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Development and Mechanical Characterization of Cyperus pangorei / Jute Fiber Reinforced Polyester Composites for Sustainable Applications

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Abstract
Natural fiber reinforced polymer composites are gaining attention as sustainable alternatives for engineering applications. In this work, a hybrid composite was developed using Cyperus pangorei and jute fibers as reinforcement with polyester resin as the matrix. The composites were fabricated using the compression moulding technique at 80 °C with a composition of 60% polyester resin, 20% Cyperus pangorei fiber, and 20% jute fiber. Mechanical performance of the composite was evaluated through tensile, flexural, impact, and compression tests according to ASTM D638, ASTM D790, ASTM D256, and ASTM D695 standards. The fabricated hybrid composite showed a maximum tensile strength of 41.76 MPa, flexural strength of 67.12 MPa, compressive strength of 64.28 MPa, and impact strength of 18.54 kJ/m², indicating good load-bearing capability. The results suggest that the hybridization of Cyperus pangorei and jute fibers with polyester resin can provide improved mechanical performance, making the developed material suitable for lightweight structural and semi-structural applications.
Keywords: *Cyperus pangorei, jute fiber, compression moulding, mechanical characterization.*

1. Introduction

Natural fiber reinforced polymer composites are widely studied in recent years because of their potential in lightweight structural applications. Many natural fibers such as jute, hemp, flax and banana have been used as reinforcement materials in polymer composites to improve mechanical performance and reduce material weight. Recent studies have shown that natural fiber composites can be used in several applications including automotive interior parts, packaging and construction materials (Iqbal et al., 2025). Jute fiber is one of the most commonly used natural fibers in polymer composites due to its good strength and availability. Several researchers have investigated the mechanical performance of jute reinforced composites and reported improvements in tensile and flexural properties when the fiber is properly distributed within the matrix (Islam et al., 2024). In recent years, hybrid natural fiber composites have gained attention where two different fibers are combined to improve the overall properties of the composite. Hybridization can improve load transfer and mechanical stability compared to single fiber reinforced composites (El Messiry et al., 2024). Cyperus pangorei fiber is traditionally used for mat weaving and handicraft products in South India. Recently, researchers have explored the possibility of using this fiber as reinforcement in polymer composites. Athijayamani et al. (2019) studied polyester composites reinforced with Cyperus pangorei fiber and reported that the fiber can improve the mechanical performance of the composite material. Although several natural fibers have been studied, research on hybrid composites using Cyperus pangorei fiber combined with jute fiber is still limited. Hybridization of these fibers may improve the strength and stiffness of the composite due to better stress distribution between the fibers and the matrix. Therefore, the present work focuses on the development of hybrid natural fiber composites using Cyperus pangorei fiber and jute fiber as reinforcement with polyester resin as the matrix material. The composite laminates were fabricated using the compression moulding technique and the mechanical behaviour of the developed composites

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was investigated [1-5].

2. Materials and Methods

2.1.Material

Cyperus pangorei fiber and jute fiber used in this study were obtained from EcoGreen Unit, Coimbatore, Tamil Nadu, India. The fibers were cleaned and dried before being used in the composite fabrication process. Polyester resin used as the matrix material was purchased from Covai Seenu & Company, Coimbatore, Tamil Nadu, India. Methyl ethyl ketone peroxide (MEKP) was used as the catalyst and cobalt naphthenate was used as the accelerator for curing the resin. In the present work, the composite was prepared with 60% resin and 40% fiber content, where the fiber portion consisted of 20% Cyperus pangorei fiber and 20% jute fiber. The fibers were used in random orientation during the fabrication process.

2.2.Composite Fabrication

The composite was fabricated using the compression moulding technique. Before fabrication, the mould surface was coated with a releasing agent (Wax) to prevent the composite from sticking to the mould. The fibres were evenly spread inside the mould to form a random fiber layer. Polyester resin was then mixed with the required amount (2 % of Resin) of catalyst and accelerator and poured over the fibers to ensure proper wetting of the fibers. The mould was closed and placed in the compression moulding machine where pressure was applied to form the composite laminate. The mould size used for fabrication was 300 mm × 300 mm × 3 mm. After curing, the composite plate was removed from the mould and allowed to stabilize. The fabricated composite was then cut into standard specimens according to ASTM standards for mechanical testing.

