

INFORMATION SHEET

STRUCTURAL MATERIALS



LVL PERFORMANCE

The information provided below has been taken from the New Zealand Timber Design Guide 2007, published by the Timber Industry Federation and edited by Professor A H Buchanan. To purchase a copy of the Timber Design Guide, visit www.nztif.co.nz

HIGH STRENGTH

The manufacturing process for LVL uses end-to-end scarf jointed veneers overlapped and continuously pressed into long beams that are straight, stable and very strong. The tension strength of LVL is as much as 3 times that of sawn timber from the same forest. Table 1 compares the characteristic stresses of LVL with those of sawn timber and glue-laminated timber.

Table 1: Characteristic stresses of LVL by manufacturer and brand, compared with sawn timber and glulam

Brand	Bending strength	Compression strength	Tension strength	Shear in beams	Compression perpendicular	Modulus of elasticity	Modulus of rigidity
	f_b	f_c	f_t	f_s	f_p	E	G
	(MP _a)	(MP _a)	(MP _a)	(MP _a)	(MP _a)	(GP _a)	(MP _a)
CHH hySPAN*	48	45	33	5.3	12	13.2	660
NelsonPine LVL10*	48	45	30	6.0	12	10.7	535
Glulam GL8	19	24	10	3.7		8.0	530
Timber MSG 8	14	18	6	3.0	8.9	8.0	

* Both companies manufacture other grades

'RECIPE' SPECIFIC

Different LVL products are made for different purposes. Designers should specify particular brands of LVL in drawings and in specifications to identify the actual properties assumed for design. Loading on the edge (as a joist) and on the flat (as a plank) are illustrated in diagram 1. Some products may have outer veneers of LVL with better quality than the inner veneers. The grade of the veneers determines properties, so manufacturers place the highest grade where they best control strength and variability. Higher grade veneers on the outer faces will increase the fastener strength for nail plates in members loaded on edge and provide better stiffness when members are loaded on the flat such as in scaffold planks, or for floor and roof panels, as shown in diagram 2 (a). Lower grade veneers can be used in the neutral axis zone when an LVL product is known to be used on the flat. Most LVL products are used with the veneers loaded "on edge", such as in joists or beams, and have properties that depend on the average quality of each veneer, because all the veneers are subjected to maximum tension and compression strains as shown in diagram 2 (b). Beams loaded on the edge have lower variability than beams loaded on the flat.

Because LVL is layered solid wood, it is anisotropic and exhibits different properties parallel and perpendicular to the grain. Bearing and joint design needs to consider stresses perpendicular to the grain. Stresses in tension perpendicular to the grain should be avoided wherever possible.

Diagram 1: Loading on the flat (as a plank) and on the edge (as a joist).

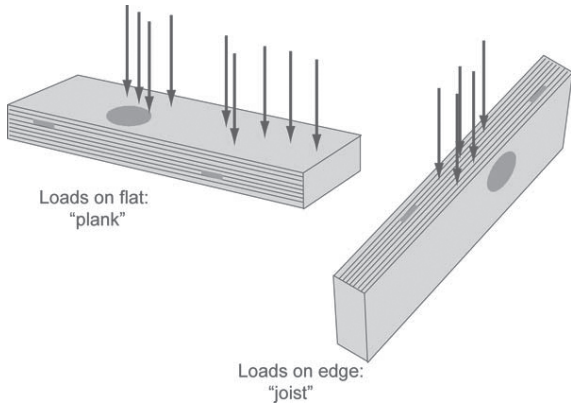
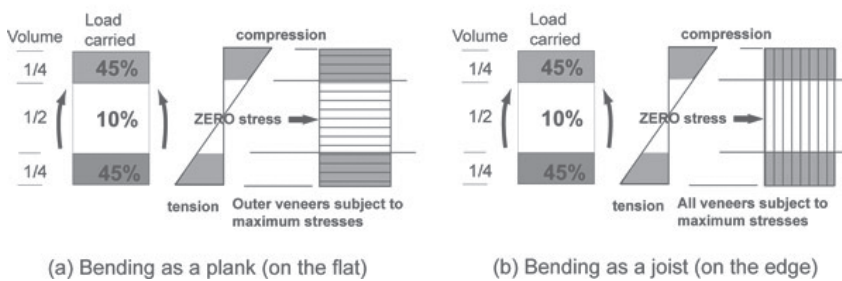


