ISSN: 2977-0041

Research Article

Journal of Material Sciences and Engineering Technology

Emerging Eco-Composite Innovations: Reinforcing Materials with Coconut Fiber, Feather Keratin, and Wood Waste

Vignesh K[1*] and Premnath K[2]

[1]*Assistant professor, Department of Mechanical Engineering, Hindusthan College of Engineering and Technology, Coimbatore, India*

[2]*Assistant professor, Department of Mechanical Engineering, Dhanalakshmi Srinivasan College of Engineering, Coimbatore India*

***Corresponding author**

Vignesh K, Assistant professor, Department of Mechanical Engineering, Hindusthan College of Engineering and Technology, Coimbatore, India.

Received: January 19, 2026; **Accepted:** January 27, 2026; **Published:** February 03, 2026

ABSTRACT

This study provides a detailed analysis of the mechanical, physical, thermal, and other features of composite materials made from chicken feathers (CFFs). The chicken feathers, which are typically regarded as a by-product, have the potential to be used as a lightweight thermal insulator due to their hydrophilic properties. For the tensile strength testing of more than 1 Type CFF Specimens tested used Universal Testing Machines (UTMs) to identify the most effective combination for reinforcing the composite material with the most favourable tensile strength value. The UTM will test the specimens at 2 percent, 4 percent, 6 per cent and 8 percent (by mass) of the reinforcing components used. According to these results, a hybrid composite comprising natural coconut, rice hulls and sawdust and using fibres with different lengths (10mm, 20mm and 30mm) and weight and volume percentages will be tested in this investigation.

Keywords: Coconut Fiber, Saw Dust, Chicken Feather, Epoxy Resin, Hardener

Introduction

New developments in eco-composite technology combine agricultural waste materials with natural fiber to produce lightweight, durable composites that lessen the impact on the environment and potentially provide new opportunities for application in automotive, aerospace, construction, and packaging industries Emerging eco-composite innovations are transforming materials engineering by integrating natural fibers such as coconut fiber, feather keratin, and wood waste to enhance mechanical performance, sustainability, and lifecycle efficiency in lightweight, high-strength applications [1-3]. Emerging eco-composites are redefining sustainable material design by integrating natural fibers from coconut, keratin-rich feathers, and repurposed wood waste to enhance mechanical performance, durability, and environmental compatibility [4]. Composites are multi-phase materials created by combining two or more distinct substances to enhance specific properties. A composite typically contains a continuous phase (the matrix) and a dispersed phase (the reinforcement) [5]. Reinforcements are classified into either fiber or particle, while the matrix and reinforcement phases may be made from a metal, ceramic, or polymer [6]. The strongest composites have a synergistic relationship between reinforcement and matrix due to the large degree of interfacing occurring in the region that bonds these phases together, which increases the composite's overall ability to perform [7,8]. The use of renewable resources such as plant fibers or bio-based polymer composites is referred to as eco-composite material [9,10]. Due to a growing concern for our environment due in part to increased regulation, increased awareness of our global environment, and the need for conservation of non-renewable resources (petroleum-based), researchers and material engineers have been working diligently to develop sustainable/green alternatives [11,12]. The use of natural fibers as reinforcement in polymer matrix composite materials because of the materials' biodegradable and renewable characteristics is gaining popularity [13,14]. Moreover, these

Citation: Vignesh K, Premnath K. Emerging Eco-Composite Innovations: Reinforcing Materials with Coconut Fiber, Feather Keratin, and Wood Waste. J Mat Sci Eng Technol. 2026. 4(1): 1-6. DOI: doi.org/10.61440/JMSET.2026.v4.102

fibers also exhibit a number of physical and mechanical properties based upon the source and method of their manufacture [15,16]. In spite of the advantages of using natural fiber as a reinforcement material as compared to the use of synthetic fibers, there are also some disadvantages related to this material [17,18]. These include lower fire resistance, higher water absorption rates, and reduced impact properties, which can constrain their application in various fields and preparation of green building materials using Coconut Fiber and Sawdust [19-21]. The objective of this paper is to determine the most optimum composition of sawdust to coconut fibre is 0% sawdust to 100% coconut fiber and the optimum thickness [22,17]. The experimental investigation and studied the effect of bamboo fibres at different weight percentages (20, 30 and 40) to modify epoxy resin. They determined that the addition of bamboo fibers has improved tensile, flexural and impact properties of epoxy resin and increased water absorption of the material [11]. The experiment on the improvement of the impact properties of PLA is an addition of fillers or reinforcements[23]. They used bamboo fiber, vetiver grass fiber and coconut fiber as alternative reinforcements in PLA Composites and determined that bamboo fiber is the most effective reinforcement among all studied reinforcements [24,20].

