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**Bamboo structures — Grading of  
bamboo culms — Basic principles and  
procedures**

*Structures en bambou — Classement des tiges de bambou*

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ISO copyright office  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Fax: +41 22 749 09 47  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by ISO Technical Committee 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](http://www.iso.org/members.html).

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## Introduction

The general principle of this document is that any type of grading procedure is acceptable, provided it is defined, controlled, and documented to the extent required to achieve the degree of reliability intended for the structural application of the product. This document specifies procedures that conform to this principle. The grading procedures outlined in this document require visual, dimensional and mechanical stages to ensure conformity.

[Annex A](#) provides an example conformance standard reflecting the requirements of this document.

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# Bamboo structures — Grading of bamboo culms — Basic principles and procedures

## 1 Scope

This document specifies grading procedures for visually and mechanically sorting round, or pole, bamboo for structural applications using such fundamental elements. Visual sorting is based on observable characteristics of the piece(s). Mechanical sorting is based on non-destructive measurement of properties known to correlate to characteristic values defining a grade.

The grading procedures in this document can be used in a quality acceptance regime, although this document does not define or address acceptance criteria.

This document is applicable only for bamboo that is graded in the seasoned state.

## 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 22156, *Bamboo — Structural design*

ISO 22157-1, *Bamboo — Determination of physical and mechanical properties — Part 1: Requirements*

ISO 12122-1, *Timber structures — Determination of characteristic values — Part 1: Basic requirements*

## 3 Terms and definitions

ISO 19624:2018

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For the purposes of this document, the following terms and definitions 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 <http://www.electropedia.org/>

### 3.1

#### **bamboo culm**

single shoot of bamboo

Note 1 to entry: A culm is comprised of the entire unaltered bamboo cross section and is usually a hollow cylinder except at nodes.

### 3.2

#### **bow**

measure of variation of culm from straight condition, reported as the ratio of greatest transverse variation to reference length of culm

### 3.3

#### **dry bamboo**

#### **seasoned bamboo**

bamboo that has been subjected to a drying process and with moisture content of 19 % or less

**3.4  
fissure**

longitudinally oriented separation or split of the bamboo wall running parallel to the fibres at the end of a culm or at any internode of the piece that may or may not penetrate through the entire wall thickness

Note 1 to entry: An example of a fissure is shown in [Figure 1](#).

**3.5  
geometric property**

measurable dimensional property of bamboo piece, generally used in reference to diameter, wall thickness, length and internode length

**3.6  
grade-determining property  
GDP**

mechanical, geometric or physical property for which a particular value should be achieved for the material to be assigned to that grade

**3.7  
indicating property  
IP**

measurement or combination of measurements made during grading, which are related to one or more of the grade-determining properties

**3.8  
initial evaluation**

process prior to grading during which the geometric, physical and mechanical properties for bamboo originating from a source region will be assessed with the aim of developing reliable selection criteria

**3.9  
internode**

usually hollow region of bamboo culm between two nodes at which diameter and wall thickness are defined

**3.10  
longitudinal indentation**

longitudinal depression running parallel to the fibres that may indicate the presence of an internal fissure that is not visible externally

Note 1 to entry: An example of a longitudinal indentation is shown in [Figure 2](#).

**3.11  
mechanical property**

measurable property of bamboo associated with both culm geometry and bamboo material properties that describes behaviour under the effects of applied load or stress, generally used in reference to member or section strength or stiffness

**3.12  
moisture content**

portion of culm weight consisting of water expressed as percentage of oven-dry weight

**3.13  
node**

transverse diaphragm region located along length of culm separating adjacent internodes

Note 1 to entry: The separation between nodes varies along the culm. When alive, nodes are locations of leaf and branch growth.



**3.14****ovality**

degree of variation of culm cross section from circular, reported as the ratio of the greatest to least diametric measurement at a specific location

**3.15****physical property**

measurable or observable property of bamboo that describes its behaviour to external influences other than stress or strain, generally used in reference to density, moisture content, etc.

**3.16****producer****supplier**

organization responsible for the grading process, which usually would be the same organization responsible for drying and preserving the bamboo culms

**3.17****proof testing**

non-destructive structural testing protocol involving loading the culm (or structural assembly) to a predetermined value to assess its ability to carry this load

Note 1 to entry: Not addressed by this document.

**3.18****source region**

geographical location from which the bamboo resource originates

**3.19****structural capacity**

load carrying capacity of a culm which is a function of mechanical, geometric and physical properties of the culm

Note 1 to entry: Usually expressed in kiloNewtons (force) or kiloNewtons-metre (moment).

