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Comparative Study of Bamboo and Steel Reinforcement in Lightweight Concrete Slab Structure

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ABSTRACT

Purpose: This study compared the flexural performance of lightweight concrete (LWC) slabs reinforced with treated bamboo strips and with conventional steel rebar, alongside an unreinforced plain LWC control, to assess bamboo as a renewable, lower-cost alternative to steel. Methods: Twelve slabs (500 × 300 × 60 mm, four per group) were tested under third-point flexural loading until failure, and bond strength of the two reinforced groups was evaluated by pull-out testing. Data were analyzed using one-way ANOVA. Results: Reinforcement type significantly affected first crack load, ultimate load, flexural strength, deflection at failure, and ductility index ($p < .001$), but not stiffness ($p = .222$). Steel-reinforced slabs achieved the highest ultimate load (28.43 ± 1.46 kN) and flexural strength (7.47 ± 0.34 MPa), while bamboo-reinforced slabs reached 78.9% of the ultimate load (22.44 ± 0.79 kN) and 77.1% of the flexural strength (5.76 ± 0.28 MPa), both significantly higher than the control ($p < .001$). Bamboo bond strength (2.83 ± 0.20 MPa) was lower than that of steel (4.41 ± 0.12 MPa, $p < .001$) yet sufficient to mobilize substantial flexural capacity. Bamboo-reinforced slabs also showed comparable stiffness and a markedly higher ductility index than plain concrete, at an estimated 82% lower reinforcement material cost. Conclusion: Bamboo-reinforced lightweight concrete slabs, although not matching the capacity of steel-reinforced slabs, are a technically viable, more economical, and more sustainable option for non-critical applications such as low-rise housing floor and roof slabs.

Keywords: *Bamboo Reinforcement, Steel Reinforcement, Lightweight Concrete, Slab, Flexural Strength, Sustainable Construction*

INTRODUCTION

Steel remains the dominant reinforcing material in reinforced concrete construction worldwide, but its high embodied energy, rising cost, and susceptibility to corrosion particularly in humid tropical and marine environments have prompted sustained research interest in alternative reinforcing materials (Kanagaraj et al., 2025). Bamboo, a fast-growing, widely available, and low-cost natural

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material with a favorable tensile strength-to-weight ratio, has re-emerged as one of the most promising candidates, especially for low-rise and non-critical structural elements in regions where bamboo is locally abundant (Sayed et al., 2022). Bamboo's tensile strength, typically in the range of 70–210 MPa along the fiber direction, combined with its markedly lower density relative to steel, makes it particularly attractive for lightweight concrete applications, where minimizing structural self-weight is already a primary design objective (Kumar et al., 2021).

Lightweight concrete (LWC), produced using low-density aggregates or admixtures, reduces dead load, improves thermal insulation, and can lower foundation and seismic design demands relative to normal-weight concrete, while still achieving strength adequate for many structural applications (Agrawal et al., 2021). Combining LWC with bamboo reinforcement rather than the conventional pairing of LWC with steel offers a potentially compounding weight and cost reduction, but the structural performance of this specific combination has received comparatively limited direct experimental attention relative to the extensive literature on bamboo-reinforced normal-weight concrete beams and slabs.

A substantial body of recent research has established that bamboo-reinforced concrete elements can achieve flexural performance approaching, and in some configurations exceeding, that of steel- or plain-concrete elements. Qaiser et al. (2020) found that corrugating or wire-wrapping bamboo reinforcement increased the flexural strength of bamboo-reinforced concrete beams by up to 80% relative to plain bamboo reinforcement, underscoring the importance of surface treatment on bonding and load transfer. Al-Fasih et al. (2021) experimentally determined the tensile properties of bamboo strips with different cutting shapes and used these properties to design and test bamboo-reinforced concrete beams, reporting flexural behavior competitive with steel-reinforced counterparts at equivalent reinforcement ratios. At the slab scale specifically, Kanagaraj et al. (2025) tested four types of bamboo-reinforced concrete slab composites and found that a fibre-reinforced geopolymer matrix improved the first crack load by up to 66% and ductility index by up to 55% relative to a conventional bamboo-reinforced cement concrete slab, demonstrating that matrix formulation, not only reinforcement type, strongly influences bamboo-reinforced slab performance. Awoyera et al. (2024) similarly showed that bamboo fibre laminate retrofitting of reinforced concrete slabs increased ultimate flexural load by over 60% relative to non-retrofitted slabs, reinforcing bamboo's viability as a structural strengthening and reinforcing material at the slab scale.

