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Bamboo structures — Engineered bamboo products — Test methods for determination of physical and mechanical properties

Structures en bambou — Produits en bambou reconstitués — Méthodes d'essai pour la détermination des propriétés physiques et mécaniques

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Foreword

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This document was prepared by Technical Committee ISO/TC 165, *Timber structures.*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Bamboo structures — Engineered bamboo products — Test methods for determination of physical and mechanical properties

1 Scope

This document specifies test methods suitable for determining the following mechanical properties of engineered bamboo products:

a) modulus of elasticity in bending;

b) shear modulus;

c) bending strength;

d) modulus of elasticity in tension parallel to the fibre;

e) tension strength parallel to the fibre;

f) modulus of elasticity in compression parallel to the fibre;

g) compression strength parallel to the fibre;

h) modulus of elasticity in tension perpendicular to the fibre;

i) tension strength perpendicular to the fibre;

j) modulus of elasticity in compression perpendicular to the fibre;

k) compression strength perpendicular to the fibre and shear strength;

i) shear strength parallel to the fibre.

In addition, the determination of dimensions, moisture content and density are specified.

This document is applicable to prismatic shapes of glued laminated bamboo and bamboo scrimber intended to resist flexure, shear, axial loads, or combinations thereof.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 22157, *Bamboo structures — Determination of physical and mechanical properties of bamboo culms — Test methods*

ISO 21625, *Vocabulary related to bamboo and bamboo products*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 22157, ISO 21625 and the following apply.

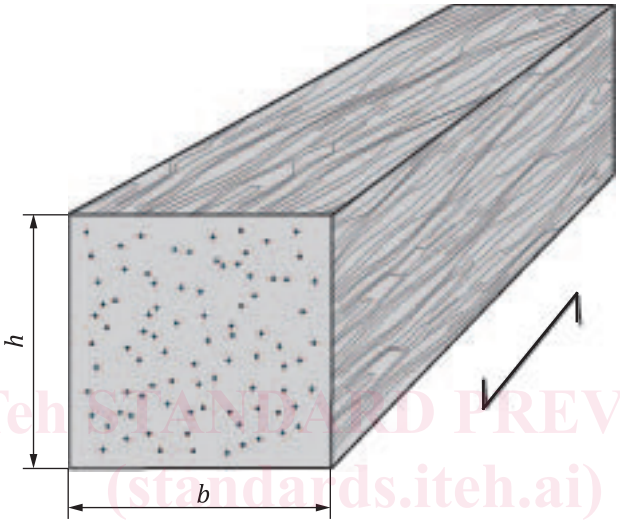
ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
bamboo scrimber
panel or structural member made of compressed bamboo fibre bundle strips or compressed bamboo fibre bundle sheet

[SOURCE: ISO 21625:2020, 3.2.17]



Key

1 width, *b*

2 depth, *h*

indicates parallel to fibre orientation

Figure 1 — Example of bamboo scrimber

3.2
bamboo strip
bamboo piece with outer and inner layers intact, made by cutting bamboo culm in longitudinal direction

3.3
bamboo lamina
thin and flat bamboo piece with rectangular cross-section, processed from *bamboo strip* (3.2) by removing the outer and inner layers of the bamboo culm wall

3.4
engineered bamboo member
assembly of individual elements made of bamboo

3.5
glued laminated bamboo
structural member formed by bonding together *bamboo strips* (3.2) with their fibres running essentially parallel

