

EXPERIMENTAL INVESTIGATION ON GEOMETRIC, PHYSICAL AND MECHANICAL PROPERTIES OF DENDROCALAMUS GIGANTEUS IN SRI LANKA

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Abstract

Bamboo is a fast-growing, low-carbon material with strong potential for sustainable construction, yet its structural use in Sri Lanka remains limited by the absence of species-specific engineering data. This study experimentally characterised the geometric, physical and mechanical properties of *Dendrocalamus giganteus* to assess its potential for structural applications. Mature culms harvested from Balangoda were evaluated using international bamboo grading and testing procedures. Geometric properties, including external diameter, wall thickness, taper, bow, ovality and internodal length, were measured on 188 culm sections. Basic density, linear mass, compression, tension and shear parallel to the fibres, and tension perpendicular to the fibres were also determined. Moisture contents of specimens in all mechanical test series ranged from 9 to 15 percent at testing. The mean external diameter and wall thickness were 157 mm and 10.8 mm, respectively, while mean basic density was approximately 662 kg/m³. Mean compressive, tensile and shear strengths parallel to the fibres were 46.85 MPa, 153.04 MPa and 8.47 MPa, respectively. Tensile strength perpendicular to the fibres was substantially lower at 1.75 MPa, indicating susceptibility to longitudinal splitting. The findings establish a first-stage engineering property dataset for the sampled material and support further structural assessment, while highlighting the need for additional tensile testing and careful detailing against splitting. Application requires consideration of sampling limitations and material variability, together with appropriate derivation of design values.

Keywords: Sustainable construction, Renewable materials, Structural grading, Orthotropic strength, Longitudinal splitting

1. Introduction

Bamboo is increasingly recognised as a renewable, low-embodied-carbon alternative to conventional construction materials, with rapid growth and a favourable strength-to-weight ratio [1], [2]. Sri Lanka contains several bamboo species, yet structural use remains limited because reliable species-specific engineering data are scarce. Bamboo is an orthotropic and naturally variable material whose properties depend on species, culm position, moisture condition and nodes; therefore, engineering properties should be established for the material and region of intended use [1]. *Dendrocalamus giganteus* (*D. giganteus*), commonly known as giant bamboo, is available in Sri Lanka and is characterised by large culm dimensions that may be advantageous for structural applications. However, a systematic engineering dataset for Sri Lankan *D. giganteus* has not been established. This study therefore characterises its geometric, physical and mechanical properties using recognised ISO procedures and provides a first-stage dataset for future structural assessment and design.

2. Materials and Methods

Mature culms of *D. giganteus*, free from visible defects, were harvested from the Balangoda region of Sri Lanka (approximately 6°39'N, 80°41'E; elevation 552 m; relative humidity 80–88%). Geometric properties, including external diameter, wall thickness, internodal length, bow, internal and external taper, and ovality, were determined at multiple positions along the culms in accordance with ISO 19624:2018 [3]. Physical properties (basic density and linear mass) and mechanical properties were determined in accordance with ISO 22157:2019 [4]. Moisture contents of specimens in all mechanical test series ranged from 9–15% at the time of testing. Compression parallel to the fibres was tested using short full-culm specimens; tension parallel to the fibres was tested using tabbed coupons cut from the culm wall; shear parallel to the fibres was evaluated using the prescribed shear specimen; and tension perpendicular to the fibres was assessed using the split-pin method. Each mechanical test series comprised 30 specimens with valid results. Table 1 summarises the geometric and physical properties.

Table 1: Summary of geometric and physical properties of *D. giganteus*.

