

Systematic Literature Review: Mechanical and Sustainability Properties of Jute Fiber Reinforced Concrete

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ABSTRACT

The present status of the study on jute fiber reinforced concrete (JFRC) is examined in this comprehensive literature review, with an emphasis on mechanical characteristics, and sustainability factors. Because of their affordability, availability locally, and eco-friendliness, natural fibers especially jute have become attractive substitutes for synthetic fibers in concrete reinforcement. The results of more than 45 peer-reviewed research that were published between 2020 and 2025 are included in this study to assess how the addition of jute fiber affects mechanical aspects behaviour, and environmental impact of concrete. The review covers the synergistic effects when mixed with other cementitious materials and determines the ideal fiber parameters (length: 10-25 mm; volume fraction: 0.1-0.6%). Although jute fiber greatly increases tensile strength, flexural strength, and fracture resistance.

KEYWORDS: Jute fiber reinforced concrete (JFRC), Jute fiber concrete, mechanical and sustainability properties.

INTRODUCTION

Concrete is a synthetic substance that is mainly used in the global building sector. It is poor in tension whereas high in compression [1-3]. Fibers could be added to concrete to increase its tensile and flexural strength. In order to improve the concrete's split tensile strength, flexural strength, robustness to impact, fatigue endurance, resistance to wear, and plasticity behaviour, the fiber is added to the composition [4]. Glass, jute [5-

7], human hair [8-10], carbon [11], coir [12, 13], PVA [14-19], steel [20], nylon [21], basalt, Polyethylene [22], polypropylene, bagasse [23], polyester [24], and plastic [25] fibers are frequently employed to enhance the properties of concrete [26]. Nevertheless, the kind of fiber, shape, orientation, and density all affect how well concrete works [27]. Jute fibers in concrete have been discovered to have better qualities and economic effectiveness than other fibers in the past few years [28]. The tensile strength, modulus of elasticity, and toughness of concrete are all increased when jute fibers are added [29, 30]. However, jute fiber is widely used in many fields due to its excellent thermal insulation properties, application in sportswear, heat resistance, automotive parts, and chemical corrosion resistance. Compared to other types of fiber, jute fiber exhibits superior performance [31].

Furthermore, jute fiber disperses easily after mixing with concrete or mortar [7]. Its cost is relatively high, but lower than that of other fiber types, although lower than that of S-fiber, glass fiber, and carbon fiber. Compared to synthetic and organic fibers, jute fiber exhibits higher stability in radioactive environments. Research into jute fiber in concrete is conducted on the properties, characteristics, and durability of fiber-reinforced concrete. Studies have shown that jute fiber reinforced concrete exhibits relatively good resistance to salt, water, corrosion and severe degradation in alkaline environments [32].

In addition, jute fibers have good resistance to alkali reaction, and adding more basalt fibers to concrete can improve the tensile strength, flexural strength and stiffness of concrete [7]. At the same time, it can also improve the wear resistance and fracture resistance of concrete. A study [33] investigated geopolymer concrete with jute fibers. The results showed that geopolymer concrete with jute fibers outperformed geopolymer concrete without basalt fibers.

Few studies have examined the effectiveness of jute fibers in concrete mixtures. Therefore, in-depth research on jute fiber concrete (JFC) is required. This review provides a detailed description of the properties of jute fibers and the mechanical properties, and sustainability assessment of JFC. This review will also serve as a guide for researchers working on jute fibers in concrete, with the goal of improving the sustainability of the construction industry in terms of building materials.

SCOPE AND METHODOLOGY

PRISMA criteria for comprehensive literature reviews are adhered to in this review. The Web of Science, Scopus, Google Scholar, and ScienceDirect databases were thoroughly searched using the following keywords: "jute fiber concrete," "jute fiber reinforced concrete," "natural fiber concrete mechanical properties," and "jute fiber sustainability." Priority was given to studies published between 2020 and 2025; essential background was provided by key previous publications as shown in Figure 1. Analysis was done on more than 45 peer-reviewed articles, comprising life cycle evaluations, review papers, and experimental research.