3. Mechanical Tests

3.1.Impact Test

3.1.1. Standard Followed

- Impact testing was conducted according to ASTM D256 using the Izod impact method.
- Specimen After and Before test is shown in Figure 2

3.1.2. Experimental Procedure

- A notched specimen was clamped vertically and struck by a pendulum hammer. The energy absorbed during fracture was recorded.
- Apparatus is shown in Figure 1

3.1.3. Impact Behaviour of Hybrid Composite

- Hybridization significantly influences impact performance:
- Cyperus Pangorei fibers enhance energy absorption.
- Jute fibers provide structural stiffness.
- Fiber bridging mechanisms resist crack growth.
- Delamination between layers absorbs impact energy.
- Hybrid natural fiber composites generally show better toughness compared to single fiber composites.

Figure 1 Universal Tensile Testing Machine

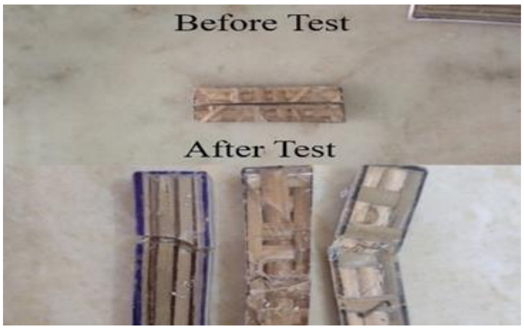

Figure 2 Tensile Test Specimens Before and After Failure

3.2.Tensile Test

3.2.1. Standard Followed

The test was performed according to ASTM D638 standard for polymer matrix composites.

3.2.2. Specimen Preparation

The composite laminates were cut into standard dog-

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bone shaped specimens as per ASTM dimensions. Care was taken to ensure:

- Uniform thickness
- Smooth edges to prevent premature failure
- Fiber alignment maintained during cutting
- Specimens were conditioned at room temperature before testing [6-10].

Specimen After and Before test is shown in Figure 4

3.2.3. Experimental Procedure

The specimen was mounted in the grips of a Universal Testing Machine (UTM). A uniaxial tensile load was applied at a constant crosshead speed until failure occurred. During loading:

- The matrix initially carries the load.
- Load gradually transfers to the Cyperus Pangorei and Jute fibers.
- Failure occurs due to fiber breakage, matrix cracking, or fiber pull-out.

Apparatus is shown in Figure 4

3.2.4. Behaviour of Hybrid Composite Under Tensile Load

For the developed hybrid composite:

- Jute fibers contribute significantly to tensile strength due to higher stiffness.
- Cyperus Pangorei fibers assist in distributing stress uniformly.
- Strong interfacial bonding improves load transfer efficiency.
- Poor bonding may lead to fiber pull-out and reduced strength.
- Unidirectional orientation exhibits maximum tensile strength along fiber direction, whereas multi-directional orientation provides balanced strength.

Figure 3 Gripping Arrangement of the Test Specimen in the Universal Testing Machine

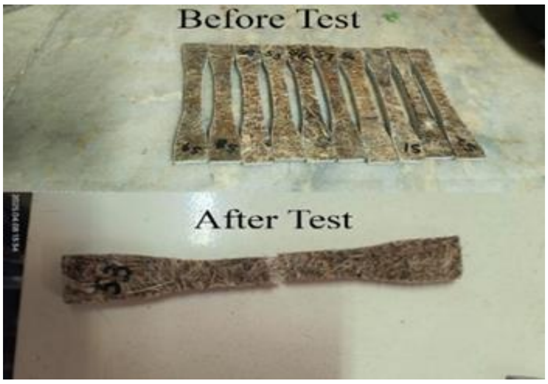

Figure 4 Composite Specimen Showing Tensile Failure

3.3. Flexural Test

3.3.1. Standard Followed

The test was conducted as per ASTM D790 using a three-point bending configuration. Specimen Before and After test is shown in Figure 6

3.3.2. Experimental Procedure

The specimen was placed on two supports and load was applied at the center until fracture. During bending:

- Upper surface experiences compressive stress
- Lower surface experiences tensile stress
- Neutral axis remains stress-free
- Failure initiates either from tensile cracking or compressive buckling of fibers.
- Apparatus is shown in Figure 5

3.3.3. Flexural Behaviour of the Hybrid Composite

In the Cyperus Pangorei / Jute composite:

- Jute fibers resist tensile stress at bottom surface.
- Cyperus fibers improve crack resistance.

