Mechanical Performance of Paving Blocks Incorporating Bamboo Powder as Partial Fine Aggregate Replacement

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Abstract: This study investigates the feasibility of using bamboo powder as a partial replacement for fine aggregate in paving block production. Bamboo powder was incorporated at replacement levels of 0%, 30%, 35%, and 40% by weight of sand. Specimens with dimensions of 105 × 105 × 60 mm were prepared using a vibration-assisted hydraulic press and evaluated in accordance with SNI 03-0691-1996 after 28 days of moist curing. Three replicate specimens were cast for each mixture, and results are reported as mean ± standard deviation. The compressive strength decreased from 193.55 ± 8.24 kg/cm² for the control mixture to 97.96 ± 5.11 kg/cm² at 30% bamboo powder replacement, followed by a gradual increase to 106.22 ± 6.37 kg/cm² and 121.56 ± 7.92 kg/cm² at 35% and 40% replacement levels, respectively. All mixtures satisfied the requirements of Quality Category D (minimum 85 kg/cm²), suitable for parks and garden applications. Water absorption increased from 5.87 ± 0.21% for the control to 6.08–7.80% for bamboo powder contents of 30–40%, shifting the classification from Category B to Category C. An optimum bamboo powder replacement level of 30% is recommended based on the balanced performance between mechanical strength and water absorption. The findings demonstrate the potential of bamboo powder as a sustainable alternative material for non-structural paving block applications.

Keywords: Bamboo powder; Compressive strength; Paving block; SNI 03-0691-1996; Sustainable construction; Water absorption

1. Introduction

The construction sector continues to expand globally, driving the adoption of innovative materials that balance performance and sustainability. Among urban infrastructure elements, paving blocks are widely used for sidewalks, parking areas, parks, and residential roads, offering advantages such as easy maintenance, dimensional consistency, anti-slip surfaces, and weather resistance. Conventional paving blocks are manufactured from mixtures of ordinary Portland cement (OPC), natural fine aggregate (sand), and water[1,2]. However, the increasing extraction of natural sand raises environmental concerns, and there is growing interest in replacing sand with locally available, low-carbon materials[3,4].

Bamboo is among the most abundant and rapidly growing plants in tropical regions[5], particularly in Indonesia, which hosts approximately 176 species[6,7]. The mechanical properties of bamboo high tensile strength, moderate stiffness, and fiber reinforcement capacity are attributed to its sclerenchyma fiber and cellulose content[8-11]. When converted to powder form, bamboo offers a lightweight alternative with a lower carbon footprint than conventional aggregates[12]. Additionally, bamboo powder contains silica and lignin, which may contribute to surface hardness and binding in cementitious matrices[13].

Prior studies have investigated bamboo in various forms as an additive or reinforcement in concrete and paving block composites, including the effect of bamboo fiber variations on concrete compressive strength[14], the effect of bamboo fiber addition on concrete compressive strength[15], bamboo weaving waste in paving blocks[16], bamboo fiber combined with fly ash in paving blocks[17], Ori bamboo fiber in concrete[18], the splitting tensile strength of bamboo fiber concrete[19], the influence of bamboo bark fiber length on concrete properties[20], bamboo fiber addition in paving block production[21], and bamboo shaving waste[22].

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However, limited work has systematically evaluated bamboo powder as a direct fine aggregate replacement in paving block production, particularly in terms of both compressive strength and water absorption at multiple substitution levels. Furthermore, most prior studies do not report experimental uncertainty, which limits the reproducibility and scientific rigor of their findings.

This study addresses these gaps by examining the mechanical performance of paving blocks incorporating bamboo powder at replacement levels of 0%, 30%, 35%, and 40% by weight of sand. Specimens were tested in compliance with SNI 03-0691-1996[23], and results are reported with mean values and standard deviations. The study hypothesizes that bamboo powder can partially substitute natural fine aggregate up to an optimum replacement level while maintaining acceptable compressive strength and water absorption performance.

2. Literature Review

Rahmatullah et al.[24] investigated bamboo stem powder as a substitute for fine aggregate in paving blocks at replacement levels of 0%, 5%, 15%, and 25%. The highest compressive strength of 9.72 MPa was obtained at 5% replacement, while water absorption peaked at 8.15% for the 15% variation. All specimens fell within Quality D according to SNI 03-0691-1996.

