

Job No.: EHB 154

Address: 891 Makarewa Browns Road, R D 6 Invercargill, New Zealand

Date: 26/02/2024

Latitude: -46.285614

Longitude: 168.368244

Elevation: 27 m

General Input

Roof Live Load	0.25 KPa	Roof Dead Load	0.25 KPa	Roof Live Point Load	1.1 Kn
Snow Zone	N5	Ground Snow Load	0.9 KPa	Roof Snow Load	0.63 KPa
Earthquake Zone	1	Subsoil Category	D	Exposure Zone	B
Importance Level	1	Ultimate wind & Earthquake ARI	100 Years	Max Height	3.8 m
Wind Region	NZ2	Terrain Category	2.0	Design Wind Speed	39.22 m/s
Wind Pressure	0.92 KPa	Lee Zone	NO	Ultimate Snow ARI	50 Years
Wind Category	High	Earthquake ARI	100		

Note: Wind lateral loads are governing over Earthquake loads, So only wind loads are considered in calculations

Pressure Coefficients and Pressures

Shed Type = Mono Enclosed

For roof $C_{p,i} = -0.3$

For roof $C_{p,e}$ from 0 m To 3.40 m $C_{p,e} = -0.9$ $p_e = -0.75$ KPa $p_{net} = -0.75$ KPa

For roof $C_{p,e}$ from 3.40 m To 6.80 m $C_{p,e} = -0.5$ $p_e = -0.42$ KPa $p_{net} = -0.42$ KPa

For wall Windward $C_{p,i} = -0.3$ side Wall $C_{p,i} = -0.3$

For wall Windward and Leeward $C_{p,e}$ from 0 m To 13.5 m $C_{p,e} = 0.7$ $p_e = 0.58$ KPa $p_{net} = 0.86$ KPa

For side wall $C_{p,e}$ from 0 m To 3.40 m $C_{p,e} =$ $p_e = -0.54$ KPa $p_{net} = -0.54$ KPa

Maximum Upward pressure used in roof member Design = 0.75 KPa

Maximum Downward pressure used in roof member Design = 0.45 KPa

Maximum Wall pressure used in Design = 0.86 KPa

Maximum Racking pressure used in Design = 0.94 KPa

Design Summary

Purlin Design

Purlin Spacing = 900 mm

Purlin Span = 4350 mm

Try Purlin 200x50 SG8 Dry

Moisture Condition = Dry (Moisture in timber is less than 16% and timber does not remain in continuous wet condition after installation)

K1 Short term = 1 K1 Medium term = 0.8 K1 Long term = 0.6 K4 = 1 K5 = 1 K8 Downward = 1.00

K8 Upward = 0.47 S1 Downward = 11.27 S1 Upward = 24.64

Shear Capacity of timber = 3 MPa Bending Capacity of timber = 14 MPa NZS3603 Amt 4, table 2.3

Capacity Checks

M _{1.35D}	0.72 Kn-m	Capacity	2.23 Kn-m	Passing Percentage	309.72 %
M _{1.2D+1.5L 1.2D+S_n 1.2D+W_{nDn}}	1.98 Kn-m	Capacity	2.97 Kn-m	Passing Percentage	150.00 %

Pole Shed App Ver 01 2022

M0.9D-WnUp	-1.12 Kn-m	Capacity	-1.76 Kn-m	Passing Percentage	157.14 %
V1.35D	0.66 Kn	Capacity	9.65 Kn	Passing Percentage	1462.12 %
V1.2D+1.5L 1.2D+Sn 1.2D+WnDn	1.82 Kn	Capacity	12.86 Kn	Passing Percentage	706.59 %
V0.9D-WnUp	-1.03 Kn	Capacity	-16.08 Kn	Passing Percentage	1561.17 %

