GLT Data

Supplier	Grade	b (mm)	d (mm)
ASH	MASSLAM 45	450	1040

Design Methodologies

Design Method	Loading Code	Load Combinations
AS 1720.1/NZ WDG - chapter 12.6	AS1170/AS1720	Default Load Combination

Loading Data

Slab Thickness (mm)	Slab Density (kg/m^3)	G_{SDL} (kPa)	Q (kPa)
240.00	500.00	1.00	3.00

Design Data AS1720.1

ψ_s	ψ_l	ψ_c	ϕ
0.7	0.4	0.4	0.85
k_4	k_6	k_9	k_{13}
1	1	1	1

Loading Conditions

Condition	Load Breadth (m)	Span (m)
Simply Supported	6.0	9

Penetration Geometry

Hole Type	d_d (mm)	a (mm)	Penetration Type
Rectangular	220	300	Reinforced

Penetration Location

x_c (m)	y_c (mm)	Eccentricity (mm)	l_s (m)	l_e (m)	l_i (m)
4.00	450	70	4.00	4.00	4.00

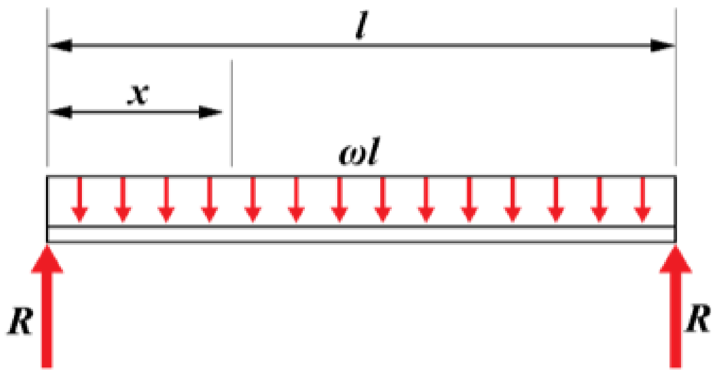
Screw Reinforcement Data AS1720.1

Q_k (N/mm)	n	$N_{d,ts}$ (kN)	L (mm)	D (mm)
137.0	2	26.00	1010	12
l_p (mm)	a_2 (mm)	$a_{3,c}$ (mm)	$a_{4,c}$ (mm)	
120	80	120	120	

Outputs Summary

Geometrical Limitations	Flexural Verification	Shear Verification	Screw Geometry	Screw Design
OK	OK	OK	OK	OK
	27.9%	4.8%		21.7%

Please note that the Beam Penetration Calculator can be utilized to confirm the beam's capacity at hole locations that may not be considered critical for the beam. For the critical section of the beam, please utilize the Beam Design Calculator to conduct Ultimate Limit State (ULS) and Serviceability Limit State (SLS) verifications.



Panel Properties

Grade	E (MPa)	G (MPa)	f'_b (MPa)	f'_s (MPa)	f'_c (MPa)	P (kg/m^3)	f'_{t90} (MPa)
MASSLAM 45	16700	1110	45	5	45	650	0.6

Section Properties

New Properties of Beam with a Penetration		Ambient
b (mm)	Breadth of beam	450
d (mm)	Depth of beam	1040
x_c (m)	Location of penetration centre in x-direction	4.00
y_c (mm)	Location of penetration centre in y-direction	450
$d_{b,u}$ (mm)	Depth of the remaining beam portion under the penetration	340
$d_{b,a}$ (mm)	Depth of the remaining beam portion above the penetration	480
d_d (mm)	Depth of penetration	220
a (mm)	Length of penetration	300
l_s (m)	Distance between the penetration to the support	4.00
l_e (m)	Distance between the penetration to the end grain of the beam	4.00
l_i (m)	Clear distance between adjacent penetrations	4.00

