
Timber structures — Testing of punched metal plate fasteners and joints

Structures en bois — Essai des connecteurs à plaque métallique emboutie et des assemblages

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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. 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 8969 was prepared by Technical Committee ISO/TC 165, *Timber structures*.

This second edition cancels and replaces the first edition (ISO 8969:1990), which has been technically revised.

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Introduction

The first edition of this International Standard was based on the recommendations of the joint committee RILEM/CIB 3TT (Working Commission W 18, *Timber structures*, of the International Council for Building Research, Studies and Documentation, and Commission 3TT, *Testing methods for timber*, of the International Union of Testing and Research Laboratories for Materials and Structures respectively) published (in English and French) in *Materiaux et Constructions*, Vol. 15, No. 88, 1982.

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Timber structures — Testing of punched metal plate fasteners and joints

1 Scope

This International Standard specifies test methods for determining the strength and stiffness of joints made with punched metal plate fasteners in load-bearing timber structures, as follows:

- a) load-slip characteristics and maximum load resulting from the lateral resistance of the embedded projections, at various angles between the direction of the applied force and
 - the axis of the plate (load-plate angle, α),
 - the direction of the grain of the timber (load-grain angle, θ);
- b) the tensile strength of the plate at various angles, α ;
- c) the compression strength of the plate at various angles, α (optional test);
- d) the shear strength of the plate at various angles, α .

This International Standard is linked to ISO 6891, which gives general test requirements.

In addition, a method for testing the nail root in alternate bending is specified in Annex A.

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*

ISO 6891, *Timber structures — Joints made with mechanical fasteners — General principles for the determination of strength and deformation characteristics*

ISO 8970, *Timber structures — Testing of joints made with mechanical fasteners — Requirements for wood density*

ASTM E8/E8M, *Standard Test Methods for Tension Testing of Metallic Materials*

3 Terms and definitions

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

3.1

punched metal plate fastener

fastener made of metal plate of thickness not less than 0,9 mm and not more than 2,5 mm, having integral projections punched out in one direction and bent perpendicular to the plane of the plate, being used as a splice plate to join two or more pieces of timber of the same thickness

NOTE For this purpose, the projections of the plate are fully embedded in the timber, using a press or roller, so that the contact surface of the plate is flush with the surface of the timber.

3.2

major axis of plate

direction giving the highest tensile strength of the plate

NOTE In many cases the punching pattern of the plate gives rise to two main directions perpendicular to each other with different strength properties.

3.3

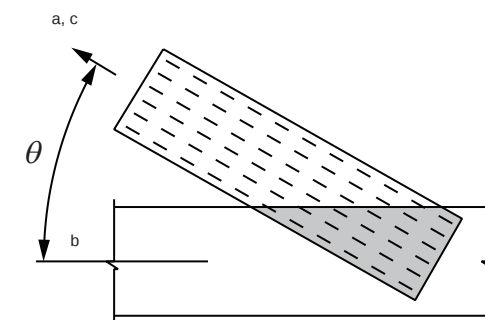
keeper nails

nails driven through the metal plate fasteners, during assembly of joints, to hold its location on the timber members before pressing

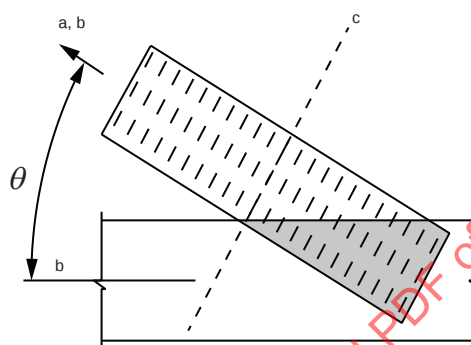
4 Symbols

The following symbols are used in this International Standard.

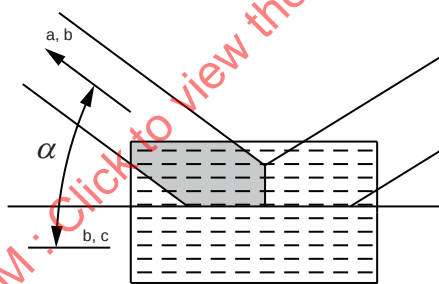
A_{gc}	cross-sectional area
A_{gp}	average gross cross-sectional area
F	force, expressed in newtons
F_{cc}	ultimate compression strength
F_{sc}	ultimate shear stress
F_{sp}	ultimate shear strength
F_{tc}	ultimate tensile strength
L_p	length of the plate in the direction parallel to the long dimension of the tooth slots, expressed in millimetres
l	length covered by plate at the interface of the two pieces of timber measured parallel to the timber grain direction (see Figure 6), expressed in millimetres
l'	plate dimension parallel to the loading direction for test specimens used to develop lateral resistance strength of metal connector plate teeth
P_{cc}	maximum compression load
P_{sp}	maximum shear load
P_{tc}	maximum tensile load
R_s	shear resistance effectiveness ratio
t_{net}	minimum thickness
W_p	width of the plate in the direction perpendicular to the long dimension of the tooth slots, expressed in millimetres
α	angle between the direction of the applied force and the major axis of the plate [see Figure 1 c)]
θ	angle between the direction of the applied force and the direction of the grain of the timber [see Figures 1 a) and b)]



a) Tooth slot direction parallel to load



b) Tooth slot direction perpendicular to load



c) Tooth slot direction at angle to load

- a Load direction.
- b Grain direction.
- c Tooth slot direction.