Deflections

Modulus of Elasticity = 6700 MPa NZS3603 Amt 4, Table 2.3 considering at least 4 members acting together

k2 for Long Term Loads = 2

Deflection under Dead and Live Load = 10.76 mm

Limit by Woolcock et al, 1999 Span/240 = 17.92 mm

Deflection under Dead and Service Wind = 13.01 mm

Limit by Woolcock et al, 1999 Span/100 = 43.00 mm

Reactions

Maximum downward = 1.82 kn Maximum upward = -1.03 kn

Number of Blocking = 0 if 0 then no blocking required, if 1 then one midspan blocking required

Rafter Design Internal

Internal Rafter Load Width = 4500 mm

Internal Rafter Span = 4350 mm

Try Rafter 2x300x50 SG8 Dry

Moisture Condition = Dry (Moisture in timber is less than 16% and timber does not remain in continuous wet condition after installation)

K1 Short term = 1 K1 Medium term = 0.8 K1 Long term = 0.6 K4 = 1 K5 = 1 K8 Downward = 1.00

K8 Upward = 1.00 S1 Downward = 6.81 S1 Upward = 6.81

Shear Capacity of timber = 3 MPa Bending Capacity of timber = 14 MPa NZS3603 Amt 4, table 2.3

Capacity Checks

M1.35D	3.59 Kn-m	Capacity	10.08 Kn-m	Passing Percentage	280.78 %
M1.2D+1.5L 1.2D+Sn 1.2D+WnDn	9.90 Kn-m	Capacity	13.44 Kn-m	Passing Percentage	135.76 %
M0.9D-WnUp	-5.59 Kn-m	Capacity	-16.8 Kn-m	Passing Percentage	300.54 %
V1.35D	3.30 Kn	Capacity	28.94 Kn	Passing Percentage	876.97 %
V1.2D+1.5L 1.2D+Sn 1.2D+WnDn	9.10 Kn	Capacity	38.6 Kn	Passing Percentage	424.18 %
V0.9D-WnUp	-5.14 Kn	Capacity	-48.24 Kn	Passing Percentage	938.52 %

Deflections

Modulus of Elasticity = 5400 MPa NZS3603 Amt 4, Table 2.3

k2 for Long Term Loads = 2

Deflection under Dead and Live Load = 5.34 mm

Limit by Woolcock et al, 1999 Span/240 = 18.75 mm

Deflection under Dead and Service Wind = 7.17 mm

Limit by Woolcock et al, 1999 Span/100 = 45.00 mm

Reactions

Maximum downward = 9.10 kn Maximum upward = -5.14 kn

Rafter to Pole Connection check

Bolt Size = M12 Number of Bolts = 2

Calculations as per NZS 3603:1993 Amend 2005 clause 4.4

Joint Group for Rafters = J5 Joint Group for Pole = J5

Minimum Bolt edge, end and spacing for Load perpendicular to grains = 60 mm

Factor of Safety = 0.7

For Perpendicular to grain loading

$K_{11} = 14.9 \text{ f}_{pj} = 12.9 \text{ Mpa}$ for Rafter with effective thickness = 100 mm

For Parallel to grain loading

$K_{11} = 2.0 \text{ f}_{cj} = 36.1 \text{ Mpa}$ for Pole with effective thickness = 100 mm

Capacity under short term loads = 21.67 Kn > -5.14 Kn

Rafter Design External

External Rafter Load Width = 2250 mm

External Rafter Span = 4318 mm

Try Rafter 300x50 SG8 Dry

Moisture Condition = Dry (Moisture in timber is less than 16% and timber does not remain in continuous wet condition after installation)

K_1 Short term = 1 K_1 Medium term = 0.8 K_1 Long term = 0.6 $K_4 = 1$ $K_5 = 1$ K_8 Downward = 0.94

K_8 Upward = 0.94 S_1 Downward = 13.93 S_1 Upward = 13.93

Shear Capacity of timber = 3 MPa Bending Capacity of timber = 14 MPa NZS3603 Amt 4, table 2.3

