International Standard ISO 8375

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Solid timber in structural sizes — Determination of some physical and mechanical properties

Bois massif en dimensions d'emploi — Détermination de certaines propriétés physiques et mécaniques

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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Solid timber in structural sizes — Determination of some physical and mechanical properties

0 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 may be correlated and more widely applied. 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 International Standard, which is based on the recommendations of CIB-W 18[1)]/RILEM 3TT[2)], 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 surveillance.

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 comparable results.

Sampling techniques, the orientation and positioning of test pieces within the test machines, and the analysis of data will be dealt with in future International Standards. Methods for the determination of shear strength and strength and stiffness in torsion are being studied and will form the subject of a future International Standard.

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 specimens 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 and field of application

This International Standard specifies laboratory methods for determining the following properties of solid timber in structural sizes:

a) modulus of elasticity in static bending;

b) shear modulus;

c) bending strength;

d) modulus of elasticity in tension;

e) tension strength parallel to the grain;

f) modulus of elasticity in compression;

g) compression strength parallel to the grain.

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

The methods apply to rectangular and square sections of solid unjointed timber or finger-jointed timber in finished sizes.

2 References

ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications.*

ISO 3130, *Wood — Determination of moisture content for physical and mechanical tests.*

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

1) Working Commission W 18, *Timber structures*, of the International Council for Building Research, Studies and Documentation.

2) Commission 3TT, *Testing methods for timber*, of the International Union of Testing and Research Laboratories for Materials and Structures.

3 Symbols and indices

3.1 Symbols

A cross-sectional area, in square millimetres

a distance between an inner load point and the nearest support in a bending test, in millimetres

E modulus of elasticity, in megapascals (newtons per square millimetre)

F load, in newtons

f strength, in megapascals (newtons per square millimetre)

G shear modulus, in megapascals (newtons per square millimetre)

h depth of section in a bending test, or the larger dimension of a section, in millimetres

I second moment of area, in millimetres to the fourth power (mm^4)

l full span in bending, length of test piece in compression and tension, in millimetres

l_1 gauge length for the determination of modulus of elasticity, in millimetres

W section modulus, in cubic millimetres

w deflection or deformation, in millimetres

ϱ density, in kilograms per cubic metre

ω moisture content

3.2 Subscripts

app apparent

c compression

m bending

t tension

u ultimate

3.3 Prefixes

Δ increment

Section one : Physical properties

4 Determination of dimensions of test specimens

The width, thickness, and length of the test specimens shall be measured in millimetres to three significant figures. All measurements shall be made when the specimens are in the moisture condition required for the tests.

If the width or thickness are likely to vary, they should be recorded as the average of three separate measurements taken at different positions on the length of each specimen.

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

5 Determination of moisture content

The moisture content (ω) of the test specimens shall be determined in accordance with ISO 3130 on a disc of full cross-section, free from knots and resin pockets. In ultimate strength tests, the disc shall be cut as close as possible to the fracture.

6 Determination of density

The density (ϱ) of the test specimens shall be determined in accordance with ISO 3131 from a disc of full cross-section, free from knots and resin pockets. In ultimate strength tests, the disc shall be cut as close as possible to the fracture.

7 Conditioning of test specimens

The test specimens shall normally be conditioned, prior to final machining and testing, to constant mass[1)] and moisture content in an atmosphere having a relative humidity of 65 ± 5 % and a temperature of 20 ± 2 °C, according to ISO 554.[2)]

Where possible, the test conditions should be the same as those in the conditioning chamber, but, where this is not possible, tests should be carried out immediately after the specimens have been removed from the conditioning chamber.

1) 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 specimen.

2) For particular investigations, it may be necessary to condition the specimens to other climate classes or moisture conditions.

Section two: Mechanical properties

8 Determination of modulus of elasticity in static bending

8.1 Test specimen

The test specimen shall have a minimum length of 19 times the nominal depth of the section.

