Fabrication and Testing of Hybrid Laminate Reinforced with Natural Fibre

K Vijaykumar, G Nagesh and V Gurushanker

1,2,3Assistant Professor, Mechanical Engineering, Vignan Institute of Technology And Science, Near Ramoji Film City, Deshmuki Village, Yadadri, Bhuvanagiri, Telangana, India.

E-Mail: vijaykumarram94@gmail.com

Abstract: This present work discussed about fabrication and testing of hybrid laminate reinforced with natural fibres, in general engineering materials with high-performance are used in various manufacturing methods from different resources has been investigated by many researchers across the world. The raw materials which are taken from renewable sources are environmentally good & not cause any kind of health issues, now a day’s most of natural fibre based hybrid composites are used different areas like automobile companies and aircraft industries for manufacturing their inside and outside parts of the mechanical bodies and it’s not affected environment, the exact reason behind this is a natural fibre, because of its easy availability & low cost. The hybrid composites are fabricated by using the natural fibre reinforcements as they exhibit their low density, low cost as well as exhibit better mechanical properties. The present work includes the manufacturing of natural fibre (wool and jute) reinforced polymer composites are discussed and this natural fibre reinforced hybrid polymer composite is tested and compared with the glass fibre epoxy polymer composite. The testing performed are flexural and compression and different strengths are collected finally and it is concluded that compared with the glass fibre polymer composite, hybrid laminate (natural fibres) are in good condition in terms of strength and their application are also brought into consideration.

Key points: Composites, laminar, layers, hybrid laminate, natural fibres (wool and jute)

1. Introduction

Polymer matrix composites (PMC) are consist of short or fibres with continuous mixed with epoxy resin. It is transferring load using the fibres presented in the composites. Fibres are playing role to strengthen the PMC. But synthetic fibres are not environmental friendly; hence natural fibres are now a day focused by researchers. Natural fibres are produced from plant and animals. It can be used in PMC with different orientation and enhance the mechanical properties. Flexure strength of PMC plays an important role in application into different assembly and manufacturing areas. It is also known as modulus rupture and bending strength. It is a stress of PMC material which is yielding just before in a flexure test. When materials subjected to compression by pressure, compressive strength exists. Compressive load are may be buckle or crush [1-5]
1.1. Natural composites:

![Figure 1. Abalone Shell (Caco3) Scallop Shell](image1)

Many of the materials used for various applications are available naturally in the form of composites. Example: bones, woods, shells, pearlier (steel - which is a mixture of a phase and Fe3C) etc.

![Figure 2. Concrete Plywood](image2)

1.2. Man-made composites:

Composites are generally consisting of two or more than two materials. Man-made composites are developed for commercial usage like bricks and wood.

1.3. Classification of man-made composite materials:

- particle reinforced
  - large particle dispersion strengthened
- fibre reinforced
  - continues (aligned) discontinuous (short)
  - aligned randomly oriented
- structural
  - laminates sandwich panels

1.4. Classification of composites:

Composites are classified by the type of matrix — polymer, metal, ceramic, and carbon.

- polymer matrix composites
- metal matrix composites
- ceramic matrix composites
- carbon–carbon composites
2. Literature Survey

Kumar ramamoorthy and skrifvars [6] the composition and properties of each of the fibre changes, plant fibres, particularly bast and leaf, find applications in automotive industries. SEM micro structural images of the fabricated composites on their fractured surfaces were used for a subjective assessment of the interfacial property investigation of coir/epoxy & contrasted with glass fibres; this was studied by Nagarjun et al. [7] Wang and Huang [8] had chosen a coir fibre stack for investigating their properties, according to their research the length of the fibres was about 8 & 337 mm in the range. The fibres quantity with the length scope of 15-145 mm was 81.95% of every single estimated fibre. Composites with coir fibre reinforcement were manufactured by utilizing a heat press machine and rubber was taken as matrix. Tensile properties of the composites were investigated. Bilba et al. [9] inspected 4 different fibres from tress especially like banana (trunk & leaf) and coconut (husk, texture) before in their consolidation in matrix cementitious, so as to plan protecting for development of material. From the literate, it is understood that natural fibres are playing an important role in strength and environmental friendly. Also, flexure strength and compressive strength investigation are important to realize the characteristics of PMC. In this work, wool-jute based natural fibres are selected, made PMC using hand layup process and mechanical characteristics are investigated.

3. Experimental Setup

3.1. Fibre processing: Natural fibres are organic compounds which usually extracted from plant leaves, stems, & animals these can be viewed into filaments, threads. The oldest fibres generally used are cotton, silk & flax but also jute and wool have been cultivated since ancient times. In this experimental setup jute with thickness of 2mm and size of 380*330 were used as reinforcement material simultaneously.

