Timber structures — Structural timber and glued laminated timber — Determination of some physical and mechanical properties

The European Standard EN 408:1995 has the status of a British Standard

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee B/518, Structural timber, to Subcommittee B/518/1, Test methods, upon which the following bodies were represented:

Department of the Environment (British Board of Agrément)
Department of the Environment (Building Research Establishment)
Institution of Civil Engineers
Institution of Structural Engineers
Timber Research and Development Association
Wood Panel Products Federation
Coopted members

This British Standard, having been prepared under the direction of the Sector Board for Building and Civil Engineering, was published under the authority of the Standards Board and comes into effect on 15 November 1995

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Contents

National foreword

This British Standard has been prepared by Subcommittee B/518/1 and is the English language version of EN 408:1995 *Timber structures — Structural timber and glued laminated timber — Determination of some physical and mechanical properties* published by the European Committee for Standardization (CEN).

This European Standard supersedes BS 5820:1979.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 13 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 408

January 1995

ICS 91.080.20

Descriptors: Timber construction, sawn timber, laminated board, determination, physical properties, mechanical properties, laboratory tests

English version

Timber structures — Structural timber and glued laminated timber — Determination of some physical and mechanical properties

Structures en bois — Bois massif et bois lamellé-collé — Détermination de certaines propriétés physiques et mecaniques

Holzbauwerke — Bauholz für tragende Zwecke und Brettschichtholz — Bestimmung einiger physikalischer und mechanischer Eigenschaften

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

Ref. No. EN 408:1995 E

Foreword

This European Standard has been prepared by the Technical Committee CEN/TC 124, Timber structures, the secretariat of which is held by DS.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 1995 and conflicting national standards shall be withdrawn at the latest by July 1995.

This standard is one of a series of standards for test methods for building materials and components. It was prepared by a working group under the convenorship of the National Standards Authority of Ireland (NSAI).

NOTE It is considered desirable to maintain the same clause numbers consistently throughout this series of standards. Consequently some clauses are void in this edition of this standard, but it is envisaged that future editions may need to include text in the clauses concerned.

No existing European Standard is superseded.

In accordance with the CEN/CENELEC Internal Regulations, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

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Introduction

The values obtained in any determination of the properties of timber depend upon the test methods used. It is therefore desirable that these methods be standardized so that results from different test centres can be correlated. Moreover, with the adoption of limit state design and with the development of both visual and machine stress grading, attention will be increasingly centred on the determination and monitoring of the strength properties and variability of timber in structural sizes. Again, this can be more effectively undertaken if the basic data are defined and obtained under the same conditions.

This European Standard, which is based on ISO 8375, specifies laboratory methods for the determination of some physical and mechanical properties of timber in structural sizes. The methods are not intended for the grading of timber or for quality control.

For the determination of shear modulus, alternative methods have been specified. The choice of which to use will depend upon the objective of the investigation and, to some extent, on the equipment available. It is recognized that the methods may not give the same results.

Following testing to this standard it is intended that the determination of characteristic values will normally be obtained according to procedures specified in other European Standards.

Attention is drawn to the advantages that may be gained, often with little extra effort, in extending the usefulness of test results by recording additional information on the growth characteristics of the piece that are tested, particularly at the fracture sections. Generally, such additional information should include grade-determining features such as knots, slope of grain, rate of growth, wane, etc., on which visual grading rules are based, and strength indicating parameters such as localized modulus of elasticity, on which machine stress grading is based.

1 Scope

This standard specifies test methods for determining the following properties of structural timber and glued laminated timber: modulus of elasticity in bending; shear modulus; bending strength; modulus of elasticity in tension parallel to the grain; tension strength parallel to the grain; modulus of elasticity in compression parallel to the grain; compression strength parallel to the grain.

In addition, the determination of dimensions, moisture content, and density are specified.

The methods apply to rectangular and circular shapes (of substantially constant cross section) of solid unjointed timber or finger-jointed timber and glued laminated timber.

This standard is not intended for quality-control test purposes.

2 Normative references

None.