Eratodi and Ariawan[22] studied engineered paving blocks from composite cement and bamboo shaving waste, achieving optimal mechanical properties at a 1:4.5:1.5 (cement:bamboo shaving:sand) ratio, with an average compressive strength of 19.8 MPa and a modulus of rupture of 16.40 MPa. The composite paving blocks met the criteria for Class II road pavement material.

Fauzy et al.[16] used bamboo weaving fiber waste as a partial aggregate substitute at 0%, 5%, 15%, and 25%. Compressive strengths at 28 days were 20.7, 17.6, 12.3, and 9.9 MPa, respectively, indicating a consistent decline with higher fiber content. Water absorption ranged from 0.1% to 0.3%, well within allowable limits.

Indrawan[17] compared paving blocks incorporating bamboo fiber and fly ash, finding that combined mixtures achieved compressive strengths of up to 252 kg/cm² at 28 days, meeting SNI Quality Classes C and D. Lestari[7] reported that 1% bamboo fiber addition to a 20 MPa concrete mix yielded the highest compressive strength improvement at 28.01 MPa.

Suhardiman[18] reported that additions of 1%, 1.5%, and 2% Ori bamboo fiber to conventional concrete increased compressive strength by 17.85%, 16.45%, and 3.14%, respectively, relative to the control. Mudjanarko et al.[25] confirmed that bamboo waste used as aggregate in paving blocks could meet SNI Quality Types C and D, supporting its role in green infrastructure.

Collectively, prior research demonstrates a consistent trade-off: bamboo-based materials improve sustainability metrics but tend to reduce compressive strength and increase water absorption at higher replacement levels[26]. The present study extends this body of knowledge by evaluating bamboo powder specifically as a fine aggregate replacement at higher substitution ratios (30–40%) than most prior work, and by providing standard deviations to support reproducibility.

3. Materials and Method

3.1. Raw Materials

Cement: Ordinary Portland Composite Cement (PCC, equivalent to ASTM Type I) conforming to SNI 15-2049-2004[27] was used. The specific gravity of cement was 3.15, with a Blaine fineness of approximately 3,200 cm²/g.

Fine Aggregate: River sand obtained from a local supplier in Pekanbaru, Riau Province, Indonesia was used as the primary fine aggregate. Prior to use, the sand was air-dried and passed through a No. 4 sieve (4.75 mm) to remove oversize particles. Laboratory characterization results are presented in Table 2.

Bamboo Powder: Bamboo waste was collected from local handicraft and furniture processing industries in Pekanbaru. The bamboo species used was Bambusa vulgaris (common bamboo). The raw bamboo culm waste was first air-dried in a sheltered area for seven days, then oven-dried at 105°C ± 5°C until constant mass was achieved (mass change < 0.1% between consecutive measurements at 1-hour intervals). The dried material was ground using a mechanical grinder and sieved through a No. 200 sieve (0.075 mm). The retained fraction passing the No. 30 sieve (0.6 mm) was collected and stored in sealed airtight containers to prevent moisture reabsorption prior to mixing. Characterization of bamboo powder is presented in Table 1.

Mixing Water: Clean potable tap water from the university laboratory supply was used, free from visible impurities, oils, and organic matter, conforming to SNI standards for concrete mixing water.

Table 1: Physical Properties of River Sand and Bamboo Powder

Property	River Sand	Bamboo Powder	Test Standard
Specific Gravity	2.61	1.23	ASTM C128
Bulk Density (kg/m³)	1,540	398	ASTM C29
Moisture Content (%)	2.1	6.8	ASTM C566
Silt Content (%)	3.2	N/A	ASTM C117
Fineness Modulus	2.75	1.87	ASTM C136

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Table 2: Experimental Workflow