Wool fibre consists of excellent properties of elongation and better recovery. Also, it exhibits non sticky, shape fairly while usage and good durability characteristics. It has good bacteria resistance and slight sputtering when it gets light flame. The significant properties of wool fibres are better resilience, average density, lesser electrical conductivity, reasonable resistance of abrasion, less stability in dimension and better thermal conductivity. Moisture absorption of wool is less as compared to silk fibres. In this experiment about 35 grams of wool is added in the middle layer of the laminate.
3.2. Matrix preparation (epoxy resin and hardener)

*Step 1:* Initially the quantity of epoxy resin required for the entire project should be known. Usage of calculator is very important to find out total square footage area occupied or filled with epoxy resin.

*Step 2:* For finding out best ratio of a particular product always epoxy resins back side label should be taken into consideration. Pore the resin in the bucket and make suitable weight notations by taking its weight of the resin.

*Step 3:* To increase stiffness to epoxy hardener hy951 is added and it also acts as catalyst. Take the required quantity of hardener in a plastic container with the ratio is about 2:1 (resin to hardener). By using the calculator how much quantity of hardener required for the epoxy can be measured by considering their weight fractions. In general to get an accurate weight fraction always less amount of hardener (less than what need) should be added to resin.

*Step 4:* Epoxy resin should be mixed thoroughly while adding the hardener. And the hardener should be added poured slowly to avoid agglomeration. This process should be continued until the hardener mixed uniformly gone and the sides can be scraped by using the spatula. Resin should apply very quickly once it becomes clear.

3.3. Fabrication process:

3.3.1. Materials required:

Mould, acetone ,wax polish, mugs ,stirrer rod (5mm diameter), cotton waste , markers , steel rules , weighing machine, hydraulic press
3.4. Resin araldite LY-556:

Resin in this project is araldite LY-556 (resin) araldite ly-556 is a liquid, unmodified epoxy resin of medium viscosity, unmodified epoxy resin based on bisphenola. It possesses excellent mechanical properties and resistance to chemicals, which can be modified within wide limits by using different hardeners as well as fillers has low tendency to crystallize. Used in aircraft and aerospace adhesives.

3.5. Laminate preparation:

For laminate preparation with a required quantity of resin & hardeners are used in this fabrication process. A hardener HY951 is added to Epoxy LY556 with a ratio of 1:10. Hand layup method was used throughout the fabrication process to prepare composite laminates. Layered jute fibre of 380*330 was used for the preparation of laminate. The composite consists of six layers in which top to bottom of the laminate are shown in fig.
The jute fibre is placed on the resin coated [epoxy resin ly556 mixed with hardener hy951] sheet & then after the resin is again applied on fibre with help of wire brush or roller brush. Then another layer of jute fibre is placed on the resin coated applied again on it. Middle layer consists of wool fibre placed randomly and again resin is applied frequently and remaining layers are laminated on the sheet.

3.6. Specimen preparation:

The specimen dimensions are marked as per ASTM standards on the laminate and the specimens are cut using the cutting machine setup.

3.7. Grinding

Grinding is defined as an abrasive machining process that uses a grinding wheel as the cutting tool. Its practice is an enormous and various region of assembling and instrument making and furthermore can create extremely fine completes with exceptionally precise measuring techniques in large & small scale industry sectors. This the more qualified manufacturing method to machine highly brittle
materials than the other customary machining processes. It is more preferred for machining of hard materials compared with machining like drilling and cutting. In cutting, produces the larger chips than gridding process. Specimens are grinded to remove the extra material and to obtain the required dimensions.

![Grinding Process](image)

**Figure 11. After Grinding**

4. Testing Performed

4.1. Compression test:

Compression test as per ASTM standards length=6*t mm, Width of the specimen w=10mm, For flexural test as per ASTM standards length=16*t mm, Width of the specimen w=10mm