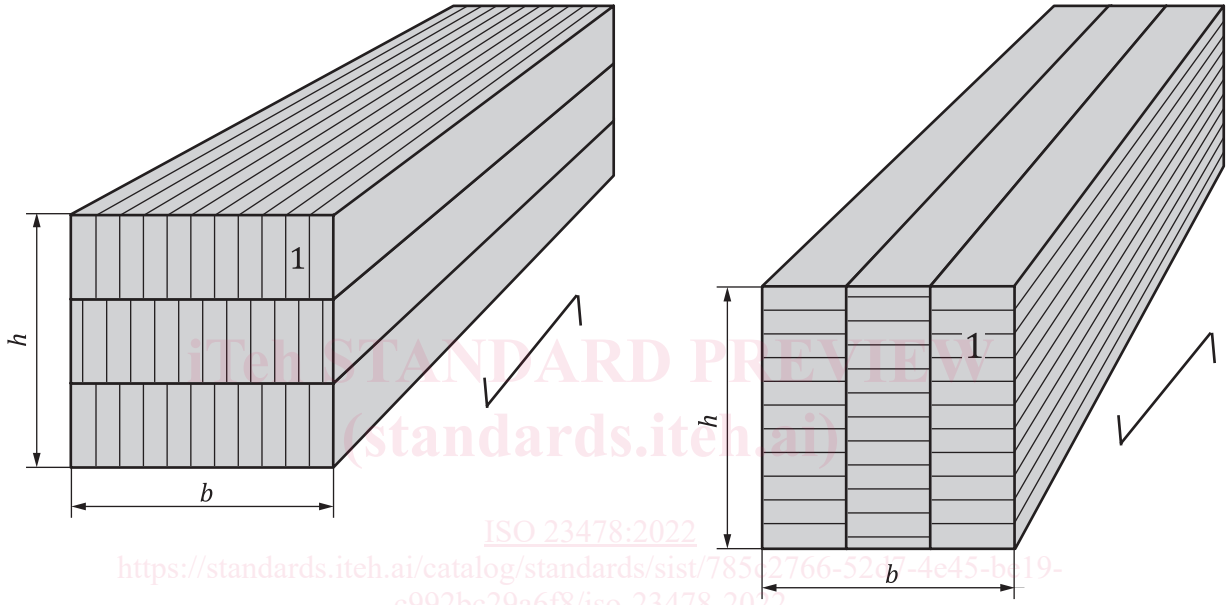
[SOURCE: ISO 21625:2020, 3.3.1.14]

3.6
non-structural joint
non-structural connection (e.g. butt, hook joint) to support manufacturing process and is not designed to transfer stress across the connection

3.7
traveller specimen
specimen identical to, and stored and conditioned identically to specimens to be tested used to obtain properties whose testing method affects the specimen

Note 1 to entry: Traveller specimens are usually used for determination of moisture content and density.

[SOURCE: ISO 22157:2019, 3.12]



a) Horizontal board orientation **b) Vertical board orientation**

Key

b	width, *b*
h	depth, *h*
1	bamboo lamina
⇄	indicates parallel to fibre orientation

Figure 2 — Example of glued laminated bamboo

4 Symbols

4.1 Symbols

A	cross-sectional area, in square millimetres;
a	distance between a loading position and the nearest support in a bending test, in millimetres;
b	width of cross-section in a bending test, or the smaller dimension of the cross-section, in millimetres;

$E_{c,0}$ modulus of elasticity in compression parallel to the fibre, in Newton per square millimetre;

$E_{c,90}$ modulus of elasticity in compression perpendicular to the fibre, in Newton per square millimetre;

$E_{m,g}$ global modulus of elasticity in bending, in Newton per square millimetre;

$E_{m,app}$ apparent modulus of elasticity in bending, in Newton per square millimetre;

$E_{t,0}$ modulus of elasticity in tension parallel to the fibre, in Newton per square millimetre;

$E_{t,90}$ modulus of elasticity in tension perpendicular to the fibre, in Newton per square millimetre;

F load, in Newtons;

$F_{c,90,max}$ maximum compressive load perpendicular to the fibre, in Newtons;

$F_{c,90,max,est}$ estimated maximum compressive load perpendicular to the fibre, in Newtons;

F_{max} maximum load, in Newtons;

$F_{max,est}$ estimated maximum load, in Newtons;

$F_{t,90,max}$ maximum tensile load perpendicular to the fibre, in Newtons;

F_y yield load, in Newtons;

F_{ult} maximum (ultimate) load applied in test, in Netwons;

$f_{c,0}$ compressive strength parallel to the fibre, in Newton per square millimetre;

$f_{c,90}$ compressive strength perpendicular to the fibre, in Newton per square millimetre;

f_m bending strength, in Newton per square millimetre;

$f_{t,0}$ tensile strength parallel to the fibre, in Newton per square millimetre;

$f_{t,90}$ tensile strength perpendicular to the fibre, in Newton per square millimetre;

G shear modulus, in Newton per square millimetre;

h depth of cross-section in a bending test, or the larger dimension of the cross-section, in millimetres;

h_0 gauge length, in millimetres;

h_t test specimen height in perpendicular to fibre tests, in millimetres;

I second moment of area, in millimetres to the fourth power;

l span in bending, or length of test specimen between the testing machine grips in compression and tension, in millimetres;

l_1 gauge length for the determination of modulus of elasticity or shear modulus, in millimetres;

m_e mass of the test piece before drying, in grams;

m_i initial mass before drying, in grams;

m_0 final oven-dry mass, in grams;

S section modulus, in millimetres to the third power;

V volume of the test piece, in millimetres to the third power;

V_0 volume of the test piece in the absolutely dry condition, in millimetres to the third power;

w moisture content;

Δ displacement, in millimetres;

δ change in slope;

ρ_{test} density under conditions of test, in grams per millimetre to the third power;

ρ_0 dry density, in grams per millimetre to the third power.

