INTERNATIONAL STANDARD

ISO 10984-2

First edition
2009-08-15

Timber structures — Dowel-type fasteners —

Part 2:
Determination of embedding strength

Structures en bois — Éléments de fixation de type cheville —

Partie 2: Détermination des valeurs de résistance des scellements

Reference number
ISO 10984-2:2009(E)

Contents

Page

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 10984-2 was prepared by Technical Committee ISO/TC 165, *Timber structures*.

ISO 10984 consists of the following parts, under the general title *Timber structures — Dowel-type fasteners*:

— *Part 1: Determination of yield moment*

— *Part 2: Determination of embedding strength*

Introduction

Dowel-type fasteners are those mechanical fasteners that are most widely used for timber structures. Their characteristics, such as yield moment, have a great effect on the mechanical performance of joints made with dowel-type fasteners under loads.

The purpose of this part of ISO 10984 is to define methods to measure the embedding strength for fasteners as one of the basic parameters to interpret the behaviour of joints under loads. The requirements are necessary to replicate the same conditions as those for timber structures in the field. Loads can be applied to the specimen either by compression or tension, whichever is relevant. This part of ISO 10984 is based on EN 383 and ASTM D5764.

ISO 10984-1 provides the test method to obtain other basic information on the behaviour of mechanical joints under loads.

Timber structures — Dowel-type fasteners —

Part 2:
Determination of embedding strength

1 Scope

This part of ISO 10984 specifies laboratory methods for determining the embedding strength of solid timber, glued laminated timber and wood-based sheet products with dowel-type fasteners.

Descriptors: timber construction, fasteners, nails (fasteners), bolts, tests, compression tests, determination, compressive strength.

2 Normative references

The following referenced documents are indispensable for the application 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 3130, *Wood — Determination of moisture content for physical and mechanical tests*

ISO 3131, *Wood — Determination of density for physical and mechanical tests*

3 Terms and definitions

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

3.1
dowel-type fastener
bolt, nail, screw, dowel or the like with plain or patterned surfaces

3.2
embedding strength
average compressive stress at maximum load in a piece of timber or wood-based sheet product under the action of a stiff linear fastener

NOTE The fastener's axis is perpendicular to the surface of the timber. The fastener is loaded perpendicular to its axis.

3.3
maximum load
Maximum load measured before the deformation of the specimen has reached the deformation limit equal to ($w_0 + 5$) mm

3.4 Fastener section dimension

3.4.1
fastener section dimension
⟨plain round or profiled fastener⟩ diameter of the shank without coating

3.4.2
fastener section dimension
⟨square fastener⟩ length of one side of the section

3.4.3
fastener section dimension
⟨oval or rectangular fastener⟩ minimum dimension of the section

4 Symbols and abbreviated terms

d	fastener section dimension, expressed in millimetres
F	load, expressed in newtons
F_{max}	maximum load, expressed in newtons
$F_{max,est}$	estimated maximum load, expressed in newtons
f_h	embedding strength, expressed in newtons per square millimetre
$f_{h,est}$	estimated embedding strength, expressed in newtons per square millimetre
K_e	elastic foundation modulus, expressed in newtons per cubic millimetre
K_i	initial foundation modulus, expressed in newtons per cubic millimetre
K_s	foundation modulus, expressed in newtons per cubic millimetre
t	test piece thickness, expressed in millimetres
w	indentation or deformation, expressed in millimetres
w_e	elastic deformation, expressed in millimetres
w_i	initial deformation, expressed in millimetres
$w_{i,mod}$	modified initial deformation, expressed in millimetres
w_0	deformation of the test apparatus at any given load, expressed in millimetres

5 Requirements

The fasteners and the timber, glued laminated timber or wood-based sheet product shall be, as far as possible, of the quality allowed by the relevant material specification.

6 Test method

6.1 Principle

The test shall be carried out on the test piece and using the apparatus shown in Figure 1. The fastener shall be uniformly embedded along its length into the wood without significant bending of the fastener. If it is difficult to avoid bending the fastener under test using the apparatus shown in Figure 1, the apparatus shown in Figure 2 may be used for tests.

