancing towards of acquiring the new markets. Composites are the ideal solution for replacement of the heavy metals by integrating the effective design, manufacturing process, quality tooling, assuring the quality with minimizing the wastage of material. Aerospace industries have adhered to the composite materials many years ago[5]. Lot of inventions are going on today for the development of hybrid composite materials [6]. The development of new polymer resin matrix materials with reinforcement fibers such as carbon, aramid and glass are widely used with high volume usage [7]. The cost of the composite material will reduce with the increase in the volume [8][9]. Fiber reinforced Plastic (FRP) are known as the high performance polymers used in various applications to resist the explosion impact, fuel injection system, blades of windmills, driving shafts in industries, highway bridges beams and rollers for paper making[10][11].

The present research work is carried out extensively for fabrication of hybrid Composites with bio degradable fibers like drumsticks along E glass fiber and aiming to evaluate the bending characteristics and the properties of the hybrid composites aligned with fibers in different orientation such as longitudinal and traverse direction.

2. Fabrication of hybrid composite

2.1 Material

Fabrication of hybrid composites involves selection of ingredients is very important in order to achieve isotropic, orthographic or even anisotropic characteristics along the dimension. In current research focused on natural drumstick fiber and E-glass fiber embedded with polyester matrix material. Even composites have alignment of fiber both in traverse and longitudinal orientation considered during composite preparation by hand layup technique.

2.2 Hand layup technique

Hand layup was one of the oldest manual techniques to fabricated laminated composite materials. In case of hybrid composites with fibrous ingredients it is well suitable for fabrication. In hand layup technique, weighted manual steel rolled used to applied compressive load to incorporate and enhance bonding between layers of drumstick fibers, E glass and polyester resin materials in alternate layers. Continuous layers of matrix and reinforcements placed in lap and applied compressive force, lead homogeneous spreading of matrix and develop wettability among them. Gas entrapping carried in wet composite and process was carried effectively till achieving standard thickness. During placing of fibers maintain alignment in longitudinal and traverse direction in separate composite preparation. After fabrication of hybrid composites, cut into standard ASTM standard and exposed to test according to standard procedure.

3. Experimentation

After fabrication of hybrid composites materials cut as per ASTM standard subjected two three point flexural test with bending machine model KIC-2-1000C make Kalpak instruments and controls, Pune, the machine had maximum capacity flexible range of 0.1 to 100 kило Newtons. Additionally instrument had Double ball screw with bellow attachment with having dia of ball screw was up 0.001mm, force applied, actuator drive and speed resolution with digital AC servo drive &servo motor used. Also had extensometers, additional load cells, hot air circulation chamber.
3.1 Test Procedure: ASTM bending test Specimens were placed by supportive anvils of a flexural testing machine at a specified distance apart. The arrangement subjected to gradual loading with bending probe, form three point flexural loading. The speed that measured by attached actuator drive and speed resolution with digital AC servo drive and recording step loading time in every 1 to 10min once.

4. Result and Discussion
In current bending test adopted applied speed range of 5mm/min and with the help of extensometer and load cell, strain gauge, determine bending modulus. Test procedure repeated for both composite samples with longitudinal and traverse fiber orientations, tabulated the result and compares them.

4.1 Bending / Flexural test graph obtained on longitudinal fiber orientation
Three point bending test results and method of test conduction was tabulated and related graph of experimentation was shown in graph. When static load applied on hybrid composite materials made with longitudinal fiber orientation plotted with length of deformation verse load applied, test was carried out till composites reaches its ultimate strength and finally leads to fracture. Complete test nomenclature was recorded and shown in graph 1. Graph clearly shows composites takes around 56N load at peak and failure at 27N load after fiber rupture.
Table 1. Specification of bend test for longitudinal fiber orientation

| Sl. No. | Particulars                  | Bending Test          |
|---------|------------------------------|-----------------------|
| 1       | Number                       | 000001                |
| 2       | Batch No                     | BGSIT18-5-19:Flexural|                        |
|         |                              | LG,F1                 |
| 3       | Sample Type                  | Strip 1Pt Ben         |
| 4       | Test Length [mm]             | 75                    |
| 5       | Width [mm]                   | 12.31                 |
| 6       | Thickness [mm]               | 5.31                  |
| 7       | Elongation Device            | CrossHead             |
| 8       | TestMode                     | Compression           |
| 9       | Load Cell Capacity           | 1000 Kgf              |
| 10      | Test Parameter               | Peak Load             |
| 11      | Speed                        | 2.5mm/min             |

Graph 1. Bending characteristics of composite sample with longitudinal fiber orientation.

