

METHODS OF TEST FOR CLEAR PLYWOOD

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THIS BRITISH STANDARD, having been approved by the Timber Industry Standards Committee, was published under the authority of the Executive Board on 24th October, 1969.

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The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 5000, fully indexed and with a note of the contents of each, will be found in the British Standards Yearbook, price 20s. The BS Yearbook may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

- BS 373. Testing small clear specimens of timber.
- BS 1203. Synthetic resin adhesives (phenolic and aminoplastic) for plywood.
- BS 1204. Synthetic resin adhesives (phenolic and aminoplastic) for wood. Part 1. Gap-filling adhesives.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

The following BSI references relate to the work on this standard:
Committee reference TIB/7/—/1

Draft for comment 68/4225

CO-OPERATING ORGANIZATIONS

The Timber Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

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| *British Door Association | *Ministry of Technology—Forest Products |
| *British Plastics Federation | Research Laboratory |
| *British Woodwork Manufacturers' Association | National Federation of Building Trades |
| Fibre Building Board Development Organisation | Employers |
| Limited | National Sawmilling Association |
| Forestry Commission | *Royal Institute of British Architects |
| Hardwood Flooring Manufacturers' Association | Softwood Agents and Brokers Association |
| Institute of Wood Science | The Royal Institution of Chartered Surveyors |
| Institution of Civil Engineers | Timber Container Confederation |
| *Institution of Municipal Engineers | *Timber Research and Development Association |
| *Institution of Structural Engineers | *Timber Trade Federation of the United Kingdom |
| *Ministry of Public Building and Works | |

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

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|---|---|
| Association of British Plywood and Veneer | Council for Codes of Practice for Buildings |
| Manufacturers | The Furniture Industry Research Association |
| British Railways Board | |
| British Wood Preserving Association | Individual experts |

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BRITISH STANDARD METHODS OF TEST FOR CLEAR PLYWOOD

FOREWORD

This British Standard has been prepared to cover methods of testing clear plywood, and is based on the United Nations FAO Standard*. It has been designed for clear plywood, defined as that manufactured from veneers containing no strength-reducing defects. The methods are not generally suitable for commercial plywood but may be used with reservations on this material. Commercial plywood in practice is seldom completely free from imperfections, and, even if manufactured to the appropriate specification, may contain defects comparable in size with certain dimensions of the specimens described below.

It must be emphasized that the results obtained when testing commercial plywood may depend on the number and location of any defects within the test specimen. If the purpose of testing commercial plywood is to obtain information to be used for structural design purposes, then the test specimen should contain strength-reducing characteristics of sufficient number and appropriately located to ensure that the results give a satisfactory estimate of the strength of the plywood when used in a structural component. It is not possible to lay down general rules for a sampling procedure, and the end use of the product must be carefully considered by the designer of the test programme when drawing up the sampling procedure. The test specimens defined in this standard may not give a completely satisfactory indication of the strength of the plywood when used in some structural components, and it may then be appropriate to use larger specimens.

The committee is actively considering methods of testing large specimens of plywood which may give a more satisfactory estimate of the strength of commercial plywood when used structurally.

NOTE 1. This standard prescribes methods of test only and should not be used or quoted as a specification. It should not be claimed that a component conforms to BS 0000 as this conveys no meaning without further qualification.

NOTE 2. As part of BSI's programme of metrication this standard is expressed in metric terms.

The metric values are given in SI units, and should be regarded as the standard; for further information reference should be made to BS 3763, 'International System (SI) units' and PD 5686, 'The use of SI units'.

Values of stress are given in terms of the N/mm^2 . This multiple has been chosen for convenience of use in this standard; values expressed in this way are numerically equal to values expressed in terms of the preferred multiple of the basic unit, the MN/m^2 (i.e. $1 \text{ N/mm}^2 = 1 \text{ MN/m}^2$).

METHODS OF TEST

1. SCOPE

This British Standard covers procedures for measuring the mechanical properties of plywood. The tests described may be used to obtain data for design purposes, to determine the effect on strength of various treatments or of various factors in processing, to ascertain properties in relation to grain or fibre direction in the material, to compare the properties of different species and for other similar purposes.