8.2 Procedure

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

The specimen shall be supported on rollers, or by other devices which achieve an acceptable free support condition. Small plates of length not greater than one-half of the nominal depth may be inserted between the specimen and the loading heads or supports to minimize local indentation.

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

Load shall be applied either at a continuous rate or in increments, avoiding impact effects, and care should be taken to ensure that the maximum load applied does not exceed the proportional limit load or cause damage to the specimen.

If continuous loading is used, the rate of movement of the loading-head shall not be greater than $3 \times 10^{-3}\,h$ mm/s, where h is the depth of the section, in millimetres.

For the purpose of determining modulus of elasticity, the slope of the load-deflection curve shall be measured over a head travel of $45 \times 10^{-3}\,h$ mm from the beginning of application of load.

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

Deflections shall be measured at the centre of a central gauge length of five times the nominal depth of the section with the deflectometer attached at the centre of the depth.

A record of load/deflection shall be made so that the deflection under an increment of load can be determined with an accuracy of 1 % or, for deflections less than 2 mm, with an accuracy of 0,02 mm.

8.3 Expression of results

The modulus of elasticity in static bending, E_m, expressed in megapascals, is given by the formula

$$E_m = \frac{a l_1^2 \Delta F}{16\, I \Delta w}$$

where

a is the distance between an inner load point and the nearest support, in millimetres;

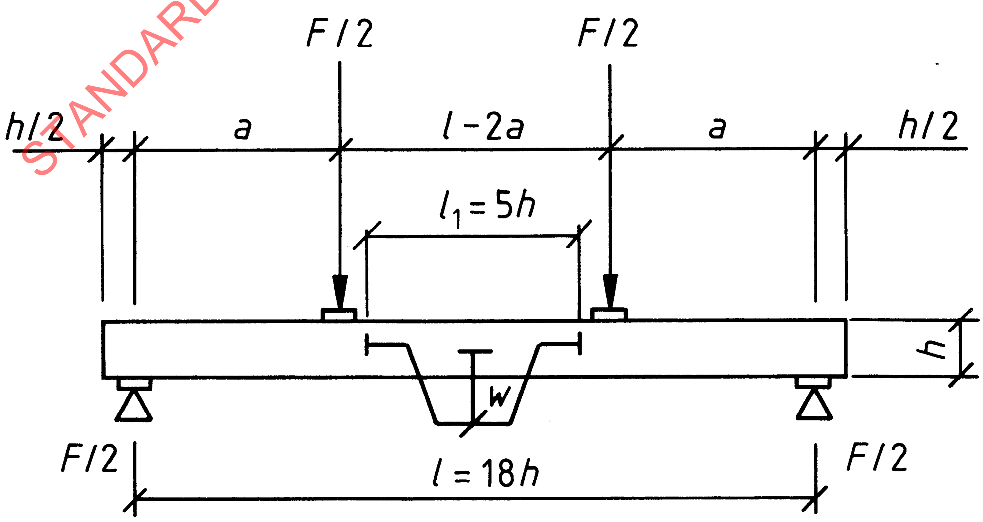

Figure 1 — Test arrangement for measuring modulus of elasticity in static bending

l_1 is the gauge length, in millimetres;

ΔF is an increment of load below the proportional limit, in newtons;

I is the second moment of area of the section, determined from its actual dimensions, in millimetres to the fourth power;

Δw is the deflection under the increment of load ΔF, in millimetres.

The modulus of elasticity shall be calculated and recorded to three significant figures.

9 Determination of shear modulus — Single span method [1]

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

9.1 Determination of modulus of elasticity in static bending

Carry out the test in accordance with clause 8.

9.2 Determination of apparent modulus of elasticity

9.2.1 Test specimen

The test specimen shall be that used for the determination of the modulus of elasticity in static bending in 9.1.

9.2.2 Procedure

The test specimen shall be loaded in centre point bending over a span equal to the gauge length used in 9.1 and including the same test length, as shown in figure 2 (see also figure 1).