Figure 1 — Relationship between the loading direction and the major axis of the plate or the timber grain direction

5 Materials

5.1 Timber

5.1.1 The timber shall be selected in accordance with ISO 8970.

5.1.2 For determination of the tensile strength, compression strength and shear strength of the plate, the timber shall be sufficiently strong for failure to occur in the plate.

5.1.3 The timber shall have a thickness consistent with the timber being used in production.

5.1.4 For each specimen, the two individual members being joined shall be cut from the same plank to ensure a specimen of balanced density. In each group of similar specimens, the timber for each specimen shall be cut from a different plank. The number of timber members selected shall be sufficient to fabricate a minimum of five joints for each combination of plate type, plate/timber orientation, timber face width, species combination and fabrication method tested.

5.1.5 Timber members for the specimens shall be cut so that the areas into which the fasteners are embedded are free from knots, local grain disturbance, fissures (such as shakes, checks and splits) and wane. Elsewhere, the members shall be free from major defects that can lead to premature failure in the timber.

5.1.6 If there are no special requirements, the timber shall be planed; the difference in thickness between adjoining pieces shall not exceed 0,5 mm.

5.1.7 The moisture content of the timber shall be determined in accordance with ISO 3130, and its density in accordance with ISO 3131.

5.1.8 The identity of the species shall, if necessary, be confirmed by botanical examination.

5.1.9 A minimum period of seven days shall elapse between assembly and testing of the test specimens to allow for fibre relaxation.

5.2 Plates

5.2.1 The sizes of plate used for the various tests shall be selected from the range of sizes produced by the plate manufacturer in such a way that the strength values for all sizes can be obtained by interpolation or extrapolation when judged to be of adequate reliability. Appropriate regression shall be used and reported.

5.2.2 The mechanical properties (tensile strength, yield stress, elongation and hardness) of the test coil metal shall meet the requirements for the specified structural grade of steel for plate manufacture.

5.2.3 The ductility of the fasteners at the nail root position shall be determined in accordance with Annex A.

5.2.4 The number of plates selected shall be sufficient to fabricate a minimum of five joints for each combination of plate type, plate/timber orientation, timber face width, species combination and fabrication method tested.

5.2.5 If the plates are to be free of oil or any substance that can alter the plate performance in service, then they shall be washed in solvent before they are used in the tests.

5.2.6 The metal plate fasteners shall be of sufficient length to induce failure in the plate metal, rather than failure by tooth withdrawal. Where necessary, it shall be permitted to clamp the metal plates, or otherwise firmly fasten them, a minimum of 50 mm from the joint to prevent withdrawal.

6 Test specimens

6.1 General

6.1.1 The specimens shall be assembled using the method (e.g. press or roller) normally used with the particular fasteners in the commercial production of structural timber components.

Metal plate fasteners shall be embedded in clear wood of the timber members, and shall be installed so that the teeth are fully embedded in the timber member and no gaps remain between the metal plate fastener and the timber member. Over-pressing shall be avoided, so that the metal plate fasteners do not embed into the timber member more than half the steel thickness.

6.1.2 If keeper nails, or any supplemental fasteners, are used in normal production to locate fasteners during assembly of the joints, and are not an integral part of the joint design method, such nails shall be omitted from the test specimens or withdrawn prior to the test. Where keeper nails are an integral part of the joint design method, are used in the manufacturing process and are intended for use in normal production of the joints, they shall be installed in the test specimens in the same proportions and with the same distribution as those intended for use in production.

6.1.3 Except as allowed in 6.3.1, the plates shall be embedded without removal of any teeth.

6.1.4 The test specimens shall be manufactured and tested with the timber at moisture content of 11 % or greater for solid-sawn timber, and 7 % or greater for structural composite timber. For certain investigations, other moisture conditions can be appropriate.

6.1.5 There shall be a sufficient number of test specimens to permit statistical treatment of the results.

In determining the number of test specimens for each type, consideration should be given to the variability of the wood substrate materials (see ISO 8970). For plate strength (tension, compression and shear), a minimum of three specimens of each type should be used, provided all achieve the same mode of failure as stated in 5.1.4 and 5.2.4. As tooth withdrawal can be expected to be a more variable property than steel strength, testing of more than three specimens should be considered as per 6.3.3.

6.2 Tensile strength of the solid metal control specimens

6.2.1 Conduct ultimate tensile strength tests on the solid metal control specimens in accordance with procedures in ASTM E8/E8M.