Step	Activity	Details	Standard / Equipment
1	Material Procurement & Preparation	Cement (PCC), river sand, bamboo waste (air-dried then oven-dried at 105°C until constant mass), clean tap water	SNI 15-2049-2004; Oven drying
2	Material Testing	Sieve analysis, specific gravity, bulk density, moisture content, silt content	SNI / ASTM standards
3	Mix Design	Four mixtures: 0%, 30%, 35%, 40% bamboo powder (by wt. of sand); cement fixed at 20%	SNI 03-0691-1996
4	Specimen Casting	Mold size 105×105×60 mm; 3 specimens per variation (12 total); vibration-assisted hydraulic press compaction	Hydraulic press; steel molds
5	Curing	Demolded after 24 h; moist curing for 28 days at ambient temperature (28 ± 2°C)	Moist burlap / water misting
6	Compressive Strength Test	Universal Testing Machine; loading rate: 0.25 MPa/s; fc = Pmax / A	SNI 03-0691-1996
7	Water Absorption Test	Oven-dry at 110°C for 24 h → weigh (Md) → immerse in water 24 h → weigh (Mw); WA (%) = (Mw−Md)/Md × 100	SNI 03-0691-1996
8	Data Analysis	Mean, standard deviation, coefficient of variation; SNI quality grade classification	Statistical analysis

3.2. Experimental Workflow

The experimental procedure followed a systematic sequence from material preparation through testing, summarized in Table 2. All laboratory activities were conducted at the Civil Engineering Laboratory, Faculty of Engineering, Islamic University Of Riau.

3.3. Mix Proportions and Specimen Preparation

Four paving block mixtures were designed in accordance with SNI 03-0691-1996. Bamboo powder was substituted for river sand at 0%, 30%, 35%, and 40% by weight of total fine aggregate. The cement content was held constant at 20% by total dry mixture weight across all variations. The water-to-cement (w/c) ratio was maintained at 0.45 for all mixtures. Table 3 presents the mix proportions for each variation.

All dry materials (cement, sand, and bamboo powder) were first weighed to ±0.1 g accuracy using a digital balance and dry-mixed in a mechanical drum mixer for 2 minutes. Water was then added gradually over approximately 1 minute while mixing continued for an additional 3 minutes to ensure homogeneity. The fresh mixture was visually inspected for uniformity before casting.

Three (3) replicate specimens were prepared for each mixture variation, yielding 12 specimens in total. The fresh mixture was placed into steel molds with inner dimensions of 105 × 105 × 60 mm in two layers, each layer being compacted using a vibration-assisted hydraulic press at a vibration frequency of 50 Hz for 10 seconds per layer. Compaction pressure was approximately 10 MPa. Specimens were demolded after 24 hours and cured under moist conditions (burlap covering, water-misted twice daily) for 28 days at ambient laboratory temperature of 28 ± 2°C[28)].

Table 3: Paving Block Mix Composition

Cement (%)	Sand (%)	Bamboo Powder (%)	Volume per Paving Block (cm³)
20	80	0	661.5
20	50	30	661.5
20	45	35	661.5
20	40	40	661.5

3.4. Testing Methods

3.4.1. Compressive Strength Test

Compressive strength tests were performed at 28 days in accordance with SNI 03-0691-1996, using a Universal Testing Machine (UTM) with a capacity of 2,000 kN and an accuracy of ±0.1 kN. Prior to testing, the bearing surfaces of each specimen were inspected for flatness; surfaces with deviations greater than 0.5 mm were capped with a thin layer of gypsum plaster to ensure uniform load distribution. The loading rate was maintained at 0.25 MPa/s. The compressive strength was calculated as:

$$fc = Pmax / A \quad (1)$$

where fc is the compressive strength (MPa), Pmax is the maximum applied load (N), and A is the cross-sectional loading area (mm²). For the 105 × 105 mm specimen, A = 11,025 mm². Each result was converted to kg/cm² for SNI grade classification (1 MPa = 10.197 kg/cm²).

3.4.2. Water Absorption Test

Water absorption was measured in accordance with SNI 03-0691-1996. After the 28-day curing period, specimens were oven-dried at 110°C ± 5°C for 24 hours and allowed to cool to room temperature in a desiccator before being weighed to obtain the oven-dry mass (Md). Specimens were then fully immersed in water at room temperature for

24 hours, surface-dried with a damp cloth, and immediately weighed to obtain the saturated surface-dry mass (Mw). Water absorption was calculated as:

$$WA\ (\%) = [(Mw - Md) / Md] \times 100 \quad (2)$$

where WA is the water absorption percentage, Mw is the saturated surface-dry mass (g), and Md is the oven-dry mass (g). All mass measurements were performed using a digital balance accurate to ±0.01 g.