3 Symbols

A	cross-sectional area, in square millimetres;
a	distance between a loading position and the nearest support in a bending test, in millimetres;
$E_{c,0}$	modulus of elasticity in compression parallel to the grain, in newtons per square millimetre;
E_m	modulus of elasticity in bending, in newtons per square millimetre;
$E_{m,app}$	apparent modulus of elasticity in bending, in newtons per square millimetre;
$E_{t,0}$	modulus of elasticity in tension parallel to the grain, in newtons per square millimetre;
F	load, in newtons;
F_{max}	maximum load, in newtons;
$F_{max,est}$	estimated maximum load, in newtons;
$f_{c,0}$	compressive strength parallel to the grain, in newtons per square millimetre;
f_m	bending strength, in newtons per square millimetre;
$f_{t,0}$	tensile strength parallel to the grain, in newtons per square millimetre;
G	shear modulus, in newtons per square millimetre;
h	depth of cross section in a bending test, or the larger dimension of the cross section, in millimetres;
I	second moment of area, in millimetres to the fourth power;
K, k	coefficients;
k_G	coefficient for shear modulus;
l	span in bending, or length of test piece between the testing machine grips in compression and tension, in millimetres;
l_1	gauge length for the determination of modulus of elasticity, in millimetres;
W	section modulus, in millimetres to the third power;

w	deformation, in millimetres;
Suffixes 1, 2	refer to loads or deformations at particular points of a test and are referred to as necessary in the text.

4 Determination of dimensions of test pieces

The dimensions of the test piece shall be measured to an accuracy of 1 %. All measurements shall be made when the test pieces are conditioned as specified in clause **7**.

NOTE If the width or thickness varies, these dimensions should be recorded as the average of three separate measurements taken at different positions on the length of each piece.

The measurements shall not be taken closer than 150 mm to the ends.

5 Determination of moisture content of test pieces

The moisture content of the test piece shall be determined on a section taken from the test piece. For structural timber the section shall be of full cross section, free from knots and resin pockets.

In strength tests, the section shall be cut as close as possible to the fracture.

6 Determination of density of test pieces

The density of the whole cross section of the test piece shall be determined on a section taken from the test piece. For structural timber the section shall be of full cross section, free from knots and resin pockets.

In strength tests, the section shall be cut as close as possible to the fracture.

7 Conditioning of test pieces

The tests shall be carried out on pieces which are conditioned at the standard environment of (20 ± 2) °C and (65 ± 5) % relative humidity. A test piece is conditioned when it attains constant mass. Constant mass is considered to be attained when the results of two successive weighings, carried out at an interval of 6 h, do not differ by more than 0,1 % of the mass of the test piece.

Where the timber to be tested is not readily conditionable to the above standard environment (e.g. for hardwoods with high densities), that fact shall be reported.

8 Determination of modulus of elasticity in bending

8.1 Test piece

The test piece shall have a minimum length of 19 times the depth of the section. Where this is not possible, the span of the beam shall be reported.

8.2 Procedure

The test piece shall be symmetrically loaded in bending at two points over a span of 18 times the depth as shown in Figure 1. If the test piece and equipment do not permit these conditions to be achieved exactly, the distance between the load points and the supports may be changed by an amount not greater than 1,5 times the piece depth, and the span and test piece length may be changed by an amount not greater than three times the piece depth, while maintaining the symmetry of the test.

