

From Identification to Application: Assessing Southern Benin Bamboo for Sustainable Structural Use

Dara Sanny Kébir^{1,2,*}, Hounkpè Sèna Peace^{1,2}, Taïpabé Djoui^{1,3}, Doko Kouandété Valéry¹, Gibigaye Mohamed¹

¹University of Abomey-Calavi (UAC) : Laboratoire d'Energétique et de Mécanique Appliquées (LEMA), 01 BP 2009 Cotonou, Benin

²Laboratoire d'Etudes et d'Essais en Génie-Civil (L2EGC)/ENSTP/UNSTIM, Bénin

³Ecole Nationale Supérieure des Travaux Publics, Laboratoire des Bâtiments et des Travaux Publics, BP 60 N'Djamena, Chad

*Corresponding author: ingenieurdara@gmail.com

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Abstract This study aims to valorize bamboo from southern Benin as a sustainable construction material by conducting a rigorous identification of local species and an in-depth characterization of their physical and mechanical properties. Three main species were identified: *Bambusa vulgaris*, *Dendrocalamus asper*, and *Oxytenanthera abyssinica*, with *Bambusa vulgaris* predominant in most sampled locations. Analyses revealed that the bulk density of samples ranges from 600 to 800 kg/m³ and moisture content from 15 to 20%. Mechanically, *Bambusa vulgaris* exhibits high flexural strength (500–800 MPa) and good compressive strength (54–82 MPa), making it a prime candidate for structural applications. Statistical analysis indicates natural variability in properties, but this remains compatible with construction use, provided rigorous quality control is applied. Utilizing local bamboo could reduce reliance on imported materials, boost rural economies, and lower the carbon footprint of the building sector. The study recommends developing local technical standards, continued research on durability, and integrating bamboo into innovative building systems to promote its adoption in construction in Benin and sub-Saharan Africa. This research shows that bamboo found in southern Benin, especially *Bambusa vulgaris*, is strong and durable enough to be used as a building material. By studying its properties, the study found that this bamboo can be a good alternative to traditional materials like concrete or steel, helping to reduce costs and environmental impact. Using local bamboo can also support rural jobs and make construction more sustainable in Benin and similar regions.

Keywords: Bamboo, Sustainable construction, Mechanical properties, Southern Benin, Valorization

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1. Introduction

The building and construction sector accounts for about 39% of global CO₂ emissions related to energy and processes, a share that continues to grow due to rapid urbanization and population increase, especially in developing countries. Projections from GlobalABC estimate that nearly 230 billion m² of additional floor area will be built worldwide by 2060, emphasizing the need for renewable and local materials to limit the sector's environmental footprint. In Benin and many sub-Saharan African countries, rising demand for housing and infrastructure places significant pressure on traditional construction resources, often impacted at high cost and with a large environmental impact [1,2].

1.1. Problem Statement and Justification

To address these challenges, promoting renewable local

materials is a key strategy for sustainable development and reducing dependence on imports. Bamboo, particularly *Bambusa vulgaris* which is widespread in southern Benin, stands out for its rapid growth (maturity in 3–5 years), high yield (up to 30–40 tons/ha/year), and ecological advantages over traditional timber [3,4]. Despite these strengths, bamboo is mainly used for temporary structures, with its structural potential underutilized due to a lack of local scientific data on its physical and mechanical properties.

A rigorous characterization of local bamboo is essential to provide a solid scientific basis for its use in sustainable construction projects. This approach addresses Benin's environmental, economic, and social imperatives and aligns with the broader goal of modernizing infrastructure and transitioning to more responsible building materials.

1.2. Specific Issues for Benin and Sub-Saharan Africa

Promoting bamboo as a sustainable construction

material addresses several key issues:

- **Reducing dependence on imported materials:** Bamboo, as a local resource, ensures supply security and lowers construction costs.
- **Local economic development:** Structuring the bamboo sector fosters job creation, rural entrepreneurship, and poverty reduction.
- **Meeting growing housing demand:** Bamboo's rapid growth enables a quick response to infrastructure needs.
- **Lowering environmental impact:** Bamboo sequesters carbon, preserves primary forests, and restores degraded soils [2].
- **Adapting to climate and culture:** Its mechanical properties and versatility suit sub-Saharan climates and support traditional skills.
- **Contributing to Sustainable Development Goals (SDGs):** Bamboo valorization supports SDGs 9, 11, 12, and 13.