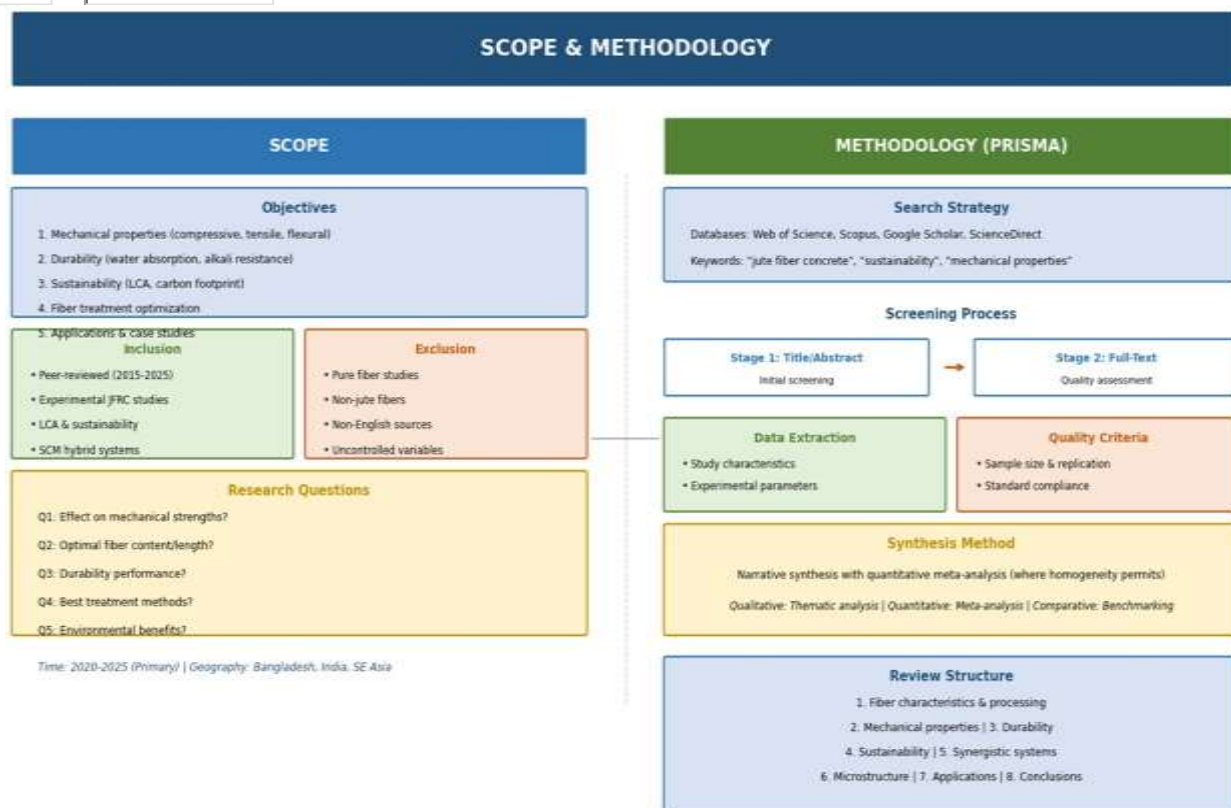


Figure 1: Methodology flowchart

JUTE FIBER CHARACTERISTICS

The bast fiber known as jute (*Corchorus capsularis* and *Corchorus olitorius*) is taken from the bark of jute plants. Important characteristics of concrete reinforcement are mentioned in Table 1.

Table 1: Jute Fiber Properties

Property	Value	Reference
Tensile Strength	250-300 MPa	[7]
Density	1.3-1.5 g/cm ³	[34]
Cellulose Content	60-65%	[7]
Lignin Content	12-15%	[7]
Elongation at Break	1.5-2.0%	[34]
Moisture Absorption	High (hygroscopic)	[34]

Strength is provided by the highest cellulose concentration, whereas lignin functions as a natural binding inside the fiber structure. Nevertheless, the alkaline cement condition presents difficulties due to the hydrophilic nature of jute fibers.