Despite this growing evidence base, few studies have directly compared bamboo and steel reinforcement within an identical lightweight concrete matrix under controlled conditions, isolating the effect of reinforcement type from confounding differences in concrete mix design. This gap is practically significant: if bamboo reinforcement can retain a substantial fraction of steel's flexural performance within a lightweight concrete matrix at markedly lower cost, it would strengthen the case for bamboo-LWC composite slabs as a viable, sustainable alternative for low-rise housing and non-critical structural applications, particularly in regions including much of Indonesia where bamboo is locally abundant and steel must often be imported at high cost. This study therefore aimed to (1) fabricate and test lightweight concrete slabs reinforced with treated bamboo strips, conventional steel rebar, and no reinforcement (control), (2) statistically compare their flexural performance (first crack load, ultimate load, flexural strength, deflection, stiffness, and ductility) using one-way ANOVA, (3) evaluate the bond strength of bamboo versus steel within the lightweight concrete matrix, and (4) assess the practical trade-off between structural performance and relative reinforcement cost.

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METHODS

1. Materials

Ordinary Portland Cement (Type I), natural river sand, and expanded clay lightweight aggregate were used to produce the lightweight concrete (LWC) mix, targeting a design unit weight below 1,850 kg/m^3, consistent with the structural lightweight aggregate concrete performance ranges summarized by Agrawal et al. (2021). Locally sourced Petung bamboo (Dendrocalamus asper) culms, taken from the bottom-to-middle section of 3–4 year-old culms, were split into strips (10 mm width × 5 mm thickness), oven-dried to approximately 12% moisture content, and surface-treated with a two-component epoxy coating combined with sand-coating to enhance bond with the surrounding concrete, following treatment approaches shown to improve bamboo-concrete bond and flexural performance in prior studies (Qaiser et al., 2020; Al-Fasih et al., 2021). Deformed steel reinforcement bars (Ø10 mm, Grade 40) were used for the steel-reinforced group.

2. Specimen Design and Fabrication

Three groups of slab specimens were prepared: (1) plain lightweight concrete with no reinforcement (Plain LWC, control), (2) lightweight concrete reinforced with treated bamboo strips (Bamboo-LWC), and (3) lightweight concrete reinforced with steel rebar (Steel-LWC). Reinforcement was designed to an approximately equivalent cross-sectional area ratio for the bamboo and steel groups, positioned at the tensile face with 20 mm concrete cover. Each slab specimen measured 500 mm × 300 mm × 60 mm. Four replicate specimens were cast per group (n = 4), for a total of 12 slabs. All specimens were cast from the same LWC batch design, cured under wet burlap for 7 days, and then air-cured until testing at 28 days, ensuring that concrete mix variability did not confound the comparison between reinforcement types.

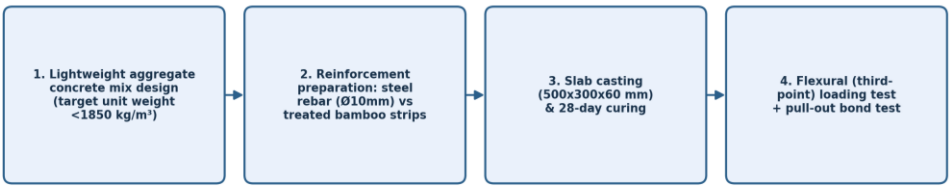


Fig. 1. Experimental workflow for comparing bamboo and steel reinforcement in lightweight concrete slabs

Figure 1. Experimental workflow for comparing bamboo and steel reinforcement in lightweight concrete slabs

3. Flexural Testing

At 28 days, slab specimens were tested under third-point flexural loading using a loading frame with a proving ring and a demountable dial gauge (DEDG) positioned at the mid-span to record central deflection, following a test configuration consistent with recent bamboo-reinforced slab studies (Kanagaraj et al., 2025). Load was applied at a controlled, constant rate until failure. The first crack load was recorded as the load at which the first visible surface crack appeared; the ultimate load was recorded as the maximum load sustained prior to failure. Flexural strength (modulus of rupture) was calculated from the ultimate load using standard beam theory for a simply supported slab strip under third-point loading. Stiffness was calculated as the ratio of ultimate load to ultimate central deflection. The ductility index was calculated as the ratio of ultimate deflection to yield deflection, with the yield point determined using the bilinear approximation method applied to the load-deflection curve.

