

Lintels and Beams Calculator

Engineering Basis

The tool is intended for the design of lintels and beams in timber framed buildings generally within the scope of NZS 3604: 1999 *Timber Framed Buildings*. However the range of applications, loads and spans is beyond what is in NZS 3604.

For each beam design, the user is presented with a range of options so that he/she may select the most suitable beam to fit within the overall design and details for the building. The options include:

MSG/VSG8 sawn timber	45 mm thick
	70 mm thick
	2/45 mm, laminated as per NZS 3604
	90 mm thick
Laminated veneer lumber (LVL)	45 mm thick
	63 mm thick
	90 mm thick
Glulam	65 mm thick
	90 mm thick
Hot rolled steel sections	Universal beams
	Parallel flanged channels

Applications

The following applications are available for the user to select:

Application
Lintel supporting a roof only
Lintel supporting roof and wall
Lintel supporting roof, wall and floor
Veranda beam
Floor beam
Deck support beam
Roof beam (ridge or intermediate)
Garage door lintel

Loaded dimension

Loaded dimension has the same meaning as defined in NZS 3604. It is a measure of the weight of construction supported by the beam or lintel, or the area exposed to wind or snow loading. For this tool, loaded dimension is based on plan dimensions. This is considered more appropriate for use by building designers, who will generally be working off plans.

Loads

Loads are calculated in accordance with the AS/NZS 1170 *Structural Design Actions* Set, but limited (where appropriate) to the scope and parameters of NZS 3604. They are applied as a uniformly distributed load along the length of the lintel or beam. Concentrated loads are not included because of the variability of magnitude and position.

Gravity loads – G:

Light roof	0.4 kPa (0.2 kPa in combination with wind uplift) (0.1 kPa for veranda roof in combination with wind uplift)
Heavy roof	0.85 kPa (0.4 kPa in combination with wind uplift)
Floor	0.4 kPa
Deck	0.4 kPa
Light wall	0.2 kPa (0.1 kPa in combination with wind uplift)
Medium wall	0.8kPa (0.2 kPa in combination with wind uplift)

The roof loads allow for the total mass of the roof cladding, the roof and ceiling framing, and the ceiling lining. Roof loads are converted to equivalent plan area at the roof slope selected by the user.

For downwards acting load cases, light roof cladding is taken as 20 kg/m² of roof area. This is based on lightweight roof cladding, as defined in NZS 3604. For upwards load cases (wind uplift) steel sheeting is allowed for to give a worst case situation. For veranda upwards loading no ceiling lining is assumed. Similarly, heavy roof cladding weights are 60 kg/m² for downwards loading, and 20 kg/m² for upwards loads.

There is no allowance for the weight of internal walls on the floor. This is the same approach as followed in NZS 3604.

External wall loads are included when selected by the user. The weight of a light wall allows for an external cladding weight of 30 kg/m² for downwards load cases (as defined in NZS 3604), and 10 kg/m² for upwards load cases. Similarly, medium wall cladding weights are 70 kg/m² for downwards loading, and 20 kg/m² for upwards loads.

Live loads - Q:

Roofs (construction and maintenance load only)	≥0.25 kPa (see below)
Floors	1.5, 2.0 or 3.0 kPa
Decks	2.0 kPa

Roof live loads are given by:

$$w = (1.8/A+0.12),$$

where $A = (\text{loaded dimension} + \text{roof overhang}) \times \text{lintel span}$.

The basic floor live loads correspond to those provided for in NZS 3604. Basic loads are reduced by the area reduction factor, ψ_a , prescribed by AS/NZS 1170.1,

where:

$$\psi_a = 0.3 + \frac{3}{\sqrt{A}}$$

Snow Loads - S:

Basic ground snow loads of 0, 0.5, and 1.0 kPa may be selected by the user, as appropriate for the NZS 3604 snow zone of the site. Snow load applied to the lintel is factored using a slope factor based on NZS 1170.3, which is more realistic than the slope factor in NZS 4203:1992 *General structural design and design loadings for buildings*.