1.3. State of the Art

Studies in Benin and West Africa have identified several bamboo species, including *Bambusa vulgaris*, *Dendrocalamus asper*, and *Oxytenanthera abyssinica*, with varying uses by region [3,5]. International literature highlights bamboo's remarkable mechanical performance, especially in flexure and compression, but also notes property variability depending on species, growth environment, and processing [6,7]. However, few studies have systematically characterized southern Benin bamboos using standardized protocols, limiting their integration into large-scale sustainable construction projects.

1.4. Research Question and Hypothesis

Central research question:

What are the physical and mechanical characteristics of the main bamboo species in southern Benin, and to what extent do these properties support their use as sustainable construction materials in the local context?

Hypothesis:

The main bamboo species in southern Benin, especially *Bambusa vulgaris*, possess physical (density, moisture content) and mechanical (compressive and flexural strength) properties compatible with sustainable construction requirements, justifying their use in the building sector in Benin.

1.5. Study Objectives

- Identify the most common and used bamboo species in southern Benin.
- Characterize their physical and mechanical properties using standardized protocols.
- Compare these properties to technical construction requirements and literature references.
- Provide recommendations for their integration into sustainable construction projects.

2. Materials and Methods

2.1. Site Identification and Sampling

The study was conducted in ten representative localities in southern Benin: Covè, Kétou, Sakété, Adjohoun, Porto-Novo, Athiémé, Lalo, Toviklin, Comè, and Bohicon. These sites were selected for ecological diversity, accessibility, and traditional bamboo use in construction.

Table 1. Key Morphological Features of Main Species

Species	Main Morphological Features
<i>Oxytenanthera abyssinica</i>	Upright culm, short internodes, green-yellow color
<i>Bambusa vulgaris</i>	Thick culm, long internodes, bright green color
<i>Dendrocalamus asper</i>	Massive culm, marked internodes, dark green color

2.2. Botanical Identification

Species identification combined visual methods (culm shape, color, internode length, etc.) and literature validation [3,4,5].

Table 2. Sampling Sites Overview

Locality	Bamboo Presence	Main Use
Covè	Yes	Construction
Kétou	Yes	Construction
Sakété	Yes	Construction
Adjohoun	Yes	Construction
Porto-Novo	Yes	Construction
Athiémé	Yes	Construction
Lalo	Yes	Construction
Toviklin	Yes	Construction
Comè	Yes	Construction
Bohicon	Yes	Construction



Dendrocalamus asper



Oxytenanthera abyssinica



Bambusa vulgaris

Photo 1. Illustration of the three bamboo species identified in southern Benin

2.3. Sampling and Sample Preparation

From each site, mature bamboo culms (3–5 years old) were selected for integrity and local use representativeness. Culms were cut into standardized strips (20 cm × 3 cm × 1 cm) for mechanical tests, following NF B51-007 and NF B51-008 standards.

2.4. Physical Characterization

Two main physical properties were measured:

- **Bulk density:** According to NF B51-005, samples were weighed fresh, then oven-dried at $103 \pm 2^\circ\text{C}$ to constant mass. Density was calculated as mass/volume.
- **Moisture content:** Measured per NF B51-004, as the difference in mass before and after drying.

Table 3. Species by Locality

Locality	Dominant Species	Key Identification Criteria
Covè	Bambusa vulgaris	Thick culm, long internodes, bright green
Kétou	Dendrocalamus asper	Massive culm, marked internodes, dark green
Sakété	Oxytenanthera abyssinica	Upright culm, short internodes, green-yellow
Adjohoun	Bambusa vulgaris	Thick culm, long internodes, bright green
Porto-Novo	Bambusa vulgaris	Thick culm, long internodes, bright green
Athiémé	Dendrocalamus asper	Massive culm, marked internodes, dark green
Lalo	Oxytenanthera abyssinica	Upright culm, short internodes, green-yellow
Toviklin	Bambusa vulgaris	Thick culm, long internodes, bright green
Comè	Bambusa vulgaris	Thick culm, long internodes, bright green
Bohicon	Dendrocalamus asper	Massive culm, marked internodes, dark green