Methods are described for determining the following properties:

static bending (Clause 4), compression (Clause 5), tension (Clause 6), panel shear (Clause 7), modulus of rigidity (Clause 8), rolling shear (Clause 9), panel impact (Clause 10), moisture content (Clause 11), and density (Clause 12).

Any of these tests, or part of them, may be undertaken.

Tests of the glue in plywood are not included as they are covered in BS 1203†.

2. TEST SPECIMENS

Specimens for test may be selected either with the long

* FAO Forestry Development Paper No. 7. Report of the Third Conference on Wood Technology 17–26 May, 1954. Rome: Food and Agriculture Organization of the United Nations, 1955. Annex 2, p. 81. See also ASTM D805–63.

† BS 1203, 'Synthetic resin adhesives (phenolic and aminoplastic) for plywood'.

dimension parallel to the face grain or with the long dimension perpendicular to the face grain, or the grain may be oriented to the long dimension at any other angle for which data is required. Specimens shall in no case be taken from less than 50 mm from the edges of the board. The test specimens shall be selected from as wide a range of the material as possible. The specimens shall be taken from a number of boards and from random positions within these boards.

2.1 To determine the average strength values for a particular species or type of construction, not less than 30 acceptable tests to measure each property shall be made.

2.2 If data derived from the tests are solely for quality acceptance, not less than 5 specimens of a type shall be tested.

3. MOISTURE CONTENT AND TEMPERATURE

The values of the mechanical properties of plywood depend upon the moisture content of the material at the time of testing. All specimens shall normally be conditioned, prior to final machining and testing, to constant mass‡ and moisture content in a conditioning chamber maintained at a relative humidity of $65 \pm 2\%$ and at a temperature of $20 \pm 3^\circ\text{C}$.

‡ Constant mass is considered to be reached when two successive weighing operations, carried out at an interval of 24 hours, do not differ by more than 0.1 % of the mass of the test piece.

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

Where it is not acceptable to adjust the strength values to other temperature and humidity conditions the tests may be carried out at other temperature and humidity conditions.

4. STATIC BENDING

4.1 Test specimen. The test specimen shall be rectangular in cross section. The depth of the specimen shall be equal to the thickness of material and the width shall be 50 mm; for depths less than 6 mm the specimen may be cut to a width of 25 mm. Where the grain direction of the face plies is parallel to the span the length of plywood specimens shall be not less than 48 times the depth* plus 50 mm; when the grain direction of the face plies is perpendicular to the span the specimen length shall be not less than 24 times the depth plus 50 mm. The actual width, depth and overall length of each specimen and the span shall be measured.

4.2 Span, supports and loading block. Centre loading shall be used. The span shall be not less than 48 times the depth* when the grain direction of the face plies of the test specimen is parallel to the span and not less than 24 times the depth when the grain direction of the face plies is perpendicular to the span. A 25 mm overhang shall be allowed at each end. The span shall be estimated from the average actual thickness of the material and need not be altered for slight variations in the thickness of individual specimens. The specimens shall be flat, and any showing excessive twist shall be rejected. Round nosed knife edges or roller bearings preferably allowing for longitudinal movement may be used; the radius of curvature of the loading block shall be 13 mm. In cases where excessive local deformation may occur under the loading points, suitable bearing plates shall be used. An apparatus suitable for making bending tests is shown in Fig. 1.

4.3 Loading procedure. The load shall be applied with a continuous motion of the movable head throughout the test. The rate of load application shall be such that the unit rate of fibre strain is equal to 0.000 05 mm per millimetre of outer fibre length per second within a permissible variation of $\pm 25\%$. The rate of motion of the movable head may be calculated as follows:

$$R = \frac{rL^2}{6h}$$

where R = rate of motion of moving head, mm/s;

L = span, mm;

h = depth of beam, mm;

r = unit rate of fibre strain, millimetres per millimetre of outer fibre length per second
(= 0.000 05).

4.4 Load-deflection curves. Data for load-deflection curves may be taken to determine the modulus of elasticity. Deflections may be taken using a dial gauge as in Fig. 1. The readings shall be taken to the nearest 0.02 mm. Increments of load shall be chosen so that not less than 12 and preferably 15 or more readings of load and deflection are taken. Automatic load and deflection

* If the plywood is more than 13 mm thick, and contains more than 5 plies, the factor 48 may be replaced by 32.

recording apparatus may be used provided the curves obtained are of sufficient magnitude to allow accurate measurement of load and deflection.