Diagram 2: Stress distributions in LVL beams (a) loaded as a plank and (b) loaded as a joist



DESIGN STANDARDS

Design loads are determined in accordance with AS/NZS 1170. Although design data for LVL is not specifically given in NZS 3603, the general principles can be used, complying with the New Zealand Building Code through Clauses 2.3 and C2.3 of NZS 3603. Proprietary design data is available from all the manufacturers. Refer to Table 1 for characteristic stresses.

STRENGTH MODIFICATION FACTORS

Because of the low variability of LVL, a number of the k factors do not apply to LVL, or are different from those in NZS 3603. Refer to manufacturer’s literature for additional information. The strength modification factors for LVL are:

1. Strength reduction factor, ϕ

Design of LVL members should use the strength reduction factor $\phi = 0.9$. This recognises the high reliability of LVL and the tight tolerances involved in its manufacture.

2. Duration of load factors

Duration of load factors k_1 for strength and k_2 for stiffness should be the same as for solid timber in Tables 2.4 and 2.5 of NZS 3603. LVL is a solid veneer product and has similar load duration properties to timber. It is manufactured in the dry condition so will behave like kiln dried solid sawn timber, except that moisture change will be slower because the glue lines provide a barrier to moisture movement.

3. Load sharing factor

Because LVL is much less variable than sawn lumber, the load sharing relationships in NZS 3603 do not hold. Hence, $k_4 = k_5 = k_6 = 1.0$

4. Moisture content factor

For use of LVL in dry conditions, no modification is required. Where LVL is subject to humid conditions such that the average moisture content would exceed 16% over a 12 month period, the moisture content factor k_{14} in Table 2 should be used for strength calculations. LVL with a moisture content exceeding 20% may be subject to a decay hazard, requiring chemical treatment of the LVL or detailing to avoid the high moisture content.

Table 2: Moisture content factor k_{14}

Property	Moisture content (MC)		
	< 16%	16% to 25%	> 25%
Bending and compression	1.0	1.53 - 0.033 MC	0.7
Tension and shear	1.0	1.35 - 0.022 MC	0.8
Modulus of elasticity	1.0	1.35 - 0.022 MC	0.8

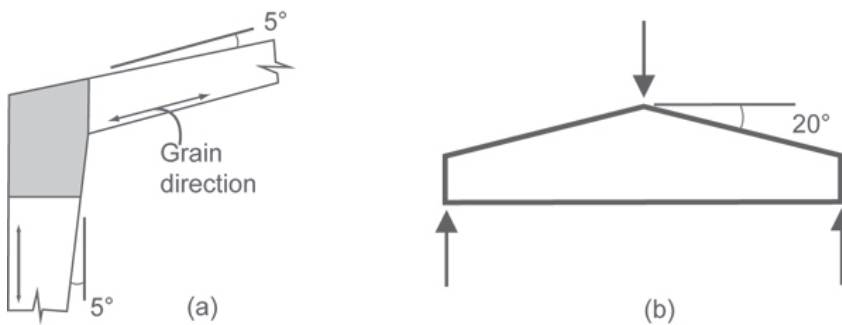
5. Sloping or curved edges

LVL is made from parallel laminated veneer. It is very strong parallel to the grain, but stresses perpendicular to the grain should be avoided, just as in solid timber. Wide sections must be handled carefully.

