

LIMIT STATES DESIGN INFORMATION for Specific Engineering Design for New Zealand Construction

Technical Note 82-07-04

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Laminated Veneer Lumber

LVL is an engineered wood material with defined and reliable strength and stiffness properties. It is suited for a wide range of structural applications, including critical elements such as large span portal frames and primary or secondary beams in commercial buildings.

For designers LVL offers;

- consistent structural performance with low variability
- third party certification of conformance with AS/NZS4357 by the Plywood Association of Australasia (PAA)
- long lengths and large cross-sectional dimensions
- a dimensionally stable product, which is easily installed on site

futurebuild manufactures a range of LVL products, each with a specific 'recipe' of material properties suitable for their intended application. This document contains general design information and material properties intended for use where members are specifically engineered for applications not covered by our product brochures. Refer to our website www.chhfuturebuild.com for design information for standard applications.



futurebuild's LVL manufacturing facility at Marsden Point is in a 30,000 m² LVL building featuring 32 metre clear spans.

General Design Information

The design information given here is specific to futurebuild's hySPAN, hyJOIST, hy90 and hyCHORD LVL products. To ensure that the required structural performance is met, designers must specify the product name.

Characteristic stresses

LVL characteristic stresses published are determined in accordance with AS/NZS4063 and so comply with the provisions of the Building Code of New Zealand through clause C2.3 in NZS3603. Refer to the characteristic stresses for each product or 'recipe' in this guide. Note that:

- Properties apply whether the product is used on flat or on edge.
- MoE is an average value which includes an allowance for shear deformation.
- Because of the low variability of LVL a lower bound E is not required.

Strength reduction factor ϕ

The strength reduction factor for design with futurebuild LVL, $\phi = 0.9$

Duration of load factor

Duration of load factors k_1 for strength and k_2 for stiffness should be as for solid timber in Tables 2.4 and 2.5 in NZS3603.

Bearing area

Bearing area factor k_3 - as per NZS3603.

Load Sharing

Load sharing factors $k_4 = k_5 = k_6 = 1.0$.

Because LVL is much less variable than sawn lumber, the load sharing relationships in NZS3603 do not hold. That is, for example, two pieces of LVL from a batch have very similar strengths whereas in timber k_4, k_5, k_6 recognise that a random stronger piece supports a random weaker piece. The characteristic stresses were derived from tests on full sized sections of each product. Lamination factors do not apply.

Stability

Stability factor k_8 - as per NZS3603.

Temperature

LVL exposed to temperatures above 55° C should be subject to special study.

Moisture content

Where LVL is used in an environment that raises the average moisture content above 15% for the maximum load case, refer to the modification factor k_{14} in NZS3603, figure 6.1.

For use in dry conditions, no modification is required. Where LVL is subject to humid (but weather-protected) conditions where the average moisture content could exceed 15% over a 12 month period, the modification factor k_{14} should be used. However, under these conditions LVL may be subjected to a decay hazard. Refer to the futurebuild technical notes on durability and treatment for this hazard.

Face grain angle

When a design includes cut, sloped or curved edges, the grain orientation factors k_{15} (for strength) and k_{16} (for stiffness) should be taken from Table 1.

For stiffness k_{16} has the same value as k_{15} for tension, but the angle is assessed as the average of the two cut edges.

Angle of cut edge (degrees)	0	3	5	10	15	20	30	45
Edge in tension	1.00	0.92	0.80	0.50	0.31	0.21	0.11	0.06
Edge in compression	1.00	0.97	0.93	0.79	0.65	0.55	0.42	0.32

Table 1 Grain orientation factor k_{15} and k_{16} for cut edges

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

Size factor

For LVL beams greater than 300mm in depth, the characteristic stresses in bending and tension should be multiplied by the size factor Table 2. This table is sourced from AS 1720.1 clause 8.4.7.

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

Table 2 Size factor

Note:

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

LVL is pressed in a billet up to 1200mm wide and 90mm thick, so large dimension structural members may be specified. Refer to the individual product sections of this technical note for the standard sizes, and contact futurebuild to enquire on the availability of other sizes.

Joint Group

The joint strength group is dependent on the LVL product, the type of fastener and the grain orientation at the joint. Table 3 is to be read in conjunction with NZS3603 Table 4.1: Classification of timber species for joint design.