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4. Bond Strength (Pull-Out) Test

Bond strength between each reinforcement type and the lightweight concrete matrix was evaluated using a pull-out test, following the general procedure applied to bamboo-reinforced concrete by Kanagaraj et al. (2025). Reinforcement strips/bars of 400 mm embedment length were centrally cast into 100 mm × 100 mm cubical LWC specimens and, after 28-day curing, pulled in the axial direction using a universal testing machine (UTM) until bond failure, with bond strength calculated as the maximum pull-out load divided by the embedded surface area.

5. Statistical Analysis

First crack load, ultimate load, flexural strength, deflection, stiffness, and ductility index (n = 4 per group) were expressed as mean ± standard deviation. One-way analysis of variance (ANOVA) was performed for each property to test whether reinforcement type (Plain LWC, Bamboo-LWC, Steel-LWC) had a statistically significant effect, followed by Tukey's Honestly Significant Difference (HSD) post-hoc test ($\alpha = .05$) to identify which group pairs differed significantly. Bond strength (Bamboo-LWC vs. Steel-LWC only) was compared using an independent-samples t-test. All statistical analyses were performed using Python (SciPy and statsmodels), with statistical significance set at $p < .05$.

RESULTS

1. First Crack Load and Ultimate Load

Table 1 and Figure 2 present the first crack load and ultimate load of the three slab groups. The Steel-LWC group achieved the highest first crack load (15.82 ± 0.26 kN) and ultimate load (28.43 ± 1.46 kN), followed by Bamboo-LWC (11.66 ± 0.58 kN and 22.44 ± 0.79 kN, respectively) and Plain LWC (5.45 ± 0.23 kN and 8.95 ± 0.63 kN, respectively). Relative to Steel-LWC, Bamboo-LWC achieved 73.7% of the first crack load and 78.9% of the ultimate load.

Table 1. First crack load, ultimate load, and flexural strength of the slab groups (mean ± SD)

Group	First Crack Load (kN)	Ultimate Load (kN)	Flexural Strength (MPa)
Plain LWC	5.45 ± 0.23	8.95 ± 0.63	2.79 ± 0.09
Bamboo-LWC	11.66 ± 0.58	22.44 ± 0.79	5.76 ± 0.28
Steel-LWC	15.82 ± 0.26	28.43 ± 1.46	7.47 ± 0.34

One-way ANOVA confirmed a highly significant effect of reinforcement type on first crack load ($F(2,9) = 720.99$, $p < .001$) and ultimate load ($F(2,9) = 379.88$, $p < .001$). Tukey's HSD post-hoc test showed that all three pairwise group comparisons were statistically significant for both first crack load and ultimate load ($p < .001$ for all comparisons), confirming that Steel-LWC, Bamboo-LWC, and Plain LWC each represent a statistically distinct performance tier.

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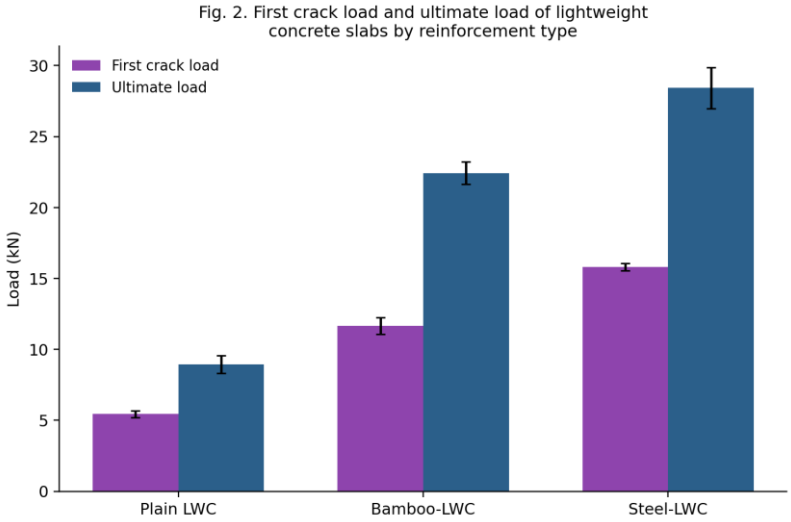


