INTERNATIONAL STANDARD

ISO 12122-6

First edition
2017-07

Timber structures — Determination of characteristic values —

Part 6: Large components and assemblies

Structures en bois — Détermination des valeurs caractéristiques —

Partie 6: Composants assemblés

Reference number
ISO 12122-6:2017(E)

Contents

Page

Foreword iv
Introduction v
1 Scope 1
2 Normative references 1
3 Terms and definitions 1
4 Symbols 1
5 Reference population 2
5.1 General 2
5.2 Prediction of test results 3
6 Sampling 3
7 Sample conditioning 4
8 Test data 4
8.1 Loading specifications 4
8.2 Testing arrangement 4
8.3 Test measurements 4
9 Evaluation of characteristic values for structural properties 4
9.1 General principles 4
9.2 Direct evaluation of characteristic value 5
9.2.1 Sampling factor k_n 5
9.2.2 Normal distribution 5
9.2.3 Log-normal distribution 6
9.3 Statistical determination of resistance models 6
9.3.1 General 7
9.3.2 Procedure 7
9.3.3 Use of prior test data 11
10 Reporting 12
Annex A (informative) **Commentary** 13
Annex B (informative) **Example of calculation according to 9.2 and 9.3** 21
Bibliography 23

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).

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).

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

For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

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

A list of all parts in the ISO 12122 series can be found on the ISO website.

Introduction

This document sets out a framework for establishing characteristic values from test results on a sample drawn from a clearly defined reference population of large components and assemblies. The characteristic value is an estimate of the property of the reference population with a consistent level of confidence prescribed in the standard.

This document is to be used in conjunction with ISO 12122-1.

Since this document is dedicated to large components and assemblies, it has to deal with a specific statistical issue, namely that the characteristic values are to be derived from a very small number of test results.

In some cases, characteristic values determined in accordance with this document may be modified to become a design value.

Annex A presents a commentary on the provisions in this document.

Annex B presents examples of the use of the statistical methods.

Timber structures — Determination of characteristic values —

Part 6:
Large components and assemblies

1 Scope

This document specifies methods of determination of characteristic values for a defined population of large components and assemblies, calculated from test values.

It establishes two methods for the determination of characteristic values:

a) direct calculation from test values;

b) calculation from a resistance model, which is firstly calibrated from test results, including calculation of error terms.

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

3 Terms and definitions

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:

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

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

3.1
large components and assemblies
parts of a timber structure consisted of at least two members, assembled together by connections

4 Symbols

$E(.)$ mean value of (.)

$Var(.)$ variance of (.)

V coefficient of variation [V = (standard deviation)/(mean value)]

V_X coefficient of variation of X

V_δ estimator for the coefficient of variation of the error term δ

$\underline{X}$ array of j basic variables $X_1 \ldots X_j$

$\underline{X}_m$ array of mean values of the basic variables

$\underline{X}_n$ array of nominal values of the basic variables

$g_{rt}\left(\underline{X}\right)$ resistance function (of the basic variables X) used as the resistance model

k_n characteristic fractile factor

m_X mean of the n sample results

n number of experiments or numerical test results

r resistance value

r_e experimental resistance value

r_{ee} extreme (maximum or minimum) value of the experimental resistance [i.e. value of r_e that deviates most from the mean value r_{em}]

r_{ei} experimental resistance for specimen i

r_{em} mean value of the experimental resistance

r_k characteristic value of the resistance

r_m resistance value calculated using the mean values $\underline{X}_m$ of the basic variables

r_n nominal value of the resistance

r_t theoretical resistance determined from the resistance function $g_{rt}\left(\underline{X}\right)$

r_{ti} theoretical resistance determined using the measured parameters $\underline{X}$ for specimen i

s estimated value of the standard deviation σ

s_δ estimated value of σ_δ

δ error term

δ_i observed error term for test specimen i obtained from a comparison of the experimental resistance r_{ei} and the mean value corrected theoretical resistance br_{ti}

η_k reduction factor applicable in the case of prior knowledge

σ standard deviation $\left[\sigma = \sqrt{\text{variance}}\right]$

5 Reference population

5.1 General

The reference population is the population of large components or assemblies that the test program is designed to represent. Prior to the carrying out of tests, a test plan shall be documented. It shall contain the objectives of the test and all specifications necessary for the selection or production of the test specimens, the execution of the tests and the test evaluation. The test plan shall cover the following details of the reference population, including structural context for the loading of the specimens:

— objectives and scope;

— prediction of test results;

— specification of test specimens and sampling;

— description of expected restraint and boundary conditions in normal service;

— loading specifications;

— testing arrangement;

— measurements;

— evaluation and reporting of the tests.

The objective of the tests shall be clearly stated, e.g. the required properties, the influence of certain design parameters varied during the test and the range of validity. Limitations of the test and required conversions (e.g. scaling effects) shall be specified.

5.2 Prediction of test results

All properties and circumstances that can influence the prediction of test results should be taken into account, including:

— geometrical parameters and their variability;

— geometrical imperfections;

— material properties;

— parameters influenced by fabrication and execution procedures;

— scale effects of environmental conditions taking into account, if relevant, any sequencing.

The expected modes of failure and/or calculation models, together with the corresponding variables, should be described. If there is a significant doubt about which failure modes can be critical, then the test plan should be developed on the basis of accompanying pilot tests.

Attention shall be given to the fact that a structural assembly can possess a number of fundamentally different failure modes.

6 Sampling

Test specimens shall be constructed, or obtained by sampling, in such a way as to represent the conditions of the real structure.

Factors that shall be taken into account include:

— dimensions and tolerances;

— material and fabrication of prototypes;

— number of test specimens;

— sampling procedures;

— restraints.

The objective of the sampling procedure is to obtain a statistically representative sample.