6.2.2 Metal connector plates selected for test specimen fabrication shall be typical of production. Test-coil metal shall be sampled from the production inventories of the metal connector plate manufacturers that are procured with a specified minimum yield or grade. Where such samples are found to exceed the specified minimum yield by more than 48 MPa, the lateral resistance strength shall be multiplied by the adjustment factor, R_Y , to account for steel yield as given in Equation (1):

$$R_Y = (F_{Y,spec}/F_{Y,test})^{(1,2G - 0,4)} \leq 1,0 \quad (1)$$

where

$F_{Y,spec}$ is the specified minimum steel yield strength, expressed in MPa;

$F_{Y,test}$ is the average measured steel yield strength of test plates, expressed in MPa;

G is the average measured specific gravity (oven-dry basis) of timber used in test joints.

Where the metal thickness of the test coil metal exceeds the minimum specified thickness by more than 5 %, the lateral resistance strength shall be multiplied by the adjustment factor, R_T , to account for steel thickness as given in Equation (2):

$$R_T = (t_{spec}/t_{test})^{0,7} \leq 1,0 \quad (2)$$

where

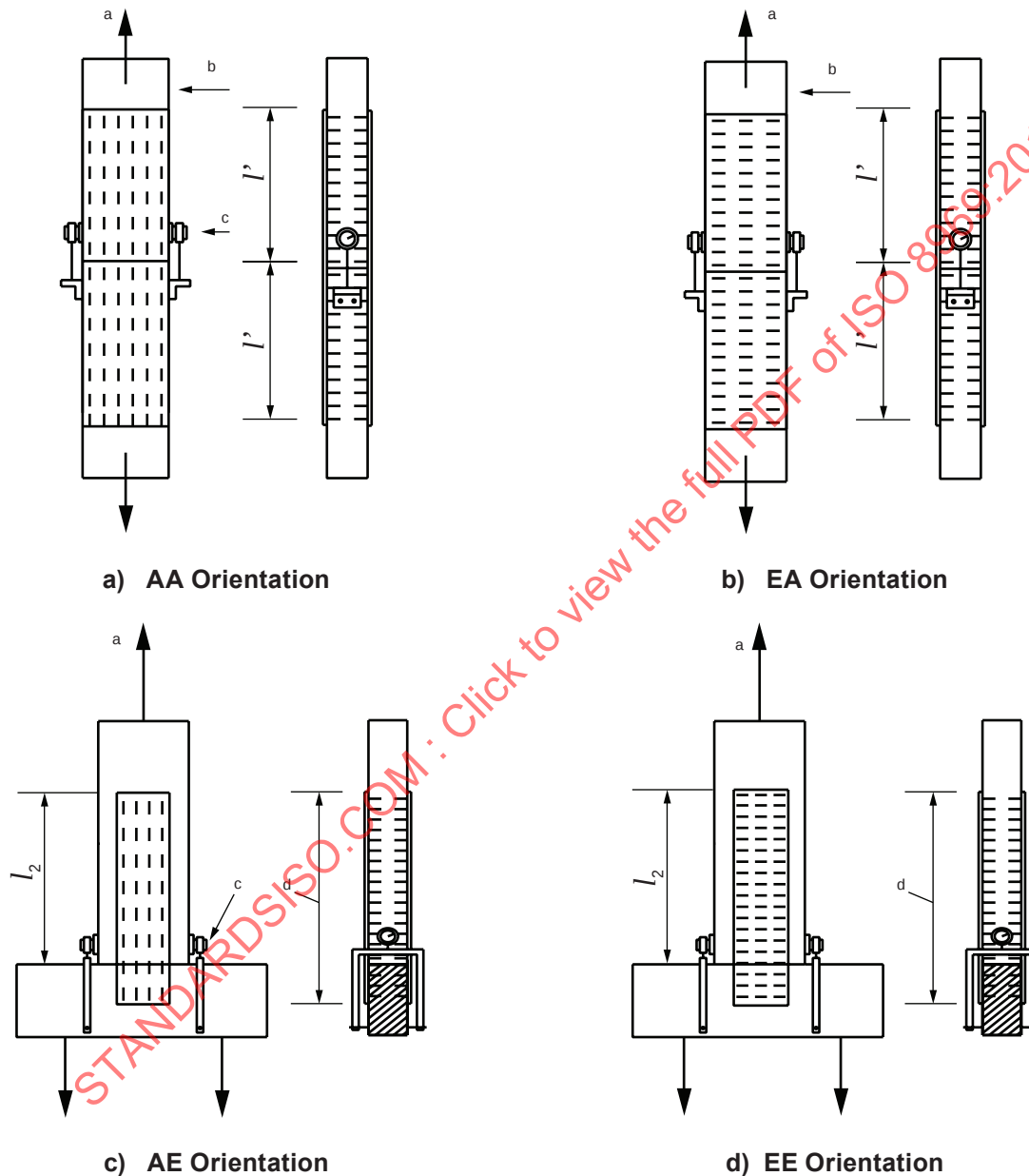
t_{spec} is the specified minimum steel thickness, expressed in millimetres;

t_{test} is the average measured steel thickness of the test plates, expressed in millimetres.

If both yield and thickness exceed the above specified limits, both adjustment factors R_Y and R_T shall be applied to the lateral resistance strength simultaneously.