The test specimen shall be supported on rollers, or by other devices which achieve an acceptable free support condition. Small plates of length not greater than one-half of the nominal depth may be inserted between the specimen and the loading heads and supports to minimize local indentation.

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

Load shall be applied either at a continuous rate or in increments, avoiding impact effects, and care should be taken to ensure that the maximum load applied does not exceed the proportional limit load or cause damage to the specimen.

If continuous loading is used, the rate of movement of the loading-head shall not be greater than $2 \times 10^{-4}\ h$ mm/s, where h is the depth of the section, in millimetres.

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

Deflections shall be measured at the centre of the span with the deflectometer attached at the centre of depth of the specimen.

A record of load/deflection shall be made so that the deflection under an increment of load can be determined with an accuracy of 1 % or, for deflections less than 2 mm, with an accuracy of 0,02 mm.

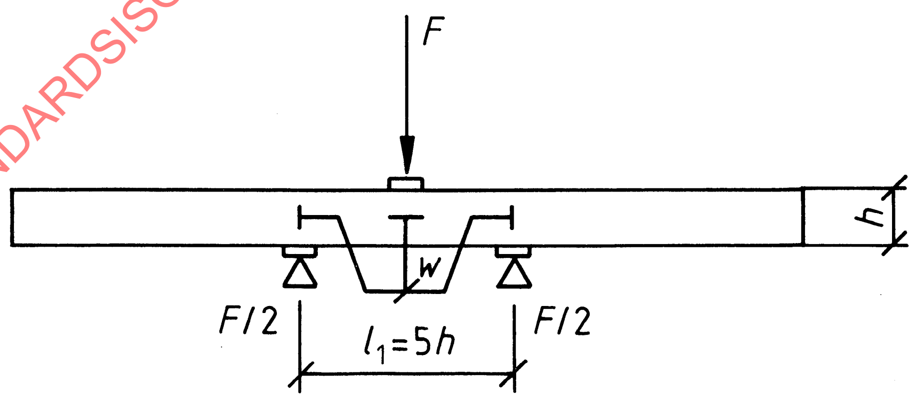

Figure 2 — Test arrangement for measuring apparent modulus of elasticity

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

9.2.3 Expression of results

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

$$E_{m, app} = \frac{l_1^3 \Delta F}{48\, I \Delta w}$$

where

l_1 is the span, in millimetres;

ΔF is an increment of load below the proportional limit load, in newtons;

I is the second moment of area of the section, determined from its actual dimensions, in millimetres to the fourth power;

Δw is the deflection under the increment of load ΔF, in millimetres.

The apparent modulus of elasticity shall be calculated and recorded to three significant figures.

9.3 Calculation of shear modulus

The shear modulus, G, in megapascals, is given by the formula

$$G = \frac{1{,}2\, h^2}{l_1^2 \left(\frac{1}{E_{m, app}} - \frac{1}{E_m} \right)}$$

where

h is the actual depth of the section, in millimetres;

l_1 is the span used in 9.2, in millimetres;

$E_{m, app}$ is the apparent modulus of elasticity, determined in 9.2, in megapascals;

E_m is the modulus of elasticity in static bending, for the same test specimen, determined in 9.1, in megapascals.

The shear modulus shall be calculated and recorded to two significant figures.

10 Determination of shear modulus — Variable span method

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

10.1 Test specimen

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

10.2 Procedure

The test specimen 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 0,035 to 0,002 5.

The specimen shall be supported on rollers, or by other devices which achieve an acceptable free support condition. Small plates of length not greater than one-half of the nominal depth may be inserted between the specimen and the loading heads and supports to minimize local indentation.

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

Load shall be applied either at a continuous rate or in increments, avoiding impact effects, and care should be taken to ensure that the maximum load applied does not exceed the proportional limit load or cause damage to the specimen.