Materials and Methods

Materials

Coconut Fiber

Coir is natural fiber, which are taking out from coconut. After harvesting, the prepared coconuts are spitted, and the Coconut oil is extracted from the inner fruit. The fiber is extracted from the pith that covers the inner kernel. In this process the elements that are between the fibers were used usually to be ploughed in clay soil to loosen up the soil. Recently, these coconut fibers have been processed and packed in various forms as coir.

Saw Dust

Saw dust particles were collected from saw mill Rajahmundry east Godavari Dist. During the machining of wood timbers for making different types of furniture's, huge amount of wood dust particles wasted to the environment and which are having more cellulose content for improving the mechanical properties. They were collected and used for making composite samples.

Chicken Feather

Chicken Feather/Vinyl Ester Composites are made using the hand lay-up method. Before commencing with this process, a layer of polyvinyl alcohol is applied to the mould box to make sure that removal of the cured plates from the mould is easy. The Chicken Feathers, measured accurately, are mixed with vinyl ester resin and then subjected to mechanical stirring for a period of 15 minutes to make them uniform. Then, the accelerator, catalyst, and promoters are added to this mixture, followed by mechanical stirring for another period of 15 minutes. This mixture is then poured into the mould to cure at normal temperature for a period of 48 hours.

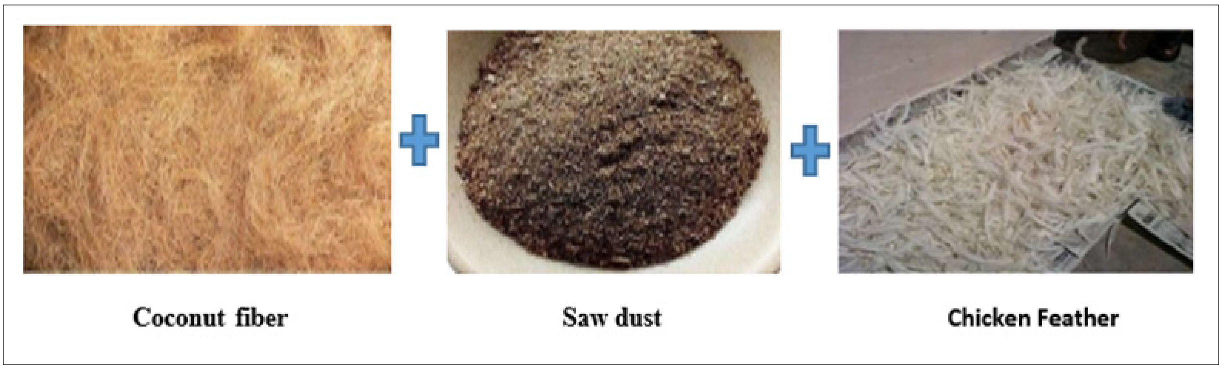

Figure 1: Constituent of Composite Materials

The natural wastes used in the study for the production of composites are shown in the above image, Figure (1). Sawdust, chicken feathers, and coconut fibers are selected for their availability, low cost, and environmentally friendly nature [25]. Although they have several useful physical properties such as lightness, fibrous nature, and good insulating qualities, still they are often considered to be industrial and agricultural wastes [26]. Through a proper mixture of such ingredients, the generation of environmental wastes, and responsible development of materials, can be achieved [27].