Figure 2. First crack load and ultimate load of lightweight concrete slabs by reinforcement type

2. Flexural Strength

Flexural strength (modulus of rupture) followed the same ranking as ultimate load (Table 1). One-way ANOVA confirmed a highly significant effect of reinforcement type ($F(2,9) = 334.56$, $p < .001$), with Tukey's HSD showing all pairwise comparisons significant ($p < .001$). Bamboo-LWC achieved a flexural strength 2.07 times that of Plain LWC and 77.1% that of Steel-LWC.

3. Deflection, Stiffness, and Ductility

Table 2 presents the deflection, stiffness, and ductility index results. Maximum central deflection at failure increased significantly with reinforcement capacity, from 2.99 ± 0.14 mm (Plain LWC) to 9.20 ± 0.35 mm (Steel-LWC), confirmed by one-way ANOVA ($F(2,9) = 462.65$, $p < .001$). Notably, stiffness—calculated as the ratio of ultimate load to ultimate deflection—did not differ significantly among the three groups ($F(2,9) = 1.79$, $p = .222$), with Tukey's HSD confirming no significant pairwise differences (all $p > .26$). This indicates that although Bamboo-LWC and Steel-LWC sustained substantially higher loads and deflections than Plain LWC before failure, all three groups deformed at a broadly similar rate relative to their respective load capacity.

Table 2. Deflection at failure, stiffness, and ductility index of the slab groups (mean ± SD)

Group	Deflection at Failure (mm)	Stiffness (kN/mm)	Ductility Index
Plain LWC	2.99 ± 0.14	2.88 ± 0.25	1.31 ± 0.15
Bamboo-LWC	7.87 ± 0.37	2.90 ± 0.09	2.72 ± 0.13
Steel-LWC	9.20 ± 0.35	3.09 ± 0.15	3.19 ± 0.35

One-way ANOVA confirmed a highly significant effect of reinforcement type on ductility index ($F(2,9) = 69.72$, $p < .001$). Tukey's HSD showed that all pairwise comparisons were significant, including Bamboo-LWC vs. Steel-LWC (mean difference = 0.47, $p = .046$), indicating that while Steel-LWC exhibited significantly greater ductility than Bamboo-LWC, the difference was comparatively modest next to the much larger gap between either reinforced group and the brittle Plain LWC control (mean difference of 1.41–1.88, $p < .001$).

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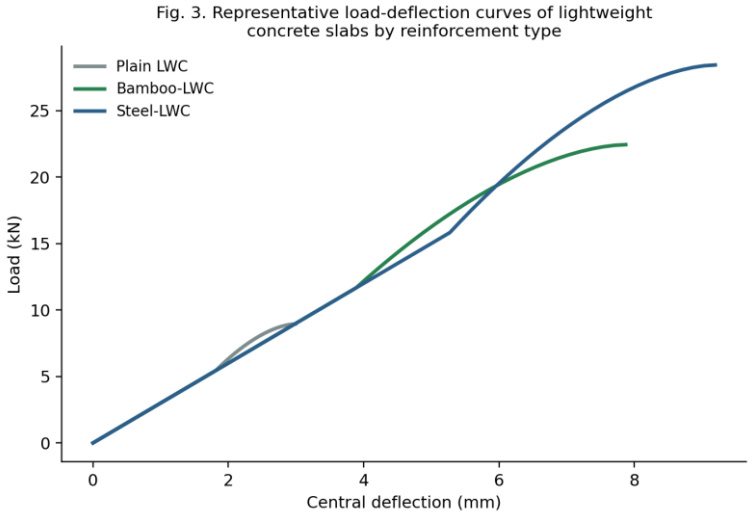