If continuous loading is used, the rate of movement of the loading-head shall not be greater than

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

where l is the span, in millimetres, and h is the depth of the section, in millimetres.

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

Deflections shall be measured at the centre of the spans with the deflectometer attached at the centre of depth of the specimen (as shown in figure 2).

A record of load/deflection shall be made so that the deflection under an increment of load can be determined with an accuracy of 1 % or, for deflections less than 2 mm, with an accuracy of 0,02 mm.

10.3 Expression of results

Calculate the apparent modulus of elasticity for each specimen and each test span, as follows.

10.3.1 Apparent modulus of elasticity

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

$$E_{m, app} = \frac{l^3 \Delta F}{48 I \Delta w}$$

where

l is the span, in millimetres;

ΔF is an increment of load below the proportional limit load, in newtons;

I is the second moment of area of the section, determined from its actual dimensions, in millimetres to the fourth power;

Δw is the deflection under the increment of load ΔF, in millimetres.

For each specimen, the values of $(1/E_{m, app})$ shall be plotted against $(h/l)^2$ as shown in figure 3. From each graph, the slope (K_1) of the best straight line through the points shall be determined. [1)]

10.3.2 Shear modulus

The shear modulus, G, in megapascals, is given by the formula

$$G = \frac{1,2}{K_1}$$

where K_1 is the slope of the straight line (see figure 3).

The shear modulus shall be calculated and recorded to two significant figures.

11 Determination of bending strength

11.1 Test specimen

The test specimen shall have a minimum length of 19 times the nominal depth of the section.

11.2 Procedure

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

The specimen shall be supported on rollers, or by other devices which achieve an acceptable free support condition. Small plates may be inserted between the specimen and the loading heads and supports to minimize local indentation.

Lateral restraint shall be provided to prevent buckling. This restraint shall permit the specimen 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 specimen or, for loads less than 10 % of the maximum load, with an accuracy of 0,1 % of the maximum load.