MECHANICAL PROPERTIES OF JUTE FIBER REINFORCED CONCRETE

Compressive Strength

The impact of jute fiber on compressive strength is still up for dispute in the scientific literature, with results differing greatly depending on mix composition and fiber properties.

Positive Effects:

- Rabbani et al. (2025) found that the compressive strength of jute fiber concrete was 2609 psi (18.0 MPa), an 11.6% enhancement above ordinary concrete's 2338 psi (16.1 MPa) [35].
- After 28 days, Bhushal et al. (2025) found that adding 0.6% volume fraction of 12 mm jute fibers to normal concrete increased compressive strength by 14.54% to 30.10% [36].

Negative Effects:

- Due to improper fiber dispersion and increasing heterogeneity, Zia and Ali found a 36% decrease in compressive strength with 5% jute fiber by cement weight and 50 mm fiber length [34].
- Because of fiber clumping, greater porosity, and reduced bonding, investigations with greater fiber content (>1.0% by volume) typically demonstrate a decrease in compressive strength [34].

Tensile Strength

Tensile characteristics are more consistently improved by jute fiber:

- At 0.6% volumetric ratio, 10–12 mm fibers showed the greatest gains of 12.24–30.42% [36].
- A 30.42% improvement using 10 mm fibers was recorded in Springer's investigation [37].
- At 0.1–0.5% fiber content and 10% additional cementitious components, best performance is achieved [7].

Flexural Strength:

- Several studies have shown increases spanning 12% to 25%.
- Flexural strength increased from 4.16 MPa (control) to 5.32 MPa with 0.40% 15 mm fibers after 7 days and from 5.94 MPa to 7.46 MPa at 28 days, according to the MDPI research from 2024 [34].
- Because of weak bonding and increasing void growth, longer fibers (35 mm) performed worse [34].

Mechanism: By bridging small fractures and enhancing post-cracking actions, jute fibers function as crack arrestors. Energy absorption capacity is increased by the fiber-matrix contact, which transmits stress from the brittle concrete matrix to the ductile fibers.

SUSTAINABILITY AND ENVIRONMENTAL IMPACT

Life Cycle Assessment (LCA)

Investigations on life cycle analysis repeatedly show that adding jute fiber has positive environmental effects:

Carbon Footprint:

- The production of jute absorbs CO₂ at levels many times greater than those of trees, making it carbon-negative.
- Jute needs little fertilizer, insecticides, or irrigation.
- Jute fibers are completely recyclable and biodegradable.

Embodied Carbon Reduction:

- Using a 25% POFA substitution, POFA-jute fiber concrete reduced embodied carbon by 19.82%.
- The ideal mixture (15% POFA + 0.25% jute fiber) improved eco-strength performance by 38.22%.
- The integration of CCA and jute fiber decreased embodied carbon whereas preserving mechanical properties [7].

Eco-Strength Efficiency (ESE)

To assess sustainability concrete, the eco-strength efficiency measurement (compressive strength/embodied carbon) was created and mentioned in Table 2.

Table 2: ESE of JF Concrete

Mix Design	ESE (MPa/kg CO ₂ /m ³)	Reference
Control (Plain Concrete)	Baseline	[7]
0.5% JF + 10% CCA	0.114 (Maximum)	[7]
1.0% JF + 20% CCA	0.068 (Minimum)	[7]

COMPARATIVE ANALYSIS WITH OTHER NATURAL FIBERS

Although it needs to be properly treated to correspond to the durability of synthetic substitutes, jute provides an ideal blend of mechanical qualities, affordability, and sustainability. The comparative analysis with other fibers is mentioned in Table 3.