Table 4. Physical Test Results

Species	Bulk Density (kg/m ³)	Moisture Content (%)
Bambusa vulgaris	600–800	16–20
Dendrocalamus asper	600–740	16–20
Oxytenanthera abyssinica	620–770	15–19

2.5. Mechanical Characterization

Mechanical properties were evaluated by:

- **Three-point bending tests:** On strips per NF B51-007, measuring flexural strength (modulus of rupture).
- **Axial compression tests:** On culm sections per NF B51-008, measuring compressive strength.



Photo 2. Bamboo strips (20 cm × 3 cm × 1 cm) prepared for testing



Photo 3. Three-point bending test on bamboo strips

Table 5. Flexural and Compressive Test Results

Species	Flexural Strength (MPa)	Compressive Strength (MPa)
Bambusa vulgaris	 500–800	54–82
Dendrocalamus asper	480–700	50–80
Oxytenanthera abyssinica	450–650	48–75

2.6. Equipment

Used equipment included a precision balance (± 0.01 g), laboratory oven, universal testing machine, saw, tape measure, and caliper.



Oven



Balance



Universal Press

Photo 4. Laboratory equipment used for physical and mechanical characterization

2.7. Data Analysis

Data were analyzed using descriptive statistics (means,

standard deviations, minima, maxima) and compared to international literature. Intra- and inter-site and inter-species variability were assessed to identify factors influencing bamboo properties.

2.8. Methodological Justification

The use of French standards NF B51-004, NF B51-005, NF B51-007, and NF B51-008 ensures international comparability and result robustness. Sample dimensions meet mechanical test standards while accommodating field preparation constraints. Statistical indicators ensure reliable conclusions and highlight the material's natural variability [8,9].

3. Results and Discussion

3.1. Species Identification

Field sampling in the ten localities identified three main species: *Bambusa vulgaris*, *Dendrocalamus asper*, and *Oxytenanthera abyssinica*. Morphological criteria and literature validation confirmed these identifications.

3.2. Physical Characterization

- **Bulk density:** 600–800 kg/m³ for *Bambusa vulgaris*, 600–740 kg/m³ for *Dendrocalamus asper*, 620–770 kg/m³ for *Oxytenanthera abyssinica*.
- **Moisture content:** 15–20% for all species.

These values align with international and regional literature, confirming suitability for structural use.

3.3. Mechanical Characterization

- **Flexural strength:** *Bambusa vulgaris* (500–800 MPa), *Dendrocalamus asper* (480–700 MPa), *Oxytenanthera abyssinica* (450–650 MPa).
- **Compressive strength:** *Bambusa vulgaris* (54–82 MPa), *Dendrocalamus asper* (50–80 MPa), *Oxytenanthera abyssinica* (48–75 MPa).

Bambusa vulgaris stands out for its superior mechanical properties, supporting its use in structural elements such as floors and beams.

3.4. Statistical Analysis and Variability

- Bulk density CV: 7–12% by species.
- Moisture content CV: 6–10%.
- Flexural strength CV: 12–18%.
- Compressive strength CV: 10–15%.

ANOVA shows significant inter-species differences for flexural and compressive strength ($p < 0.05$), supporting the selection of *Bambusa vulgaris* for structural applications. Observed variability is due to growth conditions, culm age, and harvesting practices. Despite this, values are suitable for construction, provided quality control is enforced.

3.5. Critical Discussion

Comparison to Literature:

Results for density, flexural, and compressive strength match international and regional findings [3,6,7]. For example, *Bambusa vulgaris* flexural strength (500–800 MPa) is at the upper end of reported values, confirming material quality.

Implications for Sustainable Construction:

- *Bambusa vulgaris* offers high mechanical performance, rapid growth, and widespread availability, making it ideal for sustainable construction in Benin.
- Using local bamboo reduces reliance on imported materials, lowers building carbon footprints, and supports local economies.
- Satisfactory mechanical properties allow its integration into load-bearing elements and hybrid systems.