6.3 Load-slip characteristics of plate and timber

6.3.1 The maximum load due to the lateral resistance of the plate projections and the load-slip characteristics shall be determined using the test specimen assembled as shown in Figure 2.



AA, EA, AE, EE are the designations for the orientation of the plates with respect to tooth holding, V_{LR} .

Key

l_2 125 mm min.

- a Tension.
- b Timber shall be the same width as the metal connector plates prior to assembly.
- c Timber-to-timber critical slip measurement.
- d Width EE or length AE (125 mm min.).

NOTE The following are definitions of test values:

V_{LRAA}	is the test value for metal plate fasteners loaded parallel to the grain with the plate axis (tooth slots) parallel to the load.
V_{LRAE}	is the test value for metal plate fasteners loaded perpendicular to the grain with the plate axis (tooth slots) parallel to the load.
V_{LREA}	is the test value for metal plate fasteners loaded parallel to the grain with the plate axis (tooth slots) perpendicular to the load.
V_{LREE}	is the test value for metal plate fasteners loaded perpendicular to the grain with the plate axis (tooth slots) perpendicular to the load.

Figure 2 — Test specimen assembly

For the AA and EA orientations, the plate dimension perpendicular to the grain shall be no more than 13 mm less than the timber member width. Teeth at the timber edges and at the member interface within the applicable end or edge distance shall be ground off. Edge distance shall be 6 mm measured perpendicular to timber grain. End distance shall be 13 mm measured parallel to timber grain and applies to joints loaded parallel to grain (AA and EA orientations). Alternatives to these 6 mm and 13 mm standard values shall be permitted provided the alternative values are used in the design process.

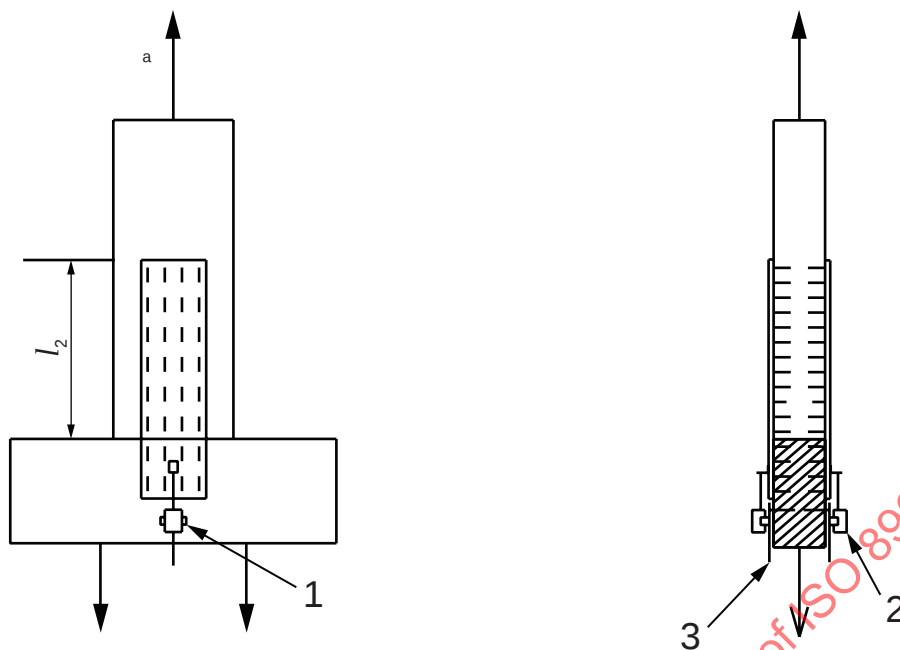
After assembly, the metal connector plate length and width shall be measured to the nearest 0,1 mm. Count the number of teeth in each side of the joint.

6.3.2 Conduct tests on the test specimens at a constant movable crosshead speed to attain ultimate load in not less than 1 min. Record the rate of loading used. Take readings of the applied load not more than every 1 780 N and the amount of corresponding slip indicated by each measuring device at each interval to permit plotting an accurate load-deformation curve. Obtain at least three readings before critical slip is reached. Continue the test until the ultimate failure load is reached. Load at critical slip shall be determined by linear interpolation between points in the load-deformation curve.

6.3.3 A minimum of five replicate test specimens shall be tested for each of the connector plate/timber orientations in Figure 2. For orientation AE and EE, displacement may be measured as shown in Figure 2 or Figure 3.

6.3.4 The length of the timber members for the specimens shall be determined according to the type of gripping apparatus used and such that the ends of the test machine grips are not less than 200 mm from the ends of the plates. In no case shall the gripping apparatus interfere with the connection at the joint or the measuring device. Where necessary, the ends of the specimen may be reinforced to avoid premature failure at the grips.

6.3.5 The test specimens shall be designed to produce the type of failure intended for each test. The plate dimension, l' , parallel to the loading direction shall be the maximum which consistently produces withdrawal failure of the teeth without inducing net section metal failure. The plate dimension perpendicular to the loading direction shall comply with 6.3.6 and 6.3.7.