$$Z_{b,a} = \frac{bd_{b,a}^2}{6}$$

$$Z_{b,u} = \frac{bd_{b,u}^2}{6}$$

$$y_g = \frac{d^2 - 2d_d d_{b,a} - d_d^2}{2(d - d_d)}$$

$$I_n = b[\frac{d^3}{12} + d(\frac{d}{2} - y_g)^2 - \frac{d_d^3}{12} - d_d(d_{b,a} + \frac{d_d}{2} - y_g)^2]$$

$$Z_n = min[\frac{I_{net}}{y_g}; \frac{I_{net}}{d - y_g}]$$

NZ Wood Design Guides (2020). Chapter 12.6

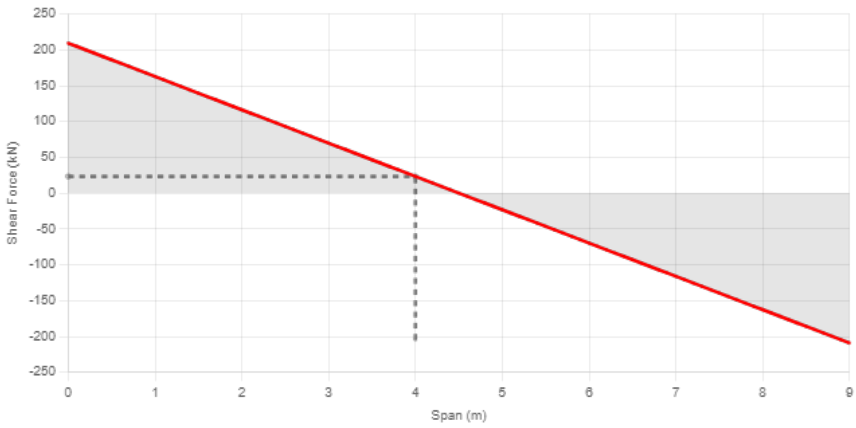
New Section Properties		Ambient
$Z_{b,a}$ (mm^3)	Section modulus of the remainng beam portion above the penetration	1.73e+7
$Z_{b,u}$ (mm^3)	Section modulus of the remainng beam portion under the penetration	8.67e+6
y_g (mm)	Distance of the center of gravity from the top edge of the beam	501.2
I_n (mm^4)	Moment of inrtia of the net section at the penetration	4.12e+10
Z_n (mm^3)	Section modulus of the net section at the penetration	7.64e+7

Loading

$G_{beam\ sw}$ (kN/m)	3.04
$G_{slab\ sw}$ (kN/m)	7.20
G_{sdl} (kN/m)	6.00
G_{total} (kN/m)	16.24
Q_{total} (kN/m)	18.00

Load Combination	1.35G	1.20G + 0.60Q	1.20G + 1.50Q	1.20G + 0.40Q + 1.00W
w (kN/m)	21.93	30.29	46.49	26.69

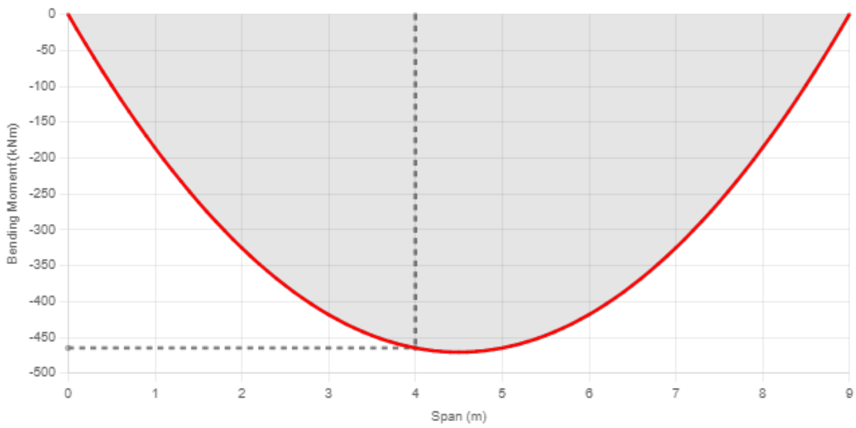
Shear Actions



V^* is the design action effect in shear at the centre of the penetration
X_c is the centre of the penetration in x-direction