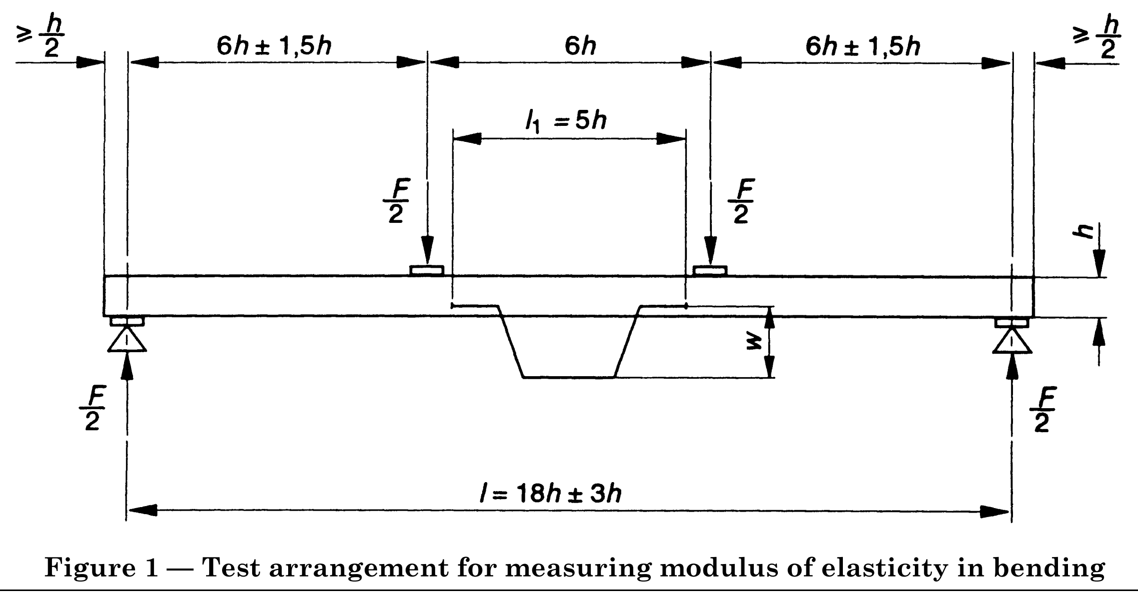

Figure 1 — Test arrangement for measuring modulus of elasticity in bending

The test piece shall be simply supported.

NOTE Small steel plates of length not greater than one-half of the depth of the test piece may be inserted between the piece and the loading heads or supports to minimize local indentation.

Lateral restraint shall be provided as necessary to prevent buckling. This restraint shall permit the piece to deflect without significant frictional resistance.

Load shall be applied at a constant rate. The rate of movement of the loading head shall be not greater than 0,003 h mm/s (see Figure 1).

The maximum load applied shall not exceed the proportional limit load or cause damage to the piece.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test piece or, for loads less than 10 % of the applied maximum load, with an accuracy of 0,1 % of the maximum applied load.

Deformations shall be measured at the centre of a central gauge length of five times the depth of the section.

Deformations shall be determined with an accuracy of 1 % or, for deformations less than 2 mm, with an accuracy of 0,02 mm.

8.3 Expression of results

The modulus of elasticity in bending

$$E_m = \frac{al_1^2 (F_2 - F_1)}{16I (w_2 - w_1)}$$

where

$F_2 - F_1$	is an increment of load on the straight line portion of the load deformation curve, in newtons (see Figure 2);
$w_2 - w_1$	is the increment of deformation corresponding to $F_2 - F_1$, in millimetres (see Figure 2).

The other symbols are as given in clause **3**.

The modulus of elasticity shall be calculated to an accuracy of 1 %.

9 Determination of shear modulus — Single span method

NOTE Measurement of the shear modulus of structural timber and glued laminated timber presents considerable difficulty but values suitable for use in design can be obtained by either one of the methods described in clauses **9** and **10**.

9.1 General

This method involves the determination of the modulus of elasticity in bending E_m and the apparent modulus of elasticity $E_{m,app}$ for the same length of test piece.

9.2 Determination of modulus of elasticity in bending

The modulus of elasticity in bending shall be determined in accordance with clause **8**.

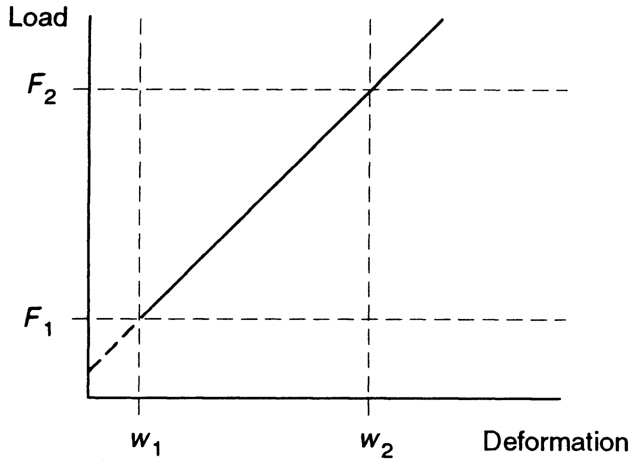

Figure 2 — Load-deformation graph within the range of elastic deformation

9.3 Determination of apparent modulus of elasticity

9.3.1 *Test piece*

The test piece shall be that used for the determination of the modulus of elasticity in bending, see **9.2**.

9.3.2 *Procedure*

The test piece shall be loaded in centre point bending over a span equal to the gauge length used in **9.2** and including the same test length, as shown in Figure 3 (see also Figure 1). In this case $l = l_1$.

