British Standard

BRITISH STANDARD

BS EN
391:2002

Glued laminated timber — Delamination test of glue lines

The European Standard EN 391:2002 has the status of a British Standard

ICS 91.080.20

National foreword

This British Standard is the official English language version of EN 391:2001. It supersedes BS EN 391:1995 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/518, Structural timber, which has the responsibility to:

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— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

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Glued laminated timber — Delamination test of glue lines

Bois lamellé collé — Essai de délamination des joints de collage

Brettschichtholz — Delaminierungsprüfung von Klebstofffugen

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Foreword

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

This European Standard supersedes EN 391:1995.

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of an identical text or by endorsement, at the latest by April 2002, and conflicting national standards shall be withdrawn at the latest by April 2002.

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.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Two delamination methods called A and B are suitable for adhesives of type I as defined in EN 301, and one method called C is suitable for adhesives of type II as defined in EN 301.

The two methods A and B have a duration of two days and a half day respectively, and method C requires four days. All are suitable for every day quality control.

1 Scope

This standard specifies three delamination methods for continuous quality control of the glue line integrity of glued laminated timber.

2 Normative references

None.

3 Terms and definitions

For the purposes of this European Standard the following terms and definitions apply:

3.1
delamination length
sum of the lengths of delaminated glue lines on both end-grain surfaces of each test piece

3.2
glued laminated timber (glulam)
structural member formed by bonding together timber laminations with the grain essentially parallel

4 Symbols

b	width of cross-section, in millimetres;
h	depth of cross-section, in millimetres;
$l_{max,delam}$	maximum delamination length of one glue line in the test piece, in millimetres;
$l_{glueline}$	length of one glue line, normally the width b shown in Figure 1, in millimetres;
$l_{tot,delam}$	delamination length of all glue lines in the test piece, in millimetres;
$l_{tot,glueline}$	entire length of glue lines on the two end-grain surfaces of each test piece, in millimetres.

5 Requirements

None.

6 Delamination test of glue lines

6.1 Principle

A gradient is introduced in the moisture content of the wood to build up internal stresses. This will result in tensile stresses perpendicular to the glue lines so that inadequate bonding quality will result in delamination of the glue lines.

6.2 Apparatus

6.2.1 Pressure vessel

A pressure vessel designed to withstand safely a pressure of at least 600 kPa (700 kPa absolute pressure) and a vacuum of at least 85 kPa (15 kPa absolute pressure), and equipped with pumps or similar device capable of giving a pressure of at least 600 kPa (700 kPa absolute pressure) and of drawing a vacuum of at least 85 kPa (15 kPa absolute pressure).

6.2.2 Drying duct

A drying duct where air is circulating at a velocity of 2 m/s to 3 m/s, and at a temperature and a relative humidity as given in Table 1.

Table 1 — Climate in the drying duct for the different methods

	Method:		
	A	**B**	**C**
Temperature °C	60 to 70	65 to 75	25 to 30
Relative humidity %	< 15	8 to 10	25 to 35

6.2.3 Balance

A balance capable of determining mass to an accuracy of 5 g.

6.2.4 Metal wedge and wooden hammer

Metal wedge and wooden hammer capable of splitting open glue lines.

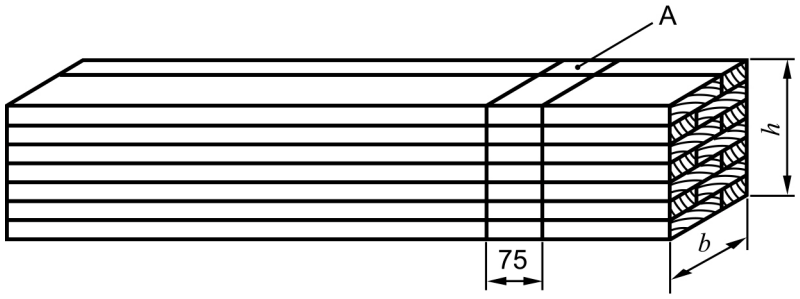
6.3 Preparation of test pieces

The test pieces shall be prepared or selected in such a manner that they are representative of the production run.

Each test piece shall be taken from a full cross-section of the laminated member to be tested, prepared by cutting perpendicular to the grain of the wood. It shall be (75 ± 5) mm in length (along the grain). The end-grain surfaces of the test piece shall be cut with a sharp saw or tool that produces a smooth surface.

If the width b of the cross-section is greater than 300 mm the test piece may be split into two or more test pieces each at least 130 mm wide. If the depth h is greater than 600 mm the test piece(s) may be cut into two or more pieces each with a depth of at least 300 mm, see Figure 1.

Dimensions in millimetres



Key

A Test piece

b Width

h High

Figure 1 — Test piece cut from a glulam member

6.4 Procedures

6.4.1 General

Before subjecting the test pieces to the test cycles, measure the total length in millimetres of glue lines on the end-grain surfaces of the test pieces.

Subject the test pieces to the appropriate test cycle described in 6.4.2, 6.4.3 or 6.4.4. The number of test cycles shall be as given in Table 2.

Table 2 — Number of test cycles to be used in the different test methods

	Method:		
	A	**B**	**C**
Number of initial cycles	2	1	1
Number of extra cycles	1	1	0

An extra test cycle need only be carried out if the total delamination percentage according to 6.5.2 is larger than the prescribed maximum value.

6.4.2 Measurement and evaluation of delamination

6.4.2.1 The delamination measurement and the evaluation of the test pieces shall take place not later than 1 h after the final drying treatment. The total glue line delamination on both end-grain surfaces of the test pieces shall be measured in millimetres.

NOTE 1 The use of a magnifying glass with a magnification of ca. 10 X and strong lighting are recommended to determine whether the opening in the glue line is a valid delamination or not.

NOTE 2 A feeler gauge of 0,08 mm to 0,10 mm thick is convenient for probing into the joint to determine if separation in the glue line actually exists.

6.4.2.2 Consider the following glue line openings as being valid delaminations:

a) a cohesive crack within the adhesive layer;

b) a failure of the glue line precisely between the adhesive layer and the wood substrate. No wood fibres are left attached to the adhesive layer;

c) a wood failure which is invariably within the first one or two layers of cells beyond the adhesive layer, in which the fracture path is not influenced by the grain angle and the growth-ring structure. It is characterized by a fine, woolly appearance of the wood fibres, which border the interface between the wood surface and the adhesive layer.

6.4.2.3 Do not regard the following glue line opening as delaminations:

a) a solid wood failure which is invariably more than two cell layers away from the adhesive layer, in which the fracture path is strongly influenced by the grain angle and the growth-ring structure;

b) isolated openings in the glue line which are less than 2,5 mm long and more than 5 mm away from the nearest delamination;

c) openings in the glue line which are found along knots or resin pockets which border the glue line, or openings in the glue line which are caused by hidden knots in the glue line. When the cause of an opening in the glue line due to the presence of a knot is suspected, the glue line shall be opened with a wedge and hammer and be inspected for the presence of a concealed knot. Should the cause of the glue line opening be due to a concealed knot, the opening shall not be considered a delamination.

6.4.3 Test cycle for method A

6.4.3.1 Place the test pieces in the pressure vessel and weigh them down. Admit water at a temperature of 10 °C to 20 °C in sufficient quantity so that the pieces are completely submerged. Separate the test pieces by stickers, wire screens, or other means in such a manner that all end-grain surfaces are freely exposed to the water. Draw a vacuum of 70 kPa to 85 kPa (i.e. an absolute pressure of 15 kPa to 30 kPa at sea level) and hold it for 5 min. Then release the vacuum and apply a pressure of 500 kPa to 600 kPa (600 kPa to 700 kPa absolute pressure) for 1 h. Whilst the test pieces are still completely immersed, repeat this vacuum pressure cycle making a two-cycle impregnating period requiring a total of 130 min.