Load Combination	1.35G	1.20G + 0.60Q	1.20G + 1.50Q	1.20G + 0.40Q + 1.00W
X_c (kN)	4	4	4	4
V^* (kN)	10.96	15.15	23.25	13.35

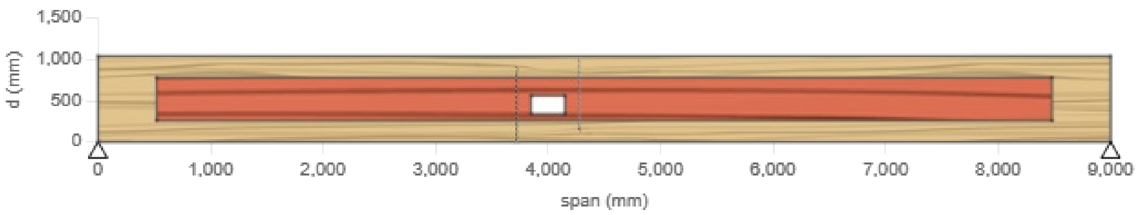
Bending Moment Actions



M^* is the design bending action effect at the centre of the penetration
X_c is the centre of the penetration in x-direction

Load Combination	1.35G	1.20G + 0.60Q	1.20G + 1.50Q	1.20G + 0.40Q + 1.00W
X_c (m)	4	4	4	4
M^*	219.27	302.90	464.90	266.90

Geometric Limitations



Note :

- The corners of rectangular openings should be rounded with a radius of r ≥15mm.
- The requirement of rounded corners in rectangular penetrations is to prevent areas of singularity and hence to reduce stress concentrations at the corner.

Description	Criteria	Check
Check that the length of penetration is ≤ $2.5d_d$	$a \le 2.5d$	OK
Check that the depth of penetration is ≤ 0.3d	$d_d \le 0.3d$	OK
Check that the depth of the remaining beam portion above the penetration is ≥ 0.25d	$d_{b,a} \ge 0.25d$	OK
Check that the depth of the remaining beam portion under the penetration is ≥ 0.25d	$d_{b,u} \ge 0.25d$	OK
Check that the distance between the penetration to the support is ≥ 0.5d	$l_s \ge 0.5d$	OK
Check that the clear distance between adjacent penetrations is ≥ max(d;300mm)	$l_i \ge$ max (d;300mm)	OK
Check that the distance between the penetration to the end grain of the beam is ≥ d	$l_e \ge d$	OK

OK

Geometrical limitations of beams with reinforced penetrations		Ambient
b (mm)	Breadth of beam	450
d (mm)	Depth of beam	1040
$d_{b,a}$ (mm)	Depth of the remaining beam portion above the penetration	480
$d_{b,u}$ (mm)	Depth of the remaining beam portion under the penetration	340
d_d (mm)	Depth of penetration	220
a (mm)	Length of penetration	300
l_s (m)	Distance between the penetration to the support	4.00
l_e (m)	Distance between the penetration to the end grain of the beam	4.00
l_i (m)	Clear distance between adjacent penetrations	4.00

Flexural Strength Verification

$$M^*_{b,a} = V_{b,a}\frac{a}{2} \qquad M^*_{b,u} = V_{b,u}\frac{a}{2}$$

NZ Wood Design Guides (2020). Chapter 12.6

Where

$$V_{b,a} = V^*\frac{d_{b,a}}{d_{b,a}+d_{b,u}} \qquad V_{b,u} = V^*\frac{d_{b,u}}{d_{b,a}+d_{b,u}}$$

φ	k_8
0.85	1

Calculation of flexural strength of beams with penetrations		Ambient
a (mm)	Length of penetration	300
$Z_{b,a}$ (mm^3)	Section modulus of the remainng beam portion above the penetration	1.73e+7
$Z_{b,u}$ (mm^3)	Section modulus of the remainng beam portion under the penetration	8.67e+6
Z_n (mm^3)	Section modulus of the net section at the penetration	7.64e+7
$d_{b,a}$ (mm)	Depth of the remaining beam portion above the penetration	480
$d_{b,u}$ (mm)	Depth of the remaining beam portion under the penetration	340