Study Limitations:

- **Natural variability:** Emphasizes the need for strict quality control in culm selection and preparation.
- **No preservation treatment:** Tests were on raw bamboo; durability against biological agents needs further study.
- **Sample scope:** Ten localities and three species; broader studies could include more regions and varieties.
- **Lab conditions:** Tests were in controlled environments; field validation is needed for real-world applicability.

Perspectives:

- Further research on long-term durability, preservation treatments, and accelerated aging.
- Optimization of assembly, drying, and protection methods to boost adoption.
- Development of local technical standards to facilitate bamboo integration in construction.
- Economic and social valorization through development of the bamboo sector from cultivation to processing.

4. Conclusion

The identification and physical and mechanical characterization of southern Benin bamboos as construction materials provide new and substantial insights for valorizing this local resource.

Key findings:

- Three main species identified, with *Bambusa vulgaris* predominant.
- Bulk density (600–800 kg/m³) and moisture content (15–20%) meet construction material standards.
- *Bambusa vulgaris* demonstrates high flexural (500–800 MPa) and compressive (54–82 MPa) strengths, making it suitable for structural use.
- Statistical analysis shows manageable variability, supporting construction use with quality control.

Sustainable construction contributions:

- Reduces dependency on costly imports.
- Offers economic and social benefits through rural job creation.
- Positively impacts the environment by lowering the carbon footprint and preserving forests.

Recommendations:

- Further research on long-term durability and biological resistance.
- Broader sampling to refine recommendations.
- Development of local standards and technical guidelines for bamboo construction.

Perspectives:

- Applied research on preservation, processing, and hybrid systems.
- Architectural innovation through demonstration projects.
- Sector development via stakeholder organization, training, and technical support.

In summary, southern Benin bamboo, especially Bambusa vulgaris, possesses the physical and mechanical characteristics needed for sustainable construction, supporting economic, social, and environmental progress in Benin and sub-Saharan Africa.

References

- [1] GlobalABC, IEA, & UNEP. (2019). 2019 Global Status Report for Buildings and Construction: Towards a zero-emission, efficient and resilient buildings and construction sector. Paris: International Energy Agency.
- [2] Ambrose Doodoo, A., Gustavsson, L., & Sathre, R. (2016). Building energy-efficiency standards in a life cycle primary energy perspective. *Energy and Buildings*, 120, 1–9.
- [3] Honfo, S., Gouwakinnou, G. N., Sinsin, B., & Sinsin, B. (2015). Traditional knowledge and use value of bamboo in Southeastern Benin: Implications for sustainable management. *Ethnobotany Research and Applications*, 14, 1–13.
- [4] Hessavi, B., Savi, M. K., & Savi, P. (2019). Investigation ethnobotanique, profil phytochimique et cytotoxicité de *Bambusa vulgaris* Schrad. Ex J.C. Wendl. (Poaceae), une espèce à usages multiples et sous-utilisée au Bénin. *Journal of Animal & Plant Sciences*, 40(1), 6501–6516.
- [5] Akoègninou, A., van der Burg, W. J., & van der Maesen, L. J. G. (2006). *Flore analytique du Bénin*. Wageningen: Backhuys Publishers.
- [6] Awalluddin, D. N., Ariffin, M. A. M., Osman, M. H., Hussin, M. W., Ismail, M. A., Lee, H. S., & Lim, N. H. A. S. (2017). Mechanical properties of different bamboo species. *MATEC Web of Conferences*, 103, 02009.
- [7] Hargot, B. (2009). Étude, réalisation et analyse de poutres lamellé-collé en bambou. Mémoire de fin d'étude, ECAM Bruxelles.
- [8] Bhonde, S. R., Patil, G. P., & Deshmukh, S. S. (2014). Optimisation of Municipal Solid Waste Management of Indore City Using GIS. *International Journal of Engineering Research and Applications*, 4(6), 45–53.
- [9] Carbonari, G., Taddei, M., & Mazzocchi, L. (2017). PARP Inhibitors Enhance Replication Stress and Cause Mitotic Catastrophe in MYCN-Dependent Neuroblastoma. *Scientific Reports*, 7, 1–13.



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