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

11.3 Expression of results

The bending strength, f_m, in megapascals, is given by the formula

$$f_m = \frac{aF_u}{2W}$$

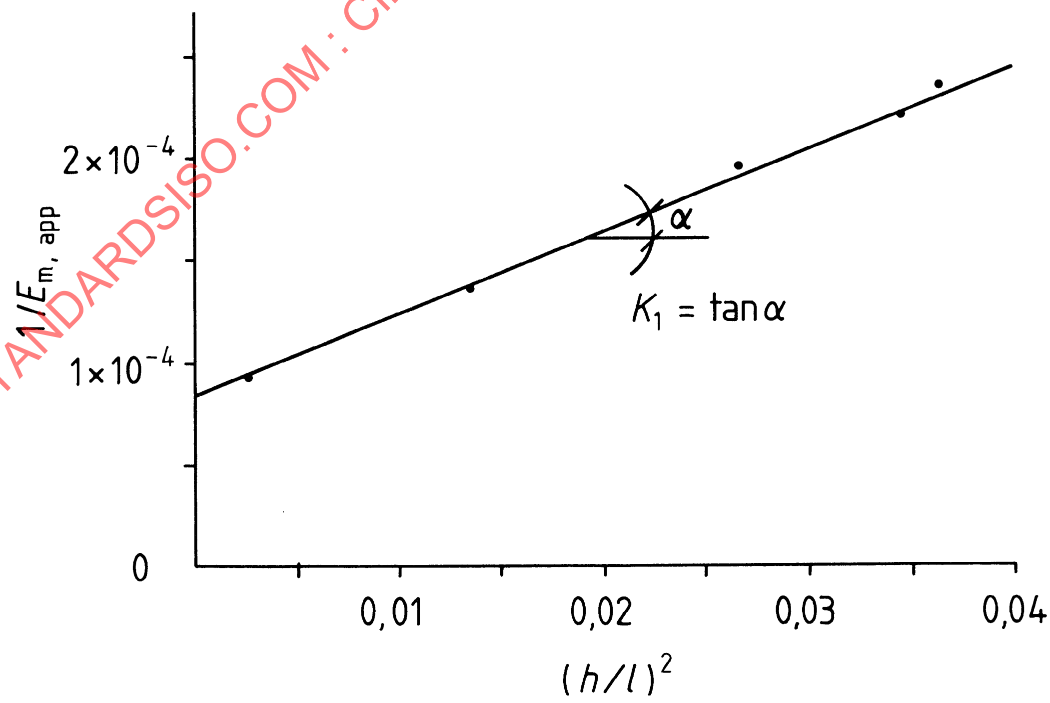

Figure 3 — Determination of shear modulus — Variable span method

1) It should be noted that, if the intercept K_2 of the line at zero $(h/l)^2$ is determined, then a value for the modulus of elasticity (E_m) is given by $1/K_2$. Although a graphical solution has been described, a direct arithmetical approach could be used to obtain values for K_1 and K_2.

where

- a is the distance between an inner load point and the nearest support, in millimetres;
- F_u is the ultimate load, in newtons;
- W is the section modulus, determined from its actual dimensions, in cubic millimetres.

The bending strength shall be calculated and recorded to three significant figures. The mode of fracture and the growth characteristics at the fracture section of each test specimen shall also be recorded.

12 Determination of modulus of elasticity in tension

12.1 Test specimen

The test specimen shall be of full cross-section, and of sufficient length to provide a test length clear of the testing machine grips of at least nine times the nominal width, i.e. the larger dimension.

12.2 Procedure

The test specimen shall be loaded using gripping devices which will permit as far as possible the application of uniform tension without inducing bending. The gripping devices and loading conditions actually used should be noted.

Load shall be applied either at a continuous rate or in increments, avoiding impact effects.

If continuous loading is used and there is no significant movement associated with the functioning of the gripping devices, the rate of movement of the loading-head shall not be greater than[1] $5 \times 10^{-5}\, l$ mm/s, where l is the length of the test specimen between the grips, in millimetres.

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

Deformation shall be measured over a gauge length of five times the nominal width of the specimen, located not closer to the ends of the grips than twice this width. Two extensometers shall be used, and shall be attached at "diagonally opposite" points on the faces of the specimen to minimize the effects of distortion (see figure 4).

A record of load/deformation shall be made so that the deformation under an increment of load can 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, in megapascals, is given by the formula

$$E_t = \frac{l_1 \Delta F}{A \Delta w}$$

where

- l_1 is the gauge length, in millimetres;
- ΔF is an increment of load below the proportional limit load, in newtons;
- A is the area of the section determined from its actual dimensions, in square millimetres;
- Δw is the deformation under the increment of load ΔF, in millimetres.

The modulus of elasticity in tension shall be calculated and recorded to three significant figures.

13 Determination of tension strength parallel to grain

13.1 Test specimen

The test specimen shall be of full cross-section, and of sufficient length to provide a test length clear of the testing machine grips of at least nine times the nominal width, i.e. the larger dimension.

13.2 Procedure

The test specimen shall be loaded using gripping devices which will permit as far as possible the application of uniform tension without inducing bending. The gripping devices and loading conditions actually used should be noted.

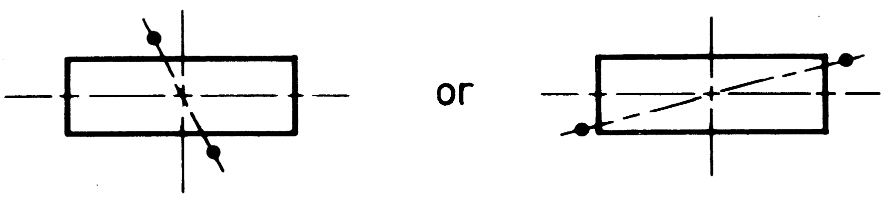

Figure 4 — Location of extensometers

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