Capacity Checks

$M_{1.35D}$	1.77 Kn-m	Capacity	4.72 Kn-m	Passing Percentage	266.67 %
$M_{1.2D+1.5L \ 1.2D+S_n \ 1.2D+W_nD_n}$	4.88 Kn-m	Capacity	6.30 Kn-m	Passing Percentage	129.10 %
$M_{0.9D-W_nUp}$	-2.75 Kn-m	Capacity	-7.87 Kn-m	Passing Percentage	286.18 %
$V_{1.35D}$	1.64 Kn	Capacity	14.47 Kn	Passing Percentage	882.32 %
$V_{1.2D+1.5L \ 1.2D+S_n \ 1.2D+W_nD_n}$	4.52 Kn	Capacity	19.30 Kn	Passing Percentage	426.99 %
$V_{0.9D-W_nUp}$	-2.55 Kn	Capacity	-24.12 Kn	Passing Percentage	945.88 %

Deflections

Modulus of Elasticity = 5400 MPa NZS3603 Amt 4, Table 2.3

k_2 for Long Term Loads = 2

Deflection under Dead and Live Load = 5.93 mm

Limit by Woolcock et al, 1999 Span/240 = 18.75 mm

Deflection under Dead and Service Wind = 7.17 mm

Limit by Woolcock et al, 1999 Span/100 = 45.00 mm

Reactions

Maximum downward = 4.52 kn Maximum upward = -2.55 kn

Rafter to Pole Connection check

Bolt Size = M12 Number of Bolts = 2

Calculations as per NZS 3603:1993 Amend 2005 clause 4.4

Joint Group for Rafters = J5 Joint Group for Pole = J5

Factor of Safety = 0.7

For Perpendicular to grain loading

$K_{11} = 14.9 \text{ f}_{pj} = 12.9 \text{ Mpa}$ for Rafter with effective thickness = 50 mm

For Parallel to grain loading

$K_{11} = 2.0 \text{ f}_{cj} = 36.1 \text{ Mpa}$ for Pole with effective thickness = 100 mm

Eccentric Load check

$V = \phi \times k_1 \times k_4 \times k_5 \times f_s \times b \times d_s \dots\dots\dots (\text{Eq 4.12}) = -25.20 \text{ kn} > -2.55 \text{ Kn}$

Single Shear Capacity under short term loads = -10.84 Kn > -2.55 Kn

Girt Design Front and Back

Girt's Spacing = 4500 mm

Girt's Span = 4500 mm

Try Girt 150x50 SG8 Dry

Moisture Condition = Dry (Moisture in timber is less than 16% and does not remain in continuous wet condition after installation)

K_1 Short term = 1 $K_4 = 1$ $K_5 = 1$ K_8 Downward = 1.00

K_8 Upward = 0.60 S_1 Downward = 9.63 S_1 Upward = 21.54

Shear Capacity of timber = 3 MPa Bending Capacity of timber = 14 MPa NZS3603 Amt 4, table 2.3

Capacity Checks

$M_{\text{Wind+Snow}}$	9.80 Kn-m	Capacity	1.25 Kn-m	Passing Percentage	12.76 %
$V_{0.9D-WnUp}$	8.71 Kn-m	Capacity	12.06 Kn-m	Passing Percentage	138.46 %

Deflections

Modulus of Elasticity = 6700 MPa NZS3603 Amt 4, Table 2.3

Deflection under Snow and Service Wind = 379.97 mm

Limit by Woolcock et al, 1999 Span/100 = 45.00 mm

Sag during installation = 24.86 mm

Reactions

Maximum = 8.71 kn

Girt Design Sides

Girt's Spacing = 4500 mm

Girt's Span = 4500 mm

Try Girt 150x50 SG8 Dry

Moisture Condition = Dry (Moisture in timber is less than 16% and does not remain in continuous wet condition after installation)