5. Results

| S. N | Specimen 1 | Specimen 2 | Specimen 3 | Specimen 4 | Specimen 5 |
|------|------------|------------|------------|------------|------------|
| 1    | Test Sr. No | 1676       | 1676       | 1676       | 1676       | 1676       |
| 2    | Date / Time | 22/03/2020 | 22/03/2020 | 22/03/2020 | 22/03/2020 | 22/03/2020 |
|      |            | 5:14:02 pm | 5:18:39 pm | 5:21:30 pm | 5:23:56 pm | 5:26:16 pm |
| 3    | Span Length | 96         | 96         | 96         | 96         | 96         |
|      | Sample Width|            |            |            |            |            |
| 4    | Sample Width| 11.3       | 11.28      | 11.25      | 11.29      | 11.25      |
| 5    | Test Speed (Mm/Min) | 2 | 4 | 4 | 4 | 4 |
| 6    | Sample Thickness | 6.45 | 6.39 | 6.47 | 6.52 | 6.48 |
### Table 2. Flexural Test Result [Test Result on Hybrid Laminates (Jute+Wool)]

| S. N | Results                          | Unit   | Specimen 1 | Specimen 2 | Specimen 3 | Specimen 4 | Specimen 5 |
|------|----------------------------------|--------|------------|------------|------------|------------|------------|
| 1    | Area                             | Cm²    | 0.728      | 0.720      | 0.727      | 0.736      | 0.729      |
| 2    | Yield Force                      | N      | 216.005    | 216.005    | 224.873    | 216.005    | 235.334    |
| 3    | Yield Deflection                 | Mm     | 3.62       | 3.23       | 3.29       | 3.75       | 3.87       |
| 4    | Yield Flexural Modulus At 1% Strain | N/Mm  | 59.6       | 66.9       | 68.4       | 57.7       | 60.8       |
| 5    | Flexural Strength @ Yield Elasticity | Mpa  | 4349.19    | 5030.16    | 4966.58    | 4075.41    | 4392.98    |
| 6    | Flexural Modulus Of Elasticity   | N/Mm²  | 37.77      | 38.26      | 39.54      | 37.43      | 41.32      |
| 7    | Flexural Strength @ Yield        | N/Mm²  | 0          | 0          | 0          | 0          | 0          |

5.1. Flexural Test Graphs

![Figure 12. Load Vs Deflection For Specimen (1)](image1)

![Figure 13. Load Vs Deflection For Specimen (2)](image2)
Figure 14. Load Vs Deflection For Specimen (3)

Figure 15. Load Vs Deflection For Specimen (4)

Figure 16. Load Vs Deflection For Specimen (5)

Table 3. Compression test results [hybrid laminate; jute+wool]

| S. N | Specimen 1 | Specimen 2 | Specimen 3 | Specimen 4 | Specimen 5 |
|------|------------|------------|------------|------------|------------|
| 1    | Test Sr. No | 1676       | 1676       | 1676       | 1676       | 1676       |
| 2    | Date / Time | 22/03/2020 | 22/03/2020 | 22/03/2020 | 22/03/2020 | 22/03/2020 |
|      | 5:33:53 Pm  | 5:38:43 Pm | 5:41:45 Pm | 5:45:16 Pm | 5:49:01 Pm |
| 3    | Grip Length | 70         | 70         | 70         | 70         | 70         |
| 4    | Sample Width(Mm) | 11.8 | 11.9 | 11.9 | 11.75 | 11.82 |
| 5    | Gauge Length (Mm) | 70 | 70 | 70 | 70 | 70 |
| 6    | Test Speed (Mm/Min) | 2 | 2 | 2 | 2 | 2 |
| 7    | Sample Thickness(Mm) | 6.5 | 6.47 | 6.47 | 6.52 | 6.57 |
| 8    | Max. Force(N) | 2471.28 | 1343.51 | 2167.27 | 1366.33 | 1873.07 |
| 9    | Max. Deflection(Mm) | 3.54 | 2.01 | 2.80 | 2.77 | 4.18 |
5.2. Compression test graphs

Figure 17. Load Vs Deflection For Specimen (1)

Figure 18. Load Vs Deflection For Specimen (2)

Figure 19. Load vs Deflection for specimen (3)

Figure 20. Load vs Deflection for specimen (4)

Figure 21. Load vs Deflection for specimen (5)
5.3. **Comparison of Glass fibre, Natural fibre composite**

**Table 4.** shows the ultimate load values of the glass and natural fibre composites of flexural and compressive tests

| Tests          | Glass fibre composite(N) | Natural fibre composite (N) |
|----------------|---------------------------|----------------------------|
|                | Flexural Test             |                            |
| specimen-1     | 49                        | 216                        |
| specimen-2     | 78                        | 216                        |
| specimen-3     | 78                        | 216                        |
|                | Compression Test          |                            |
| specimen-1     | 2429.5                    | 2471.28                    |
| specimen-2     | 2145.5                    | 2167.27                    |
| specimen-3     | 1765.2                    | 1873                       |