The fastener shall be loaded perpendicular to its axis through the steel loading apparatus, and the load and the corresponding indentation or deformation shall be measured; see Figures 1 and 2.

The loading may be either in tension [see Figures 1 and 3 a)], or in compression; see Figures 2 and 3 b). For solid timber and solid, laminated or composite wood products with only one grain direction, the loading may be either parallel to the grain [see Figures 3 a) and 3 b)] or compression perpendicular to the grain; see Figure 3 c).

NOTE The principles of this part of ISO 10984 can be used for other angles between the load and the grain.

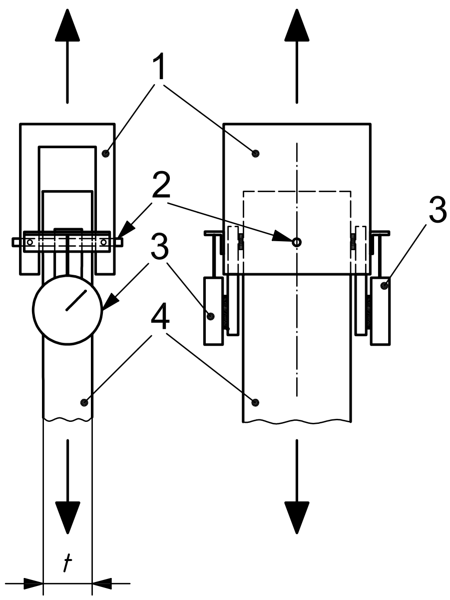
6.2 Test pieces

The test piece is a rectangular prism of wood or wood-based sheet product with a fastener placed with its axis perpendicular to the surface of the prismatic test piece. The minimum sizes of the test pieces are given in Table 1. The thickness shall be in the range $5d$ to $4d$.

NOTE The reason for this requirement is to ensure a uniform embedment stress distribution over the longitudinal axis of the fastener. Particularly in using high density material, this is of concern.

For wood-based sheet products, the thickness of the test piece shall be the thickness of the panel as produced.

For the fasteners with coatings, the coatings shall be removed before measuring the diameter and carrying out the tests.



