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Timber structures — Testing of joints made with mechanical fasteners — Requirements for timber density

Structures en bois — Essai sur assemblages réalisés par organes mécaniques — Exigences concernant la masse volumique du bois

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Foreword

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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).

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This document was prepared by Technical Committee ISO/TC 165, *Timber structures*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 124, *Timber structures*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 8970:2010), which has been technically revised.

The main changes compared to the previous edition are as follows:

In this edition the sampling method aims not only at ensuring that the selected pieces have a mean density comparable to the wood to which the test result is intended to be applied[1], but also requiring the coefficient of variation of the density to be reflected. Only then the characteristic value of the strength determined by the test can be used directly[2].

If it is not possible to obtain wood with the target mean value and variation of the wood density, the normative Annex A provides a correction method. The informative Annex B provides background to the correction procedure.

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.

Introduction

The sampling method given aims at ensuring that the selected pieces have a density distribution comparable to the timber to which the test result is intended to be applied. When this is fulfilled, the results can be used directly to determine the characteristic value of the strength parameter.

As it is often difficult to obtain a variation of the density similar to that allowed in a strength class, a correction method is given to obtain a corrected coefficient of variation for the strength parameter.

It should be kept in mind that the effect of density on the load-bearing capacity of connections is in many cases less significant than expected, and that many other parameters influence it.

Timber structures — Testing of joints made with mechanical fasteners — Requirements for timber density

1 Scope

This document specifies a method based on density, for the selection of pieces of wood used in determining the strength and stiffness properties of joints between members of structural timber made with mechanical fasteners. It is intended to be used in conjunction with a test standard specifying a test method.

It is assumed that the wood pieces are conditioned to the relevant conditions, that the wood density is normally distributed and that any deviations are reported.

This document is applicable only to specimens of structural timber.

NOTE It is emphasized that the wood density is only one of the properties that can influence the strength of a joint. Other relevant properties are, for example, growth-ring size and orientation, toughness and hardness.

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 13061-2, *Physical and mechanical properties of wood — Test methods for small clear wood specimens — Part 2: Determination of density for physical and mechanical tests*

3 Terms and definitions

No terms and definitions are listed in this document.

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/

4 Symbols

ρ is the density of a wood piece, expressed in kilograms per cubic metre.

5 Wood sampling method and requirements

5.1 General

The wood shall be at equilibrium at a relative humidity (RH) of (65 ± 5) % and a temperature of (20 ± 2) °C at the time of testing. It shall be reported whether the wood was dried or moistened during the conditioning.

NOTE The moisture content at equilibrium is lower when reached by moistening than if reached by drying, which can affect the test results. The product test standard can specify if the equilibrium condition is to be reached through drying.

The density for the actual moisture content shall be determined in accordance with ISO 13061-2.

This density is referred to as ρ_W in ISO 13061-2. The moisture content need not be determined, unless the product test standard requires it.

If other conditions, such as tropical conditions, are used, they shall be reported.

5.2 Sampling method and requirements

The sampling method is based on the principle that all selected pieces have a density distribution comparable with that of the timber to which the test results are applied. This may be assumed if Formula (1) and Formula (2) are fulfilled. The observed strengths may then be used directly for calculating characteristic values of the strength.

NOTE The test results apply only to the timber species or the group of timber species used.

The wood shall be of uniform quality and without localized defects that can influence the test results.

The mean wood density, $\rho_{m,sel}$, of the selected pieces shall satisfy the condition given by Formula (1):

$$0{,}95\,\rho_{m,tar} \le \rho_{m,sel} \le 1{,}05\,\rho_{m,tar} \tag{1}$$

where

$\rho_{m,tar}$ is the mean density of the timber to which the test results are applied;

$\rho_{m,sel}$ is the mean density of the selected pieces.

The coefficient of variation, $C_{V,\rho,sel}$, of the wood density of the selected pieces shall satisfy the condition given by Formula (2):

$$C_{V,\rho,sel} \ge C_{V,\rho,tar} \tag{2}$$

where

$C_{V,\rho,tar}$ is the coefficient of variation of the density of the timber to which the test results are applied;

$C_{V,\rho,sel}$ is the coefficient of variation of the density of selected pieces.

NOTE The target value, $C_{V,\rho,tar}$ will usually be reached if the wood densities ρ of the selected pieces cover the range:

$$[(1-k)\,\rho_{m,tar};(1+k)\,\rho_{m,tar}] \tag{3}$$

where k is a statistical factor equal to 1,65 $C_{V,\rho,tar}$, or 0,25 for cases where $C_{V,\rho,tar}$ is unknown.