3.5. Statistical Analysis

For each mixture variation, the mean value ($\bar{x}$), standard deviation (SD), and coefficient of variation (CV, %) were calculated from three replicate specimens. The standard deviation was computed as:

$$SD = \sqrt{[\Sigma(xi - \bar{x})^2 / (n - 1)]} \quad (3)$$

where xi is the individual specimen result, $\bar{x}$ is the mean, and n = 3. Results with CV > 15% were flagged for review and re-testing if necessary. Results are reported as mean ± SD. All specimens fell within the CV threshold, confirming the reproducibility of the mixing and casting procedures.

3.6. SNI 03-0691-1996 Quality Classification

Paving block quality classification follows SNI 03-0691-1996, which defines four grades based on minimum compressive strength and maximum water absorption (Table 4):

4. Results and Discussion

4.1. Material Characterization

The characterization results for river sand confirmed suitability as a fine aggregate: specific gravity 2.61, bulk density 1,540 kg/m³, moisture content 2.1%, and silt content 3.2% (within the SNI maximum limit of 5%). The fineness modulus of 2.75 indicates a medium-graded sand. Bamboo powder showed significantly lower specific gravity (1.23) and bulk density (398 kg/m³) than river sand, reflecting its lignocellulosic, porous nature. The higher moisture content of bamboo powder (6.8%) necessitated oven-drying prior to mixing to control the effective water-to-cement ratio. These properties directly influence the fresh and hardened performance of the resulting paving blocks.

4.2. Effect of Bamboo Powder on Compressive Strength

Table 5 presents the mean compressive strength and associated standard deviations for each mixture variation at 28 days. Figure 1 illustrates the corresponding trend.

The control mixture (0% bamboo powder) achieved the highest compressive strength of 193.55 ± 8.24 kg/cm², classified as SNI Quality Grade B. Upon introduction of 30% bamboo powder, compressive strength decreased substantially to 97.96 ± 5.11 kg/cm², representing a reduction of approximately 49.4% relative to the control. This initial decline is attributed to the replacement of dense, stiff sand particles with the lower-stiffness, porous bamboo powder particles, which weakens the interfacial transition zone (ITZ) between the cement paste and aggregate, promoting earlier microcrack initiation under compressive loading[6].

At 35% replacement, compressive strength recovered slightly to 106.22 ± 6.37 kg/cm², and increased further to 121.56 ± 7.92 kg/cm² at 40% replacement. This non-monotonic trend at higher replacement levels may be attributed to the finer particle size of bamboo powder filling interparticle voids at higher dosages[29], thereby improving particle packing density and partially

Table 4: Paving Block Quality Classification

Grade	Min. Comp. Strength (kg/cm²)	Max. Water Absorption (%)	Typical Application
A	≥350	≤3	Heavy traffic roads
B	≥170	≤6	Light to moderate traffic
C	≥125	≤8	Pedestrian walkways
D	≥85	≤10	Parks and garden pavements

Table 5: Average Compressive Strength of Paving Blocks at 28 Days

Bamboo Powder (%)	Compressive Strength (kg/cm²)	Std. Dev. (kg/cm²)	SNI Quality Grade	Min. Limit (kg/cm²)
0	193.55 ± 8.24	8.24	B	≥170
30	97.96 ± 5.11	5.11	D	≥85
35	106.22 ± 6.37	6.37	D	≥85
40	121.56 ± 7.92	7.92	D	≥85

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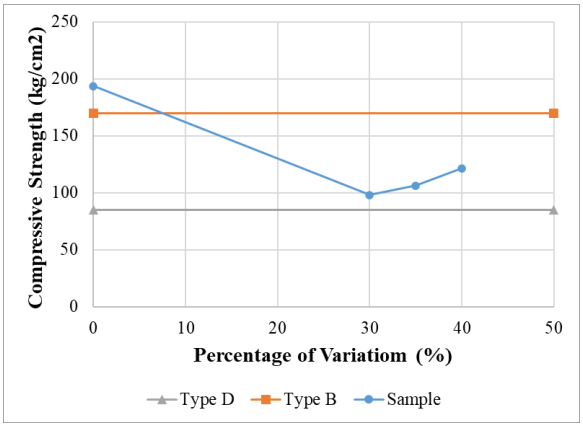

Fig. 1: The Effect of Bamboo Powder Variations on The Compressive Strength of Paving Blocks

compensating for the weaker ITZ. A similar recovery trend has been reported in bio-based aggregate composites where finer-sized organic particles improve void filling above a critical dosage[25,30,31].