Key

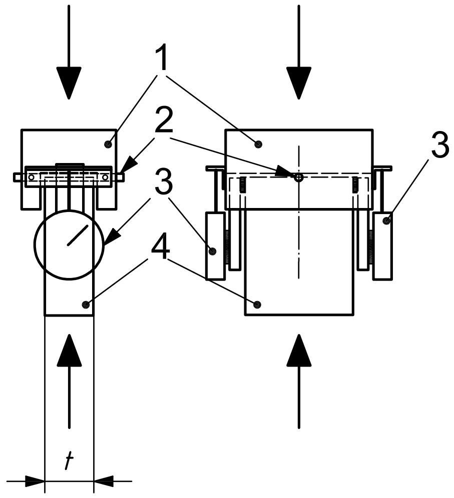
1 steel apparatus

2 fastener

3 displacement gauge attached to the test piece

4 test piece

Figure 1 — Tension test principle



Key

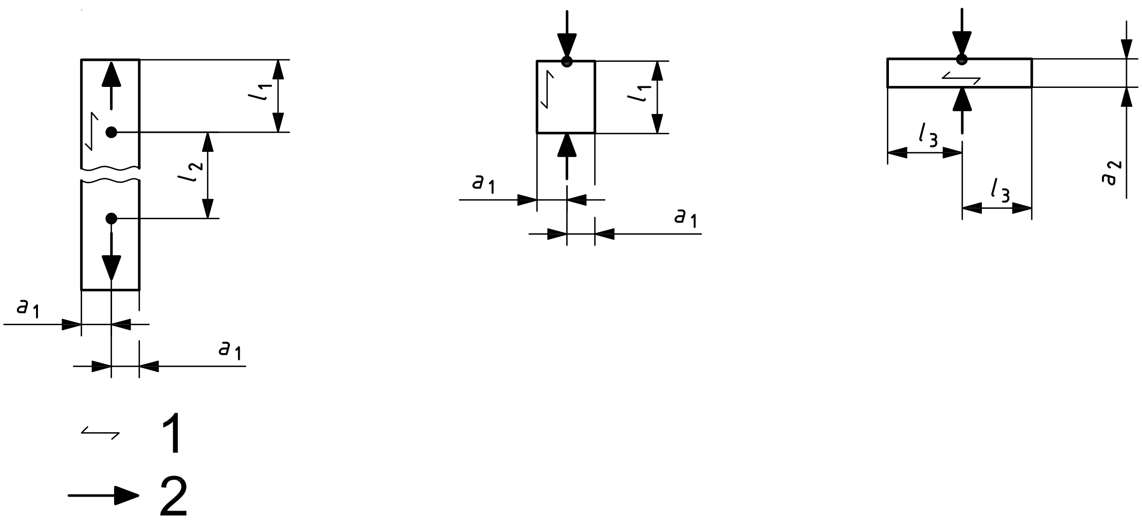
1 steel apparatus

2 fastener

3 displacement gauge attached to the test piece

4 test piece

Figure 2 — Compression test principle



a) **For tension-parallel-to-grain test** (as shown in Figure 1)

b) **For compression-parallel-to-grain test** (as shown in Figure 2)

c) **For compression-perpendicular-to-grain test** (as shown in Figure 2)

Key

1 grain direction or one of the main directions of wood-based sheet products

2 loading direction

Figure 3 — Sizes of test pieces as specified in Table 1

Table 1 — Minimum sizes of test pieces

Measurement [a]	Nails		Bolts or dowels	Test piece material
	Not pre-bored	Pre-bored		
a_1	$5d$	$5d$	$3d$	Timber or wood-based sheet products
l_1	$20d$	$12d$	$7d$	
l_2	$40d$	$40d$	$30d$	
a_2	$5d$	$5d$	$5d$	Timber or layered wood products with one grain direction
l_3	$20d$	$20d$	$20d$ [b]	

[a] Measurements given in Figure 3 are dependent on d, which is defined in Clause 4.

[b] This measurement may be reduced to $15d$ for bolts having diameters greater than 5 mm or $10d$ for dowels having diameters greater than 10 mm.

6.3 Apparatus

6.3.1 Test apparatus, designed to minimize friction between steel plates and test pieces, including equipment for measuring the geometry, moisture content, etc. of the test pieces, together with the following, shall be available.

6.3.1.1 Loading equipment, capable of applying and continuously recording the load to an accuracy of ± 1 % of the load applied to the test piece or, for loads less than 10 % of the maximum load applied to the piece, with an accuracy of ± 0,1 % of the maximum load.

6.3.1.2 Equipment, capable of continuously recording the displacement of the fasteners in the wood with an accuracy of ± 1 % of the displacement or, for displacements of less than 2 mm, with an accuracy of ± 0,03 mm.

6.4 Preparation of test pieces

Before placing the fastener, the wood material shall be conditioned to constant mass in an environment having a relative humidity of (65 ± 5) % and a temperature of (20 ± 2) °C. After fabrication, the test piece shall be conditioned again in the same environment. Constant mass is considered as having been attained when the results of two successive weighings, carried out 6 h apart, do not differ by more than 0,1 % of the mass of the test piece.

For particular investigations, it can be appropriate to condition the test piece to other moisture conditions both before and after placing the fastener. If other climatic conditions are used, they shall be reported. In tropical climates, the wood material may be conditioned in an environment having a relative humidity of (65 ± 5) % and a temperature of (25 ± 2) °C.

6.5 Procedure

6.5.1 Apparatus calibration

Initially, if relevant, the stiffness characteristic of the test apparatus may be determined to calibrate the load and deformation curve (see 6.6.2). To determine the stiffness characteristic of the test apparatus, a steel specimen with a tight-fitting pin of the same diameter as the fastener shall be placed in the apparatus and the load and deformation curve shall be determined as described in 6.5.6 and 6.5.7.

NOTE See Figure 8 for correction of the load and deformation curve taking into account the stiffness characteristics of the loading apparatus.