When a design includes principal stresses parallel to edges which have been cut sloped or curved to the longitudinal grain direction (diagram 3), the grain orientation factor k_{15} for strength given in Table 3 should be used to evaluate strength reduction at the extreme fibre edges. Examples where this might be considered are at the point of highest bending moment in a sloping rafter or column edge, such as at a knee or apex joint in a portal frame. Steep grain slopes should be avoided if possible in tension zones because the strength reduction is severe.

To determine bending deflections, the stiffness of sloping sections can be evaluated by integrating (summing) a number of small lengths of changing section depth. This method is outlined in standard texts.

Diagram 3 Examples of design for sloping grain in LVL



(a) The taper cut rafter has high tensile stress at 5° cut, so use $k_{15} = 0.8$. The column cut from the same slab has cut edge in compression, so use $k_{15} = 0.93$.

(b) Pitched tapered LVL beam with 20° sloping top surface in compression. Use $k_{15} = 0.55$

Table 3: Grain orientation factor k_{15} for cut edges

Angle of cut edge (degrees)	0	3	5	10	15	20	30	45
Cut edge in tension	1.0	0.92	0.80	0.50	0.31	0.21	0.11	0.06
Cut edge in compression	1.0	0.97	0.93	0.79	0.65	0.55	0.42	0.32

6. Size effect

For LVL beams greater than 300mm in depth, the characteristic stresses in bending and tension should be multiplied by the size factor in Table 4. This table is sourced from AS 1720.1 clause 8.4.7.

Table 4: Size factor k_{24} for strength of LVL

	Depth of LVL member (mm)							
	240	300	360	400	450	600	900	1200
Bending	1.0	1.0	0.97	0.95	0.93	0.89	0.83	0.79
Tension parallel	0.92	0.89	0.86	0.85	0.83	0.79	0.74	0.71

Notes:
 For shear and compression, size factor = 1.0
 For tension perpendicular to grain, refer to AS 1720.1

DESIGN OF JOINTS

The joint strength group is dependent on the LVL product, the type of fastener and the grain orientation at the joint as shown in Table 5, which is proprietary information based on testing by Scion to AS1649 as part of the third party product qualification to AS/NZS4357. Table 5 is to be read in conjunction with NZS 3603 Table 4.1: Classification of Timber Species for Joint Design. The higher performing joint strength groups for LVL compared with solid timber are due to the interlocking effect of adjacent veneers aligned at small angles, based on tests on specific recipes used for each brand by each manufacturer. For some applications, manufacturers can provide more information that is less conservative than the values in Table 5. For example, a 2006 revision of AS/NZS 4357 requires the provision of data on Type 17 screws, which are very effective for attaching brackets and hardware to LVL.

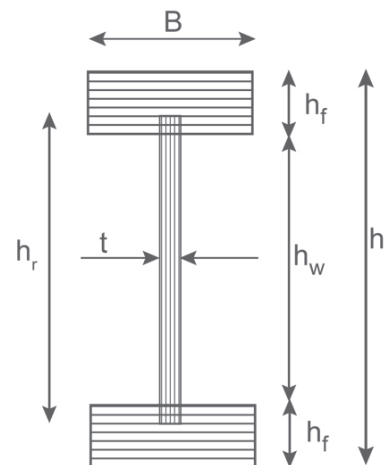
Table 5: Classification of LVL products for joint design

LVL Product	Nails and screws in lateral load	Nails and screws in withdrawal from		Bolts and Coach Screws drilled into face and loaded	
		Edge	Face	Parallel to grain	Perp to grain
Hyspan	J5	J4	J3	J3	J1
Hychord	J5	J4	J4	J3	J2
Hy90	J5	J4	J4	J4	J3
NelsonPine LVL	J5	J5	J4	J2	J1
Hybeam (flange)	J5	J4	J3	not suitable	

ENGINEERED I-JOISTS

A design method for engineered I-joists utilising LVL flanges and plywood webs such as CHH futurebuild’s “Hyjoist” and the Lumberworx’ “,” based on that in the Timber Designers’ Manual :

The method is conservative compared to published information in manufacturers’ literature and software, but it allows engineers to carry out specific design for situations outside the scope of software.



SERVICEABILITY

The deflection of any flexural member is a combination of bending deflection and shear deflection. While shear deflection is usually a small percentage of total deflection for a solid section, it is likely to be significant (15-20%) in the design of an I-joint, and must be taken into account.

I-joists have different flange and web materials. These materials have different properties which can be incorporated in the following formulae to derive section properties for bending deflection:

$$I_{web} = k_{34} t h_r^3 / 12$$

$$I_{flange} = [B(h^3 - h_w^3) / 12] - I_{web}$$

$$EI_x = E_{flange} I_{flange} + E_{web} I_{web}$$

where:

E_{flange} and E_{web} are obtained from manufacturers' literature

k_{34} = parallel ply factor = 0.33 for 9mm ply and 0.50 for 12 mm ply

Bending deflection is obtained from standard formulae.

Shear deflection may be calculated as:

$$\Delta = M_0 / (G_w A_w)$$

where:

M_0 = the bending moment at mid-span

G_w = web modulus of rigidity, obtained from manufacturers' literature

A_w = web area = $t h_r$

Total deflection is then the sum of the bending and shear deflections:

$$\Delta_{total} = k_2 (\Delta_{bending} + \Delta_{shear})$$

where:

k_2 = duration of load factor from NZS 3603

STRENGTH

Bending Capacity

The usual method (slightly conservative) to determine the maximum bending stress is to assume that the web makes no contribution to the bending strength.

$$M^* \leq \phi M_{bx}$$

$$M_{bx} = k_1 k_8 f_t A_f D_1 \times 10^{-6} \text{ kNm}$$

where:

ϕ = strength reduction factor

k_1 = load duration factor

k_8 = stability factor

f_t = flange characteristic tension stress (from manufacturers' literature)

A_f = net area of flange = $B h_f - 0.5(h_r - h_w) t$

D_1 = distance between flange centroids = $h - h_f$

Note that for values of k_8 less than the ratio of (flange characteristic tension stress) / (flange characteristic compression stress), use

$M_{bx} = k_1 k_8 f_c A_f D_1 \times 10^{-6} \text{ kNm}$, where

f_c = flange characteristic compression stress (from manufacturers' literature).

Shear Capacity

The shear capacity of an I-joint section is usually determined by calculating the panel shear in the web. This may also be limited by the capacity of the web-web joint, or the web-flange joint. Refer to manufacturers' literature for guidance.

Panel shear

$$V^* \leq \phi V_x$$

$$V_x = k_1 f_{ps} t (D_1 - 40) \text{ N}$$

where:

ϕ = strength reduction factor

k_1 = load duration factor

f_{ps} = characteristic web panel shear stress (from manufacturers' literature)

t = web thickness

$(D_1 - 40)$ = effective shear depth, with allowance for 40 mm hole in web for standard web penetrations.

Fire resistance

Large LVL members have excellent fire resistance on account of the slow and predictable charring rate when exposed to severe fires. The phenol formaldehyde adhesive used in the manufacture of LVL remains inert during fire exposure. LVL can be designed for fire resistance in the same way as glulam. From studies completed at the University of Canterbury³, the design charring rate of LVL in the standard fire test has been shown to be 0.72 mm/min.

Moisture effects

LVL responds to moisture in the same way as solid wood. For large deep LVL members, shrinkage and swelling over a normal range of ambient moisture conditions can be significant. For example a 450 mm deep beam, in conditions varying from 12% to 16% moisture content, may shrink or swell by approximately 0.8%, or 3.6 mm. Rigid paint and plaster finishes require designed control joints or slip layers to accommodate such movement, to prevent the formation of cracks. Flexible acrylic paint systems can respond to these strains as they do on normal timber.