The test piece shall be simply supported.

NOTE Small steel plates of length not greater than one-half of the depth of the test piece may be inserted between the piece and the loading heads or supports to minimize local indentation.

Lateral restraint shall be provided as necessary to prevent buckling. This restraint shall permit the piece to deflect without significant frictional resistance.

Load shall be applied at a constant rate. The rate of movement of the loading head shall be not greater than 0,0002 h mm/s.

The maximum load applied shall not exceed the proportional limit or cause damage to the piece.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test piece or, for loads less than 10 % of the maximum applied load, with an accuracy of 0,1 % of the maximum applied load.

Deformations shall be measured at the centre of the span.

Deformations shall be determined with an accuracy of 1 % or, for deformations less than 2 mm, with an accuracy of 0,02 mm.

9.3.3 *Expression of results*

The apparent modulus of elasticity $E_{m,app}$ is given by the equation

$$E_{m,\,app} = \frac{l_1^{\,3}\,(F_2 - F_1)}{48I\,(w_2 - w_1)}$$

where

$F_2 - F_1$ is an increment of load on the straight line portion of the load deformation curve, in newtons (see Figure 2);

$w_2 - w_1$ is the increment of deformation corresponding to $F_2 - F_1$, in millimetres (see Figure 2).

The other symbols are as given in clause **3**.

The apparent modulus of elasticity shall be calculated to an accuracy of 1 %.

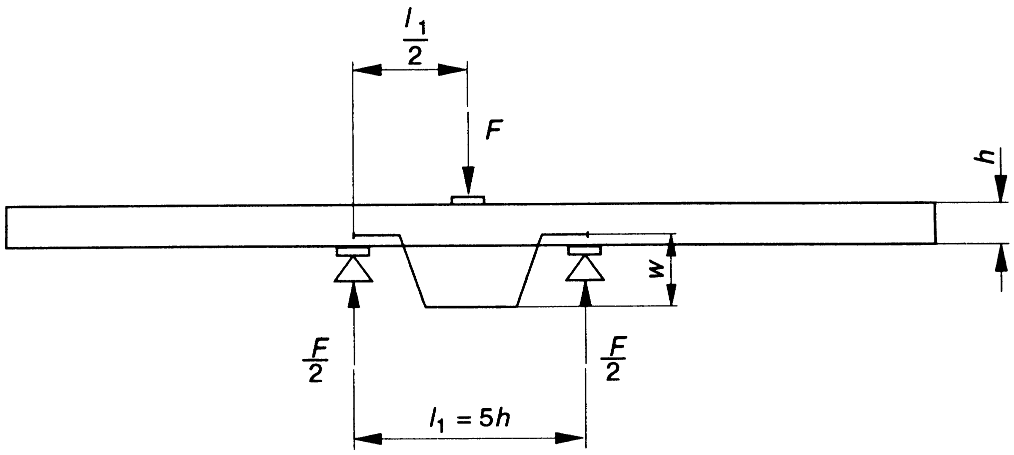

Figure 3 — Test arrangement for measuring apparent modulus of elasticity

9.4 Calculation of shear modulus

The shear modulus G is given by the equation

$$G = \frac{k_G h^2}{l_1^{\,2}\left[\dfrac{1}{E_{m,app}} - \dfrac{1}{E_m}\right]}$$

where

k_G = 1,2 for rectangular or square cross sections.

The other symbols are as given in clause **3**.

The shear modulus shall be calculated to an accuracy of 1 %.

10 Determination of shear modulus — Variable span method

10.1 General

This method involves the determination of the apparent modulus of elasticity $E_{m,app}$ for each test piece over a number of spans with the same cross section at the centre.

10.2 Test piece

The test piece shall have a minimum length of 21 times the depth of the section.

10.3 Procedure

The test piece shall be loaded in centre point bending over at least four different spans with the same cross section at the centre of each. The spans shall be chosen so as to have approximately equal increments of $(h/l)^2$ between them, within the range 0,0025 to 0,035.

The test piece shall be simply supported.

NOTE Small steel plates of length not greater than one-half of the depth of the test piece may be inserted between the piece and the loading heads or supports to minimize local indentation.

Lateral restraint shall be provided as necessary to prevent buckling. This restraint shall permit the piece to deflect without significant frictional resistance.