4.5 Calculations

4.5.1 Data

(1) Dimensions of test piece:

b = width, mm;

h = depth, mm;

L = span, mm.

(2) Load-deflection curve from which are derived:

P = maximum load, N;

ΔP = increment of load in N on the straight line portion of the load-deflection curve;

Δw = increment of deflection in mm at mid-length corresponding to ΔP .

4.5.2 Properties to be computed

(1) Equivalent fibre stress at maximum load

$$\frac{3PL}{2bh^2} \text{ N/mm}^2.$$

(Modulus of rupture).

NOTE. This expression assumes that small deflection elastic bending theory applies up to maximum load.

(2) Modulus of elasticity $\frac{\Delta PL^3}{4\Delta w bh^3} \text{ N/mm}^2$.

NOTE. This expression ignores the effect of deflection due to shear. For span/depth ratios given in 5.1, the effect of shear deflection on the modulus of elasticity calculated as above may be ignored.

4.6 Moisture content and density. The moisture content and density of each test specimen shall be determined as described in Clauses 11 and 12.

5. COMPRESSION

5.1 Test specimen. The test specimen shall be rectangular in cross section.

5.1.1 Material over 6 mm in thickness. For material over 6 mm in thickness, the specimen shall have a thickness equal to that of the material and the width shall be a minimum of 50 mm. The length shall be not greater than seven times the smaller cross-sectional dimension.

5.1.2 Material 6 mm or less in thickness. For material 6 mm and less in thickness, the specimen shall have a thickness equal to that of the material and the width shall be 25 mm. The length shall be 100 mm. Such specimens shall be supported laterally throughout the test (see 5.2).

Care shall be taken in preparing the test specimens to make the end surfaces smooth and parallel to each other and at right angles to the length.

5.2 Lateral support. Test specimens 6 mm or less in thickness shall be supported laterally to prevent buckling during the test, but undue pressure shall not be exerted against the sides of the specimen. This support shall not measurably restrain the normal compressive deformation under load. A satisfactory method of providing lateral support is illustrated in Fig. 2, and a drawing of this equipment is given in Fig. 3. The specimen is supported on both sides by 46 equally-spaced spring steel fingers of thickness 0.61 mm (23 SWG), width 17 mm and free length 38 mm.

5.3 Loading procedure. The load shall be applied through a spherical bearing block preferably of the suspended, self-aligning type. The load shall be applied with a continuous motion of the movable head to maximum load at a rate of 0.000 05 mm per millimetre of length of the specimen per second within a permissible variation of $\pm 25\%$.

5.4 Load-deformation curves. Data for load-deformation curves may be taken to determine the modulus of elasticity. Increments of load shall be chosen so that not less than 12 and preferably 15 or more readings of load and deformation are taken. The deformation shall be read to the nearest 0.002 mm. Deflectometers shall be attached over the central portion of the length of the specimen and the points of attachment shall be not less than 20 mm from the specimen ends. Automatic load and deformation recording apparatus may be used provided the curves obtained are of sufficient magnitude to allow accurate measurement of load and deformation.

5.5 Calculations

5.5.1 Data

- (1) Dimensions of test piece:

A = cross-sectional area, mm²;

L = gauge length, mm;

- (2) Load-compression curves from which are derived:

P = maximum crushing load, N;

ΔP = increment of load in N on the straight line portion of the load-deformation curve;

ΔL = increment of deformation in millimetres over gauge length L corresponding to ΔP .

5.5.2 Properties to be computed:

- (1) Compressive stress at maximum load = $\frac{P}{A}$ N/mm².

- (2) Modulus of elasticity = $\frac{\Delta PL}{\Delta LA}$ N/mm².

5.6 Moisture content and density. The moisture content and density of each test specimen shall be determined as described in Clauses 11 and 12.

6. TENSION

6.1 Test specimen. The size and shape of the test specimen shall be selected from the 3 types shown in Fig. 4. The basis for selection shall be the grain angle and the thickness of the material. If the grain of the individual plies makes angles other than 0 or 90° with the length of the specimen, type C shall be used regardless of the thickness of the material. Type A shall be used for material over 6 mm thick and type B for material 6 mm or less in thickness. The specimen shall have a thickness equal to that of the material. The thickness and width at the critical section shall be measured.