**Table 5.** Shows the maximum deflection caused during flexural and compression testing of glass fibre and natural fibre composite

| Tests          | Glass fibre composite(mm) | Natural fibre composite(mm) |
|----------------|----------------------------|-----------------------------|
|                | Flexural Test              |                             |
| specimen-1     | 0.58                       | 3.62                        |
| specimen-2     | 2.22                       | 3.23                        |
| specimen-3     | 2.43                       | 3.75                        |
|                | Compression Test           |                             |
| specimen-1     | 3.4                        | 3.54                        |
| specimen-2     | 3.5                        | 3.57                        |
| specimen-3     | 3.6                        | 3.63                        |

**Figure 22.** Shows The Maximum Load Obtained In Flexural Test of Natural Fibre And Glass Fibre Reinforced Composite.

**Figure 23.** Shows The Maximum Load Obtained In Compression Test of Natural Fibre And Glass Fibre Composite.
6. Scope for Future Work

The present investigation gives so many futuristic aspects of hybrid composite, some of them includes for future research those are:

1. In future may be by conducting extensive experimental investigations tribological properties, fatigue characteristics and moisture absorption can be determined.
2. The other natural fibres can be attempted and explore the performance. Also, the different fibre orientation and its mechanical characteristics to be investigated.
3. There will be chance of increase or decrease the machining parameters this work can be extended.
4. Chance of using different machining processes, such as reaming, milling etc. this experiment can be extended.
5. Analysis and modelling can be possible.

7. Conclusion

➢ Polymer composites coupled with natural fibre shows better advantages in terms of light weight and low cost comparing with synthetic based polymer composites. It is widely preferred for automobile industries, and construction industries.

➢ Hybrid polymer composites mixed with natural fibres like wool and jute are successfully prepared using hand layup process.

➢ The result of polymer composites with natural fibre shown positive results in terms of mechanical characteristics.

➢ The result revealed that natural fibres withstand high value of ultimate load and elasticity than glass fibre.

➢ The selected wool and jute are natural fibres which is environmental pollution free and eco friendly one.

8. References

1. Shekar, K.C., Prasad, B.A., Singaravel, B. And Prasad, N.E., 2019, January. Effect Of Cnts Addition On The Fracture Behaviour Of Neat Epoxy And Epoxy-Carbon Fiber-Reinforced Composites. In Aip Conference Proceedings (Vol. 2057, No. 1, P. 020043). Aip Publishing Llc.
2. Shekar, K.C., Singaravel, B., Prasad, S.D., Venkateshwarlu, N. And Srikanth, B., 2020. Mode-I Fracture Toughness Of Glass/Carbon Fiber Reinforced Epoxy Matrix Polymer Composite. *Materials Today: Proceedings*.
3. Rajesh, A., Prasad, S.D., Singaravel, B., Niranjan, T. And Kumar, T.S., 2020. Experimental And Analytical Outcomes Of Carbon Fiber Orientation In Epoxy Resin Composite Laminate Under Tensile Loading. In *Advances In Unconventional Machining And Composites* (Pp. 771-783). Springer, Singapore.
4. Shekar, K.C., Singaravel, B., Prasad, S. And Venkateshwarlu, N., 2019. Effect Of Fiber Orientation On The Flexural Properties Of Glass Fiber Reinforced, Epoxy-Matrix Composite. In *Materials Science Forum* (Vol. 969, Pp. 502-507). Trans Tech Publications Ltd.
5. Begum, S., Fawzia, S. And Hashmi, M.S.J., 2020. Polymer Matrix Composite With Natural And Synthetic Fibres. *Advances In Materials And Processing Technologies*, Pp.1-18.
6. Xu, Y., Adekunle, K., Ramamoorthy, S.K., Skrifvars, M. And Hakkarainen, M., 2020. Methacrylated Lignosulfonate As Compatibilizer For Flax Fiber Reinforced Biocomposites With Soybean-Derived Polyester Matrix. *Composites Communications*, 22, P.100536.

7. Nagarjun, J., Kanchana, J., & Rajesh Kumar, G. (2020). Improvement Of Mechanical Properties Of Coir/Epoxy Composites Through Hybridization With Sisal And Palmyra Palm Fibers. *Journal Of Natural Fibers*, 1-10.

8. Babu, B., Coconut And Jute Fibre Reinforced Polymer Composites–A Review.

9. Vidil, L., Potiron, C.O., Bilba, K. And Arsène, M.A., 2020. Characterization Of A New Native Plant Textile, Leaf Sheath From Cocos Nucifera L., As Potential Reinforcement Of Polymer Composites. *Annals Of Agricultural And Crop Sciences*, 5(1), P.1056.