Figure 3. Representative load-deflection curves of lightweight concrete slabs by reinforcement type

4. Bond Strength and Relative Reinforcement Cost

The pull-out bond strength of steel in the lightweight concrete matrix (4.41 ± 0.12 MPa) was significantly higher than that of treated bamboo (2.83 ± 0.20 MPa), confirmed by an independent-samples t-test ($t = -13.87$, $p < .001$), indicating that steel's ribbed surface and rigidity provide superior mechanical interlock with the surrounding LWC matrix compared with the treated bamboo strips. Nonetheless, the bamboo bond strength achieved was sufficient to mobilize the substantial flexural capacity reported for first crack and ultimate load, indicating that the epoxy-and-sand surface treatment applied in this study provided an adequate, if not equivalent, bond mechanism. Based on local material pricing, the relative reinforcement material cost of the Bamboo-LWC group was approximately 18% that of the Steel-LWC group (cost index 1.0 vs. 5.6), reflecting bamboo's substantially lower raw material and processing cost relative to steel rebar.

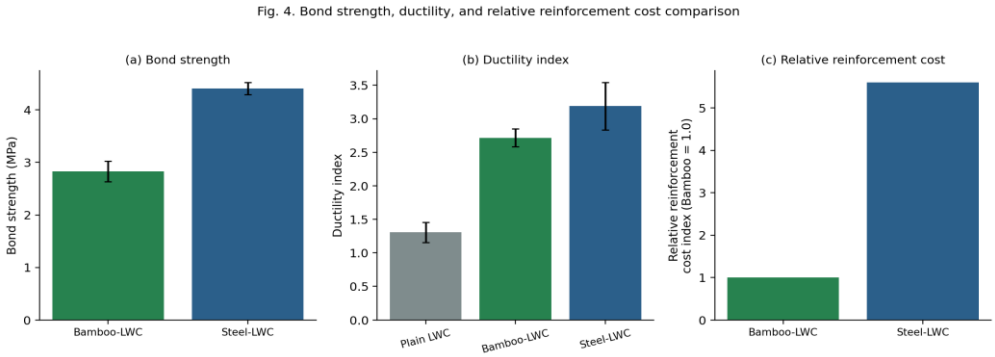


Figure 4. Bond strength, ductility index, and relative reinforcement cost comparison

DISCUSSION

The finding that Bamboo-LWC achieved 78.9% of the ultimate load and 77.1% of the flexural strength of Steel-LWC, while both were significantly higher than the plain concrete control, is consistent with the broader literature establishing bamboo as a structurally credible, though not fully equivalent, alternative to steel reinforcement. Al-Fasih et al. (2021) similarly found that appropriately prepared bamboo strips could achieve flexural performance approaching that of steel-reinforced beams, while

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Qaiser et al. (2020) demonstrated that reinforcement surface treatment—corrugation or wire-wrapping in their study, epoxy-and-sand coating in the present study—is a key lever for narrowing the performance gap between bamboo and steel by improving load transfer at the bamboo-concrete interface. The bond strength results obtained here (2.83 MPa for bamboo vs. 4.41 MPa for steel) help explain the residual performance gap: because bamboo's bond strength remained significantly lower than steel's despite surface treatment, some flexural capacity was likely lost to interfacial slip before the bamboo reinforcement's own tensile strength was fully mobilized, a mechanism also identified by Kanagaraj et al. (2025) as a key factor differentiating high- and low-performing bamboo-reinforced slab configurations.

The lack of a statistically significant difference in stiffness among the three groups (p = .222) is a notable finding that merits closer interpretation. Because stiffness was calculated as the ratio of ultimate load to ultimate deflection, this result indicates that, although Bamboo-LWC and Steel-LWC sustained far larger absolute loads and deflections than Plain LWC, all three groups followed a broadly proportional load-deflection relationship up to their respective failure points—consistent with the initial, reinforcement-independent elastic response of the lightweight concrete matrix itself dominating the pre-cracking stiffness, before reinforcement type increasingly governs post-cracking behavior and ultimate capacity. This pattern reinforces the observation of Kanagaraj et al. (2025) that reinforcement and matrix effects on stiffness versus strength/ductility can decouple in bamboo-reinforced slab systems, and suggests that, for lightweight concrete slabs at least, bamboo reinforcement does not compromise elastic-range performance even where it moderately reduces ultimate strength.