**3.20****taper**

degree of change of outer diameter (external taper), internal diameter (internal taper), section area (areal taper) or other geometric property along length of culm, expressed as percentage of the length of the culm

**3.22****unseasoned bamboo**

bamboo with moisture content greater than 19 %

**3.23****grading rules**

visual set of criteria used to sort bamboo pieces during visual grading

Note 1 to entry: Grading rules should have a demonstrated link to the grades sought.

**3.24****visual override**

process by which bamboo pieces are excluded from machine grading, because they do not meet criteria known to be important to grading and that cannot be sensed by the machine

## 4 Symbols

$b_{\max}$	maximum perpendicular distance from the centre of the culm section to the chord drawn from the centres of either end of the piece of bamboo, expressed in millimetres
$b_0$	bow of a piece of bamboo
$D$	external diameter of the bamboo culm, expressed in millimetres
$D_b$	external diameter at the base of a piece of bamboo
$D_{\max}$	maximum external diameter at a given location on a piece of bamboo
$D_{\min}$	minimum external diameter at a given location on a piece of bamboo
$D_t$	external diameter at the top of a piece of bamboo
$L$	length of a piece of bamboo, expressed in millimetres
$L_{\text{in}}$	internode length, expressed in millimetres
$L_{\text{ref}}$	reference length of a piece over which the bow of a piece of bamboo is assessed, expressed in millimetres
$\delta$	culm wall thickness, expressed in millimetres
$\alpha_e$	external taper, expressed as a percentage
$\alpha_i$	internal taper, expressed as a percentage

## 5 General

### 5.1 Grading

Grading is the process of sorting every piece of bamboo in a sample into grades according to defined selection criteria. The criteria identify dimensional, visual, geometric, mechanical and/or physical properties that reflect the bamboo's mechanical strength or structural capacity and may affect the utility of the product.

Each grade is associated with a range of mechanical, geometric, physical and/or structural properties derived from testing. The selection criteria are based on non-destructive observations and measurements that have been established to be useful to the grading process.

Grading provides a statistically significant prediction of the mechanical, geometric and/or physical properties of the population within a grade, but does not provide the properties of each individual piece.

Grading is not proof testing. Proof testing can be carried out to increase confidence in selected material, if desired. Proof testing is beyond the scope of this document.

### 5.2 Grades

The sorting criteria for a given grade should reliably infer the properties selected as the basis of the grading process. A grade can be set to correspond to a particular bamboo resource in order to make optimum use of the resource. Alternatively, a grade can be set to meet the requirements of a particular end use or specification.

### 5.3 Graded bamboo culms

Graded bamboo culms are dry (or seasoned) lengths of bamboo in their round form that have been subjected to a grading process. It should not be assumed that products derived from graded bamboo culms, such as strips or laminates, are also graded; such products would need to be subjected to a separate grading process beyond the scope of this document.

### 5.4 Grading operations

Bamboo shall be visually graded according to [Clause 6](#), and/or machine-graded according to [Clause 7](#).

The grading operation shall be comprised of a visual grader and/or machine(s) sorting an input resource into output grades. If some of the bamboo does not meet the requirements of the minimum grade, it is rejected.

### 5.5 Secondary properties

Secondary properties are physical or mechanical properties for a given grade that are neither measured nor inferred directly from the grading process. Secondary properties should not be critical to the end application of the culms. These properties are usually estimated from the grade-determining properties on the basis of previously derived correlations that are valid for the specific species.

## 6 Visual grading

### 6.1 General

Visual grading is understood to be the process of sorting material according to visually measurable characteristics known to affect the mechanical or structural properties of bamboo culms. Visual grading can be assisted by machines.

Visual grading operations shall be carried out by a grader that has received appropriate training to perform this task.

The sorting criteria for visual grading shall be referred to as grading rules, and based on characteristics known to affect the strength or structural capacity of bamboo culms. These characteristics can be divided into:

- condition properties;
- geometric properties.

It is permissible to verify the visual grade of a piece by applying the same grading rules.

Re-grading with different grading rules, or visually grading bamboo rejected by machine grading, is not permitted.

It is possible to supplement the visual grading process by non-destructively assessing properties that are known to correlate to strength or structural capacity.

### 6.2 Visual grading requirements

#### 6.2.1 General

Most grading rules can be adapted to suit a particular species and source region, provided they are developed in accordance with [8.2](#). The following requirements shall be observed when setting grading rules or visual override criteria.