Key

- 1 deflection gauge
- 2 mounting bracket
- 3 deflection gauge mounting board attached to timber member
- l_2 125 mm min.
- ^a Tension force.

Figure 3 — Test specimen assembly for measuring timber-to-plate slip

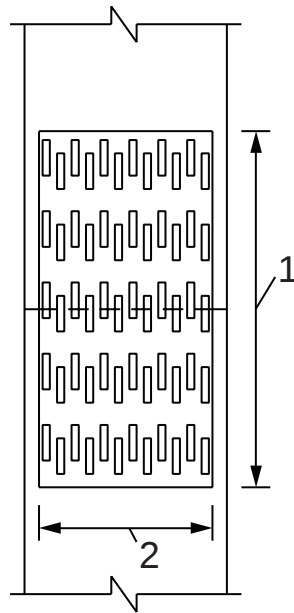
6.3.6 Test specimens assembled for evaluating metal plate fasteners perpendicular to the grain of the timber member shall be fabricated by extending the metal plate fastener length, l_2 , a minimum of 125 mm on the member being loaded parallel to the grain. To obtain the timber-to-plate slip, either measure the timber-to-timber movement as shown in Figure 2, or measure the timber-to-plate movement as shown in Figure 3. When slip is measured timber-to-timber, it is permitted to glue the plate to the member being loaded parallel to the grain to minimize plate slip on this member.

6.3.7 The plates shall be positioned to favour failure at the plate projections embedded in the member loaded perpendicular to the grain of the timber, i.e. in the cross-member.

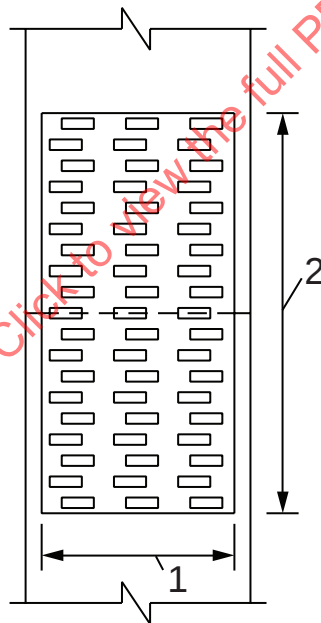
NOTE This failure mode normally occurs when $l_1 < l_2$.

6.4 Plate tensile strength

6.4.1 Plate tensile strength shall be determined using the test specimen setups shown in Figure 4.



a) Metal plate fastener width perpendicular to grain



b) Metal plate fastener length perpendicular to grain

Key

- 1 length
- 2 width

Figure 4 — Orientation of metal plate fastener with respect to the grain of the timber members

6.4.2 The length of the plate and the cross-section dimensions of the timber shall be chosen on the basis of the results found from testing the specimens described in 6.2 to ensure that failure occurs in the plate.

6.4.2.1 For tests across the metal-plate fastener width, a minimum of three test specimens shall be assembled. The metal connector plate shall be embedded in the timber members such that the width of the plate is perpendicular to the grain of the timber members [see Figure 4 a)].

NOTE It is possible to fix the plates to the timber remote from the weak point with other means, such as screws or bolts.

6.4.2.2 For tests across the metal plate fastener length, a minimum of three test specimens of a single metal connector plate length shall be assembled. The metal plate fastener shall be embedded in the timber members such that the length of the plate is perpendicular to the grain of the timber members [see Figure 4 b)].

6.4.3 The weakest cross-section near the plate centreline shall be positioned over the interface between the timber members of the joint.

6.5 Plate compression strength

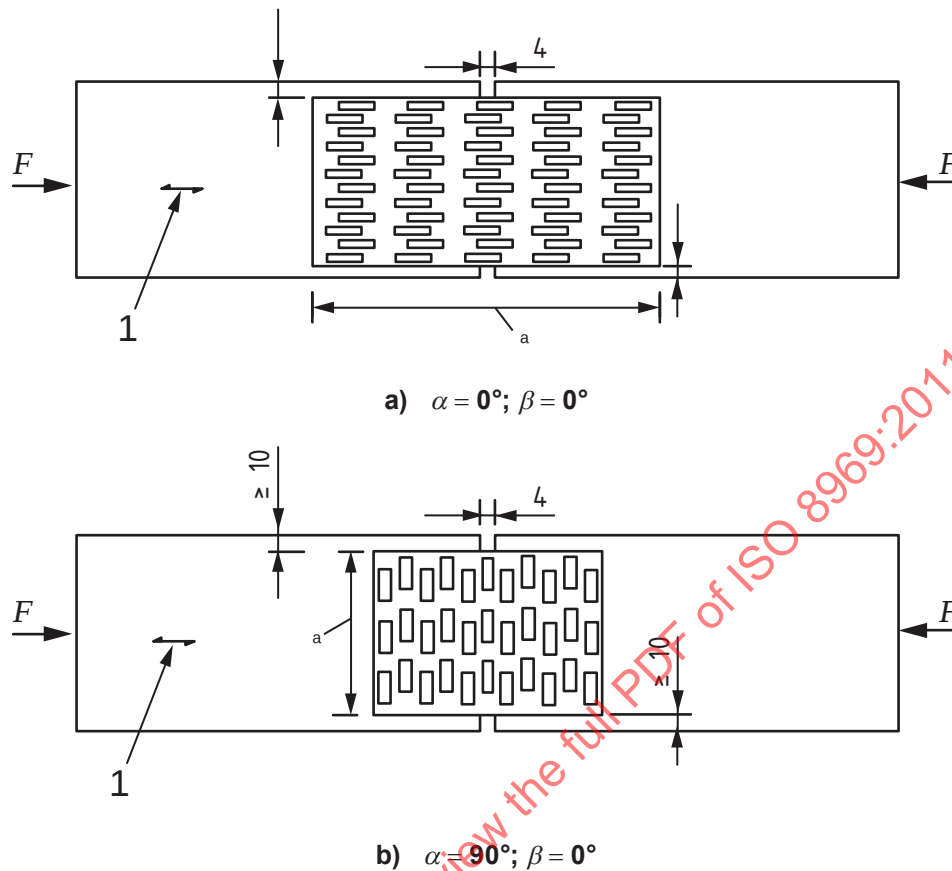
6.5.1 Compression forces are typically transferred directly from member to member and not through the plate. Test for plate compression strength is optional unless the plate is relied upon to transfer compression loads.