Property	n	Mean	Min–Max
External diameter (mm)	188	157	107–194
Wall thickness (mm)	188	10.8	6.08–20.2
Diameter/thickness ratio	188	15.16	8.37–20.63
Internodal length (mm)	30	332	217–468
Basic density (kg/m ³)	30	662	386.3–871.8
Linear mass (kg/m)	30	4.10	0.71–8.59

3. Results and Discussion

The geometric survey confirmed that *D. giganteus* is a large-diameter species, with a mean external diameter of 157 mm and a mean wall thickness of 10.8 mm. The mean diameter-to-thickness ratio of 15.2 indicates a comparatively stocky culm section. Ovality (0.04), bow (1.86%) and taper (external 0.18%; internal 0.07%) were modest, indicating reasonably regular culm geometry. The mean basic density was approximately 662 kg/m³. These geometric and physical characteristics are comparable with values reported for structural bamboo species internationally [1], [2] and provide a useful basis for subsequent grading and structural assessment in accordance with ISO 22156:2021 [5].

Table 2: Summary of measured mechanical properties of *D. giganteus*.

Property	n	Mean (MPa)	COV
Compression fibres	30	46.85	0.168
Tension fibres	30	153.04	0.887
Shear fibres	30	8.47	0.250
Tension ⊥ fibres	30	1.75	0.302

n = number of specimens; COV = coefficient of variation; || = parallel; ⊥ = perpendicular.

Table 2 summarises the measured mechanical properties. The mean compressive strength parallel to the fibres was 46.85 MPa, while the mean tensile strength parallel to the fibres was 153.04 MPa, demonstrating the strong fibre-parallel response characteristic of structural bamboo [1], [2]. The mean shear strength parallel to the fibres was 8.47 MPa. In contrast, the mean tensile strength perpendicular to the fibres was 1.75 MPa, highlighting the susceptibility of the culm wall to longitudinal splitting under transverse loading and the importance of appropriate connection detailing.

3.1 Limitations and Practical Application

The study is limited to mature, visibly defect-free culms from Balangoda and 30 specimens per mechanical test series. Results should therefore not be generalised to all Sri Lankan *D. giganteus* or to different moisture conditions. The high variability in fibre-parallel tensile strength ($COV = 0.887$) also warrants additional testing. For construction, these results can inform preliminary material assessment and grading studies; the mean strengths should not be used directly as design values. Structural application requires appropriate grading, derivation of characteristic and design values under ISO 22156:2021 [5], and verification of member and connection performance, particularly against splitting.

4. Conclusions

This study establishes a first-stage geometric, physical and mechanical property database for Sri Lankan *Dendrocalamus giganteus*. The sampled culms exhibited large diameters, moderate wall thickness, favourable basic density and strong fibre-parallel performance. Low transverse tensile strength highlights longitudinal splitting as a critical consideration for connections and concentrated loads. The findings support further structural assessment while emphasising material variability and the need for grading and structural verification. They apply to the sampled population and test conditions.

Acknowledgements

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References

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EXPERIMENTAL INVESTIGATION

Geometric, physical and mechanical properties

of *Dendrocalamus giganteus* in Sri Lanka

Locally sourced bamboo • ISO-based characterization

01 MATERIAL & EXPERIMENTAL PROGRAM



Mature bamboo culms



Test specimen

BALANGODA, SRI LANKA

188 culm sections
for geometric characterization

30 specimens per
mechanical test series

Mature, defect-free culms

GEOMETRIC

Dimensions and form
ISO 19624:2018

PHYSICAL

Density and linear mass
ISO 22157:2019

MECHANICAL

Compression, tension, shear
ISO 22157:2019

Moisture content at testing: 9–15% across all mechanical test series

02 MEAN GEOMETRIC & PHYSICAL PROPERTIES

157

mm

External diameter

10.8

mm

Wall thickness

662

kg/m³

Basic density

03 MEAN MECHANICAL STRENGTH

Test / fiber direction	MPa	COV
Tension / parallel	153.04	0.887
Compression / parallel	46.85	0.168
Shear / parallel	8.47	0.250
Tension / perpendicular	1.75	0.302

COV: coefficient of variation

0160 MPa

Low transverse strength highlights splitting risk in connections.

Average strengths are not design values; grading and structural verification are required before construction use.