5 Determination of dimensions of test specimens

The dimensions of the test specimen shall be measured to a precision of 1 % of the least cross-sectional dimensions of the member. All measurements shall be made when the test specimens are conditioned as specified in Clause 8. If the width or thickness varies within a test specimen, these dimensions should be recorded as the average of three separate measurements taken at different positions on the length of each specimen.

6 Determination of moisture content of test specimens

6.1 Moisture content by oven-dry method

6.1.1 Apparatus

6.1.1.1 Balance, suitable to weigh a specimen with a precision of at least 0,5 % of the specimen mass.

6.1.1.2 Oven, capable of drying specimen to the absolute dry condition.

6.1.2 Preparation of test pieces

Specimens for determination of moisture content shall be prepared immediately after each mechanical test. The number of specimens shall be equal to the number of test pieces for the physical or mechanical test. If traveller specimens are used, these shall be prepared immediately after each mechanical test, and placed in the drying oven.

The moisture content of the test specimen shall be determined on a section taken from the test specimen. For engineered bamboo products the section shall be of full cross-section. For perpendicular to fibre test specimens the moisture content shall be determined from the whole specimen.

In strength tests for bending, shear, tension parallel and perpendicular to fibre and compression parallel and perpendicular to fibre, the moisture content of the test specimen shall be determined near the place of failure.

6.1.3 Procedure

The test pieces shall be weighed with a precision of at least 0,5 % of the dry specimen mass prior to being placed in an oven at a temperature of (103 ± 2) °C. The initial mass is m_i.

After 24 h, the mass shall be recorded at regular intervals of not less than 2 h. The drying shall be considered to be complete when the difference between successive determinations of mass does not exceed 0,5 % of the measured mass. The final oven-dry mass is m_0.

The following modifications for bamboo scrimber shall be made. After 48 h, the mass shall be recorded at regular intervals of not less than 6 h. The drying shall be considered to be complete when the difference between successive determinations of mass do not exceed 0,1 % of the measured mass. The final oven-dry mass is m_0.

6.1.4 Calculation and expression of results

The moisture content, w, of each test piece shall be calculated with Formula (1) as the loss in mass, expressed as a percentage of the oven-dry mass:

$$w = \left[\frac{m_i - m_0}{m_0} \right] \times 100 \quad (1)$$

where

m_i is the initial mass of the test piece before drying;

m_0 is the oven-mass of the test piece.

Both m_i *and* m_0 are measured with a precision of at least 0,5 % of the dry specimen mass for laminated bamboo and of at least 0,1 % of the dry specimen mass for bamboo scrimber.

The calculated value of w shall be taken as representative of the test specimen as a whole.

6.2 Moisture content by electrical moisture meter method

6.2.1 General

Alternatively, it can be sufficiently accurate to measure moisture content by means of a moisture meter, provided that the meter is calibrated against moisture content measurements using the oven-dry method described in 6.1. Commercial conductivity moisture meters are generally only reliable for wood moisture content between about 5 % and 30 %.

6.2.2 Apparatus

6.2.2.1 Moisture meter, of any design calibrated for laminated bamboo and bamboo scrimber (using the oven-dry method described in 6.1), and capable of making an individual measurement with an error of not more than 2 % at moisture contents from 7 % to 30 %.

6.2.3 Procedure

Measure the moisture content of the test piece or traveller specimen at a location within the specimen. Measurements should be taken either at freshly cut cross-sections, or by driving deep, sharp probes into the specimen.

The area at which measurements are made shall not contain any contaminants or visible defects. Drive the electrodes into the cross-section so that the line between the tips of the needles intersects the specimen.

Make at least three measurements in each measuring area, 10 mm to 15 mm apart, to avoid any error due to the electrodes piercing an invisible defect.

6.2.4 Calculation and expression of results

Calculate the mean of the three individual measurements closest in their values, and express the average moisture content, w, as a percentage by mass, to the nearest 1 %.