The slope factor, μ_i , is given by:

$$\mu_i = 0.7(60-\alpha)/50 \quad \text{within the range } 0.7 \geq \mu_i \leq 0.$$

where $\alpha = \text{roof slope (the lower value of the range selected)}$

Snow loading is applied to the plan area of the roof supported by the lintel or roof beam.

Wind loads - W:

Wind loads are calculated in accordance with AS/NZS 1170.2, based on the site wind speeds for the wind zone selected by the user. The four NZS 3604 wind zones are included, along with extras to cater for the increasing numbers of buildings being constructed on more exposed site.

Wind Zone/speed	Basic design pressure (kPa)
Low	0.61
Medium	0.82
High	1.16
Very high	1.50
55 m/sec	1.82
60 m/sec	2.16
65 m/sec	2.54
70 m/sec	2.94

The combined pressure coefficients (C_{pi} and C_{pe}) are given in the following table:

Situation	External roofs (eave overhangs and verandas)	Roofs over enclosed spaces
Wind upwards	1.6	0.96

Wind downwards	0.2	0.5
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The area reduction factor, K_a , combination factor, K_c , local pressure factor, k_l , and porous cladding factor, K_p , were all taken as 1.0.

In calculating the reaction on the lintel, account is taken of the “leverage” effect of the load applied to the projecting portion of the eave (up or down), which can be significant for short loaded dimensions and large overhangs. Allowance was also made for the “leverage” associated with the horizontal component of the wind load on steep pitched roofs.

Load Combinations

The following load combinations are considered:

Case	Loads
1	$G+Q_l$
2	$G+Q_s$
3	Vibration (for floor beams only)
4	$G+S$
5	$1.35G$
6	$1.2G+1.5Q$
7	$1.2G+\psi_c Q+W$
8	$.9G-W$
9	$1.2G+\psi_c Q+1.2S$

Load duration factors used are 0.7 for short term loads, ψ_s , and 0.0 for long term loads, ψ_l .

The factor, ψ_c , for roof live loads in combination with wind or snow is 0.0.

Note the load factor of 1.2 for snow loads in case 9. This is a departure from AS/NZS 1170.0, and is done for compatibility with the NZS 3604 snow zones which are calculated from NZS 4203 which has a load factor of 1.2. This will be revised when NZS 3604 is revised.

Material properties

Sawn timber

The tool may be used with radiata pine, douglas fir, or macrocarpa timber in grades VSG8 and MSG8. Sizes quoted are the maximum dry finished sizes, after machining. Larger sizes may be substituted.

Design is in accordance with NZS 3603:1993 *Timber Structures Standard*, including amendment 4. “Dry” timber properties as defined by NZS 3603 are used for all applications except decks, where “green” properties are used.

The characteristic stresses for timber members, as given in NZS 3603, are:

Property	All applications except decks	Decks

Bending stress f_b (MPa)	14.0	11.1
Bearing stress perpendicular to grain f_p (MPa)	8.9	5.3
Bearing stress parallel to grain f_c (MPa) (used to calculate supporting timber members)	18.0	12.0
Modulus of elasticity E (GPa) (lower bound)	5,400	4,400

The strength duration factors are 0.6 for dead loads, 0.8 for live and snow loads, and 1.0 for wind loads.

The duration factor for deflection under long term loads, k_2 , is 2.0.

The parallel support factor, k_4 , for doubled members (eg 2/90x45) is 1.14.

The stability factor, k_8 , under uplift loading was calculated using a slenderness factor assuming full lateral restraint of the tension edge (clause 3.2.5.3 of NZS 3603).

A strength reduction factor, ϕ , of 0.8 is used for timber member design.

Laminated veneer lumber (LVL)

Design is in accordance with NZS 3603, using the lower bound of the values of engineering properties offered by the New Zealand LVL manufacturers. Sizes included are also the lower bound of the sizes offered.

The relevant characteristic stresses for LVL members used in the tool are:

Property	Stress
Bending stress f_b (MPa)	42.0
Bearing stress perpendicular to grain f_p (MPa)	12.0
Modulus of elasticity E (GPa) (lower bound)	10,700

The duration factor for deflection under long term loads, k_2 , is 1.5. Other modification factors are the same as sawn timber.