Table 3: comparative analysis of fibers

Fiber Type	Tensile Strength (MPa)	Density (g/cm ³)	Durability in Concrete	Cost	Sustainability
Jute	250-300	1.3-1.5	Moderate (requires treatment)	Low	High
Coconut (Coir)	150-220	1.2-1.5	Good	Low	High
Sisal	400-600	1.3-1.5	Moderate	Moderate	High
Hemp	300-800	1.4-1.5	Moderate	Moderate	High
Bamboo	300-600	0.6-1.1	Variable	Low	High
Steel	500-2000	7.8	Excellent	High	Low
Polypropylene	300-400	0.9	Good	Moderate	Low

CONCLUSIONS

Jute fiber reinforced concrete is a practical and sustainable substitute for traditional concrete and synthetic fiber reinforced infrastructure, as this comprehensive analysis of the literature shows. Important conclusions include:

Mechanical Efficiency:

- The ideal jute fiber concentration is between 0.1% and 0.6% by volume.
- The ideal ratio of strength to workability is achieved with fiber lengths between 10 and 20 mm.
- Although compressive strength impacts vary depending on mix composition, tensile and flexural strengths generally increase by 12–30%.
- The entire performance is improved by synergistic interactions with SCMs (fly ash, POFA, and CCA).

Advantages of Sustainability:

- substantial decrease in embodied carbon (up to 20%).
- Generation of carbon-negative fiber.
- Cost-effectiveness in comparison to artificial substitutes.
- Encouragement of rural economy in emerging nations

According to the conclusion of study findings, jute fiber concrete may satisfy the demands of sustainable building whereas offering sufficient mechanical performance if it is built and handled appropriately. To enable wider implementation in the construction sector, future studies should concentrate on longevity assessment, standardized processes, and treatment technique improvement.

References

- [1] Reddy, K.A., Kode, V.R., Malasani, P., Satish, S. and Darapu, K., 2019. Influence of Addition of Micro Silica on Strength Properties of Basalt Fiber Reinforced Multi Blended Concrete. *Int. J. Eng. Adv. Technol.(IJEAT)*, 9, pp.4463-4467.
- [2] Bheel, N., 2021. Basalt fibre-reinforced concrete: Review of fresh and mechanical properties. *Journal of Building Pathology and Rehabilitation*, 6(1), p.12.
- [3] Ja'e, I.A., bin Raja Sazrin, R.A.N., Syamsir, A., Bheel, N., Amaechi, C.V., Min, T.H. and Anggraini, V., 2024. Optimisation of mechanical properties and impact resistance of basalt fibre reinforced concrete containing silica fume: Experimental and response surface assessment. *Developments in the Built Environment*, 17, p.100368.
- [4] Sarkar, A. and Hajihosseini, M., 2020. Feasibility of improving the mechanical properties of concrete pavement using basalt fibers. *Journal of Testing and Evaluation*, 48(4), pp.2908-2917.
- [5] Bheel, N., Sohu, S., Awoyera, P., Kumar, A., Abbasi, S.A. and Olalusi, O.B., 2021. Effect of wheat straw ash on fresh and hardened concrete reinforced with jute fiber. *Advances in Civil Engineering*, 2021(1), p.6659125.
- [6] Bheel, N., Tafsirojjaman, T., Liu, Y., Awoyera, P., Kumar, A. and Keerio, M.A., 2021. Experimental study on engineering properties of cement concrete reinforced with nylon and jute fibers. *Buildings*, 11(10), p.454.
- [7] Bheel, N., Kumar, D., Ismail, F.I., Salilew, W.M., Alwetaishi, M., Waheeb, S.A. and Alkhatabi, L., 2024. Combined effect of jute fiber and corn cob ash on sustainability assessment and mechanical properties of roller compacted concrete using RSM modelling. *Scientific Reports*, 14(1), p.29724.

