Lintels and Beams: Engineering Basis

The calculator is intended for the design of lintels and beams in timber-framed buildings generally within the scope of NZS 3604. However, the range of applications, loads and spans is beyond what is in NZS 3604.

For each beam design, a range of options is presented so the user can 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
Flitch beams	The Gang-nail range
	The Pryda range

Applications

The following applications are available for the user to select:

Application	**Picture reference**
Lintel supporting a roof only	1
Lintel supporting roof and wall	2
Lintel supporting roof, wall and floor	3
Veranda beam	4
Floor beam	5
Deck support beam	6
Roof beam (ridge or intermediate)	7
Garage door lintel	8
Cantilever lintels	9

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 suite, but limited (where appropriate) to the scope and parameters of NZS 3604:2011. They are applied as a uniformly distributed load along the length of the lintel or beam. Concentrated loads are specified by manually inputting location and magnitude.

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	0.8 kPa (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/m^2 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/m^2 for downwards loading, and 20 kg/m^2 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/m^2 for downwards load cases (as defined in NZS 3604), and 10 kg/m^2 for upwards load cases. Similarly, medium wall cladding weights are 70 kg/m^2 for downwards loading, and 20 kg/m^2 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

* The area-dependent roof live load of AS/NZS 1170.1 has been removed, in accordance with the NZBC Compliance Document B1, which became effective in December 2008.

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:

Ground snow load, s_g, is calculated from the site elevation and snow region selected by the user. The snow regions are defined in both AS/NZS 1170.3 and NZS 3604. Equations used for ground snow load are as set out in clause 5.4.3 of AS/NZS 1170.3, with k_p taken as 1.25 for the ultimate limit state, and 0.85 for the serviceability limit state.

The slope factor, μ_1 for balanced load is given by:

$\mu_1 = 0.7(60-\alpha)/50$ within the range $0.7 \geq \mu_1 \leq 0$.

where α = roof slope (the lower value of the range selected)

The exposure factor, C_e, is conservatively taken as 1.0.

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 five NZS 3604:2011 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
Extra high	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

The area reduction factor, K_a, combination factor, K_c, local pressure factor, k_l, and porous cladding factor, K_p, are 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	$1.2G + \psi_c Q + W_u$
8	$.9G-W_u$
9	$1.2G + \psi_c Q + S$

Load duration factors used are 0.7 for short term loads, ψ_s, 0.0 for long term roof loads, and 0.4 for long term floor loads, ψ_l.

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

Material properties

Sawn timber

The tool may be used with Radiata Pine or Douglas Fir timber in grades VSG8 and MSG8 (SG8). Sizes quoted are the maximum dry finished sizes, after machining. Larger sizes may be substituted.

Design is in accordance with NZS 3603, 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	11.7
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)	5.40	4.40

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 of the products offered by the New Zealand LVL manufacturers.

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

Property	**Stress**
Bending stress f_b (MPa)	38.0 for 45 mm and 63 mm thick beams 34.0 for 90 mm thick beams
Bearing stress perpendicular to grain f_p(MPa)	12.0
Modulus of elasticity E (GPa) (lower bound)	11.0 for 45 mm and 63 mm thick beams 9.5 for 90 mm thick beams

The duration factor for deflection under long term loads, k_2, is 1.5. Other modification factors are the same as sawn timber. The size factor, k_{24}, as advised by the manufacturers has been applied to the section properties.

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, 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)	8.0

The duration factor for deflection under long term loads, k_2, is 1.5. The parallel support factor, k_6, and size factor, k24, 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 3679 Grade 300, is 320 MPa for flanges less than 11 mm 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, ϕM_{bx}, 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.

Flitch beams

The beams available include the "GANG-NAIL" range offered by MiTek NZ, and the "Pryda Flitch beam" range offered by Pryda NZ. Both are available from approved suppliers and fabricators respectively. Both ranges must be installed dry and only used in dry applications (lintels and floor beams).

Timber properties are based on the stresses given in NZS 3603 (including amendment 4) for MSG6 and No1 framing timber in the "dry" condition. Thus applications are limited by the calculator to lintels and floor beams only. Modification factors for the timber components are the same as those for solid timber beams, as described above.

All fabrication details are as per the manufacturer's standard specifications.

A strength reduction factor, ϕ, of 0.9 is used for the steel components, and 0.8 for the timber components, depending on which one governs the capacity of the beam in each case.

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/300.

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 2.7m 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	Picture reference	Capacity (kN)
4/100x4 end nails to trimmer stud	1	2.10
25x0.9 mm nail strap with 6/30x3.15 nails (see Figure 8.12 NZS 3604)	2	6.16
2/25x0.9 mm nail straps with 12/30x3.15 nails	3	9.96
Welded cleat with 2/M12 coach screws into trimmer stud	4	13.65
6/100x4 nails to post	5	4.75
1/M12 bolt to post (similar to Figure 9.3 (c) of NZS 3604)	6	4.87
2/M12 bolts to post (see Figure 9.3 (c) of NZS 3604)	7	9.76
Steel bracket each side of beam with 2/M12 bolts to beam and post	8	19.5
Welded cleat with 2/M12 coach screws into post	9	13.65
2/100x4 nails (or 4/90x3.15)	10	1.58
4/100x4 nails (or 6/90x3.15)	11	3.17
6/100x4 nails (or 10/90x3.15)	12	4.75
1/M12 bolt to built-up studs	13	9.76
2/M16 bolts to built-up studs	14	26.0
Welded cleat with 2/M12 coach screws into studs	15	13.65

Base fixings

The calculated wind uplift reactions are matched against the capacities of a number of fixing details to the selected foundation, as appropriate for the application. The capacities are calculated in accordance with the relevant material standard and are tabulated below.

Fixing	Picture reference	Capacity (kN)
No specific fixing required.	1	2.5
25x0.9 mm nail strap folded under wall plate, attached to stud with 6/30x3.15 nails	2	3.8
2/25x0.9 mm nail straps	3	7.6
3/25x0.9 mm nail straps	4	11.4
No specific fixing required. (NZS 3604 standard details with normal lining fixings) Directly support studs by dwang between floor joists	5	2.5
25x0.9 mm nail strap each side of stud attached to 90x90 jackstud	6	7.6
2/25x0.9 mm nail straps each side of stud attached to 90x90 jackstud	7	15.2
3/25x0.9 mm nail straps each side of stud attached to 2/140x45 jackstud	8	18.6
HDG bracket cast into foundation, with M12 bolt to post (Figure 9.2 NZS 3604)	9	12.8
HDG bracket cast into foundation, with 2/M12 bolts to post (Figure 9.2 NZS 3604)	10	25.5
No specific fixing required. (NZS 3604 standard details with normal lining fixings)	11	2.5
25x0.9 mm nail strap folded under plate, with 6/30x3.15 nails each side of stud (see Figure 8.12 NZS 3604)	12	7.6
2/25x0.9 mm nail straps folded under plate, with 6/30x3.15 nails each side of stud (similar Figure 8.12 NZS 3604)	13	15.2
3/25x0.9 mm nail straps folded under plate, with 6/30x3.15 nails each side of stud (similar Figure 8.12 NZS 3604)	14	22.8

Durability

Timber treatments are in accordance with NZS 3602 for 50-year durability as clarified and simplified by amendment 7 to NZBC Clause B2 *Durability*, based on the exposure conditions of NZS 3604.