A strength reduction factor, ϕ , of 0.9 is used for LVL member design.

Glue-laminated timber (Glulam)

Design is in accordance with NZS 3603 and AS/NZS 1328:1998 *Glued laminated structural timber*, using grade GL8.

The relevant characteristic stresses for glulam members used in the tool are:

Property	Stress
Bending stress f_b (MPa)	19.0
Bearing stress perpendicular to grain f_p (MPa)	8.9
Modulus of elasticity E (GPa) (lower bound)	8,000

The duration factor for deflection under long term loads, k_2 , is 1.5. The parallel support factor, k_6 , and size factor, k_{24} , are both calculated in accordance with section 8.7 of NZS 3603. Other modification factors are the same as sawn timber.

A strength reduction factor, ϕ , of 0.8 is used for glulam member design.

Hot rolled steel

Design is in accordance with NZS 3404.

The yield stress used for steel sections to AS/NZS 3679:1996 *Structural Steel* Grade 300, is 320 MPa for flanges less than 11mm thick, and 300MPa for thicker flanges within the range of sections covered.

All steel members except for lintels are considered fully laterally restrained by the adjacent framing at a maximum of 1.2 m spacing. Lintels are considered partially restrained at the ends, and unrestrained between. Member moment capacities, $\phi M_{b,x}$, are calculated for upwards and downwards loading at the span selected by the user, using the provisions of clause 5.6 of NZS 3404.

A strength reduction factor, ϕ , of 0.9 is used for steel member design.

Deflection criteria

1. For lintels under short and long term loading, and snow loading, deflection is limited to span/300, with a maximum of 12 mm.
2. For veranda beams floor beams, roof and deck beams, deflection under short and long term loading and snow loading, is limited to span/300, with no upper limit.
3. Floor beams have their deflection under a 1 kN concentrated load limited to 1 mm, for vibration control.
4. Garage door lintels have deflection limited to span/100, with a maximum of 25 mm.

There are no deflection criteria under wind loading for any applications.

End supports

Supports to the beam ends are checked against several criteria.

For timber beams, the required bearing area perpendicular to the grain is calculated, and a support appropriate to the application giving a greater contact bearing area is given.

The capacity of a range of support options appropriate to the application is matched against the calculated end reaction from the lintel or beam. Support capacities under axial loads are calculated in accordance with NZS 3603, based on a 2.7 m wall height and in-plane bracing by wall lining.

A check is made that the width of the selected lintel will fit into a 90 mm wall frame. Widths of selected floor and roof beams are matched against number of wall studs required.

Hold downs

The calculated wind uplift reactions are matched against the capacities of a number of hold down details, as appropriate for the application. The capacities are calculated in accordance with the relevant material Standard and are tabulated below.

Fixing	Capacity (kN)
4/100x4 end nails to trimmer stud	1.35
25x0.9 mm nail strap with 6/30x3.15 nails (see Figure 8.12 NZS 3604)	6.16
2/25x0.9 mm nail straps with 12/30x3.15 nails	9.96
Welded cleat with 2/M12 coach screws into trimmer stud	13.65
6/100x4 nails to post	4.75
1/M12 bolt to post	4.87
2/M12 bolts to post	9.76
Steel bracket each side of beam with 2/M12 bolts to beam and post	19.5
Welded cleat with 2/M12 coach screws into post	13.65
2/100x4 nails (or 4/90x3.15)	1.58
4/100x4 nails (or 6/90x3.15)	3.17
6/100x4 nails (or 10/90x3.15)	4.75
1/M12 bolt (Check NZS 3604 for fixing base of built up studs)	4.87
2/M16 bolts (Check NZS 3604 for fixing base of built up studs)	13.02
Welded cleat with 2/M12 coach screws into studs	13.65

Durability

Timber treatments are in accordance with NZS 3602:2003 *Timber and wood-based products for use in building* for 50 year durability, based on the exposure conditions of NZS 3604.