- [8] Bheel, N., Awoyera, P., Aluko, O., Mahro, S., Vilorio, A. and Sierra, C.A.S., 2020. Sustainable composite development: Novel use of human hair as fiber in concrete. *Case Studies in Construction Materials*, 13, p.e00412.
- [9] Bheel, N.D., Abbasi, S.A., Meghwar, S.L. and Shaikh, F.A., 2017, November. Effect of human hair as fibers in cement concrete. In *International Conference on Sustainable Development in Civil Engineering, Jamshoro, Pakistan*.
- [10] Bheel, N., Shams, M.A., Sohu, S., Buller, A.S., Najeh, T., Ismail, F.I. and Benjeddou, O., 2024. A comprehensive study on the impact of human hair fiber and millet husk ash on concrete properties: response surface modeling and optimization. *Scientific reports*, 14(1), p.13569.
- [11] Khan, M.B., Waqar, A., Bheel, N., Shafiq, N., Hamah Sor, N., Radu, D. and Benjeddou, O., 2023. Optimization of fresh and mechanical characteristics of carbon fiber-reinforced concrete composites using response surface technique. *Buildings*, 13(4), p.852.
- [12] Katman, H.Y.B., Khai, W.J., Bheel, N., Kirgiz, M.S., Kumar, A. and Benjeddou, O., 2022. Fabrication and characterization of cement-based hybrid concrete containing coir fiber for advancing concrete construction. *Buildings*, 12(9), p.1450.
- [13] Bheel, N., Kumar, S., Kirgiz, M.S., Ali, M., Almujiabah, H.R., Ahmad, M. and Gonzalez-Lezcano, R.A., 2024. Effect of wheat straw ash as cementitious material on the mechanical characteristics and embodied carbon of concrete reinforced with coir fiber. *Heliyon*, 10(2).
- [14] Bheel, N., Mohammed, B.S., Ali, M.O.A., Shafiq, N., Tag-eldin, E.M. and Ahmad, M., 2023. Effect of polyvinyl alcohol fiber on the mechanical properties and embodied carbon of engineered cementitious composites. *Results in Engineering*, 20, p.101458.
- [15] Bheel, N., Mohammed, B.S., Abdulkadir, I., Liew, M.S. and Zawawi, N.A.W.A., 2023. Effects of graphene oxide on the properties of engineered cementitious composites: Multi-objective optimization technique using RSM. *Buildings*, 13(8), p.2018.
- [16] Bheel, N., Baikerikar, A.V. and Mohammed, B.S., 2025. Using optimization techniques on mechanical characteristics and sustainability assessment of rubberized concrete blended with PVA fiber through response surface methodology. *International Journal of Concrete Structures and Materials*, 19(1), p.8.
- [17] Bheel, N., Ali, M.O.A., Kirgiz, M.S., Shafiq, N. and Gobinath, R., 2023. Effect of graphene oxide particle as nanomaterial in the production of engineered cementitious composites including superplasticizer, fly ash, and polyvinyl alcohol fiber. *Materials Today: Proceedings*.
- [18] Bheel, N., Chohan, I.M., Alraeeini, A.S., Alwetaishi, M., Waheeb, S.A., Alkhatabi, L. and Benjeddou, O., 2025. Optimization of durability characteristics of engineered cementitious composites combined with titanium dioxide as a nanomaterial applying RSM modelling. *Scientific Reports*, 15(1), p.9428.
- [19] Buller, A.S., Ali, M., Ali, T. and Bheel, N., 2024. Effect of silica fume on fracture analysis, durability performance and embodied carbon of fiber-reinforced self-healed concrete. *Theoretical and Applied Fracture Mechanics*, 130, p.104333.
- [20] Shams, M.A., Bheel, N., Ali, M., Ahmad, M., Najeh, T., Gamil, Y., Almujiabah, H.R. and Benjeddou, O., 2024. Fracture analysis of steel fibre-reinforced concrete using Finite element method modeling. *Frontiers in Materials*, 11, p.1355351.
- [21] Ravindran, G., Mahesh, V., Bheel, N., Chittimalla, S., Srihitha, K. and Sushmasree, A., 2023. Usage of natural fibre composites for sustainable material development: global research productivity analysis. *Buildings*, 13(5), p.1260.