K_1 Short term = 1 $K_4 = 1$ $K_5 = 1$ K_8 Downward = 1.00

K_8 Upward = 0.60 S_1 Downward = 9.63 S_1 Upward = 21.54

Shear Capacity of timber = 3 MPa Bending Capacity of timber = 14 MPa NZS3603 Amt 4, table 2.3

Capacity Checks

$M_{\text{Wind+Snow}}$	9.80 Kn-m	Capacity	1.25 Kn-m	Passing Percentage	12.76 %
$V_{0.9D-WnUp}$	8.71 Kn-m	Capacity	12.06 Kn-m	Passing Percentage	138.46 %

Deflections

Modulus of Elasticity = 6700 MPa NZS3603 Amt 4, Table 2.3

Deflection under Snow and Service Wind = 379.97 mm

Limit by Woolcock et al. 1999 Span/100 = 45.00 mm

Sag during installation = 24.86 mm

Reactions

Maximum = 8.71 kn

Middle Pole Design

Geometry

150 SED H5 (Minimum 175 dia. at Floor Level)	Dry Use	Height	3500 mm
Area	20729 mm ²	As	15546.6796875 mm ²
I _x	34210793 mm ⁴	Z _x	421056 mm ³
I _y	34210793 mm ⁴	Z _y	421056 mm ³
Lateral Restraint	3500 mm c/c		

Loads

Total Area over Pole = 20.25 m²

Dead	5.06 Kn	Live	5.06 Kn
Wind Down	9.11 Kn	Snow	12.76 Kn
Moment wind	7.62 Kn-m	Moment snow	2.56 Kn-m
Phi	0.8	K ₈	0.60
K ₁ snow	0.8	K ₁ Dead	0.6
K ₁ wind	1		

Material

Peeling	Steaming	Normal	Dry Use
f _b =	36.3 MPa	f _s =	2.96 MPa
f _c =	18 MPa	f _p =	7.2 MPa
f _t =	22 MPa	E =	9257 MPa

Capacities

PhiN _c Wind	177.99 Kn	PhiM _n Wind	7.29 Kn-m	PhiV _n Wind	36.81 Kn
PhiN _c Dead	106.79 Kn	PhiM _n Dead	4.37 Kn-m	PhiV _n Dead	22.09 Kn
PhiN _c Snow	142.39 Kn	PhiM _n Snow	5.83 Kn-m	PhiV _n Snow	29.45 Kn

Checks

$$(M_x/\Phi M_n) + (N/\Phi N_c) = 1.19 < 1 \text{ OK}$$

$$(M_x/\Phi M_n)^2 + (N/\Phi N_c) = 1.24 < 1 \text{ OK}$$

Deflection at top under service lateral loads = 44.94 mm < 35.00 mm

Drained Lateral Strength of Middle pile in cohesionless soils Free Head short pile

Assumed Soil Properties

Gamma	18 Kn/m ³	Friction angle	30 deg	Cohesion	0 Kn/m ³
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$$K0 = (1 - \sin(30)) / (1 + \sin(30))$$

$$Kp = (1 + \sin(30)) / (1 - \sin(30))$$

Geometry For Middle Bay Pole

Ds =	0.6 mm	Pile Diameter
L =	1300 mm	Pile embedment length
f1 =	2850 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

Loads

Moment Wind =	7.62 Kn-m	Moment Snow =	Kn-m
Shear Wind =	2.67 Kn	Shear Snow =	2.56 Kn

Pile Properties

Safety Factory	0.55	
Hu =	4.72 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	7.94 Kn-m	Ultimate Moment Capacity of Pile

Checks

Applied Forces/Capacities = 0.96 < 1 OK

End Pole Design

Geometry For End Bay Pole

Geometry

150 SED H5 (Minimum 175 dia. at Floor Level)	Dry Use	Height	3500 mm
Area	20729 mm ²	As	15546.6796875 mm ²
Ix	34210793 mm ⁴	Zx	421056 mm ³
Iy	34210793 mm ⁴	Zy	421056 mm ³
Lateral Restraint	mm c/c		