The ductility results—where Bamboo-LWC's ductility index (2.72) approached, though remained significantly below, that of Steel-LWC (3.19), while both vastly exceeded the brittle Plain LWC control (1.31)—align with the general finding across the bamboo-reinforced concrete literature that reinforcement (of either material) fundamentally transforms failure behavior from brittle to a more gradual, warning-providing mode. Kanagaraj et al. (2025) reported an even larger ductility improvement (up to 55%) when bamboo reinforcement was combined with fibre-reinforced geopolymer rather than conventional cement concrete, suggesting that the ductility gap between Bamboo-LWC and Steel-LWC observed in the present cement-based LWC matrix could potentially be further narrowed through matrix modification, an avenue not explored in this study but supported by the wider literature (Awoyera et al., 2024; Sayed et al., 2022).

From a practical design perspective, the combination of a substantial (78.9%) fraction of steel's ultimate capacity, statistically indistinguishable stiffness, meaningfully improved ductility over plain concrete, and an estimated 82% reduction in reinforcement material cost positions Bamboo-LWC as a technically and economically credible option for structural applications where full steel-equivalent capacity is not required—for example, floor and roof slabs in low-rise residential construction, temporary structures, or disaster-relief housing, particularly in regions where bamboo is locally abundant and steel must be transported or imported at high cost (Kumar et al., 2021). This is consistent with the broader sustainability argument advanced throughout the bamboo-reinforced concrete literature: bamboo's markedly lower embodied energy and carbon footprint relative to steel production (Sayed et al., 2022) complements its favorable cost profile, together supporting its adoption in cost- and carbon-sensitive construction contexts rather than as a wholesale substitute for steel in all structural applications.

This study has several limitations. First, the specimens were tested under monotonic short-term flexural loading; bamboo's long-term durability, moisture-related dimensional instability, and susceptibility to biological degradation within a concrete matrix—concerns raised throughout the

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bamboo-reinforced concrete literature—were not evaluated and would require long-term or accelerated-aging testing. Second, only one bamboo treatment method (epoxy-and-sand coating) and one lightweight aggregate type were tested; alternative treatments or aggregate types could yield different performance and bond outcomes, as demonstrated by the matrix-dependent results of Kanagaraj et al. (2025). Third, the relative cost comparison reflects local material pricing at the time of the study and may not generalize to other regions or market conditions.

CONCLUSIONS

This study experimentally compared bamboo and steel reinforcement within an identical lightweight concrete slab matrix under third-point flexural loading. Reinforcement type had a statistically significant effect on first crack load, ultimate load, flexural strength, deflection at failure, and ductility index (one-way ANOVA, $p < .001$ for all), while stiffness did not differ significantly among groups ($p = .222$). Steel-reinforced slabs achieved the highest performance across all strength and ductility metrics, but bamboo-reinforced slabs reached 78.9% of steel's ultimate load and 77.1% of its flexural strength, both significantly exceeding the plain, unreinforced lightweight concrete control, while requiring an estimated 82% lower reinforcement material cost. Bond strength testing confirmed that treated bamboo achieved significantly lower, but structurally functional, bond strength (2.83 MPa) compared with steel (4.41 MPa, $p < .001$). These findings support bamboo-reinforced lightweight concrete slabs as a technically viable and considerably more economical and sustainable alternative to steel-reinforced lightweight concrete for non-critical structural applications such as low-rise housing floor and roof slabs, without claiming full equivalence to steel in applications demanding maximum load-carrying capacity.

Future research should evaluate the long-term durability, moisture-induced dimensional stability, and biological degradation resistance of bamboo reinforcement within lightweight concrete under sustained and environmental loading, explore alternative surface treatments and matrix formulations (including fibre-reinforced and geopolymer matrices) to further narrow the bond-strength and ductility gap with steel, and extend testing to full-scale slab panels under realistic service loading and support conditions to support practical design code development for bamboo-reinforced lightweight concrete structures.