6.4.3.2 Dry the test pieces for a period of between 21 h and 22 h in air at 60 °C to 70 °C and a relative humidity not greater than 15 %, and circulating at a velocity of 2 m/s to 3 m/s. During drying, the test pieces shall be placed at least 50 mm apart with the end-grain surfaces parallel to the stream of air.

6.4.4 Test cycle for method B

6.4.4.1 Weigh and record to the nearest 5 g the mass of each test piece. Place the test pieces in the pressure vessel and weigh them down. Admit water, at a temperature of 10 °C to 20 °C in sufficient quantity so that the pieces are completely submerged. Separate the test pieces by stickers, wire screens, or other means in such a manner that all end-grain surfaces are freely exposed to the water.

Draw a vacuum of 70 kPa to 85 kPa (i.e. an absolute pressure of 15 kPa to 30 kPa at sea level) and hold it for 30 min. Release the vacuum and apply a pressure of 500 kPa to 600 kPa (600 kPa to 700 kPa absolute pressure) for 2 h.

6.4.4.2 Dry the test pieces for a period of approximately 10 h to 15 h in air at 65 °C to 75 °C and a relative humidity of 8 % to 10 % and circulating at a velocity of 2 m/s to 3 m/s. During drying the test pieces shall be placed at least 50 mm apart with the end-grain surfaces parallel to the stream of air.

6.4.4.3 The actual time in the drying duct shall be controlled by the mass of the test pieces. Delamination shall be observed and recorded when the mass of the test pieces has returned to within 100 %-110 % of the original mass. Record the total drying time.

6.4.5 Test cycle for method C

6.4.5.1 Place the test pieces in the pressure vessel and weigh them down. Admit water at a temperature of 10 °C to 20 °C in sufficient quantity so that the pieces are completely submerged. Separate the test pieces by stickers, wire screens, or other means in such a manner that all end-grain surfaces are freely exposed to the water. Draw a vacuum of 70 kPa to 85 kPa (i.e. an absolute pressure of 15 kPa to 30 kPa at sea level) and hold it for 30 min. Then release the vacuum and apply a pressure of 500 kPa to 600 kPa (600 kPa to 700 kPa absolute pressure) for 2 h. Whilst the test pieces are still completely immersed, repeat this vacuum pressure cycle giving a two-cycle impregnating period requiring a total of 5 h.

6.4.5.2 Dry the test pieces for a period of 90 h in air at 25 °C to 30 °C and a relative humidity in the range of 25 % to 35 %, and circulating at a velocity of 2 m/s to 3 m/s. During drying, the test pieces shall be placed at least 50 mm apart with the end-grain surfaces parallel to the stream of air.

6.5 Results

6.5.1 General

For each test piece the delamination percentages shall be calculated. If an extra cycle is performed calculate the results before and after the extra cycle.

6.5.2 Total delamination

The total delamination percentage of a test piece shall be calculated from the following formula:

$$100\,\frac{l_{\mathrm{tot,delam}}}{l_{\mathrm{tot,glueline}}}$$

6.5.3 Maximum delamination

The maximum delamination percentage for a single glue line in a test piece shall be calculated from the following formula:

$$100\,\frac{l_{\mathrm{max,delam}}}{2\,l_{\mathrm{glueline}}}$$

6.6 Test report

The test report shall include the following items:

a) reference to this European Standard;

b) date of the test;

c) identification of test pieces and members from which they have been cut. Any other relevant information, e.g. about preconditioning;

d) species of timber;

e) type of adhesive;

f) test method (A, B or C);

g) the total delamination percentage and the maximum delamination percentage after the prescribed number of cycles and any additional cycle that may be necessary;

h) any relevant observation made during or after testing;

i) signature of the person responsible for the testing.

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