6.5.2 Plate compression strength shall be determined using the test specimen setups shown in Figure 5. The length of the plate and the cross-section dimensions of the timber shall be chosen on the basis of the results found from testing the specimens described in 6.2 to ensure that failure of the plate occurs.

6.5.3 A minimum of three test specimens shall be tested at each of the angles $\alpha = 0^\circ$ and 90° .

6.5.4 The weakest cross-section near the plate centreline shall be positioned over the gap between the timber members of the joint.

Dimensions in millimetres

**Key**

1 grain direction of the timber

a Plate major axis.

Figure 5 — Specimens for plate compression strength**6.6 Plate shear strength**

6.6.1 The plate shear strength and the load-slip characteristics shall be determined using test specimens as shown in Figure 6. The thickness of the timber members shall be chosen so that failure occurs in the plate. Each test specimen shall be assembled using three timber members placed with a gap of 2 mm minimum between members, and four equal size metal connector plates, one on each side of each joint interface, with the length, L_p , of the metal connector plates inclined at an angle, α , to the timber grain direction. Less than 2 mm gap may be used only when the intended applications are addressed in design, material selection and manufacturing with quality control to limit gap size in service.

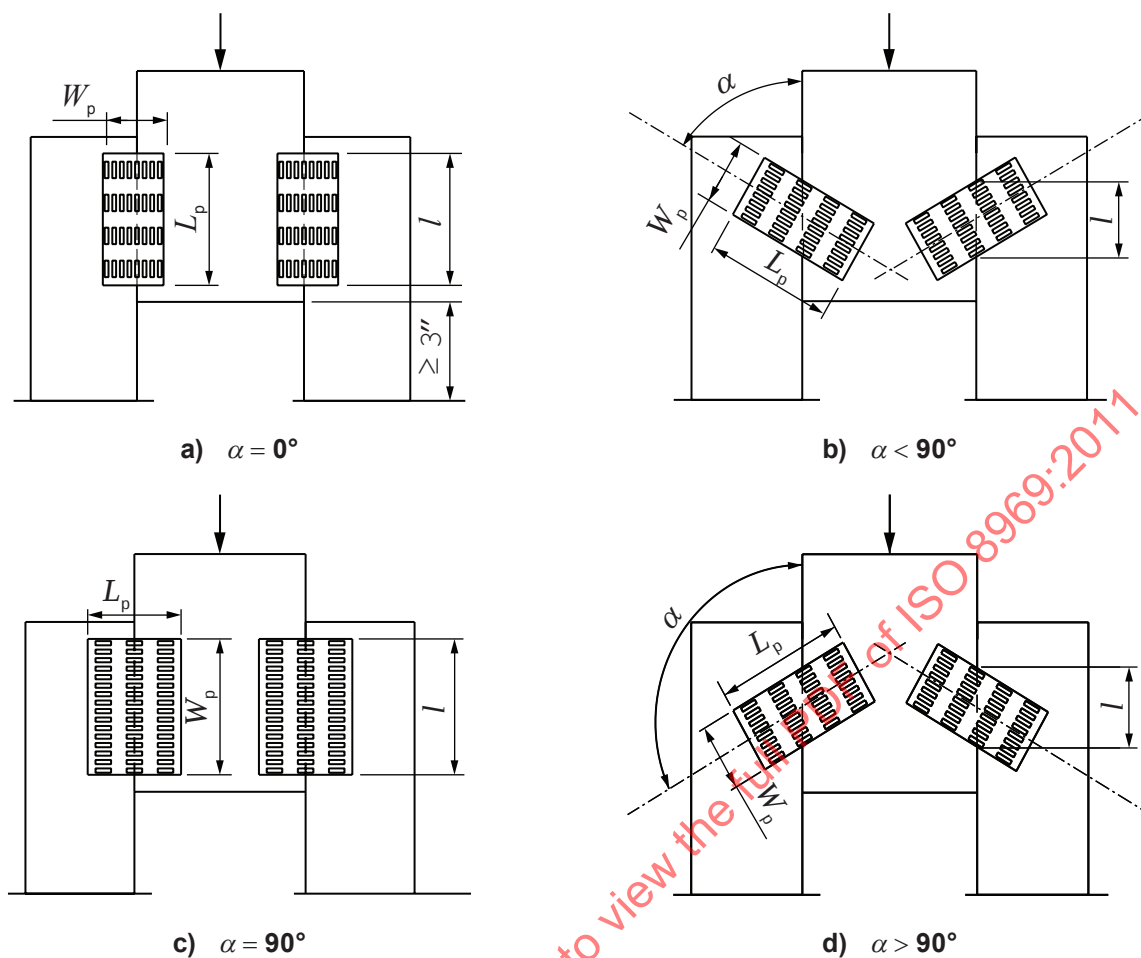


Figure 6 — Specimen for plate shear strength

Outside members of test specimen shall be maintained in a parallel and vertical orientation by suitable means of restraint.

6.6.2 A minimum of three test specimens shall be tested at each of six specific metal-plate-fastener orientations, α , equal to 0° , 30° , 60° , 90° , 120° and 150° .

7 Test procedure

7.1 General

Testing shall be carried out in accordance with ISO 6891 or other acceptable standards with the modifications given in 7.2 and 7.3.

7.2 Loading

The pre-load cycle at the beginning of the loading sequence may be omitted for any test type.

7.3 Maximum load

7.3.1 For plate compression, the strength shall be taken as the maximum load required to close the gap between the timber members.

7.3.2 For plate shear, the strength shall be taken as the highest load reached with an upper limit of the load at a slip of six times the plate thickness between the joint members if the curve is still rising at this displacement. Annex B provides guidance for interpretation of plate shear strength test results.

7.3.3 Calculate the ultimate tensile strength, F_{tc} , of each solid metal control specimen by dividing the maximum tensile load, P_{tc} , of each solid metal control specimen by the cross-sectional area, A_{gc} , of the respective solid metal control specimen as given by Equation (3):

