iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** VIII **Month of publication:** August 2026

DOI: https://doi.org/10.22214/ijraset.2026.84703

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue VIII Aug 2026- Available at www.ijraset.com

Natural Fibre versus Synthetic Fibre Reinforced Polymer Composites: A Review of Mechanical Properties and Applications

Mr. Vandan P Gaikwad[1], Dr. Mukund L Hurugade[2], Mr. Nikhil P Ambole[3]
[1]*M.Tech Student, Mechanical Design Engineering, PVPIT Budhgaon. Sangli*
[2]*Assistant Professor, Mechanical Design Engineering, PVPIT Budhgaon. Sangli*
[3]*Assistant Professor, Mechanical Design Engineering, PVPIT Budhgaon. Sangli*

Abstract: Today, the fibre-reinforced polymer composites appear virtually anywhere – from cars to buildings, from consumer products to pretty much anything else – simply because they are very lightweight, yet have a massive strength-to-weight ratio, and afford designers freedom of application. This review aims to bring together literature (since 2022 until 2026) related to existing evidence on the performance of natural fibre, synthetic fibre, and natural-synthetic hybrid composites, with a specific emphasis on tensile, flexural and impact performance. The question it also poses that most reviews fail to ask is which of these studies could actually be duplicated by someone who doesn't have access to a specialist materials lab? Fibre and matrix selection, surface treatment, hybridisation, and a few emerging applications are covered along the way, and the review closes with a look at low-cost testing alternatives for institutes that don't have calibrated impact testers or electron microscopes sitting around.

Keywords: Natural fibre composites; Synthetic fibre composites; Hybrid composites; Accessible materials; Review

I. INTRODUCTION

A composite, in the simplest terms, is a reinforcing phase (usually fibres) combined with a matrix (usually a thermoset or thermoplastic polymer). Jeff Jomboh et al., reviewing natural, synthetic, and hybrid fibre composites, point out that research interest in natural-fibre hybrids has kept climbing, and part of the reason is straightforwardly economic: natural fibres cost less and are easier to source locally than synthetic reinforcement [1]. This review works through that recent literature with an eye on exactly that point – not just what each study found, but whether its materials and equipment are realistically within reach of an ordinary academic lab.

II. SYNTHETIC FIBRE COMPOSITES

When Dawood et al. incorporated silica nanoparticles into glass and carbon fibre epoxy composite, they observed that the tensile strength of the composite increased with an addition of 2 wt % silica nanoparticles [2] – a very good result, but requires favorable dispersion (precision weighing and ultrasound equipment not available in many labs). Rongyu et al. chose a simpler method of manufacturing, namely the preparation of glass fibre-reinforced epoxy composite using a traditional hand lay-up process (no special equipment necessary) [3]. Navaneeth et al., produced composite, based on an epoxy matrix by mixing glass fibre and carbon powder as fillers and reported tribological design relevant mechanical and wear data [4].

III. NATURAL FIBRE COMPOSITES

Atmakuri et al. compared hemp and flax hybrids in epoxy and ecopoxy matrices, using Halpin-Tsai prediction alongside SEM-EDX interface imaging, and found that matrix choice on its own measurably shifts mechanical performance [5]; the SEM step, though, needs equipment that isn't universal, even if the tensile and flexural testing underneath it is standard. Sadik et al. arguably represent the most accessible end of the literature here – coir and date palm frond fibres, both cheap agricultural or coconut-industry by-products, fabricated by simple hand lay-up and run through standard tensile, flexural, compression, and shear tests [6]. Jayaraj et al. reinforced composites with Palmyra palm leaf stalk fibre, tested the usual tensile, flexural, and impact properties, and then carried that data through to the stress analysis of a spur gear [7], which is a nice example of basic testing feeding directly into a structural application. Mahesh paired jute with wood dust, both about as low-cost and locally available as reinforcement gets, fabricated entirely by hand lay-up [8].

Jasmin et al. contributed further baseline data on natural fibre composites using standard mechanical testing [9], and Venkatesh et al. pushed natural fibre hybrids into automotive components, testing wear behaviour with ASTM G99 pin-on-disc equipment – again, comparatively accessible [10].