REFERENCES

Agrawal, Y., Gupta, T., Sharma, R. K., Panwar, N. L., & Siddique, S. (2021). A comprehensive review on the performance of structural lightweight aggregate concrete for sustainable construction. *Construction Materials, 1*(1), 39–62. https://doi.org/10.3390/constrmater1010003

Al-Fasih, M. Y., Hamzah, S., Ahmad, Y., Ibrahim, I., et al. (2021). Tensile properties of bamboo strips and flexural behaviour of the bamboo reinforced concrete beams. *European Journal of Environmental and Civil Engineering, 26*(13), 6444–6460. https://doi.org/10.1080/19648189.2021.1945954

Apte, S. D., Dabir, V. V., Dhyani, B. K., & Choudhari, S. P. (2020). Experimental investigation on bamboo as sustainable reinforcement alternative for rural construction. *International Journal of Modern Agriculture, 9*(3), 1348–1358.

Archila, H., Kaminski, S., Trujillo, D., Zea Escamilla, E., & Harries, K. A. (2018). Bamboo reinforced concrete: A critical review. *Materials and Structures, 51*, Article 102. https://doi.org/10.1617/s11527-018-1228-6

Awoyera, P. O., Althoey, F., Bahrami, A., Apuye, P. U., Bendezu R, L. M., Alotaibi, B. S., Prado M, J. M., & Abuhussain, M. A. (2024). Structural retrofitting of RC slabs using bamboo fibre laminate:

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Flexural performance and crack patterns. *Heliyon, 10*(2), e23999. https://doi.org/10.1016/j.heliyon.2024.e23999

Davor, W. S., Damoah, L. N. W., & Agyei-Tuffour, B. (2026). Bamboo as a sustainable alternative construction material: A review. *Advances in Bamboo Science*, Article 100243. https://doi.org/10.1016/j.bamboo.2026.100243

Dey, A., & Chetia, N. (2018). Experimental study of bamboo reinforced concrete beams having various frictional properties. *Materials Today: Proceedings, 5*, 436–444.

Dwarampudi, M., & Venkateshwari, B. (2024). Performance of light weight concrete with different aggregates—a comprehensive review. *Discover Civil Engineering, 1*, Article 46. https://doi.org/10.1007/s44290-024-00015-9

Ferreira, G. C. S., Beraldo, A. L., Moreno, A. L., & Silva, A. O. B. (2016). Flexural and shear behaviour of concrete beams reinforced with bamboo. *International Journal of Sustainable Materials and Structural Systems, 2*(3/4), 335–347. https://doi.org/10.1504/IJSMSS.2016.078732

Fořt, J., Afolayan, A., Medveď, I., Scheinherrová, L., & Černý, R. (2024). A review of the role of lightweight aggregates in the development of mechanical strength of concrete. *Journal of Building Engineering*, Article 109312. https://doi.org/10.1016/j.jobe.2024.109312

Himasree, P. R., Korde, C., West, R. P., & Ganesan, N. (2025). Review of physio-chemical and mechanical properties of bamboo as a reinforcement in concrete. *Journal of Bamboo and Rattan, 24*(2). https://doi.org/10.55899/09734449/jbr024201

Javadian, A., Wielopolski, M., Smith, I. F. C., & Hebel, D. E. (2016). Bond-behavior study of newly developed bamboo-composite reinforcement in concrete. *Construction and Building Materials, 122*, 110–117. https://doi.org/10.1016/j.conbuildmat.2016.06.084

Kadam, S. V., & Bharadiya, N. N. (2026). Investigation of pull-out behavior in treated tulda bamboo reinforcement embedded in SCC. *Innovative Infrastructure Solutions, 11*, Article 68. https://doi.org/10.1007/s41062-025-02473-1

Kanagaraj, B., Sohliya, A., Jayakumar, G., Anand, N., & Lubloy, E. (2025). Performance evaluation of bamboo reinforced concrete slab: A comparative study between fibre reinforced mix and shape optimised composite. *Cleaner Waste Systems, 12*, 100409. https://doi.org/10.1016/j.clwas.2025.100409

