
**Bamboo — Determination of physical and
mechanical properties —**

**Part 1:
Requirements**

*Bambou — Détermination des propriétés physiques et mécaniques —
Partie 1: Exigences*
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 22157-1 was prepared by Technical Committee ISO/TC 165, *Timber structures*, in collaboration with INBAR, International Network for Bamboo and Rattan.

ISO 22157 consists of the following parts, under the general title *Bamboo — Determination of physical and mechanical properties*:

— Part 1: Requirements

— Part 2: Laboratory manual

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Introduction

This part of ISO 22157 was originally prepared and submitted by INBAR, the International Network for Bamboo and Rattan, which is an international agency with its head office in Beijing. The aim is to bring bamboo towards the level of an internationally recognized and accepted building and engineering material. INBAR aims to do so in favour of the well-being of lower income groups in developing countries, and in favour of a better environment in bamboo-growing countries.

Discussion about the need of an International Standard started already in 1988, during the International Bamboo Workshop in Cochin, India. Due to lack of funds, the real work started as late as in 1997, when INBAR was launched as an International Agency, and when the Dutch Government provided the required funding.

In 1998, draft texts were written and distributed to a group of specialists inside INBAR who acted as volunteers and spent their time and expertise to propose improvements. Members of this group met for the first time in a meeting on 30-31 October 1998 in San José, Costa Rica. Participants were N.S. Adkoli, K. Ghavami, R. Gnanaharan, H.N.S. Jagadeesh, J.J.A. Janssen, K.S. Pruthi, I.V. Ramanuja Rao, D. Sands, J.O. Siopongco, K. Stochlia and D. Tingley.

During 1999, the results from this meeting were incorporated in the draft texts. In September, these were discussed in a meeting with ISO/TC 165 in Harbin, China. In October 1999, a meeting took place with representatives of the National Standard Institutes of Bangladesh, China, Colombia, Ecuador, Ethiopia, India, Indonesia, Nepal, Philippines, Tanzania, Thailand and Vietnam. This meeting was held at FPRDI in Los Baños, Philippines. The outcome of this meeting was a considerable improvement of the texts, and a general agreement to submit the draft texts to ISO for the formal procedure.

Besides INBAR, CIB (especially committee W 18 B) has also been involved in the preparation. Discussions during meetings of W 18 B (e.g. Singapore 1987 and Kuala Lumpur 1992) have greatly contributed.

Because this part of ISO 22157 is the first International Standard on bamboo, it does not cancel or replace other documents in whole or in part, besides the draft documents prepared and distributed for internal discussion by INBAR during 1998 and 1999. For similar reasons, significant technical changes from previous editions apply only to these previous draft documents.

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Bamboo — Determination of physical and mechanical properties —

Part 1: Requirements

1 Scope

This part of ISO 22157 specifies test methods for evaluating the following characteristic physical and strength properties for bamboo: moisture content, mass per volume, shrinkage, compression, bending, shear and tension.

This part of ISO 22157 covers tests on specimens of bamboo that are conducted to obtain data, which can be used to establish characteristic strength functions and to arrive at the allowable stresses. The data can also be used to establish the relationship between mechanical properties and factors, such as moisture content, mass per volume, growth site, position along the culm, presence of node and internode, etc., for quality-control functions.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1

bamboo culm

single shoot of bamboo that is usually hollow, except at nodes which are often swollen

2.2

bamboo clump

cluster of bamboo culms emanating from two or more rhizomes in the same place

2.3

cross-sectional area

area of the section perpendicular to the direction of the principal fibres and vessels

NOTE This is calculated as $(\pi/4) \times [D^2 - (D - 2t)^2]$, in which D and t are the means of the outer diameter and the wall thickness, resulting from measurements on the specimen.

2.4

outer diameter

diameter of a cross-section of a piece of bamboo measured from two opposite points on the outer surface

2.5

moisture content

percentage of water related to oven-dry mass

2.6

wall thickness

thickness of the wall of a piece of bamboo

3 Symbols and abbreviated terms

The following symbols and units apply.