Load Combination	1.35G	1.20G + 0.60Q	1.20G + 1.50Q	1.20G + 0.40Q + 1.00W
V^* (kN)	10.96	15.15	23.25	13.35
$V_{b,a}$ (kN)	6.42	8.87	13.61	7.81
$V_{b,u}$ (kN)	4.55	6.28	9.64	5.53
$M^*_{b,a}$ (kNm)	0.96	1.33	2.04	1.17
$M^*_{b,u}$ (kNm)	0.68	0.94	1.45	0.83

Bending Capacity

$$M_{d,n} = \Phi k_1 k_8 k_{24} Z_n f'_b \qquad M_{d,b,a} = \Phi k_1 k_8 k_{24} Z_{b,a} f'_b \qquad M_{d,b,u} = \Phi k_1 k_8 k_{24} Z_{b,u} f'_b$$

NZ Wood Design Guides (2020). Chapter 12.6

Where

$$k_{24} = (\frac{150}{d_{b,a}})^{0.167} \;,\; for\;\; M_{d,b,a}\;\; calculation$$

$$k_{24} = (\frac{150}{d})^{0.167} \;,\; for\;\; M_{d,n}\;\; calculation$$

$$k_{24} = (\frac{150}{d_{b,u}})^{0.167} \;,\; for\;\; M_{d,b,u}\;\; calculation$$

Calculation of design capacity in bending		Ambient
d (mm)	Depth of beam	1040
$d_{b,a}$ (mm)	Depth of the remaining beam portion above the penetration	480
$d_{b,u}$ (mm)	Depth of the remaining beam portion under the penetration	340
$Z_{b,a}$ (mm^3)	Section modulus of the remainng beam portion above the penetration	1.73e+7
$Z_{b,u}$ (mm^3)	Section modulus of the remainng beam portion under the penetration	8.67e+6
Z_n (mm^3)	Section modulus of the net section at the penetration	7.64e+7
f'_b (MPa)	Characterstic value in bending	45

Load Combination	1.35G	1.20G + 0.60Q	1.20G + 1.50Q	1.20G + 0.40Q + 1.00W
k_1	0.57	0.57	0.80	1.00
$M_{d,n}$ (kNm)	1205.63	1205.63	1692.12	2115.15
$M_{d,b,a}$ (kNm)	310.23	310.23	435.42	544.27
$M_{d,b,u}$ (kNm)	164.88	164.88	231.41	289.27
M^* (kNm)	219.27	302.90	464.90	266.90

Capacity Check

$$U_a = \frac{M^*}{M_{d,n}} + \frac{M^*_{b,a}}{M_{d,b,a}} + \frac{N^*}{d_d} \leq 1 \qquad U_u = \frac{M^*}{M_{d,n}} + \frac{M^*_{b,u}}{M_{d,b,u}} + \frac{N^*}{N_d} \leq 1$$

Load Combination	1.35G	1.20G + 0.60Q	1.20G + 1.50Q	1.20G + 0.40Q + 1.00W
Utilization (U_a)	18%	26%	28%	13%
Utilization (U_a)	19%	26%	28%	13%

28% *Ambient*

Shear Strength Verification

The design capacity in shear for beams with reinforced or unreinforced penetrations shall satisfy the following:

$$V_{d,n} \geq V^* \qquad V_{d,n} = \Phi k_1 A_{s,n} f'_v \qquad A_{s,n} = \frac{2}{3} b(d - d_d)$$

NZ Wood Design Guides (2020). Chapter 12.6

φ
0.85

Calculation of shear strength of beams with penetrations		Ambient
b (mm)	Breadth of beam	450
d (mm)	Depth of beam	1040
d_d (mm)	Diameter or depth of the penetration	220
f'_v (MPa)	Characteristic value in shear	5
$A_{s,n}$ (mm^2)	Net shear plane area at the penetration	2.46e+5