LVL Product	Nails and screws in lateral load	Type 17 screws in lateral load	Nails and screws in withdrawal		Type 17 screws in withdrawal Edge and face	Bolts and Coach Screws in lateral load: drilled into face	
			Edge	Face		Parallel to grain	Perpendicular to grain
hyONE	J5	J4	J4	J4	J3	J3	J1
hySPAN	J5	J4	J4	J4	J3	J3	J1
hyCHORD	J5	J4	J4	J4	J3	J3	J2
hy90	J5	J4	J4	J4	J4	J4	J3
hyJOIST (flange)	J5	J4	J4	J4		not suitable	

Table 3: Classification of LVL products for joint design

The higher performing joint strength groups for LVL are due to the interlocking effect of adjacent veneers aligned at small angles.

Fire resistance

The method for calculating the fire resistance of LVL products is described in NZS3603 section 9. This method is applicable for sections at least 90mm in any dimension. Recommendations derived from a testing programme on CHH futurebuild LVL at the University of Canterbury* are;

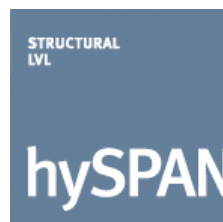
- The design method used for predicting the fire performance of futurebuild LVL exposed to post-flashover fires is to use the experimentally found char rate $\beta = 0.72\text{mm/minute}$ to determine a reduced cross-section, and design using normal temperature properties without considering a heat-affected layer of wood below the char line.
- Design using the char rate $\beta = 0.65\text{mm/minute}$ (complying with NZS3603) to calculate a reduced cross section which can be used with normal temperature properties, with an allowance for a 7mm to 9mm zero-strength layer of LVL below the char line.

This data has not been confirmed for LVL made by other manufacturers.

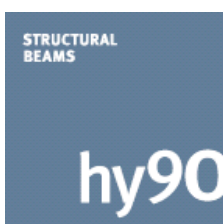
* Warren Peter Lane, 2005, "Ignition, Charring and Structural Performance of Laminated Veneer Lumber", Department of Civil Engineering, University of Canterbury, Christchurch, New Zealand

Standard section sizes and characteristic material properties

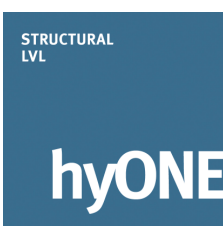
Carter Holt Harvey futurebuild manufactures four LVL products for structural applications, each with specific properties and section sizes.



hySPAN is futurebuild's most versatile LVL product. It has the highest structural properties and is available in the largest range of sizes and lengths. hySPAN is typically specified for structural beams and is also used for lintels, rafters and floor joists in residential structures.



hy90 is a 90mm thick LVL product manufactured primarily for lintels or beams to match 90mm wall light timber frame. It has lower structural properties than Hyspan but its thickness offers better member stability when used as long span structural beams or columns.



hyONE is a 90mm thick high stiffness LVL product manufactured primarily for lintels or floor beams where large spans or depth restrictions apply.



hyCHORD is available in smaller section sizes to match ordinary kiln-dried timber. hyCHORD is primarily specified as roof truss chords, but can also be used for lintels, rafters, purlins, floor joists, wall studs or other members where smaller section sizes are required.



hyJOIST is an engineered 'I-beam' utilising LVL flanges and a plywood web. It is ideally suited to floor joist and rafter applications due to its light weight, straightness and the ability to cut large holes through the web (e.g. for services or ventilation).



The limit state design characteristic properties for hySPAN are detailed in Table 4.

hySPAN		
Elastic Moduli (MPa)		
Modulus of Elasticity	E	13,200
Modulus of Rigidity	G	660
Characteristic stresses (MPa)		
Bending	f_b	48
Tension parallel to grain	f_t	33
Compression parallel to grain	f_c	45
Shear in beams	f_s	5.3
Compression perpendicular to grain	f_p	12
Joint Group	See Table 3	

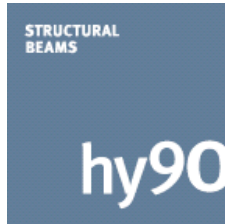
Table 4 – Characteristic design stresses for hySPAN

Standard section sizes, properties and design capacities for hySPAN are detailed in Table 5.