Load shall be applied at a constant rate. The rate of movement of the loading head shall be not greater than

$$\frac{5 \times 10^{-5} l^2}{6\,h} \text{ mm/s}$$

The symbols are as given in clause **3**.

The maximum load applied shall not exceed the proportional limit load or cause damage to the piece.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test piece or, for loads less than 10 % of the applied maximum load, with an accuracy of 0,1 % of the maximum applied load.

Deformations shall be measured at the centre of the spans.

Deformation shall be determined with an accuracy of 1 % or, for deformations less than 2 mm, with an accuracy of 0,02 mm.

10.4 Expression of results

10.4.1 ***General***

The apparent modulus of elasticity for each piece and each test span shall be calculated as described in **10.4.2** and **10.4.3**.

10.4.2 ***Apparent modulus of elasticity***

The apparent modulus of elasticity $E_{m,app}$ is given by the equation

$$E_{m,\,app} = \frac{l_1^{\,3}\,(F_2 - F_1)}{48I(w_2 - w_1)}$$

where

$F_2 - F_1$ is an increment of load on the straight line portion of the load deformation curve, in newtons (see Figure 2);

$w_2 - w_1$ is the increment of deformation corresponding to $F_2 - F_1$, in millimetres (see Figure 2).

The other symbols are as given in clause **3**.

For each piece, the values of $1/E_{m,app}$ shall be plotted against $(h/l)^2$ as shown in Figure 4 and the slope K_1 of the best straight line through the points shall be determined.

NOTE A value for the modulus of elasticity E_m is given by $1/K_2$, where K_2 is the intercept of the line at zero $(h/l)^2$.

10.4.3 ***Shear modulus***

The shear modulus G is given by the equation

$$G = \frac{k_G}{K_1}$$

where

k_G = 1,2 for rectangular or square cross sections, and K_1 is the slope of the straight line (see Figure 4).

The shear modulus shall be calculated to an accuracy of 1 %.

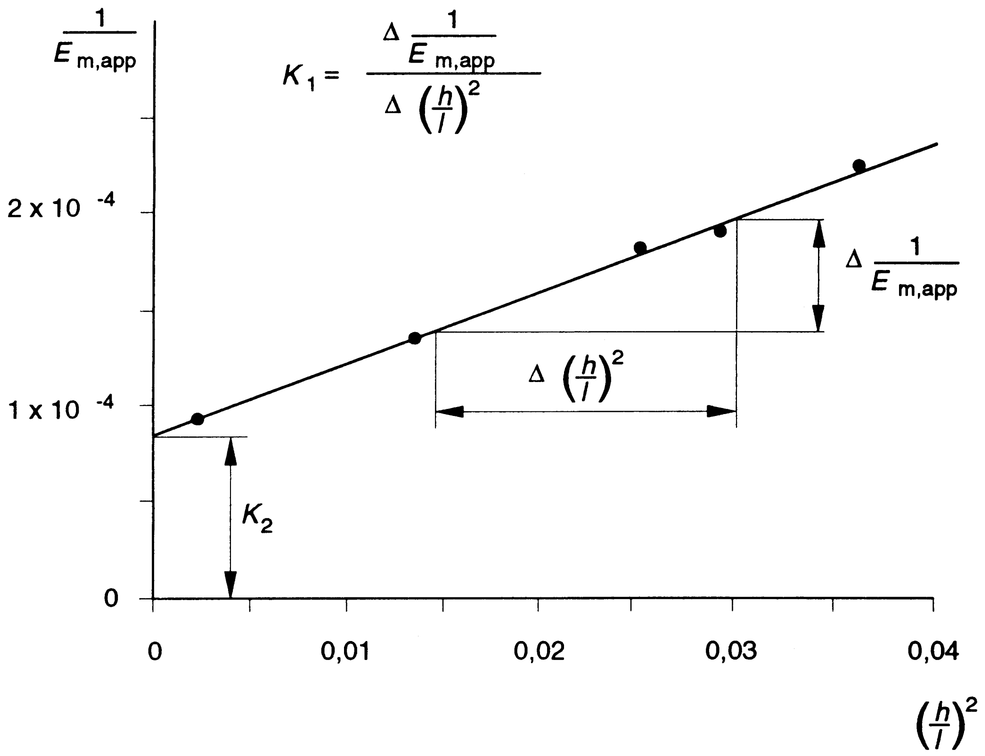

Figure 4 — Determination of shear modulus — Variable span method

11 Determination of bending strength

11.1 Test piece

The test piece shall normally have a minimum length of 19 times the depth of the cross section. Where this is not possible, the span of the beam shall be reported.