Load Combination	1.35G	1.20G + 0.60Q	1.20G + 1.50Q	1.20G + 0.40Q + 1.00W
k_1	0.57	0.57	0.80	1.00
$V_{d,n}$ (kN)	595.93	595.93	836.40	1045.50
V^*(kN)	10.96	15.15	23.25	13.35

Capacity Check

$$U = \frac{V^*}{V_{d,n}} \leq 1$$

Load Combination	1.35G	1.20G + 0.60Q	1.20G + 1.50Q	1.20G + 0.40Q + 1.00W
Utilization (U)	2%	3%	3%	1%

3% *Ambient*

Additional Shear Strength Verification

Beams with rectangular penetrations reinforced with fully threaded screws and glued-in-rods (internal reinforcement) shall additionally satisfy the following:

$$V_{d,p} \geq V^* \qquad V_{d,p} = \Phi k_1 k_4 k_6 k_{58} A_{s,n} f'_s$$

$$k_{58} = \frac{1}{1.84(1+\frac{a}{d})(\frac{d_d}{d})^{0.2}} \qquad A_{s,n} = \frac{2}{3} b(d - d_d)$$

NZ Wood Design Guides (2020). Chapter 12.6

k_4	k_6	φ
1	1	0.85

Calculation of additional shear strength of beams with penetrations/th>		Ambient
b (mm)	Breadth of beam	450
d (mm)	Depth of beam	1040
a (mm)	Length of penetration	300
d_d (mm)	Diameter or depth of the penetration	220
k_{58}	Factor to account for the increased shear demand in internally reinforced penetrations	0.58
f'_s (MPa)	Characteristic value in shear	5
$A_{s,n}$ (mm^2)	Net shear plane area at the penetration	2.46e+5

Load Combination	1.35G	1.20G + 0.60Q	1.20G + 1.50Q	1.20G + 0.40Q + 1.00W
k_1	0.57	0.57	0.80	1.00
$V_{d,p}$ (kN)	342.95	342.95	481.33	601.67
V^*(kN)	10.96	15.15	23.25	13.35

Capacity Check

$$U = \frac{V^*}{V_{d,p}} \leq 1$$

Load Combination	1.35G	1.20G + 0.60Q	1.20G + 1.50Q	1.20G + 0.40Q + 1.00W
Utilization (U)	3%	4%	5%	2%

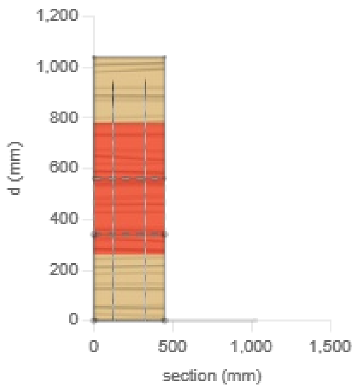
5% *Ambient*

Note: If verification of additional shear stresses for internally reinforced rectangular penetrations is not satisfied, external reinforcement shall be used.

Screw Geometry

$$l_{ef,1} = d_{b,a} \quad or \quad l_{ef,1} = d_{b,u} \quad for\ rectangulaer\ holes$$

prEN 1995-1-1 section 8.3.6.2 (6)



Section For Reinforced Beam Penetration

The presented screw arrangement is for penetrations near left end of beam. Please note that the crack lines will be reversed as we go from left to the right side of beam. Therefore, we highly recommend to check position of crack line before placing the screws. Alternatively screw length can be taken as the full beam depth. (check the drop down of screw length L for more information.)