A graph of the compressive strength values is shown in Figure 1.

Figure 1 shows the results of the compressive strength test of paving blocks with variations of bamboo powder of 0%, 30%, 35% and 40%. The compressive strength results demonstrate that the incorporation of bamboo powder significantly influences the mechanical performance of paving blocks. The control mixture exhibited the highest compressive strength, while mixtures containing bamboo powder showed a gradual reduction as the replacement level increased.

Despite the reduction from the control, all bamboo powder mixtures met the minimum compressive strength threshold of 85 kg/cm² (SNI Quality Grade D), confirming their suitability for non-structural, low-traffic applications such as parks and garden paths. The relatively low coefficients of variation (CV: 2.6–5.2%) across all mixtures indicate consistent specimen preparation and testing.

Similar trends have been reported in previous studies involving bio-based material such as rice husk ash, sawdust, and coconut fiber, where excessive replacement levels led to strength degradation due to increased porosity and weaker bonding mechanisms.

4.3. Effect of Bamboo Powder on Water Absorption

Table 6 presents the water absorption results with standard deviations for each mixture variation at 28 days.

The control specimen exhibited the lowest water absorption at 5.87 ± 0.21%, classified as SNI Quality Grade B (maximum 6%). Incorporation of bamboo powder progressively increased water absorption: 6.08 ± 0.34% at 30%, peaking at 7.80 ± 0.47% at 35%, with a slight decrease to 7.29 ± 0.52% at 40%. All bamboo powder specimens were classified as Quality Grade C (maximum 8%).

The graph illustrating the water absorption test results for each variation is shown in Figure 2.

As shown in Figure 2, water absorption results reveal a clear increasing trend with higher bamboo powder content. The control specimen exhibited the lowest absorption value, while mixtures containing 35% and 40% bamboo powder showed significantly higher water absorption

The non-monotonic decrease at 40% (from 7.80% at 35% to 7.29% at 40%) is consistent with the improved particle packing hypothesis discussed in Section 4.2, where higher bamboo powder dosage results in better void filling, reducing total accessible pore volume. Nevertheless, both the 35% and 40% specimens exhibited water absorption values well above the SNI Grade B limit (6%), indicating that bamboo powder contents above 30% may compromise long-term durability in exposed environments.

At 30%, the water absorption value of 6.08% only marginally exceeded the Grade B threshold of 6.0%, remaining well within the Grade C limit of 8%. This narrow margin underscores the sensitivity of mix water absorption to bamboo powder content at this substitution level.

The increasing water absorption with higher bamboo powder content is primarily driven by the inherently hygroscopic nature of bamboo's lignocellulosic constituents (cellulose, hemicellulose, and lignin), which readily absorb and retain moisture[32]. Additionally, the irregular morphology and internal porosity of bamboo powder particles create additional capillary pathways within the cementitious matrix, increasing overall pore connectivity and water penetration[33].

Table 6: Water Absorption of Paving Blocks at 28 Days

Bamboo Powder (%)	Water Absorption (%)	Std. Dev. (%)	SNI Quality Grade	Max. Limit (%)
0	5.87 ± 0.21	0.21	B	6
30	6.08 ± 0.34	0.34	C	8
35	7.80 ± 0.47	0.47	C	8
40	7.29 ± 0.52	0.52	C	8