If Formula (1) and Formula (2) are not fulfilled and if permitted by the product test standard, the observed strengths shall be corrected according to Annex A.

6 Test report

The following information shall be included in the test report:

a) reference to this document, i.e. ISO 8970:2020;

b) the wood species or wood species group;

c) the conditioning used, including whether moistened or dried during conditioning;

d) the densities of the selected wood pieces at the time of testing, the mean density and the coefficient of variation;

e) if determined, the moisture content of the selected wood pieces at the time of testing;

f) evidence that the selected pieces satisfy the conditions required in this document or possible deviations;

g) any other information which can influence the use of the test results.

Annex A
(normative)

Corrections to target conditions

A.1 General

If the density distribution of the sample deviates from that of the timber to which the test results are applied, the observed resistances R shall be corrected as given in this annex. Background information is given in Annex B.

A.2 Mean value

The observed resistances, R_i, shall be corrected as given by Formula (A.1).

$$R_{i,\rho m} = R_i(\rho_{m,tar}/\rho_{m,sel})^c \tag{A.1}$$

where

R_i is the observed resistance for wood piece i;

$R_{i,\rho m}$ is the observed resistance for wood piece i corrected to refer to ρ_m;

c is the exponent that corrects observations to $\rho_{m,tar}$;

$\rho_{m,tar}$ is the mean density of the timber to which the test results are applied;

$\rho_{m,sel}$ is the mean density of all selected pieces.

Formula (A.1) shall be used if Formula (1) and Formula (2) are not fulfilled, provided it is stated in the Test report.

The exponent c shall be established from testing a wider range of densities of the wood species for the relevant failure mode(s), see Annex B. An upper and a lower bound should be determined. When $\rho_{m,tar} > \rho_{m,sel}$ the lower bound c_{lower} is used, otherwise the upper bound c_{upper} is used.

NOTE 2 For European softwood, some upper and lower bounds for the exponent c are given in Table A.1.

Table A.1 — Values of the exponent *c* for European softwood

Configuration	c_{lower}	c_{upper}	c_{cor}
Withdrawal of smooth nail and staples[a]	1,5	2,0	2,0
Withdrawal of ringed nail	1,0	1,5	1,5
Withdrawal of coated nail or staple	1,0	2,0	2,0
Withdrawal of screw	0,8	1,2	1,2
Pull-through of head	0,8	1,2	1,2
Embedment	0,8	1,2	1,2

[a] Including twisted nails and nails with longitudinal groves.

A.3 Coefficient of variation

If the variation of the density of the timber to which the test results are applied, $C_{V,\rho,\mathrm{tar}}$ is larger than that of the density of the selected pieces, $C_{V,\rho,\mathrm{sel}}$, the characteristic value of the resistance shall be calculated using a corrected coefficient of variation $C_{V,R,\mathrm{cor}}$ given by Formula (A.2).

$$C_{V,R,\mathrm{cor}} = [C_{V,R,\mathrm{obs}}{}^2 + c_{\mathrm{cor}}{}^2(C_{V,\rho,\mathrm{tar}}{}^2 - C_{V,\rho,\mathrm{sel}}{}^2)]^{0,5} \quad \text{(A.2)}$$

where

$C_{V,R,\mathrm{obs}}$ is the coefficient of variation of the observed resistance;

$C_{V,R,\mathrm{cor}}$ is the coefficient of variation of the resistance corrected to $C_{V,\rho}$;

c_{cor} is the exponent for correction for coefficient of variation.

The exponent c_{cor} shall be established from testing a wider range of densities of the wood species for the relevant failure mode(s), see Annex B.

NOTE For European softwood, some values for the exponent c_{cor} are given in Table A.1.

Annex B
(informative)

Background information

B.1 Correction for mean value

The coefficient of variation $C_{V,R,\text{obs}}$ of measured resistances R_i, consists of a contribution $C_{V,R,\rho}$ related to the variation of the density and a random contribution $C_{V,R,\text{ran}}$. The random contribution covers variation of the wood properties not correlated to the density, uncertainties from inserting the fasteners and differences between the fasteners. These contributions are by nature independent and related as

$$C_{V,R,\text{obs}} = \sqrt{C_{V,R,\rho}^{\ 2} + C_{V,R,\text{ran}}^{\ 2}} \tag{B.1}$$

The random contribution could within reason be assumed to be proportional to the resistance, and therefore represented by a constant coefficient of variation.

The two contributions can be separated by estimating the exponent c that minimizes the variation of the corrected resistance $R_{i,\text{cor}}$ defined as

$$R_{i,\text{cor}} = R_i(\rho_{\text{mean}}/\rho_i)^c \tag{B.2}$$

where ρ_i are the actual densities for the sample and ρ_{mean} is their mean value.