Attention should be drawn to any difference between the test specimens and the product population that could influence the test results.

7 Sample conditioning

Test samples shall be conditioned to represent the reference population as detailed in ISO 12122-1.

8 Test data

8.1 Loading specifications

The loading and environmental conditions to be specified for the test shall include:

— loading points;

— expected loading time history;

— restraints;

— temperatures;

— relative humidity;

— loading by deformation or force control, etc.

Load sequencing shall be selected to represent the anticipated use of the structural assembly, under both normal and severe conditions of use. Interactions between the structural response and the apparatus used to apply the load shall be taken into account where relevant.

Where structural behaviour depends upon the effects of one or more actions that will not be varied systematically, then those effects shall be specified by their representative values.

8.2 Testing arrangement

The test equipment shall be relevant for the type of tests and the expected range of measurements. Special attention shall be given to measures to obtain sufficient strength and stiffness of the loading and supporting rigs, and clearance for deflections, etc.

8.3 Test measurements

Prior to the testing, all relevant properties to be measured for each individual test specimen shall be listed.

9 Evaluation of characteristic values for structural properties

9.1 General principles

Two methods are described in this document:

— direct evaluation of characteristic values from test results (see 9.2);

— evaluation of characteristic values from a model including error calculation (see 9.3).

NOTE 1 Both methods are acceptable, but if there are less than 10 test results, the second method is preferred, since the first method can lead to conservative characteristic values with a low number of test results.

When evaluating test results, the behaviour of test specimens and failure modes should be compared with theoretical predictions. When significant deviations from the predicted behaviour occur, an explanation shall be sought: this might involve additional testing, perhaps under different conditions, or modification of the theoretical model.

The result of a test evaluation shall be considered valid only for the specifications and load characteristics considered in the tests. If the results are to be extrapolated to cover other design parameters and loading, additional information from previous tests or from theoretical bases shall be used.

The derivation of a characteristic value from tests (see 9.2) should take into account:

a) the scatter of test data;

b) statistical uncertainty associated with the number of tests;

c) prior statistical knowledge.

NOTE 2 Annex A gives additional explanation about variability of test results.

If the response of large components or assemblies depends on influences not sufficiently covered by the tests such as

— time and duration effects,

— scale and size effects,

— different environmental, loading and boundary conditions, and

— resistance effects,

then a behaviour model shall be derived and shall take such influences into account as appropriate (see 9.3).

9.2 Direct evaluation of characteristic value

9.2.1 Sampling factor k_n

A sampling factor is used in the evaluation of characteristic value detailed in both 9.2 and 9.3. The values for this factor shall be drawn from Table 1.

Where using the direct evaluation of the characteristic value from the test results, the 5 percentile value of a property, X, shall be found by using either a normal distribution fitted through the test data as indicated in 9.2.1 or a log-normal distribution fitted through the test data as indicated in 9.2.2.

Table 1 — Values of k_n for the 5 % characteristic value

n	1	2	3	4	5	6	8	10	20	30	∞
V_X known	2,31	2,01	1,89	1,83	1,80	1,77	1,74	1,72	1,68	1,67	1,64
V_X unknown	–	–	3,37	2,63	2,33	2,18	2,00	1,92	1,76	1,73	1,64

9.2.2 Normal distribution

The characteristic value shall be calculated using Formula (1).

$$X_k = m_X \left\{1 - k_n V_X\right\} \quad (1)$$

The value of k_n shall be obtained from Table 1 using either of the following two cases:

— The row "V_X known" shall be used if the coefficient of variation of the structural property of the reference population, V_X, or a realistic upper bound of it, is known from prior knowledge.

— The row "V_X unknown" shall be used if the coefficient of variation V_X is not known from prior knowledge and so, needs to be estimated from the sample using Formulae (2) and (3):

$$s_X = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - m_X\right)^2} \tag{2}$$

$$V_X = \frac{s_X}{m_X} \tag{3}$$

9.2.3 Log-normal distribution

The characteristic value shall be calculated using Formulae (4) and (5).

$$X_k = \exp\left[m_Y - k_n s_Y\right] \tag{4}$$

where:

$$m_Y = \frac{1}{n}\sum_i \ln\left(x_i\right) \tag{5}$$

The value of k_n shall be obtained from Table 1 using either of the following two cases:

— The row "V_X known" shall be used if the coefficient of variation of the structural property of the reference population, V_X, or a realistic upper bound of it, is known from prior knowledge with s_Y as given in Formula (6).

$$s_Y = \sqrt{\ln\left(V_X^2 + 1\right)} \approx V_X \tag{6}$$

— The row "V_X unknown" shall be used if the coefficient of variation V_X is not known from prior knowledge and so s_Y is estimated from the sample as given in Formula (7).

$$s_Y = \sqrt{\frac{1}{n-1}\sum_i\left(\ln x_i - m_Y\right)^2} \tag{7}$$

9.3 Statistical determination of resistance models

In 9.3, the procedures (methods) for calibrating resistance models and for deriving characteristic values from tests are defined. Use will be made of available prior information (knowledge or assumptions).

Based on the observation of actual behaviour in tests and on theoretical considerations, a "resistance model" shall be developed, leading to the derivation of a resistance function. The validity of this model shall be then checked by means of a statistical interpretation of all available test data. If necessary, the resistance model shall be adjusted until sufficient correlation is achieved between the theoretical values and the test data.

Deviation in the predictions obtained by using the resistance model shall also be determined from the tests. This deviation shall be combined with the deviations of the other variables in the resistance function in order to obtain an overall indication of deviation. These other variables shall include:

— deviation in material strength and stiffness;

— deviation in geometrical properties.

The characteristic resistance shall be determined by taking account of the deviations of all the variables.