$$F_{tc} = \frac{P_{tc}}{A_{gc}} \quad (3)$$

The cross-sectional area of each solid metal control specimen is determined by multiplying the minimum thickness, t_{net} , of the solid metal control specimen by the width, W , of the solid metal control specimen as given by Equation (4):

$$A_{gc} = t_{net}W \quad (4)$$

The F_{tc} values for all six, or more, solid metal control specimens from an individual coil of steel shall be averaged together, and the average value shall be used in 7.3.4.

7.3.4 Determine the theoretical ultimate shear stress, F_{sc} , of the solid metal by multiplying the average ultimate tensile stress, F_{tc} , by 0,577 as given by Equation (5):

$$F_{sc} = 0,577F_{tc} \quad (5)$$

7.3.5 For each shear test specimen, calculate the metal connector plate ultimate shear strength, F_{sp} , by dividing the maximum shear load carried by the test specimen, P_{sp} , by four times the average gross cross-sectional area, A_{gp} , of all four plates on the test specimen as given by Equation (6):

$$F_{sp} = P_{sp}/4 A_{gp} \quad (6)$$

The gross cross-sectional area of each metal connector plate, A_{gp} , is obtained by multiplying the minimum thickness of the metal connector plate, t_{net} , by the calculated shear length of the metal connector plate, l , (see Figure 6), as given by Equation (7):

$$A_{gp} = t_{net}l \quad (7)$$

The three, or more, F_{sp} values calculated for each orientation shall be averaged together, and the average value for each orientation shall be used in 7.3.6.

7.3.6 Calculate the shear resistance effectiveness ratio, R_s , for each orientation of the metal connector plate, by dividing the average metal connector plate ultimate shear stress, F_{sp} , for each orientation by the theoretical ultimate shear stress of the matched solid metal control specimen, F_{sc} , as given by Equation (8):

$$R_s = F_{sp}/F_{sc} = F_{sp}/0,577F_{tc} \quad (8)$$

This resistance ratio shall be permitted to be used to multiply steel shear design capacities determined in accordance with approved methods for a solid (unperforated) steel section otherwise equal in size to a perforated plate of the type tested. A similar approach shall be permitted to be followed with the results of the steel tension and steel compression test results.

7.3.7 Calculate the ultimate compression strength, F_{cc} , of each solid metal control specimen by dividing the maximum compression load, P_{cc} , of each solid metal control specimen by the cross-sectional area, A_{gc} , of the respective solid metal control specimen as given by Equation (9):

$$F_{cc} = P_{cc}/A_{gc} \quad (9)$$

8 Test results

Test results shall be calculated in accordance with ISO 6891 or other acceptable standards.