Figure 5 Composite Specimen Mounted for Three-Point Bending Test

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- Hybridization enhances stiffness and reduces brittle fracture.
- Good fiber–matrix adhesion delays crack propagation.
- Flexural strength is generally higher than tensile strength due to combined stress states.

Figure 6 Composite Specimens Before and After Flexural Testing

3.4.Compression Test

3.4.1. Standard Followed

The test was performed according to ASTM D695 standard. Specimen Before and After test is shown in Figure 7 [11-15].

3.4.2. Experimental Procedure

The specimen was placed between compression platens and axial compressive load was applied until failure.

3.4.3. Compression Behaviour of Hybrid Composite

Under compression:

- Fibers resist buckling.
- Matrix prevents lateral deformation.
- Good fiber dispersion increases compressive resistance.

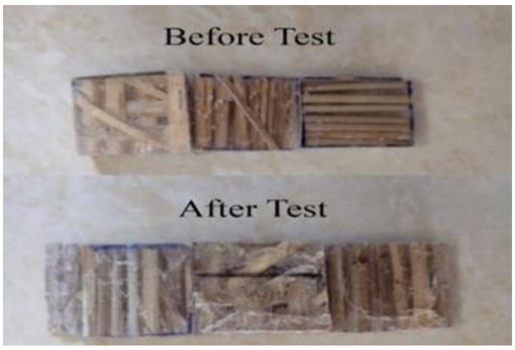

Figure 7 Flexural Failure of Composite Specimens

- Poor bonding leads to micro-cracks and premature failure Shown in Table 1.
- Hybrid reinforcement improves compressive strength due to restricted fiber buckling and better stress distribution.

4. Results and Discussion

Table 1 Mechanical Test Results of Composite Specimens

SAMPLE DIMENSION	SAMPLE	IMPACT TEST BREAKING POINT (kJ/m^2)	TENSILE TEST BREAKING POINT (MPa)	FLEXURAL TEST BREAKING POINT (MPa)	COMPRESSION TEST BREAKING POINT (MPa)
15 mm	1	13.83	23.4	43.33	53.68
	2	12.74	21.86	40.92	51.37
	3	15.12	25.18	45.61	55.04
30 mm	1	14.85	32.4	53.67	59.68
	2	13.26	29.74	50.81	56.92
	3	16.42	35.08	55.94	62.13
50 mm	1	16.68	38.6	65	61.32
	2	14.93	35.42	62.78	58.64
	3	18.54	41.76	67.12	64.28

4.1.Impact Test Results

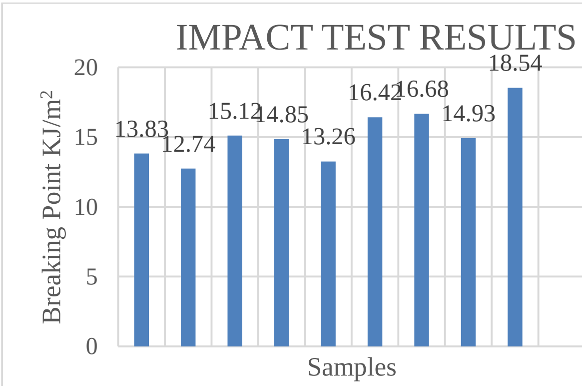

Figure 8 Experimental Impact Test Results

The Results are illustrated in Figure 8. The impact test results show that the energy absorbed by the composite increases as the specimen dimension increases. For the 15 mm specimen, the impact strength values are around 13–15 kJ/m², while the 30 mm specimen shows values around 14–16 kJ/m². The 50 mm specimen shows higher values around 15–18

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kJ/m². This indicates that larger specimens are able to absorb more impact energy before failure. The improvement in impact strength may be due to better fiber distribution and bonding between the natural fibers and polyester matrix.