Product Code	Dimensions (mm x mm)	Mass (kg/m)	I_{xx} (10^6 mm^4)	Z_{xx} (10^3 mm^3)	J (10^6 mm^4)	EI (10^9 Nmm^2)	$\phi f_b Z_x$ (kNm)
HS150x45	150 x 45	4.2	12.7	169	3.7	167	7.29
HS170x45	170 x 45	4.7	18.4	217	4.3	243	9.36
HS200x45	200 x 45	5.6	30.0	300	5.2	396	13.0
HS240x45	240 x 45	6.7	51.8	432	6.4	684	18.7
HS300x45	300 x 45	8.4	101	675	8.3	1337	29.2
HS360x45	360 x 45	10.0	175	972	10.1	2309	42.0
HS400x45	400 x 45	11.2	240	1200	11.3	3168	51.8
HS150x63	150 x 63	6.0	17.7	236	9.2	234	10.2
HS200x63	200 x 63	7.8	42.0	420	13.4	554	18.1
HS240x63	240 x 63	9.4	72.6	605	16.7	958	26.1
HS300x63	300 x 63	11.7	142	945	21.7	1871	40.8
HS360x63	360 x 63	14.1	245	1361	26.7	3233	58.8
HS400x63	400 x 63	15.6	336	1680	30.0	4435	72.6
HS450x63	450 x 63	17.6	478	2126	34.2	6315	91.9
HS600x63	600 x 63	23.4	1134	3780	46.7	14969	163.3

Table 5 – hySPAN section sizes and properties

hySPAN is available in lengths up to 12 metres. For specific engineering design, sections may be possible up to 1200mm deep by either 45mm or 63mm thick and up to 16 metres in length. Contact futurebuild for availability of non-standard sizes and lengths.



The limit state design characteristic properties for hy90 are detailed in Table 6.

hy90		
Elastic Moduli (MPa)		
Modulus of Elasticity	E	9,500
Modulus of Rigidity	G	475
Characteristic stresses (MPa)		
Bending	f_b	35
Tension parallel to grain	f_t	19
Compression parallel to grain	f_c	28
Shear in beams	f_s	5.3
Compression perpendicular to grain	f_p	10
Joint Group	See Table 3	

Table 6 – Characteristic design stresses for hy90

Standard section sizes, properties and design capacities for hy90 are detailed in Table 7.

Product Code	Dimensions (mm)	Mass (kg/m)	I_{xx} (10^6 mm^4)	Z_{xx} (10^3 mm^3)	J (10^6 mm^4)	EI (10^9 Nmm^2)	$\emptyset f_b Z_x$ (kNm)
HY150x90	150x90	8.8	25.3	338	22.7	240	10.6
HY200x90	200x90	11.6	60.0	600	34.8	570	18.9
HY240x90	240x90	13.8	104	864	44.5	985	27.2
HY300x90	300x90	17.2	203	1350	59.1	1924	42.5
HY360x90	360x90	20.8	350	1944	73.7	3324	61.2
HY400x90	400x90	23.0	480	2400	83.4	4560	75.6

Table 7 – hy90 section sizes and properties

hy90 is available in lengths up to 7.2 metres. For specific engineering design, sections may be possible up to 1200mm deep by 90mm thick and up to 16 metres in length. Contact futurebuild for availability of non-standard sizes and lengths.

The limit state design characteristic properties for hyONE are detailed in Table 8.

hyONE		
Elastic Moduli (MPa)		
Modulus of Elasticity	E	16,000
Modulus of Rigidity	G	660
Characteristic stresses (MPa)		
Bending	f_b	48
Tension parallel to grain	f_t	33
Compression parallel to grain	f_c	45
Shear in beams	f_s	5.3
Compression perpendicular to grain	f_p	12
Joint Group	See Table 3	

Table 8 – Characteristic design stresses for hyONE

Standard section sizes, properties and design capacities for hyONE are detailed in Table 9.

Product Code	Dimensions (mm)	Mass (kg/m)	I_{xx} (10^6 mm ⁴)	Z_{xx} (10^3 mm ³)	J (10^6 mm ⁴)	EI (10^9 Nmm ²)	$\emptyset f_b Z_x$ (kNm)
HO240x90	240x90	13.4	104	864	44.5	1659	37.3
HO300x90	300x90	16.7	203	1350	59.1	3240	58.3
HO360x90	360x90	20.1	350	1944	73.7	5599	84.0
HO400x90	400x90	22.3	480	2400	83.4	7680	103.7

Table 9 – hyONE section sizes and properties

hyONE is available in lengths up to 7.2 metres. Contact futurebuild for availability of non-standard sizes and lengths.



The limit state design characteristic properties for hyCHORD are detailed in Table 10.

hyCHORD		
Elastic Moduli (MPa)		
Modulus of Elasticity	E	11,000
Modulus of Rigidity	G	550
Characteristic stresses (MPa)		
Bending	f_b	48
Tension parallel to grain	f_t	30
Compression parallel to grain	f_c	45
Shear in beams	f_s	5.3
Compression perpendicular to grain	f_p	12
Joint Group	See Table 3	

Table 10 – Characteristic design stresses for hyCHORD

Standard section sizes, properties and design capacities for hyCHORD are detailed in Table 11.

Product Code	Dimensions (mm)	Mass (kg/m)	I_{xx} (10^6 mm^4)	Z_{xx} (10^3 mm^3)	J (10^6 mm^4)	EI (10^9 Nmm^2)	$\phi f_b Z_x$ (kNm)
HC90x35	90x35	1.9	2.13	47.3	1.0	23.4	2.04
HC90x45	90x45	2.4	2.73	60.8	1.9	30.1	2.62
HC115x45	115x45	3.1	5.70	99.2	2.6	62.7	4.28
HC140x45	140x45	3.8	10.3	147	3.4	113	6.35
HC190x45	190x45	5.1	25.7	271	4.9	283	11.7

Table 11 – hyCHORD section sizes and properties

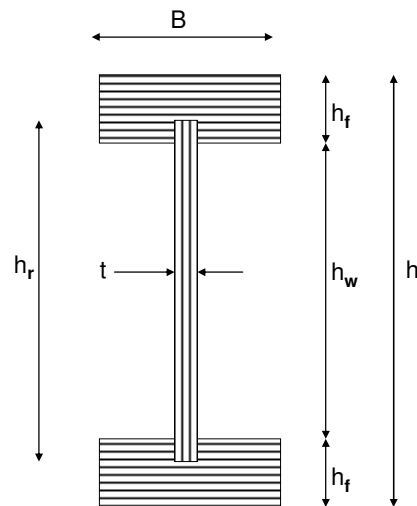
hyCHORD is available in lengths up to 7.2 metres. If larger section sizes or longer lengths are required designers should refer to the hySPAN selection tables.

Standard hyJOIST sizes and dimensions are detailed in Table 12.

hyJOIST Product Code	Overall depth	Flange width	Flange thickness	Web thickness	Web height	Distance between flanges	Mass
	h	B	h_w	t	h_r	h_w	
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(kg/m)
HJ200 45	200	45	36	9	152	128	2.6
HJ240 63	240	63	36	9	192	168	3.9
HJ240 90	240	90	36	12	198	168	5.5
HJ300 63	300	63	36	9	252	228	4.2
HJ300 90	300	90	36	12	258	228	5.9
HJ360 63	360	63	36	9	312	288	4.5
HJ360 90	360	90	36	12	318	288	6.3
HJ400 90	400	90	36	12	358	328	7.4

Table 12 – hyJOIST section sizes for New Zealand

hyJOIST is available in lengths up to 12 metres.



hyJOIST section terminology

Design with hyJOIST

The designIT software enables a significant amount of specific design to be carried out which utilises strength and rigidity properties determined from extensive testing of each hyJOIST section. This testing has determined that conventional elastic analysis is somewhat conservative. Designers are encouraged to use the designIT software for optimal design.

There may however be some instances where engineers may wish to carry out their own specific design, or for situations outside the scope of the designIT software. The following information gives the methodology for determining section properties and design capacities. The design methodology is based on that in the Timber Designers' Manual (3rd edition) by E.C. Ozeltun and J.A. Baird, and engineers should refer to this publication for more detail if required.

Serviceability

The deflection of any structural 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 (some 15-20%) in the design of an I-joist, and must be taken into account.

hyJOIST is manufactured from an LVL flange and a plywood web. The materials have different properties which can be incorporated in the following formulae to derive section properties for bending deflection:

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

$$I_{web/flange\ notch} = t(h_r^3 - h_w^3) / 12$$

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

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

$$G_f J = G_f 2 B h_f^3 / 3$$

where:

$$E_{flange} = 13,200 \text{ MPa}$$

$$E_{web} = 12,000 \text{ MPa}$$

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

$$G_f = \text{flange modulus of rigidity} = 660 \text{ MPa}$$

G_fJ (Torsional rigidity) is required for calculation of slenderness coefficients and is not a serviceability parameter.

Shear deflection for single span applications may be calculated as:

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

where:

$$M_0 = \text{the maximum bending moment}$$

G_w = web modulus of rigidity = 625 MPa

A_w = web area = $t h_r$

Special consideration should be given to the calculation of the shear deflection of statically indeterminate members. Structural analysis programs with the ability to model orthotropic materials are recommended.

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

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

where:

k_2 = duration of load factor from NZS 3603

hyJOIST section properties using the above formulae and material properties are shown in Table 13:

hyJOIST Product Code	I_{xx}	I_{yy}	EI_x	EI_y	$G_w A_w$	$G_f J$
	mm ⁴ x 10 ⁶	mm ⁴ x 10 ⁶	Nmm ² x 10 ⁹	Nmm ² x 10 ⁹	N x 10 ⁶	Nmm ² x 10 ⁶
HJ200 45	22.0	0.55	289	7.2	0.86	924
HJ240 63	47.7	1.50	628	19.8	1.08	1293
HJ240 90	69.0	4.37	906	57.7	1.49	1848
HJ300 63	80.4	1.50	1,057	19.8	1.42	1293
HJ300 90	116.9	4.37	1,532	57.7	1.94	1848
HJ360 63	122.3	1.50	1,605	19.8	1.76	1293
HJ360 90	178.6	4.38	2,338	57.7	2.39	1848
HJ400 90	227.7	4.38	2,978	57.8	2.69	1848

Table 13 – hyJOIST section properties for deflection calculation in New Zealand

where:

I_{xx} Moment of Inertia about the xx axis

I_{yy} Moment of Inertia about the yy axis

EI_{xx} Flexural rigidity about the xx axis

EI_{yy} Flexural rigidity about the yy axis

$G_w A_w$ Shear rigidity in the y direction

$G_f J$ Torsional rigidity

Strength

Bending Capacity

The usual method, although slightly conservative, to determine the maximum bending stress is to assume that the web makes no contribution to the bending strength. ϕM_b is calculated based on the critical flange stresses (tension or compression) due to bending by the following expressions.

For bending about the xx axis:

For $k_8 \geq 0.73$, where the tension flange is critical:

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

For $k_8 < 0.73$

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

where:

ϕ = strength reduction factor = 0.9 for futurebuild LVL

k_1 = load duration factor (NZS 3603)

k_8 = stability factor (NZS 3603)

f_t = flange characteristic tension stress = 33 MPa

f_c = flange characteristic compressive stress = 45 MPa

A_f = net area of flange = $B h_f - t (h_r - h_w) / 2$

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

hyJOIST section properties using the above formulae and material properties are shown in Table 14.

Shear Capacity

The shear capacity of a hyJOIST section is determined by calculating the panel shear in the web. This may be limited by the capacity of the flange-web joint. Note that the web-flange joint in hyJOIST has been configured to eliminate the possibility of rolling shear in the web-flange interface.

Panel shear

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

where:

ϕ = strength reduction factor = 0.9 for futurebuild LVL

k_1 = load duration factor (NZS 3603)

f_{ps} = characteristic web panel shear stress = 6.1 MPa

t = web thickness

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

Note: The shear capacity of hyJOIST may be limited due to flange-web shear stress. Please observe maximum Shear capacity shown in Table 14 below.

hyJOIST section properties using the above formulae and material properties are shown in Table 14.

hyJOIST Product Code	Bending capacity ^{1,2}	Shear capacity ^{1,3}
	$\emptyset M_{bx}$	$\emptyset V_{ps}$
	kNm	kN
HJ200-45	7.4	6.1
HJ240-63	13.1	8.1
HJ240-90	18.5	10.8
HJ300-63	16.9	<i>10.8</i>
HJ300-90	24.0	<i>12.6</i>
HJ360-63	20.8	<i>12.6</i>
HJ360-90	29.4	<i>12.6</i>
HJ400-90	33.1	<i>12.6</i>

Table 14 – hyJOIST bending and shear capacity values for New Zealand

Notes

1. Capacities based on $k_1 = 1.0$
2. Bending capacity based on $k_8 \geq 0.73$
3. Shear capacity values in italics are limited by flange-web shear stress.

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