The exponent c is easily found by trial but can also be derived mathematically. The variation of $R_{i,\text{cor}}$ is then an estimate of the random contribution $C_{V,R,\text{ran}}$ since it represents the variation not explained by the variation of the density.

This estimate for c should be used to transform a resistance parameter determined for a certain mean density and variation to another mean density with the same variation.

B.2 Correction for coefficient for variation

When the target coefficient of variation $C_{V,\rho,\text{tar}}$ is higher than the one of the test sample $C_{V,\rho,\text{sel}}$ it is convenient to define a correction factor

$$c_{\text{cor}} = C_{V,R,\rho}/C_{V,\rho,\text{sel}} \tag{B.3}$$

where $C_{V,R,\rho}$ is obtained by rewriting Formula (B.1)

$$C_{V,R,\rho} = \sqrt{C_{V,R,\text{obs}}^{\ 2} - C_{V,R,\text{ran}}^{\ 2}} \tag{B.4}$$

$C_{V,R,\text{cor}}$ is the coefficient of variation of the resistance for the target density variation, $C_{V,\rho,\text{tar}}$, which is sought. As Formula (B.1) also applies to the corrected variations and assuming that $C_{V,R,\text{ran}}$ is independent of $C_{V,R,\rho}$, an estimate for $C_{V,R,\mathrm{cor}}$ can be obtained from Formula (B.1) by substituting $C_{V,R,\rho,\mathrm{cor}}$ with $c_{\mathrm{cor}}C_{V,\rho,\mathrm{tar}}$

$$C_{V,R,\mathrm{cor}} = \sqrt{C_{V,R,\mathrm{ran}}{}^2 + (c_{\mathrm{cor}}C_{V,\rho,\mathrm{tar}})^2} \tag{B.5}$$

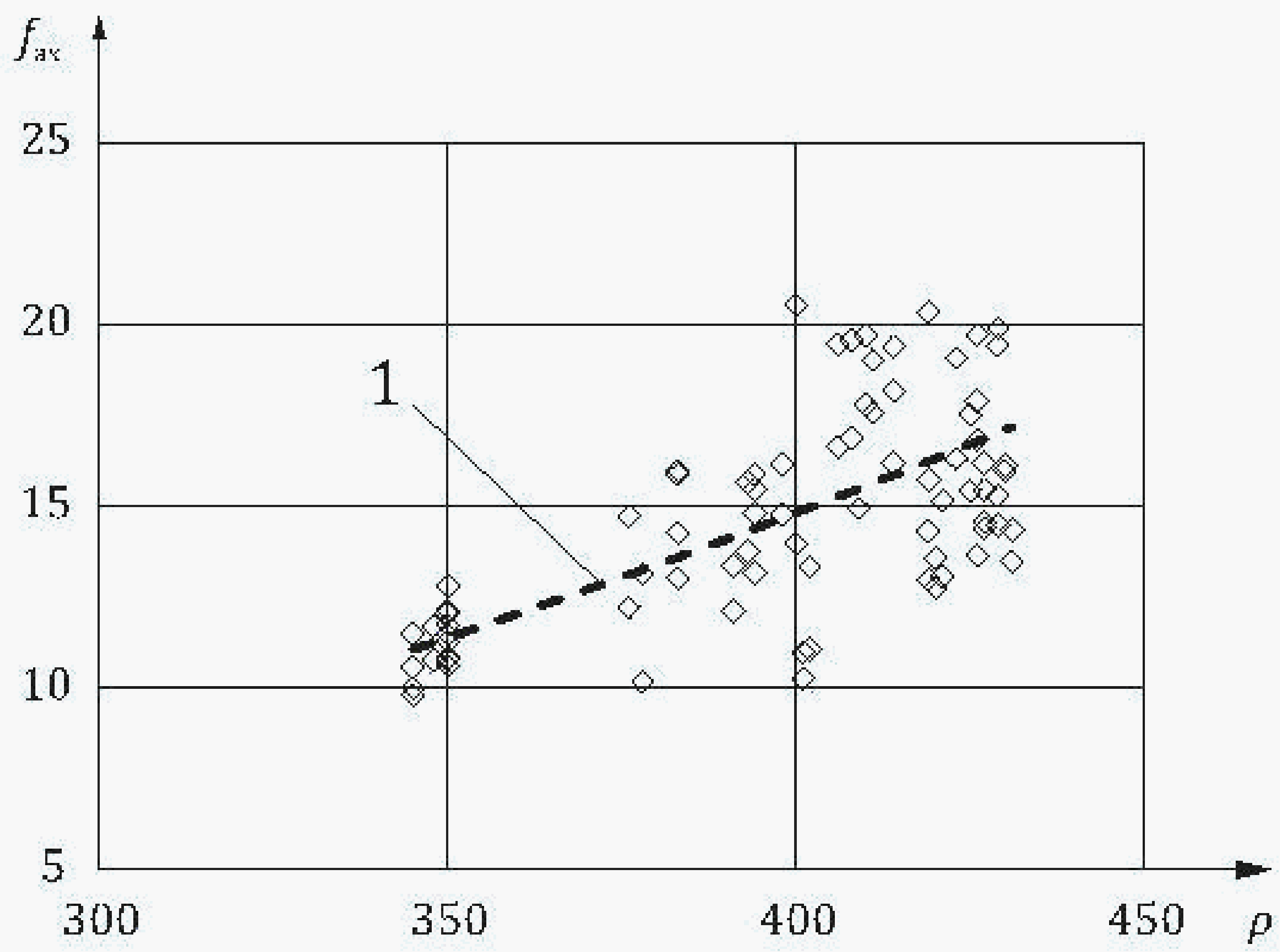
When isolating $C_{V,R,\mathrm{ran}}$ from Formula (B.1) this can be rewritten as