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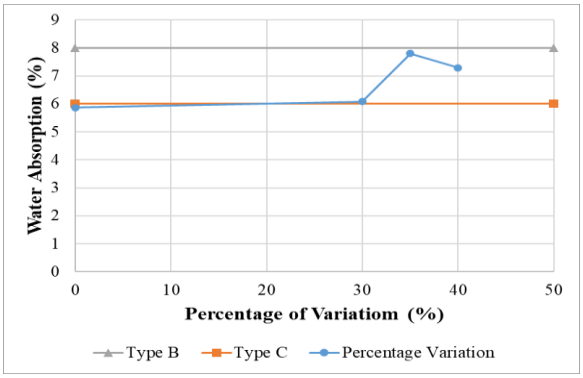

Fig. 2: Water Absorption of Paving Block

4.4. Relationship Between Compressive Strength and Water Absorption

An inverse relationship between compressive strength and water absorption is evident: as bamboo powder content increased from 0% to 30%, compressive strength decreased substantially while water absorption increased. This reflects the dominant role of porosity in controlling both mechanical and durability performance. Porous bamboo particles weaken load-bearing capacity while simultaneously providing additional moisture pathways within the cement matrix.

The non-monotonic trend observed at 35% and 40% (strength recovery and absorption decrease) suggests a secondary effect attributable to void filling at higher bamboo powder dosages. However, the net mechanical performance of these mixtures remains inferior to the control, and their water absorption levels indicate diminished resistance to environmental moisture.

From a practical standpoint, the 30% replacement level represents the optimum trade-off: it satisfies SNI Quality Grade D for compressive strength (97.96 kg/cm² vs. minimum 85 kg/cm²) and Grade C for water absorption (6.08% vs. maximum 8%), while offering the highest sand-replacement ratio within acceptable performance limits

4.5. Durability Considerations and Limitations

Although the paving blocks incorporating bamboo powder met SNI Grade D classification for both compressive strength and water absorption, several durability concerns must be acknowledged. Bamboo powder is a lignocellulosic material susceptible to moisture-induced dimensional changes, biological degradation by fungi and bacteria, and interfacial deterioration under repeated wet–dry cycles[34–36]. At higher replacement levels, greater porosity and hygroscopicity may accelerate these mechanisms over time.

While cement encapsulation of bamboo particles limits direct microbial access, studies on organic fiber-reinforced cementitious composites have documented interfacial degradation after prolonged exposure to moisture and thermal cycling[34]. Furthermore, the present study was limited to 28-day testing and did not assess long-term performance, freeze–thaw resistance, abrasion resistance, or biological susceptibility. These parameters are critical for broader deployment scenarios.

The use of bamboo powder at replacement levels of 30–40% is therefore recommended exclusively for non-structural, low-exposure applications such as garden paths, landscaping, and decorative pavements in sheltered environments. Future research should evaluate surface treatment strategies—such as silane coupling agents or cement–silica fume coatings—to mitigate the hygroscopic behavior of bamboo particles at the interfacial zone.

5. Conclusion

This study investigated the mechanical performance of paving blocks incorporating bamboo powder as a partial fine aggregate replacement at levels of 0%, 30%, 35%, and 40% by weight of sand. The following conclusions are drawn:

a) Compressive strength decreased from 193.55 ± 8.24 kg/cm² (control, Grade B) to 97.96 ± 5.11 kg/cm² at 30% bamboo powder replacement, with a gradual recovery to 121.56 ± 7.92 kg/cm² at 40%. All bamboo powder mixtures satisfied SNI Quality Grade D (minimum 85 kg/cm²), confirming suitability for low-traffic, non-structural applications.

b) Water absorption increased from 5.87 ± 0.21% (Grade B) for the control to a range of 6.08–7.80% for bamboo powder contents of 30–40%, classifying all bamboo powder specimens as Grade C. All results remained within the Grade C maximum limit of 8%.

c) A non-monotonic behavior was observed at 35% and 40% replacement levels for both compressive strength (partial recovery) and water absorption (slight decrease from 35% to 40%), tentatively attributed to improved particle packing at higher bamboo powder dosages.

d) 30% bamboo powder replacement level is recommended as the optimum, balancing compressive strength and water absorption while maintaining SNI Grade D compliance.

Future studies should evaluate long-term durability, biological resistance, freeze–thaw performance, and life-cycle environmental impact to support broader deployment of bamboo powder-based paving materials.