Experimental

Matrix Material

Epoxy Resin

Epoxy LY 556, a member of the 'epoxide' family, is used as the matrix material, commonly known as bisphenol A diglyceryl ether. The hardener, NN'-bis(2-aminoethylethane-1,2-diamine), designated as HY-951, is used in conjunction with the epoxy resin. Both the epoxy resin and hardener were supplied by Ciba Geigy India Ltd. Carbon fibers (CFs) were collected from a farmhouse in Rourkela, located in eastern India. These CFs were cleaned with a polar solvent such as ethanol and dried. After removing the quills, short fibers (10-15 mm in length, with an aspect ratio of ~3000) were obtained. The fibers were mixed with the epoxy by stirring at room temperature until the polymerization reaction began. The mixture was then poured into suitable molds to create disc-shaped samples with a diameter of 12 mm and a thickness of 2.5 mm. Four samples were prepared under identical temperature and conditions: sample A (pure epoxy resin), sample B (epoxy + 10% CF fiber), sample C (epoxy + 20% CF fiber), and sample D (epoxy + 30% CF fiber). The matrix provides a medium for binding and holding reinforcements together into a solid. It offers protection to the reinforcements from environmental damage, serves to transfer load, and provides finish, texture, color, durability and functionality. The unsaturated isenthalpic polyester resin is used as the matrix which are prepared by the reaction of polyhydric alcohols and dibasic organic acids are having a relative density as 1.11-1.23 g/cm3 and boiling range as145-1480C and the thermal deformation temperature is 50- 60oC.It is completely continuous. The matrix provides a medium for binding and holding reinforcements together into a solid. It offers protection to the reinforcements from environmental damage, serves to transfer load, and provides finish, texture, color, durability and functionality [28,29]. The matrix binds the fiber reinforcement, gives the composite component its shape and determines its surface quality. A composite matrix may be a polymer, ceramic, metal or Carbon. Here's a guide to selection [30].