11.2 Procedure

The test piece shall be symmetrically loaded in bending at two points over a span of 18 times the depth as shown in Figure 1. If the test piece and equipment does not permit these conditions to be achieved exactly, the distance between the inner load points and the supports shall be changed by an amount not greater than 1,5 times the depth of the test piece, and the span and test piece length may be changed by an amount not greater than three times the depth of the test piece, while maintaining the symmetry of the test.

The test piece shall be simply supported.

NOTE 1 Small steel plates of length not greater than one-half of the depth of the test piece may be inserted between the piece and the loading heads or supports to minimize local indentation.

Lateral restraint shall be provided as necessary to prevent buckling. This restraint shall permit the piece to deflect without significant frictional resistance.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test piece.

Load shall be applied at a constant loading-head movement so adjusted that maximum load is reached within (300 ± 120) s.

NOTE 2 This rate should be determined from the results of preliminary tests. The objective is that the time to reach F_{max} for each piece is 300 s.

The time to failure for each test piece shall be recorded and its average reported. Any single piece diverging more than 120 s from the target of 300 s shall be reported.

11.3 Expression of results

The bending strength f_m is given by the equation

$$f_m = \frac{aF_{max}}{2W}$$

The symbols are as given in clause **3**.

The bending strength shall be calculated to an accuracy of 1 %.

The mode of fracture and the growth characteristics at the fracture section of each test piece shall be recorded.

12 Determination of modulus of elasticity in tension parallel to the grain

12.1 Test piece

The test piece shall be of full structural cross section, and of sufficient length to provide a test length clear of the testing machine grips of at least nine times the larger cross-sectional dimension.

12.2 Procedure

The test piece shall be loaded using gripping devices which will permit as far as possible the application of a tensile load without inducing bending. The gripping devices and loading conditions actually used shall be reported.

Load shall be applied at a constant rate. The rate of strain in the piece shall be not greater than 0,00005 per s.

The maximum load applied shall not exceed the proportional limit load or cause damage to the test piece.

NOTE If significant movement occurs, for example with wedge type grips, preliminary tests may be needed to establish a rate of movement of the machine cross-head.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test piece or, for loads less than 10 % of the applied maximum load, with an accuracy of 0,1 % of the maximum applied load.

Deformation shall be measured over a length of five times the width of the piece, located not closer to the ends of the grips than twice this width. Two extensometers shall be used, and shall be positioned to minimize the effects of distortion.

Deformations shall be determined with an accuracy of 1 % or for deformations less than 2 mm, with an accuracy of 0,02 mm.

12.3 Expression of results

The modulus of elasticity in tension $E_{t,0}$ is given by the equation

$$E_{t,0} = \frac{l_1(F_2 - F_1)}{A(w_2 - w_1)}$$

where

- $F_2 - F_1$ is an increment of load on the straight line portion of the load deformation curve, in newtons (see Figure 2);
- $w_2 - w_1$ is the increment of deformation corresponding to $F_2 - F_1$, in millimetres (see Figure 2).

The other symbols are as given in clause **3**.

The modulus of elasticity in tension shall be calculated to an accuracy of 1 %.

13 Determination of tension strength parallel to the grain

13.1 Test piece

The test piece shall be of full structural cross section, and of sufficient length to provide a test length clear of the testing machine grips of at least nine times the larger cross-sectional dimension.

13.2 Procedure

The test piece shall be loaded using gripping devices which will permit as far as possible the application of a tensile load without inducing bending. The gripping devices and loading conditions actually used shall be reported.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test piece.

Load shall be applied at a constant loading-head movement so adjusted that maximum load is reached within (300 ± 120) s.

NOTE This rate should be determined from the results of preliminary tests. The objective is that the time to reach F_{max} for each piece is 300 s.

The time to failure for each test piece shall be recorded and its average reported. Any single piece diverging more than 120 s from the target of 300 s shall be reported.

13.3 Expression of results

The tensile strength $f_{t,0}$ is given by the equation

$$f_{t,0} \quad \frac{F_{max}}{A}$$

The symbols are as given in clause **3**.