6.5.2 Placement of fastener

The diameter of the fastener and the thickness of the test piece shall be measured and recorded in millimetres to an accuracy of 1 %.

The fasteners shall be placed in the same way as they are used in practice (e.g. pre-boring or no pre-boring for nails, tight-fitting holes for dowels, oversized holes for bolts).

A guide may be used to ensure that the axis of the fastener is perpendicular to the surface of the test piece.

6.5.3 Placement of test piece in apparatus

The test piece shall be placed symmetrically in the test apparatus. For tension tests and compression-parallel-to-the-grain tests, the load shall be applied in the direction of the grain of the test piece. For compression-perpendicular-to-the-grain tests, the load shall be applied perpendicular to the grain of the test piece.

6.5.4 Transducer location

The relative displacement of the dowel-type fastener with respect to the test specimen shall be measured between the steel apparatus that holds the dowel and the points on the side faces of the specimens, at the level of the centreline of the dowel. Displacement transducers shall be placed on opposite edges.

NOTE 1 For the compression test as given in Figure 2, measurement of the machine cross-head movement is an adequate method of recording the embedment of the fastener.

NOTE 2 Examples of test set ups are given in Figures 1 and 2.

6.5.5 Estimation of maximum load

The estimated maximum load, $F_{\text{max,est}}$, shall be determined on the basis of experience, calculation or preliminary tests. The estimations may be adjusted as described in 6.6.3.

6.5.6 Application of load

The loading procedure as shown in Figure 4 shall be followed except that, for particular tests, the preload cycle up to 0,4 $F_{\text{max,est}}$ may be omitted as shown in Figure 5 with a corresponding adjustment to the total testing time.

The load shall be increased to 0,4 $F_{\text{max,est}}$ and maintained for 30 s. The load shall then be reduced to 0,1 $F_{\text{max,est}}$ and maintained for 30 s. Thereafter the load shall be increased.

The test shall then be stopped either when the maximum load is reached or when the deformation is $w_0 + 5$ mm.

The load shall be increased or decreased at a constant rate of loading-head movement. The loading rate shall be so adjusted that the maximum load is reached within (300 ± 120) s.

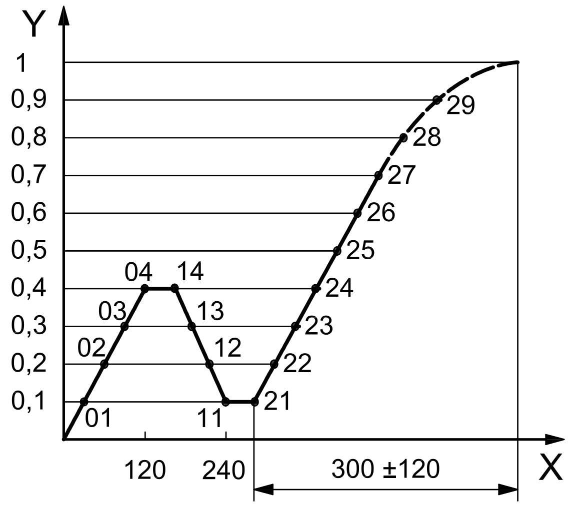
6.5.7 Recording of deformation

Deformations w_{01}, w_{04}, w_{14}, w_{11}, w_{21}, w_{24}, w_{26} and w_{28}, corresponding to the points 01, 04, 14, 11, 21, 24, 26 and 28 as shown in Figure 4, shall be recorded. When employing the loading procedure as given in Figure 5, deformations w_{01}, w_{04}, w_{06} and w_{08}, corresponding to the points 01, 04, 06 and 08 as shown in Figure 5, shall be recorded. Deformation shall be the mean of the two transducers for each test piece to give the load and deformation curve, for example, as shown in Figure 6 under the loading procedure given in Figure 4. The deformation at maximum load, F_{max}, shall also be recorded.

When a continuous load versus deformation curve is not available, measurements of deformation shall be taken at each 0,1 $F_{\text{max,est}}$ increment of load; see Figures 4 and 5.