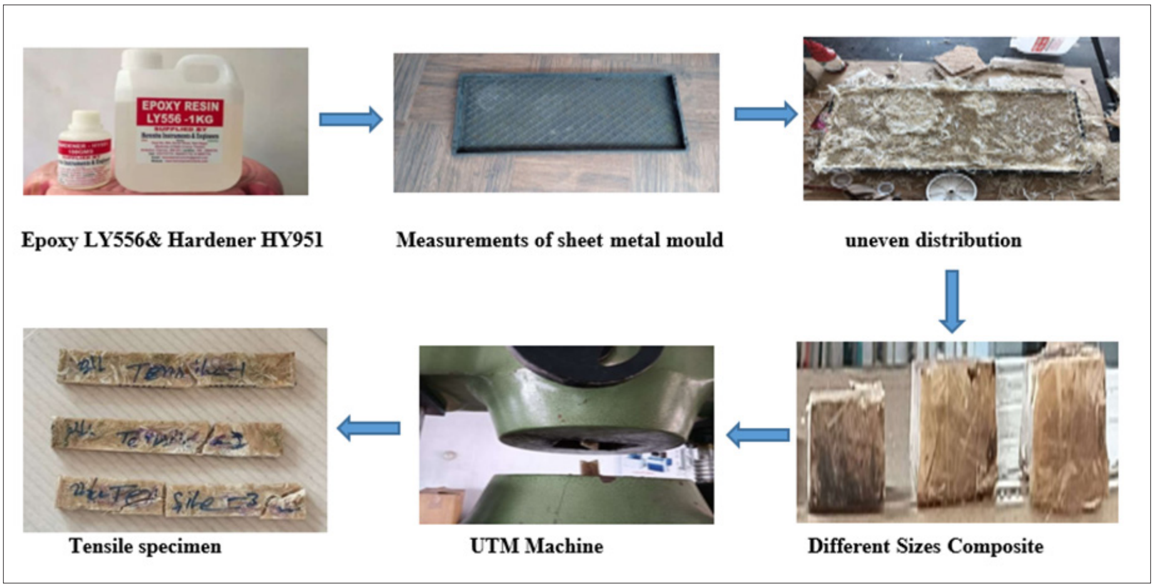

Figure 2: preparation of Composites for Tensile test

The manufacturing process for composite materials, as illustrated in Figure (2), begins with the procurement of epoxy resin (i.e. LY556) and a hardener (i.e. HY951) in order to mix them in accordance with the stoichiometric ratio recommended for optimal curing. A template is also produced from sheet-metal and dimensions calculated accurately in order to produce the desired composite size The mixed resin then poured into the previously prepared template and manually spread across the template to properly saturate the reinforcement [31,32]. Variability of the manual layup process and the mixing sequence will most likely cause the resin and the reinforcement to not be spread evenly through the laminate surface; therefore, there will be a difference in the thickness of the laminate as well as in its size [33]. Once the curing process has been completed, the composite panels removed from the template and visually examined for any defects. A specified number of tensile test specimens are cut from the cured laminate using a standard pattern for cutting tensile test specimens. Each cut specimen is carefully marked according to standard practices in sample preparation prior to commencing testing [1]. The tensile test process is carried out using a Universal Testing Machine in a controlled environment with respect to load application. The recorded data includes the amount of load applied and the resulting amount of deformation measured [34].

Table 1: Constituents Weights

run	Thickness	wt. % coconut fiber	wt. % saw dust	wt. % chicken feather	wt. % resin
1	10	5	8	7	80
2	20	5	13	12	70
3	30	5	18	17	60
4	10	10	5	5	80
5	20	10	10	10	70
6	30	10	15	15	60
7	10	15	2	3	80
8	20	15	5	10	70
9	30	15	10	15	60

Figure 3: 3-Point Flexural Testing

Figure (3) illustrates the testing equipment used for a three-point flexural test of the manufactured composite specimens to assess their bending characteristics. The test equipment consists of two support rollers and a loading nose positioned in the centre providing the test with a defined loading arrangement [35]. The procedure for this type of flexural testing follows standard flexural testing methods by supporting the rectangular composite samples on the support rollers with a set distance between them (span) and applying a controlled amount of load by adjusting the speed of the crosshead until failure [36]. Each specimen will exhibit multiple types of failures due to bending or deflection before ultimately breaking due to fracture within the tensile region of the composite material [37] . The results from the flexural testing can be utilised to determine the flexural modulus and flexural strength of each composite material being tested [38].

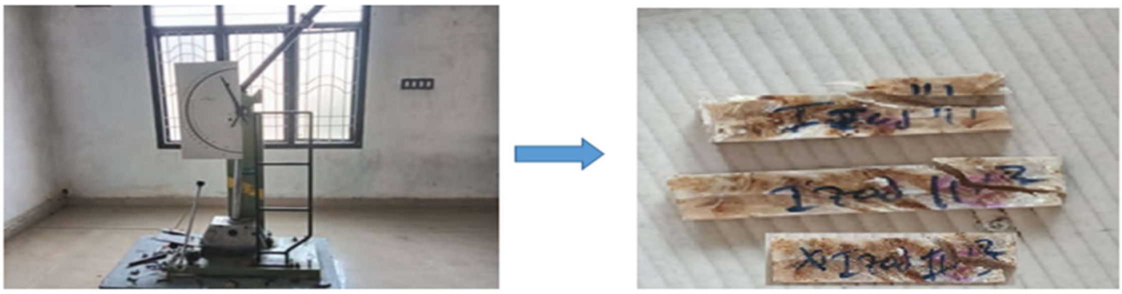

Figure 4: Izod impact test

Izod impact testing of the engineered composite material is illustrated in Figure (4). The test samples must be made according to the definitions of the ISO standard for notch placement and orientation of the sample as it stands in the fixture with the pendulum above the notch [39]. Each sample receives a single force of impact and is then broke using a predetermined set of forces, which cause an impact force on the sample. After testing, the pieces created after breaking will be collected and inspected to determine what failure mode occurred [40]. The amount of fibre pull-out, initiation of the crack and extent of the crack are all directly related to the way in which that composite was able to generate energy during the test [41]. By analysing the amount of impact energy recorded from each sample, it is possible to conclude whether or not that type of composite has sufficient durability and suitability for use in applications that require load-bearing properties and have a high likelihood of being impacted.

Result and Discussion

Mechanical testing of fabricated composite specimens showed significant mechanical performance differences as a function of the composite's filler size (10, 20, and 30) and ratio of resin-hardener (80:20, 70:22, and 60:25). Therefore, it was determined that there is a strong relationship between mechanical performance and both the size of the filler, and the resin-hardener mixture.