4.2 Bending / Flexural test graph obtained on Transverse fiber orientation

Bending test results of hybrid composites with transverse fiber orientation exposed that sudden fracture takes place due to fiber failure and matrix collapse in composites. Graphs clearly shows that ultimate load
carry capacity of the composite around 24N and fracture place at load 12N after matrix collapse its shown in graph 2.

### Table 2. Specification of bend test for transverse fiber orientation

| Sl. No. | Particulars                | Bending Test                  |
|---------|----------------------------|-------------------------------|
| 1.      | Number                     | 000001                        |
| 2.      | Batch No.                  | BGSIT18-5-19\Flexural\LG,F2  |
| 3.      | Sample Type                | Strip 1Pt Ben                |
| 4.      | Test Length [mm]           | 75                            |
| 5.      | Width [mm]                 | 12.39                         |
| 6.      | Thickness [mm]             | 5.18                          |
| 7.      | Elongation Device          | CrossHead                    |
| 8.      | TestMode                   | Compression                   |
| 9.      | Load Cell Capacity         | 1000 Kgf                     |
| 10.     | Test Parameter             | Peak Load                     |
| 11.     | Speed                      | 2.5mm/min                     |

Graph 2. Bending characteristics of composite sample with transverse fiber orientation

The current experimental result exposed on eventual evidence on strength specially flexural strength of drumstick, E glass and epoxy hybrid composite materials mainly depends upon types of fiber and orientation of fibers with matrix combination. The results tabulated completely extracted from the experimental investigation from both fiber orientation longitudinal and transverse placed. In case of fiber longitudinal orientation, applied load effectively transfer through a fiber length and distributed into matrix phase, makes strengthened the composite effectively.
Matrix phase shows resistance towards fatigue and crack when external static load acting on it. Overall composite exposed resistance to flexural break and results high load carrying capacity due to reduced the internal lattice spatial distance between the particles in composites leads plastic conditioned flow exist in Table 3.

**Table 3.** Cumulative bending test results of Composites

| Parameters                          | Longitudinal fiber orientation | Transverse fiber orientation |
|-------------------------------------|--------------------------------|------------------------------|
| C.S.Area [mm²]                     | 65.366                         | 64.18                        |
| % Elongation                        | 35.67                          | 29.39                        |
| Strain                              | 0.04525                        | 0.02204                      |
| 3Pt Bend Flexural Strength [MPa]    | 18.19                          | 8.21                         |
| Peak Load [N]                       | 56.133                         | 24.26                        |
| Stress @ 60 % of Peak [N/mm²]       | 0.51                           | 0.23                         |
| Youngs Modulus(Y) [N/mm²]           | 5.08                           | 3.32                         |
| 3Pt Bend Modulus [MPa]              | 934.08                         | 693.04                       |

between ingredients of composites. In order to compare with result obtained from graph clearly indicates flexural strength/ bending strength of the composites with fibers in longitudinal orientation shows significantly higher than fiber orientation in traverse direction. Fibers oriented in traverse direction have less bending strength than of longitudinal orientation due to anisotropic characteristic properties of composites, wetting problem arises and gas entrapment in composite materials. Summary, due to longitudinal positioning of fiber carry the load effectively along the length of fiber in traverse orientation. Results were tabulated and compared below.

Cumulative bending test results shows longitudinal fiber orientation composites have excellent bending characteristic than fibers were placed transverse in terms of ultimate load and fracture.

**5. Conclusion**

The Paper mainly focused on fabricates the new composites, including drum stick, E glass and polyester resin combination successfully. Hybrid composites developed with the combination of both longitudinal and transverse fiber orientation with hand layup technique. ASTM standard test specimens were subjected to flexural or bending test and tabulated the results. The results concluded that longitudinal fiber orientation had 200% higher flexural / bending strength than compare to fiber orientation in traverse direction in fiber composites. Almost 20% Elongation more in longitudinal fiber orientation.
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