IV. HYBRID COMPOSITES

Hasan et al.'s jute-glass hybrid laminates are a good starting point here: positioning the glass plies at the outer surface of a five-layer stack gave the highest impact strength (378 kJ/m²) of any layup tested, using ordinary hand lay-up and a calibrated pendulum impact tester [11]. Ullah et al. treated flax/glass and jute/glass hybrids with KOH, a cheap process needing little more than basic glassware, and saw clear gains in tensile, flexural, and impact strength over untreated laminates [12]. Gupta et al. combined a representative volume element with finite element analysis to study jute/glass hybrids, validating the model against physical tests [13] – useful work, though the FE side of it needs simulation software and expertise that a purely experimental, low-equipment study can't assume. Lokesh et al. worked with a less common fibre, Calamus rotang (rattan), hybridised with glass, and used regression analysis on measured bending strength rather than anything computational, which needs nothing more than a spreadsheet [14].
It is interesting to note a comparison between carbon fibre, jute fibre, and carbon fibre and jute fibre hybrid, which is done by Maithil et al. [15] because carbon fibre due to its high cost is not available outside specialist suppliers, in spite of its numerous advantages. Marichelvam et al. developed structural hybrid composites of fibres of Madar, Gongura and Hibiscus cannabinus as a low-cost resin system [16]. Islam et al. used NaOH at different fibre loadings for jute/hemp composites [17] and Fegade et al. found that jute combined with hemp (jute providing stiffness, hemp providing toughness) compared well to composites of either fibre alone, using just conventional hand lay-up and mechanical testing [18].

V. EMERGING APPLICATIONS

Pyromelting, together with this literature indicates that natural fibre composites are progressing from their traditional functions – primarily non-structural applications (packaging, interior trim), to semi-structural or even lightly structural applications, such as gears [7] and automotive parts [10]. Funnily enough, most of this transition has been achieved without special processing methods, but only with the standard hand lay-up and standard test methods.

VI. ACCESSIBLE, LOW-EQUIPMENT TESTING ALTERNATIVES

An attitude that pervades this literature is dependence on an equipment that is not available in every place; calibrated pendulum impact testers (Hasan et. al. [11]), electron microscope (Atmakuri et. al. [5]). There are viable alternatives for comparative academic tasks in which cubic centimeters aren't a necessary, certifiable accuracy. Very simply, E = mgh is all that you need to order laminates by impact resistance damage resistance with a drop-weight device created from available equipment and a known mass dropped from a known height.A self-built drop-weight rig, which incorporates a guided release release system and a known mass dropped from a known height, can order laminates by impact resistance damage resistance using nothing more than E = mgh. A portable (handheld) Shore D durometer provides a relatively low-cost measurement of hardness comparison. The Archimedes water-displacement method requires only a digital scale and a beaker of water and works well to get a reasonable estimate of the density and void-content without a muffen furnace or acid digestion. There remains a widespread need for Tensile and Flexural Testing (ASTM D3039, D790) but this is the standard equipment in most engineering institutions, and is used routinely for concrete or metals testing, not a machine that had to be bought specifically for composites testing.

VII. TEST STANDARDS REFERENCED IN THE LITERATURE

The typical ASTM procedures, such as D3039 (tensile), D790 (flexural), and D256 (Izod pendulum impact) [19, 20, 21] are used in most of these studies. Substitution of the pendulum testing method mentioned above would be recommended in a review if a pendulum testing device were not available.

VIII. RESEARCH GAPS AND FUTURE DIRECTIONS

While this is perhaps the most important practical limitation in getting access to this type of research – aside from the costs of conducting such research – it is somewhat surprising that very few of the studies referenced here state anything direct about whether such equipment is somewhat practical for replication outside of high-tech, publicly funded labs.
It appears that no one has yet directly correlated the low-equipment tests (drop weight impact, Shore D hardness) with the calibrated standard tests they seek to replace – that still needs to be done.

Limited data exist for fatigue and durability for the newer, less expensive hybrid systems discussed in this paper (jute-hemp, jute-coir, Calamus rotang-glass).

IX. CONCLUSION

Synthesized fiber composites are still superior in terms of raw mechanical performance, but with the use of cheap natural fibers, such as jute and coir, E-glass, polyester or epoxy fibers, natural fibre composites and hybrid composites are steadily catching up. If the institute lacks specialized fabrication or testing equipment as described in Section 2, then the alternatives presented in Section 6 (drop-weight impact, Shore D hardness, Archimedes density) provide a viable means of gaining useful comparative data with relatively simple equipment and hand tools.

REFERENCES

[1] Jeff Jomboh, K., Garkida, A.D., Alemaka, E.M., Yakubu, M.K., Alkali, V.C., Eze, W.U., Lawal, N. (2024). Properties and applications of natural, synthetic and hybrid fiber reinforced polymer composite: A review. AIMS Materials Science, 11(4), 774–801.