Tensile Strength

With respect to specimens containing a filler size of 10, it is noted that there was an increase in tensile strength from 20 MPa to 25 MPa when there was a decrease in the percentage of resin from 80 wt% to 60 wt%. Thus, this indicates that as the cross-link density of the resin is increased, so too is the capability for an increased load transfer. This pattern of behaviour is also exhibited for the 20 and 30-size fillers; however, the 60%-25% ratio of resin to hardener yielded maximum values of 25 MPa and 16 MPa for the greater and lesser sizes respectively. The greatest tensile strength among those configurations was that of the 20-size filler, thus leading to the conclusion that the distribution of the particles is effective for providing good stress distribution within the matrix.

Flexural Strength

When adding fillers to a resin or polymer, flexural strength of the resin/polymer can be affected by both the amount of filler added and the size of the filler particles. With only a small amount of resin applied to the filler (approximately 60:40 ratio of resin to hardener), flexural strength of the added filler increased from 9.2 Mpa to 12.5 Mpa as resin content decreased. While the largest improvement in flexural strength was seen with filler sizes of 20#s to 30#s, the maximum flexural strength was 52.5 Mpa at 60:25 ratio of resin to hardener. This increase in flexural strength is thought to be due to improved adhesion at the interface of resin/filler particles and higher strength being achieved through better resistance to bending. However, with a filler size of 30, the increase in flexural strength did exceed filler size of 10; however, the increase in flexural strength remained lower than the maximum strength that was achieved by using 20# filler size likely due to agglomeration of particles at larger sizes.

Impact Strength

The impact strength was consistent with the trend how the resin content decreased but also the increase in impact strength was due to lower resin content, where it would reach an optimal value within size 10, example, at 8 J to 13 J, as the resin decreased. Size 20 had the highest impact strength of 20 J within this formulation. This indicates that an ideal relationship exists between the stiffness of the molded part and its ability to absorb energy. Following the 70:23 mix beyond this ratio, a potential decrease in the impact strength was noted, possibly resulting from increased brittleness because the higher amount of hardener present. In contrast, the impact strength values for size 30 were modest, supporting the theory that when the filler sizes are larger in diameter, they may impede the ability of the material to provide resistance against crack propagation.

Table 2: Test reports data Tensile strength vs flexural strength vs Impact strength

size	wt. % resin hardener	Tensile strength (Mpa)	Flexural strength (Mpa)	Impact strength (J)
10	80	20	9.2	8
10	70	22	12.5	11
10	60	25	12.5	13
20	80	21	42	11
20	70	23	47	20
20	60	25	52.5	15
30	80	13	25	9
30	70	14	34	14
30	60	16	38	12

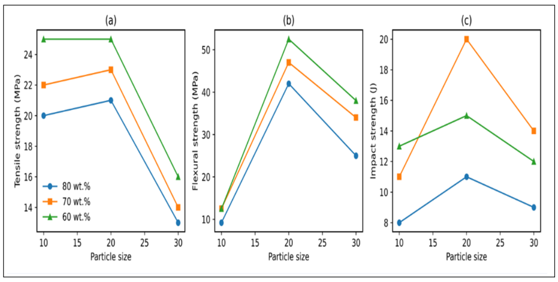

Figure 5: Comparison Graph Tensile Vs Flexural Vs Impact

Conclusion

The fabrication of coconut fiber, chicken feather, & saw dust and epoxy resin and hardener hybrid composite as reinforcement of different fiber size with unsaturated polyester resin as matrix using compression mounding technique various mechanical testing is performed as per ASTM standards. The natural hybrid fiber composites of 20mm fiber size have more tensile strength than other fiber size can withstand the tensile strength of 23Mpa followed by the 10mm fiber size and 30mm fiber size composites which holds the value of 22.5Mpa and 15Mpa and which shows high improvement of 1% and 23% than other fiber size hybrid composites. The maximum flexural strength of natural hybrid composites is delivered by 20mm fiber size of 47.16Mpa followed by 10mm and 30mm fiber size composites which holds the value of 10.8Mpa and 33Mpa respectively. And it shows much improvement of 32.41% and 10.6 % than other fiber size hybrid composites. There is trivial improvement in the impact strength of natural hybrid composites of 20mm fiber size of 15.3J followed by 10mm and 30mm fiber size composites which holds the value of 10.5J and 11.7J respectively. Also, it has high improvement of 12.8% and 9.6% than other combinations. The 20mm fiber size exhibited superior tensile and flexural strength compared to others.