- [22] Hamah Sor, N., Ali, T.K.M., Vali, K.S., Ahmed, H.U., Faraj, R.H., Bheel, N. and Mosavi, A., 2022. The behavior of sustainable self-compacting concrete reinforced with low-density waste Polyethylene fiber. *Materials Research Express*, 9(3), p.035501.
- [23] Bheel, N., Kennedy, C., Zardari, S., Salilew, W.M., Almaliki, A.H. and Benjeddou, O., 2024. Effect of costus lucianus bagasse fibre on fresh and hardened concrete using RSM modelling. *Scientific Reports*, 14(1), p.24556.
- [24] Ali, M., Kumar, A., Rizvi, S.H. and Bheel, N., 2025. Effect of polyester fiber on compressive strength and split tensile strength properties of high strength concrete. *Mehran University Research Journal Of Engineering & Technology*, 44(1), pp.159-170.
- [25] Awoyera, P.O., Oluyemi, F., Bheel, N., Aluko, O., de Azevedo, A.R. and Olalusi, O.B., 2024. Morphology and strength of concrete incorporating natural rubber latex and plastic fibers. In *Green materials in civil engineering* (pp. 201-217). Woodhead Publishing.
- [26] Shams, M.A., Bheel, N., Abid, M.M., Alraeeini, A.S., Almaliki, A.H., Dodo, Y.A. and Benjeddou, O., 2025. Exploring Fracture Energy in Engineered Cementitious Composites: A Comprehensive Review. *International Journal of Concrete Structures and Materials*, 19(1), p.66.
- [27] Kumbhar, V.P., 2014. An overview: basalt rock fibers-new construction material. *Acta Eng. Int*, 2(1), pp.11-18.
- [28] Ahmad, J., Arbili, M.M., Majdi, A., Althoey, F., Farouk Deifalla, A. and Rahmawati, C., 2022. Performance of concrete reinforced with jute fibers (natural fibers): A review. *Journal of Engineered Fibers and Fabrics*, 17, p.15589250221121871.
- [29] Zhang, T., Yin, Y., Gong, Y. and Wang, L., 2020. Mechanical properties of jute fiber-reinforced high-strength concrete. *Structural Concrete*, 21(2), pp.703-712.
- [30] Zakaria, M., Ahmed, M., Hoque, M.M. and Islam, S., 2016. Scope of using jute fiber for the reinforcement of concrete material. *Textiles and clothing sustainability*, 2(1), p.11.
- [31] Sonali, S., Farzana, M., Haque, M.M., Saha, A., Khan, R.A. and Mollah, M.Z.I., 2023. Natural fiber reinforced polymer-based composites: importance of jute fiber. *GSC Adv Res Rev*, 15(1), pp.021-029.
- [32] Sridhar, J., Gobinath, R. and Kirgiz, M.S., 2022. Comparative study for efficacy of chemically treated jute fiber and bamboo fiber on the properties of reinforced concrete beams. *Journal of Natural Fibers*, 19(15), pp.12224-12234.
- [33] Mohammed, A.D.A.A., Ronghui, W. and Huseien, G.F., 2024. Mechanical properties of natural jute Fiber-Reinforced geopolymer concrete: effects of various lengths and volume fractions. *Journal of Composites Science*, 8(11), p.450.
- [34] Mohammed, A.D.A.A., Ronghui, W. and Huseien, G.F., 2024. Mechanical properties of natural jute Fiber-Reinforced geopolymer concrete: effects of various lengths and volume fractions. *Journal of Composites Science*, 8(11), p.450.
- [35] RABBANI, M., ISLAM, M., HOSSAIN, M., Tusar, A.H. and Hasan, M.A., 2025. Mechanical Properties and Performance Analysis of Natural Fiber Reinforced Concrete Using Jute and Coconut Fibers. *INTERNATIONAL JOURNAL*, 2(1), pp.30-38.
- [36] Bhushal, T., Haque, M.R., Islam, M.R. and Al Mohmud, H., 2025. Investigation of the Mechanical Properties and Durability Performance of Jute Fiber Concrete. *Journal of Engineering Advancements*, 6(04), pp.138-146.

- [37] Sonani, S. and Suthar, J., 2025, April. Mechanical Properties of Jute Fiber Reinforced Concrete. In *International Conference on Innovative Trends in engineering for Sustainability* (pp. 249-256). Singapore: Springer Nature Singapore.