[2] Dawood, T.S., Fadhil, B.M., Ramadan, D.O. (2023). Improving the mechanical properties of carbon-epoxy and glass-epoxy composites using silica nanoparticles. Journal of University of Duhok, 26(2), 682–692.

[3] Rongyu, J., Ruoyu, S., Yuan, L., Xuezhong, L. (2024). Research on the preparation and mechanical properties of glass fiber-reinforced epoxy resin composites. In Proceedings of the 18th Annual Conference of China Electrotechnical Society (ACCES 2023). Springer, Singapore.

[4] Navaneeth, I.M., Suhas, P., Maruthi Prashanth, B.H., Prashanth Pai, M., Chethan, K.M., Razak, A. (2024). Mechanical and wear studies on epoxy composites with glass fiber reinforcement and carbon powder fillers. In Smart Materials and Manufacturing Technologies for Sustainable Development (SME 2023). Springer, Cham.

[5] Atmakuri, A., Palevicius, A., Vilkauskas, A., Janusas, G. (2022). Numerical and experimental analysis of mechanical properties of natural-fiber-reinforced hybrid polymer composites and the effect on matrix material. Polymers, 14(13), 2612.

[6] Sadik, T., Muthuraman, S., Sivaraj, M., Negash, K., Balamurugan, R., Bakthavatsalam, S. (2022). Mechanical behavior of polymer composites reinforced with coir and date palm frond fibers. Advances in Materials Science and Engineering, 2022, 9882769.

[7] Jayaraj, M., Ashok, S.K., Thirumurugan, R., Shanmugam, D., Mahendran, M. (2024). Mechanical properties and stress analysis of natural fiber reinforced polymer composite spur gear. Journal of Engineering Sciences, 11(2), D1–D8.

[8] Mahesh, V. (2022). Development and physio-mechanical characterization of sustainable jute-wood dust reinforced hybrid composites. Journal of Natural Fibers, 19(16), 13995–14004.

[9] Jasmin, N.M., Sathish, S., Senthil, T.S., Naidu, B.A., Das, A.D., Arun, K.K., Subbiah, R., Srinivasan, K. (2023). Investigation on natural fiber reinforced polymer matrix composite. Materials Today: Proceedings, 74, 60–63.

[10] Venkatesh, R., Santhosh Kumar, P.C., Senthilkumar, A., Phani Krishna, J., Chandramohan, P., Aneesh, V.N., Malladi, A., Priya, C.B., Ramaraj, E. (2023). Mechanical interlocking approaches to the prediction of mechanical and tribological behavior of natural fiber-reinforced polymer hybrid nanocomposites for automotive applications. Advances in Polymer Technology, 2023, 6685060.

[11] Hasan, M.M., Islam, M.A., Hassan, T. (2024). Analysis of jute-glass fiber reinforced epoxy hybrid composite. Heliyon, 10(24), e40924.

[12] Ullah, S., Palevicius, A., Janusas, G., Ul-Hasan, Z. (2025). Enhancing mechanical and impact properties of flax/glass and jute/glass hybrid composites through KOH alkaline treatment. Polymers, 17(6), 804.

[13] Gupta, A., Shohel, S.M., Singh, M., Singh, J. (2024). Study on mechanical properties of natural fiber (jute)/synthetic fiber (glass) reinforced polymer hybrid composite by representative volume element using finite element analysis: A numerical approach and validated by experiment. Hybrid Advances, 6, 100239.

[14] Lokesh, K.S., Shrinivasa Mayya, D., Yashwanth, H.L., Sharanya, I.S., Nikam, H., Channa Keshava Reddy, K.L., Kumar, S. (2024). Mechanical characterization and regression analysis of Calamus rotang based hybrid natural fibre composite with findings reported on retrieval bending strength. Scientific Reports, 14(1), 1–17.

[15] Maithil, P., Gupta, P., Chandravanshi, M.L. (2023). Study of mechanical properties of the natural-synthetic fiber reinforced polymer matrix composite. Materials Today: Proceedings.

[16] Marichelvam, M.K., Labesh Kumar, C., Kandakodeeswaran, K., Thangagiri, B., Saxena, K.K., Kishore, K., Wagri, N.K., Kumar, S. (2023). Investigation on mechanical properties of novel natural fiber-epoxy resin hybrid composites for engineering structural applications. Case Studies in Construction Materials, 19, e02356.

[17] Islam, M.Z., Sabir, E.C., Syduzzaman, M. (2024). Experimental investigation of mechanical properties of jute/hemp fibers reinforced hybrid polyester composites. SPE Polymers, 5(2), 192–205.