Authors' Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by [Vignesh K]. The first draft of the manuscript was written by [Vignesh K] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this Article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Ethics Approval

The entire work is the original work of the authors

Consent for publication

All the authors have given their consent to publish the paper

References

1. Santhosh N, Praveena BA, Gowda AC, Duhduh AA, Rajhi AA, et al. Innovative eco-friendly bio-composites: A comprehensive review of the fabrication, characterization, and applications. Reviews on Advanced Materials Science. 2024. 63: 20240057.
2. Nassar MMA, Alzebdeh KI, Pervez T, Al-Hinai N, Munam A. Progress and challenges in sustainability, compatibility, and production of eco-composites: A state-of-art review, J. Appl. Polym. Sci. 2021138: 51284.
3. Suárez L, Castellano J, Díaz S, Tcharkhtchi A, Ortega Z. Are natural-based composites sustainable? Polymers. 2021. 13: 2326.
4. Teja JK, Biju PC, Varma CG, Kumar RR, Singh D, et al. Fatigue behavior of hybrid eco-composites: A review. Materials Today: Proceedings. 2023. 72: 2245-2250.
5. Chawla KK. Foams, fibers, and composites: Where do we stand? Materials Science and Engineering: A. 2012. 557: 2-9.
6. Hollaway LC, Leeming M, editors. Strengthening of reinforced concrete structures: Using externally-bonded FRP composites in structural and civil engineering. Elsevier. 1999.
7. Mohanty AK, Misra M, Drzal LT. Sustainable bio-composites from renewable resources: opportunities and challenges in the green materials world. Journal of Polymers and the Environment. 2002. 10: 19-26.
8. Zini E, Scandola M. Green composites: an overview. Polymer composites. 2011. 32: 1905-1915.
9. Khalil HA, Bhat AH, Yusra AI. Green composites from sustainable cellulose nanofibrils: A review. Carbohydrate polymers. 2012. 87: 963-979.
10. Jawaid MH, Khalil HA. Cellulosic/synthetic fibre reinforced polymer hybrid composites: A review. Carbohydrate polymers. 2011. 86: 1-8.
11. Gupta A. Synthesis, chemical resistance, and water absorption of bamboo fiber reinforced epoxy composites. Polymer composites. 2016. 37: 141-145.
12. Ramesh M, Palanikumar K, Reddy KH. Plant fibre-based bio-composites: Sustainable and renewable green materials. Renewable and Sustainable Energy Reviews. 2017. 79: 558-584.
13. Bledzki AK, Gassan J. Composites reinforced with cellulose-based fibres. Progress in polymer science. 1999. 24: 221-274.
14. Oksman K. Mechanical properties of natural fibre mat reinforced thermoplastic. Applied Composite Materials. 2000. 7: 403-414.