A	The cross-sectional area in mm ² , Calculated as $(\pi/4) \times [D^2 - (D - 2t)^2]$, in which D and t are the means of the measurements on the specimen.
D	The outer diameter in mm.
δ	Deflection or deformation in mm (pronounced “delta”).
E	The modulus of elasticity in MPa.
F	The load in N.
G	The shear modulus in MPa.
I_B	The second moment of area in mm ⁴ .
L	Full span in bending; length of test piece in compression, shear and tension, in mm.
m	Mass in g (kg is also allowed as a unit).
MC	Moisture content in %.
π	Usually taken as 3,14.
ρ	Mass by volume (density) in kg/m ³ (pronounced “rho”).
σ	Stress in MPa (pronounce “sigma”).
t	Wall thickness in mm.
τ	Shear stress in MPa (pronounced “tau”).
V	Volume of test piece in mm ³ , calculated as $A \times L$, or as measured.
W	Section modulus in mm ³ .
\times	Symbol for multiplication.

Subscript

ult Ultimate (used for strength at failure)

NOTE 1 MPa = 1 N/mm²

4 Organization and use of this part of ISO 22157

4.1 Introduction

This part of ISO 22157 is organized to provide clear requirements for standard tests to be carried out to determine the properties of bamboo as a building or engineering material. The manual for laboratory staff, ISO/TR 22157-2, is complementary to this part.

NOTE This allows for a more formal content of this part of ISO 22157, and a practical and informal guide (a “how to do it”) in the manual.

4.2 General procedures

4.2.1 Measurement and weight

Prior to each test, the dimensions of each specimen shall be measured correct to

- 10 mm for the length of the culm,
- 1 mm for the length or height of a specimen, parallel to the axis of the culm,
- 1 mm for the diameter of the culm; in each cross-section, the diameter shall be taken twice, in directions perpendicular to each other, and
- 0,1 mm for the wall thickness; in each cross-section, the wall thickness shall be taken four times, in the same places as the diameter has been taken (twice).

The specimen shall be weighed correct to

- 10 g for a culm,
- 1 g for a specimen of more than 100 g, and
- 0,1 g for a specimen of less than 100 g.

4.2.2 Temperature and humidity

To avoid significant changes in strength properties, all test specimens shall be tested within the temperature range of $27\text{ °C} \pm 2\text{ °C}$, and the relative air humidity range of $70 \pm 5\%$.

NOTE This allows for a comparison of test results, and reproducible tests.

However, if tests are meant for local use of the results in the region itself, or if the laboratory is unable to follow the conditions specified above, ambient temperature and relative humidity can be used. The exact values of the temperature and relative humidity of the air shall be recorded, and mentioned in the test report.

4.2.3 Rate of loading

The rate of loading of the testing machine shall not vary by more than $\pm 20\%$ from the specified speed for a given test. The load shall be applied continuously without interruption at the required speed throughout the test. The rate of traverse of the movable head of the testing machine shall mean the free running or no-load speed of the head in the mechanical-drive type of machine, and the loaded head speed for testing machines of the hydraulic loading type.

4.2.4 Calibration

All apparatus and testing equipment used in obtaining data shall be calibrated at sufficiently frequent intervals to ensure accuracy.

5 Sampling and storage of specimens

5.1 Sampling

Material for any particular species shall be taken:

- in the case of tests on properties for commercial purposes: from a number of different localities, representative of different growth conditions throughout the geographical range of the species;
- in the case of scientific research: from localities determined by the purpose of the research, and mentioned in the design-report of the tests;

From each locality, the selection, marking, etc., of the different consignments, and all the details of the various clumps and culms, shall be reported.

5.2 Selection

Bamboo culms shall be selected from various clumps in the standing condition, by a qualified person who can identify the species and understand the various implications involved in conversion and testing. Whenever necessary and convenient, the testing authority shall inspect the locality before felling.