9 Test report

9.1 The test report for determining lateral resistance strength of metal plate fastener teeth shall include the following information:

- a) date of fabrication, date of test, and date of report;
- b) test sponsor and test agency;
- c) complete description of test method and loading procedure used, if there are any variations from this International Standard;
- d) description of pressing equipment, including roller diameter, roller press description, jigg apparatus, and any plate setting or pre-pressing techniques, if used;
- e) number of teeth in the failure zone;
- f) rate of load application;
- g) elapsed time of test;
- h) load deformation curve, or a minimum of three load, and corresponding deformation, readings prior to achieving critical slip;
- i) load at critical slip;
- j) maximum load obtained before failure and maximum load per plate unit values;
- k) description of type of failure;
- l) size and species of timber members;
- m) either a detailed drawing of the metal connector plate showing type, model, size, thickness, material and manufacturer, or a written description of the plate noting size, thickness, tooth spacing, material and manufacturer along with a photograph showing both faces;
- n) moisture content of timber members at time of fabrication;
- o) oven-dry specific gravity of timber members;
- p) number of test specimens tested;
- q) embedment equipment and method;
- r) certification of calibration of the testing machine;
- s) mill certification data for the test metal coil heat number, or the results of solid metal control specimens.

9.2 The test report for determining strength properties of metal plate fasteners under shear force shall include the following information:

- a) date of test and date of report;
- b) test sponsor and test agency;
- c) identification of metal connector plates: manufacturer, model, type, material, finish, shape, dimensions, and other pertinent information;

- d) complete description of test method and loading procedures used, if there are any deviations from the prescribed methods as outlined in this International Standard;
- e) number of test specimens tested;
- f) rate of load application;
- g) elapsed time of test;
- h) all test data, including maxima, minima, and averages;
- i) shear resistance effectiveness ratio for each individual test specimen and averages for all identical test specimens;
- j) description of type and path of failure;
- k) summary of findings;
- l) certification of calibration of the testing machine;
- m) results of the solid metal control specimen tests conducted in accordance with ASTM E8/E8M.

9.3 The test report for determining strength properties of metal plate fasteners under tension force shall include the following information:

- a) date of test and date of report;
- b) test sponsor and test agency;
- c) identification of metal connector plates: manufacturer, model, type, material, finish, shape, dimensions, and other pertinent information; metal connector plate material specifications shall include allowable tensile stress; also, identification of fasteners, such as type, size, quantity, and quality as well as the method of installing the metal connector plates and their fasteners, used for load transfer in the case of nail-on plates, including the nail-hole description;
- d) detailed drawings or photographs of test specimens before testing, if not fully described otherwise;
- e) complete description of test method and loading procedure used, if there are any deviations from the methods as outlined in this International Standard;
- f) number of test specimens tested;
- g) rate of load application;
- h) elapsed time of test;
- i) all test data, including maxima, minima, and averages;
- j) effectiveness ratios for each individual test specimen and average values for all identical test specimens; description of type and path of failure;
- k) summary of findings;
- l) results of the solid metal control specimen test conducted in accordance with ASTM E8/E8M.

Annex A (normative)

Test of nail root in alternate bending

A.1 Field of application

A recommended method for determining the properties of the fasteners at the nail root position by means of an alternate nail-bend test is specified. The method can be unsuitable for some types of fastener. In such cases, an alternative test method shall be specially devised and the method fully described in the test report.

A.2 Test specimen

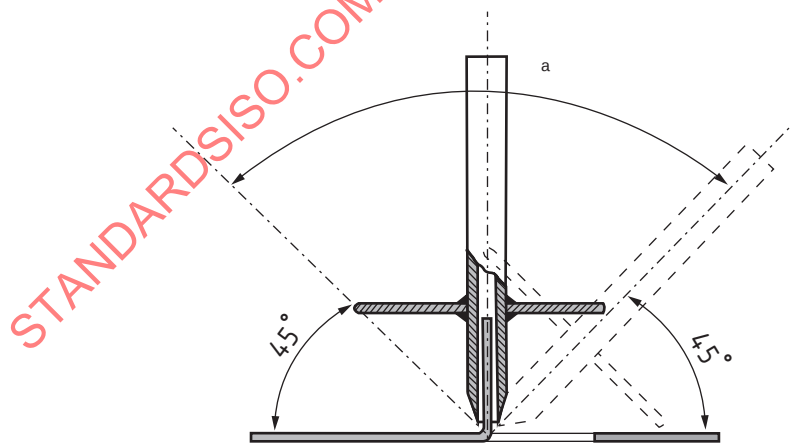
Test one nail at the centre of the fastener, one at the middle of one edge and one at either corner diagonally opposite the nail at the middle of one edge.

A.3 Test method

Apply a suitably shaped tool over one nail of the fastener in such a way that the bending force is applied along one face of the nail. Rotate the nail through 45° in a direction normal to its face and then successively through 90° in 5 s, reversing directions, as indicated in Figure A.1. Repeat the bending until the nail snaps off the fastener.

A.4 Test results

Record the number of bends for each nail (excluding the initial 45° movement) up to failure. It is for the user of this International Standard to determine acceptable criteria as to the acceptable number of bends.



a One bend equals 90° .

Figure A.1 — Nail-bend test