References

1) T. Mulyono, "Technology of Concrete: From Theory to Practice", 4th ed., pp. 207–326, 2019.
2) B.A. Tombeg, and R. Rumbayan, "Construction Material Technology", Polimdo Press, Manado, 2020.
3) Mulyati and S. Maliar, “Effect of fly ash as aggregate

replacement on compressive strength of paving blocks," Jurnal Momentum, vol. 17 (1) (2015).
4) A.N. Majid and S. Permana, "Use of fine aggregate from paving block waste for concrete mixtures," J. Konstr., vol. 19 (2), pp. 440–450 (2021).
5) A.D.Y. Winoto, "Bamboo construction for buildings," Ensiklopedia Teknik Bangunan (2014).
6) P. Zakikhani, R. Zahari, M.T.H. Sultan, and D.L. Majid, "Extraction and preparation of bamboo fibre-reinforced composites," Materials and Design, vol. 63, pp. 820–828 (2014). https://doi.org/10.1016/j.matdes.2014.06.058.
7) A. Widjaja, "The spectacular Indonesian bamboos" (2019).
8) Morisco, "Bamboo Engineering," Nafiri Offset, Yogyakarta, Indonesia (1996).
9) T. Afrin, T. Tsuzuki, and X. Wang, "Bamboo fibres and their unique properties," in Proc. Combined (NZ and AUS) Conference of the Textile Institute, Natural Fibres in Australasia, Dunedin, pp. 77–82 (2009).
10) K. Okubo, T. Fujii, and Y. Yamamoto, "Development of bamboo-based polymer composites and their mechanical properties," Composites Part A: Applied Science and Manufacturing, vol. 35 (3), pp. 377–383 (2004).
11) S. Subash, S.J.B. Retnam, and E.R.J. Dhas, "A review of extraction of bamboo fibres and its properties," International Journal of Advanced Chemical Sciences and Applications, vol. 5 (2), pp. 22–27 (2017).
12) R.H. Dairi and Aminuddin, "Utilization of natural lime as partial cement replacement with sea sand in concrete mixtures," Jurnal Media Inovasi Teknik Sipil Unidayan, vol. 2, pp. 124–131 (2017).
13) V. Ordonez, H. Baykara, A. Riofrio, M. Cornejo, and R. Rodríguez, "Preparation and characterization of Ecuadorian bamboo fiber–low-density polyethylene (LDPE) biocomposites," Evergreen, vol. 10 (1), pp. 43–54 (2023). https://doi.org/10.5109/6781037.
14) D.D. Lestari, "Effect of bamboo fiber mixture variations on the compressive strength of fiber concrete," Dinamika Teknik Sipil, vol. 15 (1), pp. 1–7 (2022). https://doi.org/10.23917/dts.v1i1.17027.
15) J.O. Simanjuntak and S. Lubis, "Effect of bamboo fiber addition on the compressive strength of concrete," CONSTRUCT: Jurnal Teknik Sipil, vol. 1 (2), pp. 70–75 (2022).
16) A.R. Fauzy, A.D. Limantara, and Y.C.S. Purnomo, "Utilization of bamboo weaving waste as a standard mix design additive for paving blocks," Jurnal Manajemen Teknologi & Teknik Sipil, vol. 1 (1), pp. 137–147 (2018).
17) Indrawan, "Comparative analysis of bamboo fiber and fly ash paving blocks," Universitas Narotama (2017).
18) M. Suhardiman, "Study of the effect of Ori bamboo fiber addition on compressive and tensile strength of concrete," Jurnal Teknik, vol. 1 (2) (2011).
19) H. Ramadani, "Analysis of the effect of bamboo fiber addition on splitting tensile strength of concrete," Universitas Medan Area, Medan (2019).
20) Ma'ruf, Ismeddiyanto, and A. Kurniawandy, "Effect of bamboo bark fiber length on the mechanical properties of concrete," Jom FTTEKNIK, vol. 2 (2) (2015).
21) M. Nur, N. Aida, and P.N. Ketapang, "Effect of bamboo fiber addition in paving block production on compressive strength," UII (2018).
22) I.G.L.B. Eratodi and M.D. Ariawan, "Engineering of composite cement from bamboo shaving waste as an alternative road pavement material (paving block)," J. Tek. Sipil, vol. 14 (1), pp. 20–28 (2017).
23) Standar Nasional Indonesia, "SNI 03-0691-1996: Bata Beton (Paving Block)," Badan Standardisasi Nasional (1996).
24) M.H. Rahmatullah, A.I.N. Diana, and S. Fansuri, "Utilization of bamboo stem powder waste as a fine aggregate substitute in paving blocks: effects on compressive strength and water absorption," Jurnal Teknik Sipil, vol. 3 (2), pp. 387–394 (2022). https://doi.org/10.31284/j.jts.2022.v3i2.3325.
25) S.W. Mudjanarko, M. Mayestino, N. Rasidi, Indrawan, and I.M. Setiawan, "Bamboo waste as part of the aggregate pavement: the way of green infrastructure in the future," MATEC Web of Conferences, vol. 138, p. 03013 (2017). https://doi.org/10.1051/matecconf/201713803013.
26) D. Behera, S.S. Pattnaik, D. Nanda, P.P. Mishra, and S. Manna, "A review on bamboo fiber reinforced composites and their potential applications," Emergent Materials, vol. 8, pp. 157–172 (2025). https://doi.org/10.1007/s42247-024-00832-9.
27) Standar Nasional Indonesia, "SNI 15-2049-2004: Portland Cement," Badan Standardisasi Nasional (2004).
28) S. Ram, A. Dengri, and R. Kumar, "Assessment of compressive strength in ordinary Portland cement concrete: a study of curing methods and duration," Evergreen, vol. 11 (2), pp. 640–651 (2024). https://doi.org/10.5109/7183321.
29) A. Ardianisa, "Effect of catalyst type and particle size on the properties of cement board from petung bamboo waste," Master's Thesis, Universitas Gadjah Mada, Yogyakarta, Indonesia (2013).
30) H. Sosiati, Hidayatullah, and S. Hamdan, "Effect of woven E-glass and bamboo stacking sequences on the properties of laminated composites using polyester matrix filled with eggshell microparticles," Evergreen, vol. 11 (2), pp. 693–700 (2024). https://doi.org/10.5109/7183343.