6.2 Shaping of specimen. The test specimen shall be shaped in accordance with Fig. 4. Specimens may be obtained by using a template in conjunction with a vertical spindle woodworking shaper.

6.3 Loading procedure. The load shall be applied continuously throughout each test with the movable head of the testing machine moving at 0.015 mm/s. The specimen shall be held in wedge type, self-tightening and self-aligning grips, or in toothed plates.

6.4 Load extension curves. The modulus of elasticity may

be determined from load extension curves taken. Increments of load shall be chosen so that not less than 12 and preferably 15 or more readings of load and extension are taken. The extensometer shall be attached at the central portion of the length of the specimen at the centre of the portion of constant cross section and readings shall be taken to the nearest 0.002 mm. Automatic load and extension recording apparatus may be used provided the curves obtained are of sufficient magnitude to allow accurate measurement of load and extension.

6.5 Calculations

6.5.1 Data

- (1) A = minimum area of cross section of test length, mm²;

L = gauge length, mm.

- (2) Load extension curve from which are derived:

P = maximum load, N;

ΔP = increment of load in N on the straight line portion of the load-extension curve;

ΔL = increment of extension in mm over gauge length L corresponding to ΔP .

6.5.2 Properties to be computed:

- (1) Tensile stress at maximum load = $\frac{P}{A}$ N/mm².

- (2) Modulus of elasticity $\frac{\Delta PL}{\Delta LA}$ N/mm².

6.6 Moisture content and density. The moisture content of each test specimen shall be determined as described in Clause 11. A rectangular piece of material taken from the same portion of the board as the test specimen shall be used to determine the density.

7. PANEL SHEAR

7.1 Definition of panel shear stress. Stresses which tend to distort into the shape of a rhombus any square element lying in a plane parallel to the surface of the plywood while the surface of the plywood remains plane (see Fig. 15).

7.2 Test specimen. The dimensions of the test specimen shall be as shown in Fig. 5. The size and thickness of the reinforcing pads shall be as indicated. The pads may be made from maple, birch, beech or any other species with approximately the same strength characteristics; alternatively plywood pads may be used.

A jig for accurate location of the pads shall be used; a satisfactory method of assembly is shown in Fig. 6. An outline drawing of suitable test apparatus is shown in Fig. 7, and a photograph in Fig. 8. To minimize friction, suitable bearings may be inserted at the corners of the frame. Material up to 13 mm in thickness requiring a total load of less than 45 000 N may be tested by this method. For materials greater than 13 mm in thickness, the dimensions of the reinforcing blocks and the test frame would have to be increased, but at the moment it is not possible in this standard to make specific recommendations. The thickness of the specimen shall be measured.

The material shall be conditioned to standard humidity and temperature (Clause 3) prior to gluing on the pads (which should also have been conditioned) and then conditioned again before testing. The tests are usually made with the face grain of the material parallel or perpendicular to the sides of the loading rig, but tests may also be made with the grain inclined to the sides.

7.3 Loading procedure. The load shall be applied by compression along a diagonal. The movement of the cross-head of the testing machine shall be continuous at a rate of $0.0333 \text{ mm/s} \pm 25 \%$.

7.4 Calculations. The maximum panel shear stress on the plywood shall be calculated as follows:

$$f_s = \frac{0.707P}{Lh}$$

where f_s = maximum panel shear stress, N/mm^2 ;

P = maximum applied load, N ;

L = side of square panel specimen, mm (see Fig. 5);

h = thickness of specimen, mm .

7.5 Moisture and density. After the test a section shall be cut out of the panel, weighed and measured, and used to determine the moisture content and density of the specimen as described in Clauses 11 and 12.

8 MODULUS OF RIGIDITY

8.1 Direction of grain. The grain direction of the individual plies shall be parallel or perpendicular to the edges of the test specimen.

NOTE. This method of test is primarily designed for material in which the grain of the individual plies is parallel and perpendicular to the edge of the specimen. Provided however that the deflections are measured as illustrated in Fig. 9, it may also be used for plywood cut at other angles.