$$C_{V,R,\mathrm{cor}} = \sqrt{C_{V,R,\mathrm{obs}}{}^2 + c_{\mathrm{cor}}{}^2(C_{V,\rho,\mathrm{tar}}{}^2 - C_{V,\rho,\mathrm{sel}}{}^2)} \tag{B.6}$$

B.3 Example

A total of 80 withdrawal tests performed with ring shank nails, tested in radial and tangential direction in 40 timber samples gives $C_{V,\rho,\mathrm{sel}}$ = 0,072 and $C_{V,R,\mathrm{obs}}$ = 0,197 (assuming results from radial and tangential directions to be independent). By trial it is found that c = 1,98 minimises the variation of $R_{\mathrm{i,cor}}$, which becomes $C_{V,R,\mathrm{ran}}$ = 0,143. See also Figure B.1.

$C_{V,R,\mathrm{ran}}$ is not very sensitive to the actual value of c. Values of c between 1,75 and 2,2 give $C_{V,R,\mathrm{ran}}$ < 0,144.



Key

f_{ax} withdrawal strength, MPa

ρ density, kg/m^3

1 density raised to c = 1,98

Figure B.1 — Data used in the example

The following calculations are made using Formulae (B.4), (B.3) and (B.6).

$$C_{V,R,\rho} = \sqrt{0{,}197^2 - 0{,}143^2} = 0{,}136$$

c_{cor} = 0,136/0,072 = 1,89

Taking $C_{V,\rho,tar}$ = 0,10 then

$$C_{V,R,cor} = \sqrt{0{,}197^2 + 1{,}89^2 \left(0{,}10^2 - 0{,}072^2\right)} = 0{,}237$$

The two estimates for c are very similar, especially considering that $C_{V,R,ran}$, as mentioned, is not very sensitive to the actual value of c.

If only 58 tests are used, ignoring the samples with the higher and lower densities, the following values are obtained:

$C_{V,\rho}$ = 0,036, $C_{V,R,obs}$ = 0,176, c = 2,0, $C_{V,R,ran}$ = 0,161, $C_{V,R,\rho}$ = 0,072 and c_{cor} = 2,0

The two values of c are still very similar so c = 2 is a stable estimate for this test series. $C_{V,R,ran}$, which is assumed to be constant, is changed from 0,143 to 0,161, which is certainly within the expected uncertainty.

If the parameters obtained from these 58 tests are used to estimate $C_{V,R}$ for all 80 tests with $C_{V,\rho}$ = 0,072 it is found that

$$C_{V,R,80} = \sqrt{0{,}176^2 + 2{,}0^2 \left(0{,}072^2 - 0{,}036^2\right)} = 0{,}216$$

which is reasonably close to $C_{V,R,obs,80}$ = 0,197.

B.4 Comments

Using test results from a sound sample should ensure that the two correction factors c and c_{cor} become very similar, so it is sufficient to determine the value of c by minimising the coefficient of variation of $R_{i,cor}$ as defined in Formula (B.2).

Applying test results from other (sound) samples might give significantly different values of c, so general values should be given as a range.

If c and c_{cor} become different or if using a subsample changes the estimated values of c and c_{cor} significantly it is probably a sign of a sample with an unnatural composition.

If the results are to be corrected to a higher mean density, a low estimate should be used as this will be the safe value, and visa-versa. Correction to a higher coefficient of variation should use a high estimate of c.

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