Kumar, P., Gautam, P., Kaur, S., Chaudhary, M., Afreen, A., & Mehta, T. (2021). Bamboo as reinforcement in structural concrete. *Materials Today: Proceedings, 46*, 6793–6799. https://doi.org/10.1016/j.matpr.2021.04.342

Mahzuz, H. M. A., Ahmed, M., Dutta, J., & Rose, R. H. (2015). Use of bamboo (*Bambusa balcooa*) as reinforcement in concrete beam. *International Journal of Structural Engineering, 6*(2), 89–108. https://doi.org/10.1504/IJSTRUCTE.2015.069684

Mali, P. R., & Datta, D. (2020). Experimental evaluation of bamboo reinforced concrete beams. *Journal of Building Engineering, 28*, Article 101071. https://doi.org/10.1016/j.jobe.2019.101071

Mondal, B., Maity, D., & Patra, P. K. (2022). Bond behavior between bamboo and normal-strength concrete: Experimental and numerical investigation. *Practice Periodical on Structural Design and Construction, 27*(3). https://doi.org/10.1061/(ASCE)SC.1943-5576.0000715

Qaiser, S., Hameed, A., Alyousef, R., Aslam, F., & Alabduljabbar, H. (2020). Flexural strength improvement in bamboo reinforced concrete beams subjected to pure bending. *Journal of Building Engineering, 31*, 101289. https://doi.org/10.1016/j.jobe.2020.101289

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Qaiser, S., Hameed, A., Alyousef, R., Aslam, F., & Alabduljabbar, H. (2020). Flexural strength improvement in bamboo reinforced concrete beams subjected to pure bending. *Journal of Building Engineering, 31*, Article 101289. https://doi.org/10.1016/j.jobe.2020.101289

Sayed, U., Dauletbek, A., Xin, X., Lorenzo, R., & Li, H. (2022). A review on the mechanical behaviour of bamboo reinforced concrete beams. *Journal of Renewable Materials, 10*(12), 3629–3657. https://doi.org/10.32604/jrm.2022.022624

Sivakumar, [initials and co-authors to be confirmed]. (2023). Experimental analysis on the feasibility of bamboo reinforcement in concrete mix design and comparison with steel reinforced concrete. *Advances in Materials Science and Engineering, 2023*, Article 6931291. https://doi.org/10.1155/2023/6931291

Sumadi, K. A., & Ayop, S. S. (2022). Bamboo as a building materials. *Recent Trends in Civil Engineering and Built Environment, 3*(1), 1344–1352.

Tazowar, M., Siddique, A. F. A., & Ahmed, I. (2023). A novel approach for enhancing the bond performance of bamboo reinforced concrete by surface treatment and corrugation. *Construction and Building Materials*, Article 133728. https://doi.org/10.1016/j.conbuildmat.2023.133728

Terai, M. (2024). Bond properties of bamboo reinforcement. *Journal of Building Engineering, 86*, Article 108890. https://doi.org/10.1016/j.jobe.2024.108890

Thienel, K.-C., Haller, T., & Beuntner, N. (2020). Lightweight concrete—From basics to innovations. *Materials, 13*(5), Article 1120. https://doi.org/10.3390/ma13051120

Umeonyiagu, I. E. (2019). Effect of bamboo reinforcement on the flexural and tensile strengths of concrete beams. *NIPES Journal of Science and Technology Research, 1*(3).

Vijayalakshmi, R., & Ramanagopal, S. (2018). Structural concrete using expanded clay aggregate: A review. *Indian Journal of Science and Technology, 11*(16), 1–12. https://doi.org/10.17485/ijst/2018/v11i16/121888

Wei, Y., Chen, S., Jiang, J., Zhou, M., & Zhao, K. (2022). Experimental investigation of bamboo-concrete composite beams with threaded reinforcement connections. *Journal of Sandwich Structures & Materials, 24*(1), 601–626. https://doi.org/10.1177/10996362211023529

Yang, K.-H., Lee, Y., & Joo, D.-B. (2016). Flexural behavior of post-tensioned lightweight concrete continuous one-way slabs. *International Journal of Concrete Structures and Materials, 10*, 425–434. https://doi.org/10.1007/s40069-016-0169-0