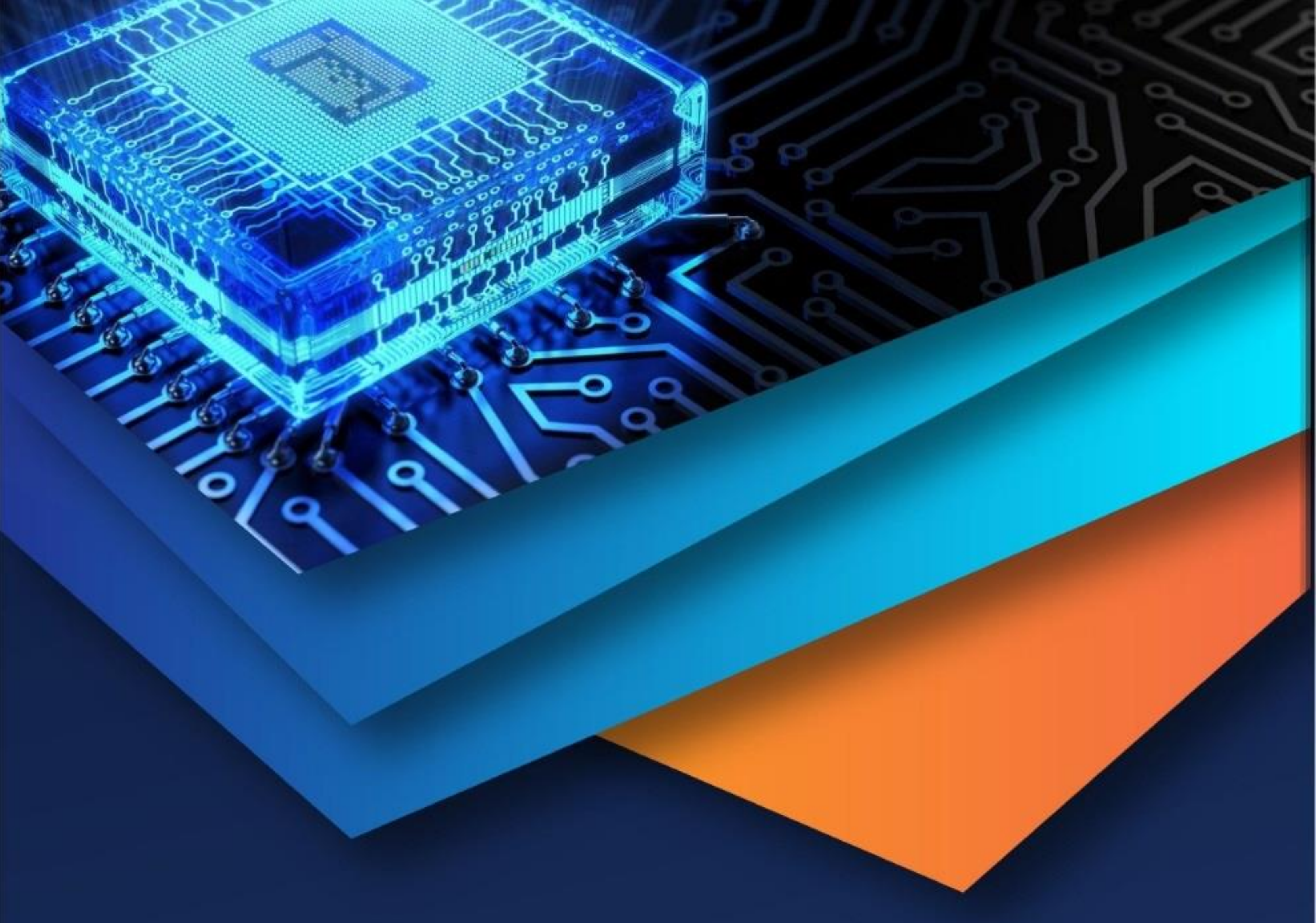
[18] Fegade, R., Chaudhari, R., Nehete, R., Tale, V., Mate, D., Yadav, S., Wadate, P., Kolgiri, S. (2026). Development and mechanical characterization of hybrid natural fiber-reinforced polymer matrix composites for structural applications. Journal of Polymer & Composites.

[19] ASTM International. (2017). ASTM D3039/D3039M – Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials (current edition). West Conshohocken, PA: ASTM International.

[20] ASTM International. (2017). ASTM D790 – Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials (current edition). West Conshohocken, PA: ASTM International.

[21] ASTM International. (2023). ASTM D256 – Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics (current edition). West Conshohocken, PA: ASTM International.

1186



10.22214/IJRASET

INDEX COPERNICUS

45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY