Ingenieur Holzbau.de

A campaign by
Studiengemeinschaft Holzleimbau e.V.

Finnish Woodworking Industries

Laminated veneer lumber (LVL) bulletin

New European strength classes

September 2020

1 Introduction

Laminated veneer lumber (LVL) is a structural timber product which has been widely used for a wide range of structural and non-structural applications during the last decades.

The European LVL industry (Metsä Wood, Pollmeier Massivholz GmbH & Co. KG, STEICO SE and Stora Enso) has decided to launch LVL strength classes. This bulletin introduces the classes along with other product and design provisions not yet covered in the respective standards.

The strength classes shall be introduced in the coming revision of EN 14374 as product categories.

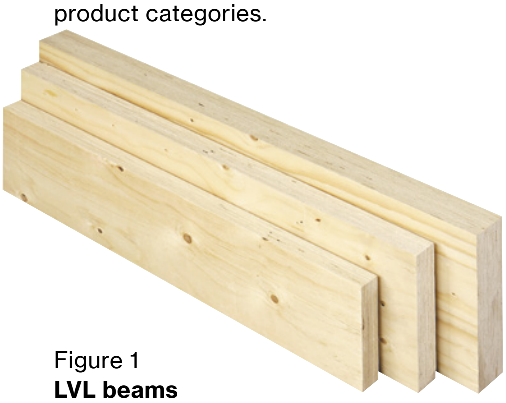


Figure 1
LVL beams

2 Laminated veneer lumber

LVL is a structural product being manufactured according to the harmonized product standard EN 14374.

LVL is defined as a wood-based composite consisting of veneers, glued together predominantly parallel to the grain in adjacent layers which may have crossband veneers. Several panels of such “primary” LVL can be bonded by face-gluing in order to achieve a LVL product with larger thicknesses, called glued laminated LVL (GLVL).

Both products, primary LVL and glued laminated LVL shall have symmetrical layup and may either only comprise parallel veneers (LVL-P) or at least two crossband veneers (LVL-C), see Figure 2.

LVL may be designed as beams, plates, studs or panels. LVL may also be used as components for elements or other engineered wood products. Guidance for the design may be found in Eurocode (EN 1995 with National Annexes) or in handbooks, e.g. LVL Handbook for Europe published by the Federation of the Finnish Woodworking Industries.

LVL may be made from coniferous or broadleaf species. At the time of publication of this bulletin LVL made from spruce, pine and beech is available.

Due to its manufacture, the glue lines in LVL can withstand dry, humid and exterior conditions, which means that they are applicable in service classes 1, 2 and 3 conditions according to EN 1995-1-1. LVL products in service class 3 conditions require preservative treatment.

LVL is an orthotropic material. The edgewise bending and tension strength depends on a size effect parameter s for both primary LVL and glued laminated LVL. For glued laminated LVL (GLVL) which might have significantly higher thickness, size effect parameters $s_{m,flat}$ and $s_{v,flat}$ are needed for the flatwise bending and shear strength. Table 1 shows the definitions of the strengths, moduli of elasticity and shear moduli in the different orientations and of the related size effect parameters.

Figure 2
Laminated veneer lumber without an with crossband veneers

b width
t thickness
l length
⥃ grain direction

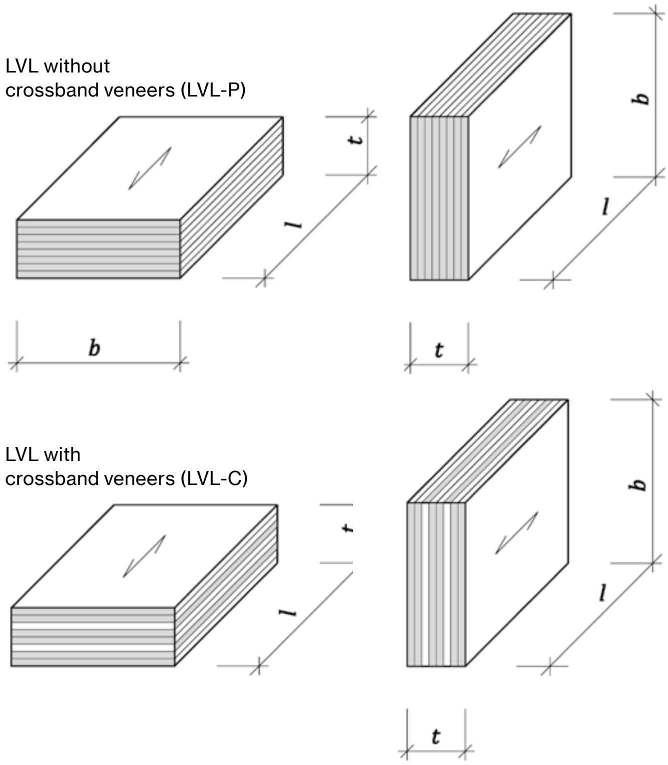
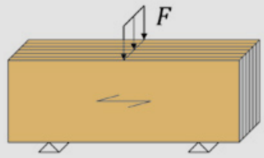
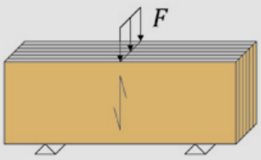


Table 1:
Symbols for strengths, moduli of elasticity and shear moduli

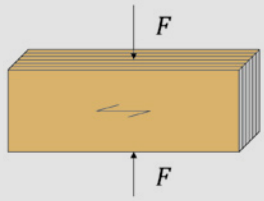


$f_{m,0,edge}$, s, and $E_{m,0,edge}$

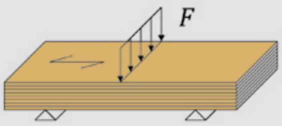
$f_{c,0}$, and $E_{c,0}$



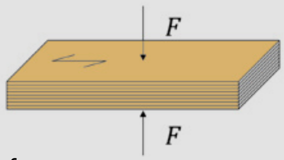
$f_{m,90,edge}$, $E_{m,90,edge}$ and $f_{v,90,edge}$



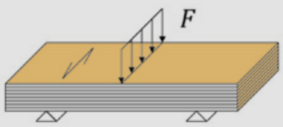
$f_{c,90,edge}$ and $E_{c,90,edge}$



$f_{m,0,flat}$, $s_{m,flat}$ and $E_{m,0,flat}$



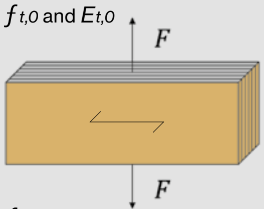
$f_{c,90,flat}$ and $E_{90,flat}$



$f_{m,90,flat}$ and $E_{m,90,flat}$

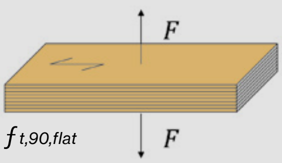
$f_{t,0}$ and $E_{t,0}$

$f_{v,0,edge}$ and $G_{0,edge}$

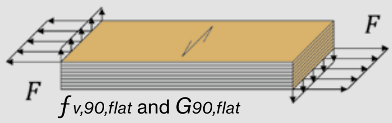


$f_{t,90,edge}$ and $E_{t,90,edge}$

$f_{v,0,flat}$, $s_{v,flat}$ and $G_{0,flat}$



$f_{t,90,flat}$



$f_{v,90,flat}$ and $G_{90,flat}$

3 Strength classes

Tables 2 and 3 (see next pages) show the strength classes for LVL. These strength classes will be named product categories in the future harmonized product standard EN 14374.

The strength classes do comprise the strength, stiffness and density values which are usually needed for design. Further characteristics might be declared as individual values aside the strength class.

A link between the strength classes given in tables 2 and 3 and different LVL products can be found on the websites of the manufacturers.

Table 2:
Strength class for LVL without crossband veneers (LVL-P)

	Property [a]	Symbol	Unit	LVL 32 P	LVL 35 P	LVL 48 P	LVL 50 P	LVL 80 P
				Strength class				
Bending strength	Edgewise, parallel to grain (depth 300 mm)	$f_{m,0,edge,k}$	N/mm²	27	30	44	46	75
	Flatwise, parallel to grain	$f_{m,0,flat,k}$	N/mm²	32	35	48	50	80
	Size effect parameter	s	–	0,15	0,15	0,15	0,15	0,15
Tension strength	Parallel to grain (length 3 000 mm)	$f_{t,0,k}$	N/mm²	22	22	35	36	60
	Perpendicular to grain, edgewise	$f_{t,90,edge,k}$	N/mm²	0,5	0,5	0,8	0,9	1,5
Compression strength	Parallel to grain for service class 1	$f_{c,0,k}$	N/mm²	26	30	35	42	69
	Parallel to grain for service class 2 [b]	$f_{c,0,k}$	N/mm²	21	25	29	35	57
	Perpendicular to grain, edgewise	$f_{c,90,edge,k}$	N/mm²	4	6	6	8,5	14
	Perpendicular to grain, flatwise (except pine)	$f_{c,90,flat,k}$	N/mm²	0,8	2,2	2,2	3,5	12
	Perpendicular to grain, flatwise, pine	$f_{c,90,flat,k,pine}$	N/mm²	MDV [c]	3,3	3,3	3,5	– [d]
Shear strength	Edgewise parallel to grain	$f_{v,0,edge,k}$	N/mm²	3,2	3,2	4,2	4,8	8
	Flatwise, parallel to grain	$f_{v,0,flat,k}$	N/mm²	2,0	2,3	2,3	3,2	8
Modulus of elasticity	Parallel to grain	$E_{0,mean}$ [e]	N/mm²	9 600	12 000	13 800	15 200	16 800
	Parallel to grain	$E_{0,k}$ [f]	N/mm²	8 000	10 000	11 600	12 600	14 900
	Perpendicular to grain, edgewise	$E_{c,90,edge,mean}$ [g]	N/mm²	MDV [c]	MDV [c]	430	430	470
	Perpendicular to grain, edgewise	$E_{c,90,edge,k}$ [h]	N/mm²	MDV [c]	MDV [c]	350	350	400
Shear modulus	Edgewise, parallel to grain	$G_{0,edge,mean}$	N/mm²	500 [i]	500 [i]	600	650	760
	Edgewise, parallel to grain	$G_{0,edge,k}$	N/mm²	300 [i]	350 [i]	400	450	630
	Flatwise, parallel to grain	$G_{0,flat,mean}$	N/mm²	320 [i]	380 [i]	380	600	850
	Flatwise, parallel to grain	$G_{0,flat,k}$	N/mm²	240 [i]	270 [i]	270	400	760
Density		ρ_{mean}	kg/m³	440	510	510	580	800
		ρ_k	kg/m³	410	480	480	550	730

a Additional strength, stiffness and density properties not covered by the strength class given in this Table may be declared as individual values.
b Value may also be applied in Service Class 1 as a conservative value.
c Property is not expressed as product category but rather as individual manufacturer's declared value (MDV).
d Strength class not produced from pine.
e Covering $E_{m,0,edge,mean}$, $E_{t,0,mean}$, $E_{m,0,flat,mean}$, and $E_{c,0,mean}$.
f Covering $E_{m,0,edge,k}$, $E_{t,0,k}$, $E_{m,0,flat,k}$, and $E_{c,0,k}$.
g Covering $E_{t,90,edge,mean}$.
h Covering $E_{t,90,edge,k}$.
i Property need not to be tested, if all other properties meet the minimum values for the strength class.
j Covering $E_{m,90,edge,mean}$, $E_{t,90,edge,mean}$ and $E_{c,90,edge,mean}$.
k Covering $E_{m,90,edge,k}$, $E_{t,90,edge,k}$ and $E_{c,90,edge,k}$.

Table 3:
Strength class for LVL with crossband veneers (LVL-C)

	Property [a]	Symbol	Unit	Strength class					
				LVL 22 C	LVL 25 C	LVL 32 C	LVL 36 C	LVL 70 C	LVL 75 C
Bending strength	Edgewise, parallel to grain (depth 300 mm)	$f_{m,0,edge,k}$	N/mm²	19	20	28	32	54	60
	Flatwise, parallel to grain	$f_{m,0,flat,k}$	N/mm²	22	25	32	36	70	75
	Size effect parameter	s	–	0,15	0,15	0,15	0,15	0,15	0,15
	Flatwise, perpendicular to grain	$f_{m,90,flat,k}$	N/mm²	MDV [c]	MDV [c]	7	8	32	20
Tension strength	Parallel to grain (length 3 000 mm)	$f_{t,0,k}$	N/mm²	14	15	18	22	45	51
	Perpendicular to grain, edgewise	$f_{t,90,edge,k}$	N/mm²	4	4	5	5	16	8
Compression strength	Parallel to grain for service class 1	$f_{c,0,k}$	N/mm²	18	18	18	26	54	64
	Parallel to grain for service class 2 [b]	$f_{c,0,k}$	N/mm²	15	15	15	21	45	53
	Perpendicular to grain, edgewise	$f_{c,90,edge,k}$	N/mm²	8	8	9	9	45	23
	Perpendicular to grain, flatwise (except pine)	$f_{c,90,flat,k}$	N/mm²	1,0	1,0	2,2	2,2	16	16
	Perpendicular to grain, flatwise, pine	$f_{c,90,flat,k,pine}$	N/mm²	MDV [c]	MDV [c]	3,5	3,5	– [d]	– [d]
Shear strength	Edgewise parallel to grain	$f_{v,0,edge,k}$	N/mm²	3,6	3,6	4,5	4,5	7,8	7,8
	Flatwise, parallel to grain	$f_{v,0,flat,k}$	N/mm²	1,1	1,1	1,3	1,3	3,8	3,8
	Flatwise, perpendicular to grain	$f_{v,90,flat,k}$	N/mm²	MDV [c]	MDV [c]	0,6	0,6	MDV [c]	MDV [c]
Modulus of elasticity	Parallel to grain	$E_{0,mean}$ [e]	N/mm²	6 700	7 200	10 000	10 500	11 800	13200
	Parallel to grain	$E_{0,k}$ [f]	N/mm²	5 500	6 000	8 300	8 800	10 900	12200
	Perpendicular to grain, edgewise	$E_{c,90,edge,mean}$ [j]	N/mm²	MDV [c]	MDV [c]	2 400	2 400	MDV [c]	MDV [c]
	Perpendicular to grain, edgewise	$E_{c,90,edge,k}$ [k]	N/mm²	MDV [c]	MDV [c]	2 000	2 000	MDV [c]	MDV [c]
	Perpendicular to grain, flatwise	$E_{m,90,flat,mean}$	N/mm²	MDV [c]	MDV [c]	1 200	2 000	MDV [c]	MDV [c]
	Perpendicular to grain, flatwise	$E_{m,90,flat,k}$	N/mm²	MDV [c]	MDV [c]	1 000	1 700	MDV [c]	MDV [c]
Shear modulus	Edgewise, parallel to grain	$G_{0,edge,mean}$	N/mm²	500 [i]	500 [i]	600	600	820	820
	Edgewise, parallel to grain	$G_{0,edge,k}$	N/mm²	300 [i]	300 [i]	400	400	660	660
	Flatwise, parallel to grain	$G_{0,flat,mean}$	N/mm²	70 [i]	70 [i]	80	120	430	430
	Flatwise, parallel to grain	$G_{0,flat,k}$	N/mm²	55 [i]	55 [i]	60	100	380	380
	Flatwise, perpendicular to grain	$G_{90,flat,mean}$	N/mm²	MDV [c]	MDV [c]	22	22	MDV [c]	MDV [c]
	Flatwise, perpendicular to grain	$G_{90,flat,k}$	N/mm²	MDV [c]	MDV [c]	16	16	MDV [c1]	MDV [c]
Density		ρ_{mean}	kg/m³	440	440	510	510	800	800
		ρ_{k}	kg/m³	410	410	480	480	730	730

4 Tolerances

4.1 General

Maximum deviations of sizes and angles are related to nominal sizes at moisture contents between 5% and 15%.

NOTE: The usual moisture content of LVL dispatched from factory is between 8 – 10%.

4.2 Measurement of actual sizes

Thickness, width and length shall be measured according to EN 324-1.

NOTE: According to EN 324-1 measurements are done at the actual moisture content.

4.3 Determination of corrected sizes and maximum deviations

Corrected sizes at reference moisture content shall be calculated from the swelling and shrinkage values according to Table 8 and actual sizes.

The corrected sizes of LVL, which is not sanded or pressure treated, based on measurements shall not deviate from the nominal sizes by more than the maximum deviations at the reference moisture content given in Table 4. For sanded or pressure treated LVL the maximum deviations from nominal sizes are subject to individual agreements.

5 Additional design provisions

5.1 General

This chapter covers additional design rules for structural LVL which are not covered by EN 1995-1-1:2004 + AC:2006 + A1:2008 + A2:2014 and EN 1995-1-2:2004 + AC:2009, respectively. It is intended to move this or similar design rules to these standards during revision.

5.2 Deformation factors k_{def} for structural LVL with crossband veneers

The values given in Table 5 are recommended.

5.3 Requirements for compression perpendicular to the grain

For the design of structural laminated veneer lumber made of coniferous species without or with crossband veneers subjected to compression stresses perpendicular to the grain the $k_{c,90}$-values and the increase of the actual contact length may be taken from Table 6.

Table 5:
Deformation factors k_{def} for structural LVL with crossband veneers (LVL-C)

Material	Service class		
LVL-C	1	2	3
except subject to flatwise bending or flatwise shear	0,60	0,80	2,00
subject to flatwise bending or flatwise shear	0,80	1,00	2,50

Table 6:
$k_{c,90}$-values and increase of the actual contact length for the design of compression strength perpendicular to the grain for structural LVL

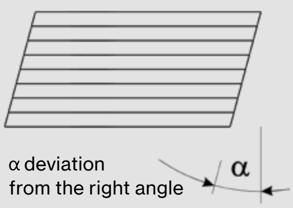
Loading direction	$k_{c,90}$-values	Increase of the actual contact length[a]
Edgewise compression strength $f_{c,90,edge,k}$	1,0	15 mm
Flatwise compression strength $f_{c,90,flat,k}$ parallel to the grain of the outermost veneers	1,4	30 mm
Flatwise compression strength $f_{c,90,flat,k}$ perpendicular to the grain of the outermost veneers	1,4	15 mm

[a] One-sided or two-sided increase of the actual contact length, but not more than a, ℓ or $\ell_1/2$ according to EN 1995-1-1.

Table 4:
Maximum deviations from nominal sizes and nominal angles for laminated veneer lumber not sanded and not treated by pressure treatment

	Nominal sizes for	Maximum deviations
Thickness t	$t \leq 27$ mm	± 1 mm
	27 mm < $t \leq 57$ mm	± 2 mm
	$t > 57$ mm	± 3 mm
Width b	$b \leq 300$ mm	± 2 mm
	300 mm < $b \leq 600$ mm	± 3 mm
	$b > 600$ mm	± 0,5 %
Length ℓ	$\ell \leq 5$ m	± 5 mm
	5 m < $\ell \leq 20$ m	± 0,1 %
	$\ell > 20$ m	± 20 mm
Maximum deviation of the right angles of the cross-section, see Figure 3		1:50 (approximately 1,1°)

Figure 3
Example of the angle of a cross-section of laminated veneer lumber



6 Additional product properties

6.1 General

Due to the current rules for the development of harmonized product standards some building physics properties cannot be declared according to the current and the future version of EN 14374. This is also true for EN 14374:2004 with respect to the swelling and shrinkage properties of LVL.

The following subsections are in line with the current version of the harmonized product standard for wood-based panels, EN 13986 or with the future harmonized product standard for LVL, EN 14374. Some have been part of FprEN 14374:2018 but had to be deleted within the standardisation process due to formal reasons.

6.2 Water vapour permeability

The water vapour permeability of LVL is either:

a) determined and expressed as water vapour resistance factors according EN ISO 12572, or
b) taken from tabulated data for plywood from EN ISO 10456 and expressed as individual values of the water vapour resistance factor, where linear interpolation may be used.

6.3 Airborne sound insulation (surface mass)

The airborne sound insulation of LVL shall be expressed as an individual value of airborne sound insulation *R* (in dB), based on, either:

a) testing, according to EN ISO 10140-2 and EN ISO 717-1, or
b) calculation, according to Equation (1).
$R = 13 \times \log_{10}(m_A) + 14$ dB (1)

If option b) is chosen, the airborne sound insulation *R* of a single LVL panel shall be calculated from the mean surface mass m_A (in kg/m²) by the Equation (1), which is valid for frequencies between 1 kHz and 3 kHz and for surface masses larger than 5 kg/m².

6.4 Sound absorption

The sound absorption of LVL is expressed as an individual value of sound absorption coefficient α, either:

a) based on testing, according to EN ISO 354, or
b) taken as α = 0,1, for a frequency range of 250 Hz to 500 Hz, and α = 0,3, for a frequency range of 1 000 Hz to 2 000 Hz.

6.5 Thermal conductivity

Thermal conductivity of LVL is expressed as an individual value of thermal conductivity λ (in W/mK), either:

a) based on testing, according to EN 12664, or
b) taken from Table 7, where linear interpolation may be applied.

6.6 Air permeability

The performance of air permeability of LVL is determined and expressed as an individual value of the air permeability coefficient *K* according to EN 12114.

6.7 Swelling and shrinkage values for LVL

Swelling and shrinkage values can be regarded as constant values for moisture content below fibre saturation.

Swelling and shrinkage values can either be expressed:

a) as individual values based on testing, according to EN 318, or
b) by reference to this bulletin, taken from Table 8.

Table 7:
Thermal conductivity λ for laminated veneer lumber

Mean density ρ (kg/m³)	Thermal conductivity λ (W/mK)
300	0,09
500	0,13
700	0,17
1 000	0,24

Table 8:
Swelling and shrinkage values for LVL in % per % change of moisture content

		In the direction of the thickness	In the direction of the length	In the direction of the width
LVL-P	Softwood veneers	0,32	0,01	0,32
	Hardwood veneers	0,45	0,01	0,40
LVL-C	Softwood veneers	0,32	0,01	0,03
	Hardwood veneers	0,45	0,01	0,03

Literature

EN 318:2002
Wood based panels – Determination of dimensional changes associated with changes in relative humidity

EN 1995-1-1:2004 + AC:2006 + A1:2008 + A2:2014, Eurocode 5:
Design of timber structures - Part 1-1: General – Common rules and rules for buildings

EN 1995-1-2: :2004 + AC:2009, Eurocode 5:
Design of timber structures – Part 1-2: General - Structural fire design

EN 12114:2000
Thermal performance of buildings – Air permeability of building components and building elements – Laboratory test method

EN 12664:2001
Thermal performance of building materials and products – Determination of thermal resistance by means of guarded hot plate and heat flow meter methods – Dry and moist products of medium and low thermal resistance

EN 13986:2004
Wood-based panels for use in construction – Characteristics, evaluation of conformity and marking

EN 14374:2005
Timber structures – Structural laminated veneer lumber (LVL) – Requirements

FprEN 14374:2018
Timber structures – Laminated veneer lumber (LVL) – Requirements

EN ISO 354:2003
Acoustics – Measurement of sound absorption in a reverberation room (ISO 354)

EN ISO 717-1:2013
Acoustics – Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation (ISO 717-1)

EN ISO 10140-2:2010
Acoustics – Laboratory measurement of sound insulation of building elements – Part 2: Measurement of airborne sound insulation (ISO 10140-2)

EN ISO 10456:2010
Building materials and products. Hygrothermal properties – Tabulated design values and procedures for determining declared and design thermal values

EN ISO 12572:2017
Hygrothermal performance of building materials and products – Determination of water vapour transmission properties (ISO 12572)

Imprint

Publishers
Studiengemeinschaft Holzleimbau e.V.
Heinz-Fangman-Str. 2
D-42287 Wuppertal
www.brettschichtholz.de
info@brettschichtholz.de
and
Federation of
Finnish Woodworking Industries
Snellmaninkatu 13
FI-00170 Helsinki
www.puutuoteteollisuus.fi
info@puutuoteteollisuus.fi

supported by
Metsä Wood
P.O.Box 50
FI-02020 Metsä

Pollmeier Massivholz GmbH & Co. KG
Pferdsdorfer Weg 6
D-99831 Creuzburg

STEICO SE
Otto-Lilienthal-Ring 30
D-85622 Feldkirchen

Stora Enso Wood Products,
Varkaus LVL
P.O.Box 169
FI-78201 Varkaus

1st edition published: September 2019
2nd revised edition: September 2019
3rd revised edition: September 2020

Picture credits
Title page:
Aalto university & Stora Enso / Vesa Loikas, Finland
Figure 1:
Metsä Wood, Finland
Figure 2, 3 and Figures in Table 1:
Ulrich Hübner, Austria