8.2 Test specimen. The test specimen shall be square with the thickness equal to the thickness of the material and the length and width not less than 25 nor more than 40 times the thickness. The thickness, width and length of each specimen shall be measured.

8.3 Loading procedure. The test specimen shall be supported on rounded supports having a radius of curvature not greater than 6 mm on the opposite ends of a plate diagonal and loaded in a similar manner on the opposite ends of the other diagonal. In order that the loads may be applied at the corners, metal plates shall first be attached as shown in Fig. 9. The loading and supporting frame shall be rigid. The load shall be applied with a continuous and uniform motion of the movable head at a rate of $0.000\,05$ times the length of the plate in millimetres per second, within a permissible variation of $\pm 25 \%$.

8.4 Deformation measurements. The deformation shall be measured to the nearest 0.02 mm at two points on each diagonal equidistant from the centre of the plate. These measurements shall be made at the quarter points of the diagonals. The plate shall not be stressed beyond its elastic range and increments of load shall be chosen so that not less than 12 and preferably 15 load deformation readings are taken. Specimens shall be reasonably flat. Any showing excessive initial curvature shall be rejected. To eliminate the effects of any slight initial curvature, two sets of data shall be obtained, the second set with the plate rotated 90° about an axis through the centre of the plate and perpendicular to the plane of the plies. The two results shall be averaged to obtain the shear modulus for the plate. A satisfactory arrangement for measuring relative deformations is indicated in Fig. 9; the dial readings in this case give twice the average deflection of the four points.

8.5 Calculation. The modulus of rigidity shall be calculated as follows:

$$G = \frac{3u^2P}{2h^3w}$$

where G = modulus of rigidity, N/mm^2 ;

P = load applied to each corner, N ;

h = thickness of the plate, mm ;

w = deflection relative to the centre, mm ;

u = distance from the centre of the panel to the point where the deflection is measured, mm .

NOTE. The average value of P/w may be taken from the slope of a load-deflection curve.

8.6 Moisture and density. After test a section may be cut out of the panel, weighed and measured; and used to determine the moisture content and density of the specimen described in Clauses 11 and 12.

Where additional tests are to be made on the plate a separate matched moisture specimen shall be provided when the specimen is cut out, in which case this moisture specimen shall be subjected to the same conditioning as the plate itself.

9. ROLLING SHEAR

9.1 Introductory. Rolling shear is the term applied to a particular type of failure which occurs in certain of the veneers of plywood (see Fig. 10). In Fig. 10 rolling shear failure has taken place in the veneer marked 'A'. The surface produced by the failure appears as though the fibres have rolled off each other (Fig. 11), and the term is derived from this fact. Formally, rolling shear is defined in relation to planes perpendicular to the grain direction in the affected veneer; a square element in one of these planes distorts into a rhombus under the action of rolling shear stresses.

Rolling shear stresses may be critical in some applications of plywood, for example in box beams, I-beams and stiffened panels where plywood is glued to solid wood or to other plywood. It is recognized that the apparent failing stress will depend on the geometry of the joint and the following test has been selected for comparative purposes.

9.2 Test specimen. The test is made on the double lap tension specimen shown in Fig. 12. The specimens comprise two 25 mm wide central strips of plywood to which are glued two 25 mm wide cover plates having the face grain perpendicular to their length. The cover plates are positioned so that there is a 25 mm double lap joint at one end and a 50 mm double lap joint at the other; the gap between the ends of the central strips is 6 mm. The centre strips both have the face grain parallel to their lengths. The plywood strips are conditioned as required before assembly and the assembled specimens are again conditioned before testing. The glue used to assemble the specimens shall conform with the minimum requirements for type MR of BS 1204: Part 1*.

9.3 Test procedure. The specimen is weighed before test, positioned in the testing machine and held with toothed grips as shown in Fig. 13. The load is applied with the movable head of the testing machine moving at 0.01 mm/s , and the load at failure is recorded.

9.4 Calculations. The result for any specimen which fails in a manner other than in rolling shear in the shorter lap (for example as shown at 'A' in Fig. 10) shall be rejected.

* BS 1204, 'Synthetic resin adhesives (phenolic and aminoplastic) for wood', Part 1, 'Gap-filling adhesives'.