6.5.8 Determination of moisture content and density

The moisture content and density of a test piece shall be determined after conditioning in accordance with ISO 3130 and 3131, respectively, on undamaged blocks cut from the part beneath the fastener hole of the embedment specimen immediately after the test.

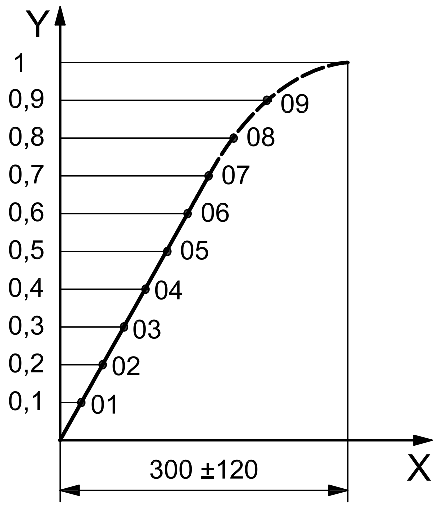


Key

X time, expressed in seconds

Y $F/F_{max,est}$

Figure 4 — Loading procedure with pre-loading cycle

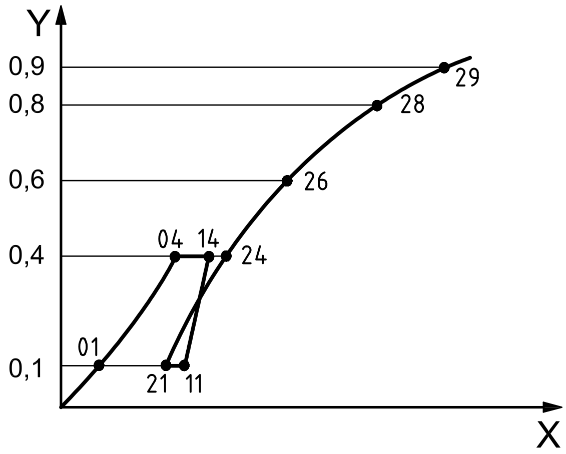


Key

X time, expressed in seconds

Y $F/F_{max,est}$

Figure 5 — Loading procedure without pre-loading cycle



Key

X deformation, w

Y $F/F_{max,est}$

Figure 6 — Idealized load and deformation curve and measurements

6.6 Results

6.6.1 Calculations

6.6.1.1 The embedding strength, f_h, and the estimated embedding strength, $f_{h,est}$, shall be calculated to an accuracy of 1 % using Equations (1) and (2), respectively:

$$f_h = \frac{F_{max}}{dt} \quad (1)$$

$$f_{h,est} = \frac{F_{max,est}}{dt} \quad (2)$$

6.6.1.2 Under the loading procedure as given in Figure 4, the following values, if relevant, shall be calculated from the recorded measurements:

a) Initial deformation, w_i:

$$w_i = w_{04} \quad (3)$$

b) Modified initial deformation, $w_{i,mod}$:

$$w_{i,mod} = \frac{4}{3}\left(w_{04} - w_{01}\right) \quad (4)$$

c) Elastic deformation, w_e:

$$w_e = \frac{2}{3}\left(w_{14} + w_{24} - w_{11} - w_{21}\right) \quad (5)$$

d) Initial foundation modulus, K_i:

$$K_i = \frac{0,4 f_{h,est}}{w_i} \quad (6)$$

e) Foundation modulus, K_s:

$$K_s = \frac{0{,}4 f_{h,est}}{w_{i,mod}} \tag{7}$$

f) Elastic foundation modulus, K_e:

$$K_e = \frac{0{,}4 f_{h,est}}{w_e} \tag{8}$$

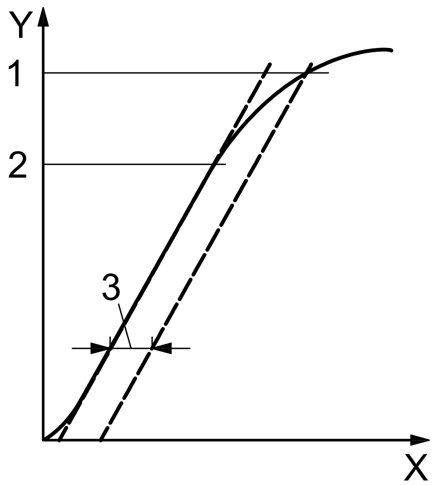
g) Deformation at 0,6 F_{max}, equal to $w_{0,6}$

h) Deformation at 0,8 F_{max}, equal to $w_{0,8}$

6.6.1.3 Under the alternate loading procedure as given in Figure 5, the following values, if relevant, shall be determined from the recorded load-deformation curve:

— Yield load: the load at which a line offset from the straight line fitted to the initial portion of the load-deformation curve by an amount equal to 5 % of the fastener section dimension intersects the load-deformation curve as shown in Figure 7.

— Proportional limit load: the load at which the load-deformation curve deviates from a straight line fitted to the initial portion of the load-deformation curve as shown in Figure 7.



Key

X deformation

Y load

1 yield load

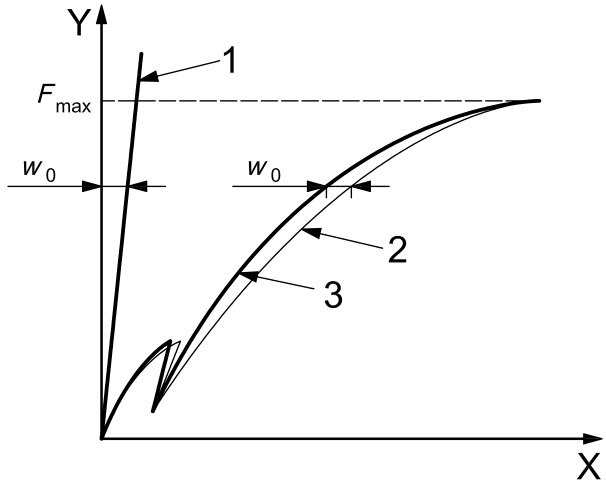
2 proportional limit load

3 5 % of the fastener section diameter

Figure 7 — Determination of yield load and proportional limit load

6.6.2 Calibration of load-versus-deformation curve

The measured load versus deformation curve may, if relevant, be corrected as shown in Figure 8. If it is not relevant, this calibration procedure is not necessarily applied to the load and deformation curve.



Key

X deformation

Y load

1 load versus deformation curve from calibration test

2 measured load and deformation curve

3 corrected load and deformation curve

NOTE 1 It is relevant to correct the curve when the deformation of the test apparatus is greater than 10 % of the fastener embedment at F_{max}.

NOTE 2 The measured deformation at the load, F, is reduced by the deformation, w_0, at the same load found by the apparatus calibration.

Figure 8 — Correction of the measured load versus deformation curve taking into account the stiffness characteristics of the load apparatus

6.6.3 Adjustments

If, during the execution of the tests, the mean value of the maximum load of the tests already carried out deviates by more than 20 % from the estimated value, this value shall be adjusted correspondingly for subsequent tests. The mean value of the maximum loads already determined may be accepted without adjustment as part of the final results. In the case where adjustment of the estimated maximum load is required, the values of deformation and foundation modulus determined in Equations (2) to (8) shall be adjusted in a corresponding manner.

7 Test report

The test report shall include the following:

a) name and address of test laboratory;

b) date of test report;

c) reference to this part of ISO 10984;

d) description of the fasteners: type, diameter, strength characteristics and surface treatment of the fastener (including anticorrosion protection);

e) description of the test piece: species, density, grain direction;

f) description of the testing method: size of the test pieces, diameter of the hole, rate of loading;

g) conditioning of test pieces before and after preparation;

h) number of replicate tests;

i) density and moisture content of specimen at test;

j) calculated values for derived parameters.

Bibliography

[1] EN 383, *Timber structures — Test methods — Determination of embedment strength and foundation values for dowel type fasteners*

[2] ASTM D5764, *Standard Test Method for Evaluating Dowel-Bearing Strength of Wood and Wood-Based Products*

ICS 91.080.20

Price based on 12 pages