4.2.Tensile Test Results

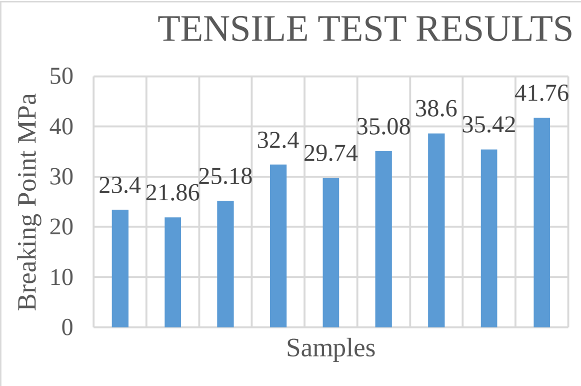

Figure 9 Tensile Breaking Strength of Composite Specimens

The Results are illustrated in Figure 9. From the tensile test results, it can be observed that the tensile strength increases with the increase in specimen dimension. The 15 mm specimen shows tensile strength values around 21–25 MPa, while the 30 mm specimen shows values around 29–35 MPa. The 50 mm specimen reaches higher values around 35–41 MPa. This shows that the composite becomes stronger under tensile loading as the specimen dimension increases. The improvement may be due to effective stress transfer between the fibers and polyester matrix, which improves the load carrying capacity of the composite [16-20].

4.3.Flexural Test Results

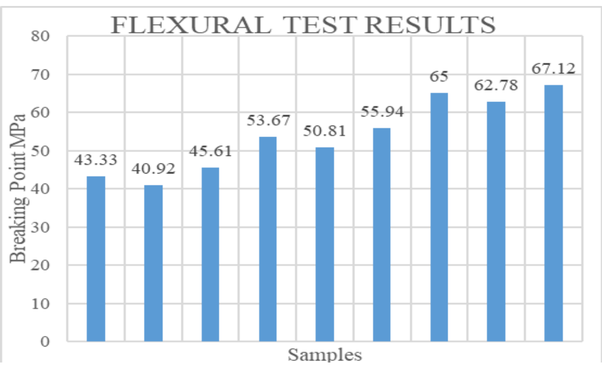

Figure 10 Flexural Strength Variation for Different Composite Specimens

The Results are illustrated in Figure 10. The flexural test results indicate that the flexural strength of the composite increases with increasing specimen dimension. The 15 mm specimen shows flexural strength around 40–45 MPa, whereas the 30 mm specimen shows values around 50–55 MPa. The 50 mm specimen exhibits higher values around 62–67 MPa. This suggests that larger specimens can withstand higher bending loads before failure. The improvement in flexural strength may be due to better fiber reinforcement and improved interfacial bonding within the composite structure.

4.4.Compression Test Results

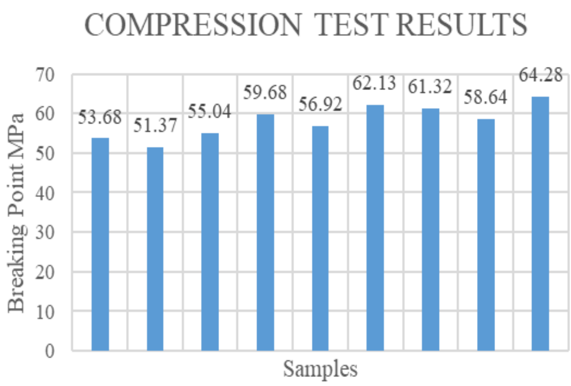

Figure 11 Compression Test Results of Composite Specimens

The Results are illustrated in Figure 11. From the compression test results, it is observed that the compressive strength increases as the specimen dimension increases. The 15 mm specimen shows compressive strength values around 51–55 MPa, while the 30 mm specimen shows values around 56–62 MPa. The 50 mm specimen reaches higher values around 58–64 MPa. This indicates that the composite has better resistance to compressive loads for larger specimen dimensions. The improvement may be attributed to uniform fiber distribution and good bonding between the fibers and matrix, which helps the composite resist deformation under compression.

References

[1]. R. Vijay and D. L. Singaravelu, "Experimental investigation on mechanical properties of Cyperus pangorei–jute fibre based natural fibre composites," Int. J. Polymer Analysis and Characterization, vol. 21, no. 3, pp. 225–235, 2016.

