BRITISH STANDARD

BS EN
1194:1999

Timber structures — Glued laminated timber — Strength classes and determination of characteristic values

The European Standard EN 1194:1999 has the status of a British Standard

ICS 79.060.99; 91.080.20

National foreword

This British Standard is the English language version of EN 1194:1999.

The UK participation in its preparation was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/5, Structural use of timber, which has the responsibility to:

— aid enquirers to understand the text;

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

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Additional information

It should be noted that design stresses in the form of characteristic values (as described in this standard) are suitable for use in designs carried out to ENV 1995-1-1, but are not appropriate for use in permissible stress designs carried out to BS 5268-2.

Cross-references

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 7 and a back cover.

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Timber structures — Glued laminated timber — Strength classes and determination of characteristic values

Structure en bois — Bois lamellé-collé — Classes de résistance et détermination des valeurs caractéristiques

Holzbauwerke — Brettschichtholz — Festigkeitsklassen und Bestimmung charakteristischer Werte

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CEN

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

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

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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 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 1999, and conflicting national standards shall be withdrawn at the latest by October 1999.

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.

This standard is one of a series of standards for building materials. It was prepared by a working group under the joint convenorship of Association Française de Normalisation (AFNOR) and British Standards Institution (BSI).

This standard includes a normative annex on calculation of characteristic properties and a normative annex on examples of combinations of laminations and marking of glued laminated timber.

Introduction

A strength class system enables combinations of grade and species to be classified together with a common set of strength properties. Such a system simplifies the process of marketing glued laminated timber by reducing the number of options at the specification/supply interface.

1 Scope

This standard specifies a system of strength classes for horizontally laminated structural glued laminated timber with four or more laminations. A number of strength classes are defined and characteristic strength and stiffness properties and densities are given. This standard is currently limited to softwood glued laminated timber.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 338, *Structural timber — Strength classes.*

EN 384, *Structural timber — Determination of characteristic values of mechanical properties and density.*

EN 385: 1995, *Finger jointed structural timber — Performance requirements and minimum production requirements.*

EN 386, *Glued laminated timber — Performance requirements and minimum production requirements.*

EN 408, *Timber structures — Structural timber and glued laminated timber — Determination of some physical and mechanical properties.*

EN 1193, *Timber structures — Structural and glued laminated timber — Determination of shear strength and mechanical properties perpendicular to the grain.*

ENV 1995-1-1, *Eurocode 5 — Design of timber structures — Part 1-1: General rules and rules for buildings.*

3 Definitions

For the purposes of this standard, the following definitions apply.

3.1

glued laminated timber

structural member formed by bonding together timber laminations with the grain running essentially parallel

3.2

characteristic values

refer to ENV 1995-1-1

3.3

homogeneous glued laminated timber

glued laminated timber with a cross-section where all laminations are of the same grade (strength class) and species (or species combinations)

3.4

combined glued laminated timber

glued laminated timber with a cross-section comprising inner and outer laminations of different grades (strength classes) and species (or species combinations)

3.5

horizontally laminated glued laminated timber

see horizontal glulam defined in EN 386. For elements stressed in bending, the load is applied perpendicular to the wide faces of the laminations

3.6

thickness

lesser dimension perpendicular to the longitudinal axis

3.7

width

greater dimension perpendicular to the longitudinal axis

3.8

depth

dimension perpendicular to the longitudinal axis of a beam, in the plane of the bending forces

4 Symbols

Main symbols:

E_0	modulus of elasticity parallel to the grain, in newtons per square millimetre;
f	strength, in newtons per square millimetre;
h	depth of a bending specimen or width of a tension specimen, in millimetres;
k	factor;
l	length, in millimetres;
ρ	density, in kilograms per cubic metre;

Subscripts:

c	compression;
g	properties of glued laminated timber;
j	properties of laminate end joints;
k	characteristic;
l	properties of laminations;
m	bending;
mean	mean value;
size	size factor;
t	tension;
v	shear;
0	parallel to grain;
90	perpendicular to grain;
05	5-percentile.

5 Strength classes

5.1 Table 1 and Table 2 give the characteristic strength, stiffness and density properties for four standard strength classes.

NOTE 1 The compression strength perpendicular to grain corresponds to the test method given in EN 1193. These values are approximately half of those used in some timber design codes for the strength verification of supports.

NOTE 2 The shear strength values are derived from actual values used in existing timber design codes.

5.2 The values of bending strength are related to elements with a depth h of 600 mm. The values of tension strength parallel to grain are related to elements with a width h of 600 mm.

6 Compliance

6.1 General

Glued laminated members may be assumed to comply with the requirements for a strength class provided they meet the requirements of either **6.2** or **6.3**.

6.2 Compliance based on tests

A glued laminated member can be assigned to one of the strength classes given in Tables 1 and 2 if its characteristic properties, derived from tests in accordance with EN 408 and EN 1193, are not less than the values given in those tables.

NOTE The basic required properties are the bending strength and the bending modulus of elasticity. The other properties necessary for design purposes can be taken directly from Tables 1 and 2.

Table 1 — Characteristic strength and stiffness properties in N/mm^2 and densities in kg/m^3 (for homogeneous glulam)

Glulam strength class		GL 24h	GL 28h	GL 32h	GL 36h
Bending strength	$f_{m,g,k}$	24	28	32	36
Tension strength	$f_{t,0,g,k}$	16,5	19,5	22,5	26
	$f_{t,90,g,k}$	0,4	0,45	0,5	0,6
Compression strength	$f_{c,0,g,k}$	24	26,5	29	31
	$f_{c,90,g,k}$	2,7	3,0	3,3	3,6
Shear strength	$f_{v,g,k}$	2,7	3,2	3,8	4,3
Modulus of elasticity	$E_{0,g,mean}$	11 600	12 600	13 700	14 700
	$E_{0,g,05}$	9 400	10 200	11 100	11 900
	$E_{90,g,mean}$	390	420	460	490
Shear modulus	$G_{g,mean}$	720	780	850	910
Density	$\rho_{g,k}$	380	410	430	450

Table 2 — Characteristic strength and stiffness properties in N/mm^2 and densities in kg/m^3 (for combined glulam)

Glulam strength class		GL 24c	GL 28c	GL 32c	GL 36c
Bending strength	$f_{m,g,k}$	24	28	32	36
Tension strength	$f_{t,0,g,k}$	14	16,5	19,5	22,5
	$f_{t,90,g,,k}$	0,35	0,4	0,45	0,5
Compression strength	$f_{c,0,g,k}$	21	24	26,5	29
	$f_{c,90,g,k}$	2,4	2,7	3,0	3,3
Shear strength	$f_{v,k,g}$	2,2	2,7	3,2	3,8
Modulus of elasticity	$E_{0,g,mean}$	11 600	12 600	13 700	14 700
	$E_{0,g,05}$	9 400	10 200	11 100	11 900
	$E_{90,g,mean}$	320	390	420	460
Shear modulus	$G_{g,mean}$	590	720	780	850
Density	$\rho_{g,k}$	350	380	410	430

It is assumed that bending specimens have a depth h of 600 mm or more and a thickness b of 150 mm or more. It is assumed that tension specimens have a width h of 600 mm or more and a thickness b of 150 mm or more. If the cross-section dimensions are lower than these reference values, the test results shall be multiplied by:

$$k_{size} = \left(\frac{b}{150}\right)^{0,05}\left(\frac{h}{600}\right)^{0,1}$$

Test specimens shall have at least one laminate end joint in the laminations in which the tension stress is maximum.

6.3 Compliance based on calculations

6.3.1 The laminations shall have the necessary mechanical properties (derived in accordance with EN 384 and EN 408) to produce mechanical properties of glued laminated timber equal to or greater than the values given in Tables 1 and 2.

Formulae for calculating the mechanical properties of glued laminated timber from the lamination properties are given in annex A. They shall be used to establish the mechanical properties for glulam strength classes of Tables 1 and 2, and may also be used to calculate the mechanical properties of glued laminated timber not corresponding to these strength classes.

The basic requirements for the laminations which are used in the formulae of annex A are the tension characteristic strength and the mean tension modulus of elasticity. The density of the laminations is an indicative property. These properties shall be either the tabulated values given in EN 338 or derived according to the following principles.

Where the values of EN 338 are not used, the establishment of the characteristic tension strength shall be based on tests carried out in accordance with EN 408 and calculated according to the principles given in EN 384, with the following exceptions.

— If the dimensions of the specimens are lower than the reference size dimensions (h = 150 mm, l = 2 000 mm), the test results shall be multiplied by:

$$k_{size} = \left(\frac{h}{150}\right)^{0,1}\left(\frac{l}{2\,000}\right)^{0,1}$$

— The tension modulus of elasticity shall be measured on a zone randomly selected within the specimen length. The length of measurement shall be at least five times the width of the specimen.

— The factor k_v as given in EN 384 for machine graded timber shall be taken as 1,0.

NOTE 1 Examples of beam lay-ups using the basic required properties and corresponding to glulam strength classes of Tables 1 and 2 are given in Table B.1 of annex B.

NOTE 2 Examples of beam lay-ups using EN 338 strength classes and corresponding to glulam strength classes of Tables 1 and 2 are given in Table B.2 of annex B.

6.3.2 The laminate end joints of all laminations shall meet at least one of the following requirements a and b.

Requirement a:

$$f_{t,j,k} \geq 5 + f_{t,0,l,k}$$

where

$f_{t,j,k}$ is the characteristic tension strength of the laminate end joints in full width determined in accordance with EN 408 but with a knot-free specimen with a free length of 200 mm, in newtons per square millimetre; and

$f_{t,0,l,k}$ is the characteristic tension strength of the laminations, as defined in **6.3.1**, in newtons per square millimetre.

Requirement b:

$$f_{m,j,k} \geq 8 + 1,4 f_{t,0,l,k}$$

where

$f_{m,j,k}$ is the characteristic bending strength of the laminate end joints in full width determined in flatwise bending in accordance with EN 386, in newtons per square millimetre; and

$f_{t,0,l,k}$ is the characteristic tension strength of the laminations, as defined in **6.3.1**, in newtons per square millimetre.

NOTE For finger joints the requirements apply directly to the actual joints tested, i.e. without a factor k_f as in **7.1.4** of EN 385:1995.

Annex A (normative)

Calculation of characteristic properties

The formulae given in Table A.1 may be used to calculate mechanical properties for homogeneous glued laminated timber made from softwood laminations.

Table A.1 — Mechanical properties of glued laminated timber (all strength and stiffness values are given in N/mm^2)

Property		
Bending	$f_{m,g,k}$	$= 7 + 1{,}15 f_{t,0,l,k}$
Tension	$f_{t,0,g,k}$	$= 5 + 0{,}8 f_{t,0,l,k}$
	$f_{t,90,g,k}$	$= 0{,}2 + 0{,}015 f_{t,0,l,k}$
Compression	$f_{c,0,g,k}$	$= 7{,}2\, f_{t,0,l,k}^{0,45}$
	$f_{c,90,g,k}$ *)	$= 0{,}7\, f_{t,0,l,k}^{0,5}$
Shear**)	$f_{v,g,k}$	$= 0{,}32\, f_{t,0,l,k}^{0,8}$
Modulus of elasticity	$E_{0,g,mean}$	$= 1{,}05\, E_{0,l,mean}$
	$E_{0,g,05}$	$= 0{,}85\, E_{0,l,mean}$
	$E_{90,g,mean}$	$= 0{,}035\, E_{0,l,mean}$
Shear modulus	$G_{g,mean}$	$= 0{,}065\, E_{0,l,mean}$
Density	$\rho_{g,k}$	$= 1{,}10\, \rho_{l,k}$

*) The compression strength perpendicular to grain corresponds to the test methods given in EN 1193. These values are approximately half of those used in some timber design codes for the strength verification of supports.

**) The shear strength values are derived from actual values in existing timber design codes.

For combined glued laminated timber the formulae apply to the properties of the individual parts of the cross-section. It is assumed that zones of different lamination grades amount to at least 1/6 of the beam depth or two laminations, whichever is the greater.

The stress analysis may be carried out by linear elastic beam theory. The strength verification shall be made at all relevant points of the cross-section.

NOTE For the special case of glulam bending elements for which the inner laminations have a tension strength higher than or equal to 0,75 times the outer laminations tension strength, simplifications to the theory may be done according to the following recommendations:

— the bending strength ($f_{m,g,k}$) should be calculated using the tension strength of the outer laminations;

— the other strength properties ($f_{t,0,g,k}$, $f_{t,90,g,k}$, $f_{c,0,g,k}$, $f_{c,90,g,k}$, $f_{v,g,k}$) should be calculated using the tension strength of the inner laminations;

— the modulus of elasticity parallel to grain ($E_{0,g,mean}$, $E_{0,g,05}$) should be calculated using the tension modulus of elasticity of the outer laminations;

— the other stiffness properties ($E_{90,g,mean}$, $G_{g,mean}$) should be calculated using the tension

modulus of elasticity of the inner laminations;

— the density ($\rho_{g,k}$) should be calculated using the density of the inner laminations.

Annex B (normative)

Examples of beam lay-ups

Glued laminated timber with beam lay-ups as shown in Tables B.1 and B.2 complies with all mechanical properties of the strength classes given in Tables 1 and 2.

Table B.1 — Examples of beam lay-ups complying with Tables 1 and 2 (required lamination properties in accordance with 6.3.1)

Glulam strength classes	GL 24	GL 28	GL 32	GL 36
Homogeneous glulam				
Tension strength, in N/mm^2	14,5	18	22	26
Tension modulus of elasticity, in N/mm^2	11 000	12 000	13 000	14 000
Density, in $kg/m^{3*)}$	350	370	390	410
Combined glulam**)				
Tension strength, in N/mm^2	14,5/11	18/14,5	22/18	26/22
Tension modulus of elasticity, in N/mm^2	11 000/9 000	12 000/11 000	13 000/12 000	14 000/13 000
Density, in $kg/m^{3*)}$	350/320	370/350	390/370	410/390*)

*) The density values are indicative properties.

**) For combined glulam, the required properties are given for outer/inner laminations.

Table B.2 — Examples of beam lay-ups complying with Tables 1 and 2 (lamination strength classes in accordance with EN 338)

Glulam strength classes	GL 24	GL 28	GL 32
Homogeneous glulam	C24	C30	C40
Combined glulam: outer/inner laminations	C24/C18	C30/C24	C40/C30

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