Cite: Harmiyati et al., "Mechanical Performance of Paving Blocks Incorporating Bamboo Powder as Partial Fine Aggregate Replacement". Evergreen, 13 (04) 1512-1519 (2026). https://doi.org/10.5109/7452636.

31) A. Kumar, S. Kumar, and S. Jindal, “Enhancing composite material fabrication through optimization: employing fruit peel or shell powder as reinforcements using Taguchi-GRA-PCA methodology,” Evergreen, vol. 11 (2), pp. 701–712 (2024). https://doi.org/10.5109/7183345.
32) G. Illya and I. Bali, “Comparative study of mechanical properties of bamboo fibers,” Jurnal Muara Sains, Teknologi, Kedokteran, dan Ilmu Kesehatan, vol. 5 (2), pp. 383–390 (2021).
33) A.F. Ridassepri, F. Rahmawati, K. Raras Heliani, Chairunnisa, J. Miyawaki, and A.T. Wijayanta, “Activated carbon from bagasse and its application for water vapor absorption,” Evergreen, vol. 7 (3), pp. 409–416 (2020). https://doi.org/10.5109/4068621.
34) B. Kumar and D. Dahiya Grover, “Optimizing agricultural waste powder epoxy composite for enhanced strength using a hybrid Taguchi-GRA-PCA approach,” Evergreen, vol. 11 (2), pp. 713–721 (2024). https://doi.org/10.5109/7183347.
35) D. Sukirna, D.J. Dhaneswara, J. Siregar, and J. Fajar, “Synthesis of mesoporous silica from sugarcane bagasse ash using Pluronic 123 as a colorant adsorbent for brilliant green,” Evergreen, vol. 11 (2), pp. 1366–1374 (2024). https://doi.org/10.5109/7183448.
36) S. Shettigar, M.C. Gowrishankar, and M. Shettar, “Review on aging behavior and durability enhancement of bamboo fiber-reinforced polymer composites,” Molecules, vol. 30 (15), art. 3062 (2025). https://doi.org/10.3390/molecules30153062.