Loads

Total Area over Pole = 10.125 m²

Dead	2.53 Kn	Live	2.53 Kn
Wind Down	4.56 Kn	Snow	6.38 Kn
Moment Wind	3.81 Kn-m	Moment snow	1.28 Kn-m
Phi	0.8	K8	0.60
K1 snow	0.8	K1 Dead	0.6
K1wind	1		

Material

Peeling	Steaming	Normal	Dry Use
fb =	36.3 MPa	fs =	2.96 MPa
fc =	18 MPa	fp =	7.2 MPa
ft =	22 MPa	E =	9257 MPa

Capacities

PhiNcx Wind	178.07 Kn	PhiMnx Wind	7.29 Kn-m	PhiVnx Wind	36.81 Kn
PhiNcx Dead	106.84 Kn	PhiMnx Dead	4.38 Kn-m	PhiVnx Dead	22.09 Kn
PhiNcx Snow	142.46 Kn	PhiMnx Snow	5.84 Kn-m	PhiVnx Snow	29.45 Kn

Checks

$$(M_x/\Phi M_{nx}) + (N/\Phi N_{cx}) = 0.60 < 1 \text{ OK}$$

$$(M_x/\Phi M_{nx})^2 + (N/\Phi N_{cx}) = 0.35 < 1 \text{ OK}$$

$$\text{Deflection at top under service lateral loads} = 24.34 \text{ mm} < 37.90 \text{ mm}$$

Ds =	0.6 mm	Pile Diameter
L =	1300 mm	Pile embedment length
f1 =	2850 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

Loads

$$\text{Total Area over Pole} = 10.125 \text{ m}^2$$

Moment Wind =	3.81 Kn-m	Moment Snow =	1.28 Kn-m
Shear Wind =	1.34 Kn	Shear Snow =	1.28 Kn

Pile Properties

Safety Factory	0.55	
Hu =	4.72 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	7.94 Kn-m	Ultimate Moment Capacity of Pile

Checks

$$\text{Applied Forces/Capacities} = 0.48 < 1 \text{ OK}$$

Drained Lateral Strength of End pile in cohesionless soils Free Head short pile

Assumed Soil Properties

Gamma	18 Kn/m ³	Friction angle	30 deg	Cohesion	0 Kn/m ³
K0 =	$(1 - \sin(30)) / (1 + \sin(30))$				
Kp =	$(1 + \sin(30)) / (1 - \sin(30))$				

Geometry For End Bay Pole

Ds =	0.6 mm	Pile Diameter
L =	1300 mm	Pile embedment length
f1 =	2850 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

Loads

Moment Wind =	3.81 Kn-m	Moment Snow =	1.28 Kn-m
Shear Wind =	1.34 Kn	Shear Snow =	1.28 Kn

Pile Properties

Safety Factor	0.55	
Hu =	4.72 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	7.94 Kn-m	Ultimate Moment Capacity of Pile

Checks

Applied Forces/Capacities = $0.48 < 1$ OK

Uplift Check

Density of Concrete = 24 Kn/m³

Density of Timber Pole = 5 Kn/m³

Due to cast in place pile, the surface interaction between soil and pile will be rough thus angle of friction between both is taken equal to soil angle of internal friction

Ks (Lateral Earth Pressure Coefficient) for cast into place concrete piles = 1.5

Formula to calculate Skin Friction = Safety factor (0.55) x Density of Soil(18) x Height of Pile(1300) x Ks(1.5) x 0.5 x tan(30) x Pi x Dia of Pile(0.6) x Height of Pile(1300)

Skin Friction = 13.65 Kn

Weight of Pile + Pile Skin Friction = 17.91 Kn

Uplift on one Pile = 10.63 Kn

Uplift is ok