Screw reinforcement data		Ambient
$d_{b,a}$ (mm)	Depth of the remaining beam portion above the penetration	480
$d_{b,u}$ (mm)	Depth of the remaining beam portion under the penetration	340
d_d (mm)	Depth of penetration	220
L (mm)	Length of screw reinforcement	1010
$l_{ef,1}$ (mm)	Effective length of screw reinforcement (max of d_{ba} and d_{bu})	480
$l_{ef,2}$ (mm)	Effective length of screw reinforcement	530
D(mm)	Outer thread diameter	12
a_2 (mm)	Spacing across to the grain	80
$a_{3,c}$ (mm)	Distance from center of the screw-part in timber to the end grain	120
$a_{4,c}$ (mm)	Distance from center of the screw-part in timber to the edge	120
l_p (mm)	Depth of screw penetration	120

Description	Criteria	Check
Effective length of screw reinforcement	$l_{ef,2} \geq l_{ef,1}$	OK
Spacing across to the grain	$a_2 \geq 5D$	OK
Distance from center of the screw-part in timber to the edge	$a_{4c} \geq 5D$	OK
		OK

Screw Design

Design Capacity for Fully Threaded Screw Reinforcements

The design capacity (Nd,j) for fully threaded screws or glued-in-rods as reinforcement shall satisfiy the following:

$$N_{d,j} \geq N^*_{90,r}$$

Where $N_{d,j}$ is the lesser of: $N_{d,j} = \Phi k_1 n Q_k$ $\quad N_{d,j} n N_{d,ts}$

AS1720.1 CL4.3.3.4

φ	k_{13}
0.85	1

Design capacity calculation for fully threaded screws		Ambient
Q_k (N/mm)	Characterstic withdrawal capacity of the screw	137
$N_{d,ts}$ (kN)	Design tensile capacity of the screw (refer screw manufacturer's specifications)	26
l_p (mm)	Depth of nail penetration into supporting member	120
n	number of screws in the first row	2
$N_{d,j}$ (kN)	Design capacity	27.95

Design Action Effect in Tension Perpendicular to Grain

$$N^*_{90,r} = N^*_{90,r,V} + N^*_{90,r,M} \qquad k_{59} = 0.83 + 0.013\frac{a}{d_d}$$

$$N^*_{90,r,V} = \frac{V^*}{4}\left(\frac{k_{59}d_d}{d}\right)\left[3 - \left(\left(\frac{k_{59}d_d}{d}\right)^2\right)\right]\left[1 + k_{60}\left(\frac{k_{59}d_d}{d}\right)\right] \qquad k_{60} = 0.57 + 0.533\frac{a}{d_d}$$

$$N^*_{90,r,M} = \frac{0.1M^*}{d}\left(\frac{k_{59}d_d}{d}\right)^2\left[1 + k_{61}\left(\frac{k_{59}d_d}{d}\right)\right] \qquad k_{61} = 0.05 + 0.113\frac{a}{d_d}$$

NZ Wood Design Guides (2020). Chapter 12.6

Calculation of design action effect in tension perpendicular to grain		Ambient
d (mm)	Depth of beam	1040
d_d (mm)	Diameter or depth of the penetration	220
a (mm)	Length of penetration	300
k_{59}	Factors for the load demand in timber and glulam beam with penetrations	0.85
k_{60}	Factors for the load demand in timber and glulam beam with penetrations	1.30
k_{61}	Factors for the load demand in timber and glulam beam with penetrations	0.20

Load Combination	1.35G	1.20G + 0.60Q	1.20G + 1.50Q	1.20G + 0.40Q + 1.00W
V^* (kN)	10.96	15.15	23.25	13.35
M^* (kNm)	219.27	302.90	464.90	266.90
$N^*_{90,r,V}$ (kN)	1.80	2.48	3.81	2.19
$N^*_{90,r,M}$ (kN)	0.70	0.97	1.49	0.86
$N^*_{90,r\ multiplier}$	1.14	1.14	1.14	1.14
$N^*_{90,r}$ (kN)	2.86	3.95	6.06	3.48

Capacity Check

$$U = \frac{N^*_{90,r}}{N^*_{90,d,j}} \leq 1$$

Load Combination	1.35G	1.20G + 0.60Q	1.20G + 1.50Q	1.20G + 0.40Q + 1.00W
Utilization (U)	10%	14%	22%	12%

22% *Ambient*