[2]. K. N. Keya, N. A. Kona, F. A. Koly, and R. A. Khan, "Natural fiber reinforced polymer composites: History, types, advantages and applications," Materials Engineering Research, vol. 1, no. 2, pp. 69–85, 2019.
[3]. S. Sonali, A. Kumar, and P. Sharma, "Natural fiber reinforced polymer-based composites: Importance of jute fiber," GSC Advanced Research and Reviews, vol. 15, no. 2, pp. 120–128, 2023.
[4]. G. Ekundayo, M. S. Hossain, and M. A. Islam, "Jute fibre reinforced polymer composites in structural applications: A review," Journal of Materials and Polymer Science, vol. 32, no. 4, pp. 455–472, 2024.
[5]. A. K. Bledzki and J. Gassan, "Composites reinforced with cellulose based fibres," Progress in Polymer Science, vol. 24, no. 2, pp. 221–274, 1999.
[6]. M. Jawaid and H. P. S. Abdul Khalil, "Cellulosic/synthetic fibre reinforced polymer hybrid composites: A review," Carbohydrate Polymers, vol. 86, no. 1, pp. 1–18, 2011.
[7]. D. Ramesh, S. Palanikumar, and K. Hemachandra Reddy, "Mechanical property evaluation of sisal–jute–glass fiber reinforced polyester composites," Composites Part B: Engineering, vol. 48, pp. 1–9, 2013.
[8]. S. Sathish Kumar, T. P. Sathish Kumar, and R. Rajini, "Mechanical and morphological characterization of hybrid natural fiber reinforced composites," Materials Today: Proceedings, vol. 45, pp. 1234–1240, 2021.
[9]. M. Zolfakkar, H. H. Masjuki, and M. A. Kalam, "Mechanical performance of jute fiber reinforced epoxy composites," Materials & Design, vol. 56, pp. 249–256, 2014.
[10]. J. George, M. S. Sreekala, and S. Thomas, "A review on interface modification and characterization of natural fiber reinforced polymer composites," Polymer Engineering & Science, vol. 41, no. 9, pp. 1471–1485, 2001
[11]. M. M. Kabir, H. Wang, K. T. Lau, and F. Cardona, "Chemical treatments on plant-based natural fibre reinforced polymer composites: An overview," Composites Part B: Engineering, vol. 43, no. 7, pp. 2883–2892, 2012.
[12]. S. Fiore, T. Scalici, and A. Valenza, "Effect of surface treatment on mechanical properties of natural fiber reinforced composites," Composites Part B: Engineering, vol. 68, pp. 14–21, 2015
[13]. A. N. Netravali and S. Chabba, "Composites get greener," Materials Today, vol. 6, no. 4, pp. 22–29, 2003.
[14]. ASTM D3039/D3039M-17, "Standard test method for tensile properties of polymer matrix composite materials," ASTM International, 2017.
[15]. ASTM D790-17, "Standard test method for flexural properties of unreinforced and reinforced plastics," ASTM International, 2017.
[16]. M. Jawaid and H. P. S. Abdul Khalil, "Cellulosic/synthetic fibre reinforced polymer hybrid composites: A review," Carbohydrate Polymers, vol. 86, no. 1, pp. 1–18, 2011.
[17]. A. K. Bledzki and J. Gassan, "Composites reinforced with cellulose based fibres," Progress in Polymer Science, vol. 24, no. 2, pp. 221–274, 1999.
[18]. K. L. Pickering, M. G. A. Efendy and T. M. Le, "A review of recent developments in natural fibre composites and their mechanical performance," Composites Part A: Applied Science and Manufacturing, vol. 83, pp. 98–112, 2016.
[19]. M. Sanjay, P. Madhu, G. R. Arpitha, L. L. Naik, K. Gopalakrishna and B. Yogesha, "Applications of natural fiber reinforced polymer composites: A review," Materials Today: Proceedings, vol. 5, no. 1, pp. 657–664, 2018.
[20]. O. Faruk, A. K. Bledzki, H. P. S. Abdul Khalil and M. K. Sain, "Biocomposites reinforced with natural fibers: 2000–2010," Progress in Polymer Science, vol. 37, no. 11, pp. 1552–1596, 2012.