The tensile strength shall be calculated to an accuracy of 1 %.

The mode of fracture and growth characteristics at the fracture section of each test piece shall be recorded. If failure is associated with the grips, this shall be reported.

14 Determination of modulus of elasticity in compression parallel to the grain

14.1 Test piece

The test piece shall be of full cross section, and shall have a length of six times the smaller cross-sectional dimension. The end surfaces shall be accurately prepared to ensure that they are plane and parallel to one another and perpendicular to the axis of the piece.

14.2 Procedure

The test piece shall be loaded concentrically using spherically seated loading-heads or other devices which permit the application of a compressive load without inducing bending. After an initial load has been applied the loading-heads shall be locked to prevent angular movement. The gripping devices and loading conditions actually used shall be reported.

Load shall be applied at a constant rate. The rate of movement of the loading-head shall be not greater than 0,00005 l mm/s.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test piece, or for loads less than 10 % of the applied maximum load, with an accuracy of 0,1 % of the maximum applied load.

Deformation shall be measured over a central gauge length of four times the smaller cross-sectional dimension of the piece. Two extensometers shall be used, and shall be positioned to minimize the effects of distortion.

Deformations shall be determined with an accuracy of 1 % or, for deformations less than 2 mm, with an accuracy of 0,02 mm.

14.3 Expression of results

The modulus of elasticity in compression $E_{c,0}$ is given by the equation

$$E_{c,0} = \frac{l_1\,(F_2 - F_1)}{A(w_2 - w_1)}$$

where

$F_2 - F_1$ is an increment of load on the straight line portion of the load deformation curve, in newtons (see Figure 2);

$w_2 - w_1$ is the increment of deformation corresponding to $F_2 - F_1$, in millimetres (see Figure 2).

The other symbols are as given in clause **3**.

The modulus of elasticity in compression shall be calculated to an accuracy of 1 %.

15 Determination of compression strength parallel to grain

15.1 Test piece

The test piece shall be of full cross section, and shall have a length of six times the smaller cross-sectional dimension. The end surfaces shall be accurately prepared to ensure that they are plane and parallel to one another and perpendicular to the axis of the piece.

15.2 Procedure

The test piece shall be loaded concentrically using spherically seated loading-heads or other devices which permit the application of a compressive load without inducing bending. After an initial load has been applied the loading-heads shall be locked to prevent angular movement. The gripping devices and loading conditions actually used shall be reported.

The loading equipment used shall be capable of measuring the load to an accuracy of 1 % of the load applied to the test piece.

Load shall be applied at a constant loading-head movement so adjusted that maximum load is reached within (300 ± 120) s.

NOTE This rate should be determined from the results of preliminary tests. The objective is that the time to reach F_{max} for each piece is 300 s.

The time to failure of each test piece shall be recorded and its average reported. Any single piece diverging more than 120 s from the target of 300 s shall be reported.

15.3 Expression of results

The compressive strength $f_{c,0}$ is given by the equation

$$f_{c,0} = \frac{F_{max}}{A}$$

The symbols are as given in clause **3**.

The compressive strength shall be calculated to an accuracy of 1 %.

The mode of fracture and growth characteristics at the fracture section of each test piece shall be reported.

16 Test report

16.1 General

The test report shall include details of the test piece, the method of test used and the test results.

16.2 Test piece

The following information shall be given.

a) Species.

b) Size of test piece. In addition, for glued laminated timber, the type of glue used and the orientation and the number of laminations.

c) Country, region or mill of origin of the material sampled. In addition, for glued laminated timber, the factory of origin.

d) Method of selection of test piece.

e) Grade or any relevant pre-selection.

f) Method of conditioning.

g) Any other information which may have influenced the test results, for example drying history.

16.3 Method of test

The following information shall be given.

a) Methods of test used.

b) Temperature and relative humidity at the time of test.

c) Equipment used.

d) Any other information which may influence the use of the test results.

16.4 Test results

The following information for each test piece shall normally be given.

a) Moisture content at time of test.

b) Density.

c) Actual dimensions.

d) Moduli and/or strength values.

e) Failure mode.

f) Time to failure and average value for all similar tests.

g) Any other information which may influence the use of the test results, for example growth characteristics or grading machine indicating parameter at the fracture section.

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