For scientific research, the culms selected for testing shall be sound and free from any defects, and shall be representative of average dominant bamboo culms of the locality. For commercial tests, they must fairly represent the total population that is to be used for construction purposes, even if the entire population has its drawbacks. Broken, damaged and discoloured bamboos shall be discarded.

The required number of culms shall be randomly selected from different clumps, blocks and compartments. For commercial tests, they shall be of the same mature age group.

Immediately after selection, the bamboo may be marked "T" in the standing condition, at breast height, and the testing authority shall be informed of the locality, so that further special instructions, if any, may be considered.

5.3 Felling, marking and conversion

Before felling, one ring shall be marked at a height of one metre from the ground with white or black paint, and the following data shall be recorded:

- the name of the species (botanical and local);
- the name of the locality;
- the number of clumps and culms selected;
- the age of the culms;
- details about the marks on the culms;
- number of nodes between ground level and the ring of paint;
- date of felling and of despatch;
- signature.

Also before felling, each culm shall be marked at a distance of about 0,25 m above the ring of paint; if digits 6 or 9 are used, these shall be underlined.

The culms shall be felled according to good local practice, but the ring of paint shall be kept on the culm. In the horizontal position the culm shall be divided into parts to be used for tests or to be thrown away. The parts to be used shall be marked with a ring at the lower end, and the mark of the culm shall be repeated on each part. Also, a mark regarding the position in the culm shall be added, indicating "bottom", "middle" or "top", each being 1/3 of the usable part of the culm. The height of these parts in the culm shall be recorded, in metres, from the level where the culm has been felled. Only then shall the culm be divided into parts.

5.4 Despatch

Material should be despatched as early as possible, preferably within two weeks after felling. In case it is not possible to send the material immediately, the material shall be stored in a shady place, protected from rain, and free of contact with the soil. If a risk of cracking exists, the ends can be covered with coal tar, paraffin wax or varnish, or any other appropriate cover.

If the tests are meant for commercial purposes, specimens shall be tested in air-dry conditions. In the case of scientific research, tests might be done on green specimens, in which case the specimens shall be despatched immediately. As bamboo is highly susceptible to attack by destroying agents in many countries, it may need prophylactic treatment to keep it intact during despatch, transit and storage.

All the details of a particular consignment shall be rechecked and signed and dated by the dispatcher. The details shall be sent along with the documents of the consignments.

5.5 Receipt and storage of the bamboo culms

On receipt of the material by the testing authority, the particulars of identification of the various culms shall be checked, and a proper record shall be kept.

The bamboo culms shall be stored for as short a duration as possible, in such a way that no deterioration shall take place.

5.6 Marking and conversion into test specimens

Specimens shall be cut for the various tests, and suitable markings (e.g. project number, consignment number, culm number, etc.) shall be made for complete identification of each specimen.

The sequence of tests shall be such as to eliminate, as far as possible, changes due to storage and weather conditions, which might affect the comparison of results.

The number of specimens in each test shall not be less than twelve.

5.7 Test report

The test report shall include the following information:

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- a) the name and address of the laboratory, the date, and the name of the responsible researcher;
 - b) a reference to this part of ISO 22157, and to applicable national standards;
 - c) details of the test specimens, as mentioned in 5.3;
 - d) temperature and air humidity in the laboratory;
 - e) equipment used, and any other information which may influence the use of the test results;
 - f) the test results, including the values of moisture content and the mass per volume, the actual dimensions, moduli and/or strength values, mode of failure, and any other information which may influence the use of the test results (e.g. position along the culm);
 - g) details about the statistical treatment of the test results, including the methods used and the results obtained; the accuracy of a mean value shall be half the standard deviation, and the accuracy of a standard deviation shall be half its own standard deviation;
 - h) data about the adjustment to a 12 % moisture content, if applicable.

6 Moisture content

6.1 Scope

This clause specifies a method for determining the moisture content of bamboo for physical and mechanical tests.