15. Malkapuram R, Kumar V, Negi YS. Recent development in natural fiber reinforced polypropylene composites. Journal of reinforced plastics and composites. 2009. 28: 1169-1189.
16. Holbery J, Houston D. Natural-fiber-reinforced polymer composites in automotive applications. Jom. 2006. 58: 80-86.
17. Prasad GE, Gowda BK, Velmurugan R. Comparative study of impact strength characteristics of treated and untreated sisal polyester composites. Procedia Engineering. 2017. 173: 778-785.
18. Sain M, Park SH, Suhara F, Law S. Flame retardant and mechanical properties of natural fibre–PP composites containing magnesium hydroxide. Polymer degradation and stability. 2004. 83: 363-367.
19. Faruk O. Abaca fibre reinforced PP composites and comparison with jute and flax fibre PP composites. eXPRESS polymer letters. 2007.
20. Satheesh Kumar S, Murugesan R, Sivaraja M, Athijayamani A. Innovative eco-friendly concrete utilizing coconut shell fibers and Coir pith Ash for sustainable development. Sustainability. 2024. 16: 5316.
21. Gholampour A, Ozbakkaloglu T. A review of natural fiber composites: properties, modification and processing techniques, characterization, applications. Journal of Materials Science. 2020. 55: 829-892.
22. Tawasil DN, Aminudin E, Abdul Shukor Lim NH, Nik Soh NM, Leng PC, et al. Coconut fibre and sawdust as green building materials: A laboratory assessment on physical and mechanical properties of particleboards. Buildings. 2021. 11: 256.
23. Abbass OA, Salih AI, Al Hurmuzy OM. Study of the mechanical and physical properties of bio-composite material based on wheat starch and wheat straw fibers. InIOP Conference Series: Materials Science and Engineering. 2020. 745: 012075.
24. Navaranjan N, Neitzert T. Impact strength of natural fibre composites measured by different test methods: a review. InMATEC web of conferences. 2017. 109: 01003.
25. Rowell RM. Characterization and factors effecting fiber properties. Natural polymers and agrofibers based composites. 2000.
26. Hemath Kumar G, Mohit H. Mechanical and Statistical Characteristics of Chicken Feather Fiber Reinforced Polymer Composites. 2019.
27. Pickering KL, Efendy MA, Le TM. A review of recent developments in natural fibre composites and their mechanical performance. Composites Part A: Applied Science and Manufacturing. 2016. 83: 98-112.
28. Alovsat TY. Classification and properties of composites based on matrix material. World Journal of Advanced Research and Reviews. 2024. 24: 2278-2282.
29. Hamzat AK, Murad MS, Adediran IA, Asmatulu E, Asmatulu R. Fiber-reinforced composites for aerospace, energy, and marine applications: an insight into failure mechanisms under chemical, thermal, oxidative, and mechanical load conditions. Advanced Composites and Hybrid Materials. 2025. 8: 152.
30. Banhart D, Monir S, Durieux O, Day RJ, Jones M, et al. A review of experimental and numerical methodologies for impact testing of composite materials. Sensing Technology. 2024. 2: 2304886.
31. Bhong M, Khan TK, Devade K, Krishna BV, Sura S, et al. Review of composite materials and applications. Materials today: proceedings. 2023.
32. Rashid AB, Haque M, Islam SM, Uddin Labib KR, Chowdhury P. Breaking boundaries with ceramic matrix composites: A comprehensive overview of materials, manufacturing techniques, transformative applications, recent advancements, and future prospects. Advances in Materials Science and Engineering. 2024. 2024: 2112358.
33. Pawar US, Chavan SS, Mohite DD. Synthesis of glass FRP-natural fiber hybrid composites (NFHC) and its mechanical characterization. Discover Sustainability. 2024. 5: 44.
34. ASTM S. Standard test methods for flexural properties of unreinforced and reinforced plastics and electrical insulating materials. ASTM D790. Annual book of ASTM Standards. 1997.
35. ASTM International. Standard test method for flexural properties of polymer matrix composite materials. ASTM International. 2007.
36. Gupta M, Gundlapalle R, Annapoorna E, Al-Farouni M, Tyagi LK, et al. Flexural behavior of composite material under three point bending load. InE3S Web of Conferences. 2024. 507: 01061.
37. Reddy N, Jiang J, Yang Y. Biodegradable composites containing chicken feathers as matrix and jute fibers as reinforcement. Journal of Polymers and the Environment. 2014. 22: 310-317.
38. Kushwaha PK, Kumar R. Effect of silanes on mechanical properties of bamboo fiber-epoxy composites. Journal of Reinforced Plastics and Composites. 2010. 29: 718-724.
39. ISO. ISO 179-1: 2023: Plastics-Determination of Charpy impact properties: Part 1: Non-instrumented impact test. International Standards Organisation. 2023.
40. ISO E. 179-2 Plastics—Determination of Charpy Impact Properties-Part2: Instrumented Impact Test. EN ISO: Geneva, Switzerland. 2020.
41. Salman RK, Sulaiman BH, Al-Moayed OM, Al-Ogaidi B, Erkliğ A. Numerical study on Charpy impact test of multi-layered nano polymer composite. InAIP Conference Proceedings. 2025. 3338: 020027.