

Job No.: EHB 190**Address:** 26 Waituna Gorge Road, Invercargill, New Zealand**Date:** 01/05/2024**Latitude:** -46.479454**Longitude:** 168.689696**Elevation:** 28.5 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	C
Importance Level	1	Ultimate wind & Earthquake ARI	100 Years	Max Height	4.1 m
Wind Region	NZ4	Terrain Category	2.0	Design Wind Speed	44.36 m/s
Wind Pressure	1.18 KPa	Lee Zone	NO	Ultimate Snow ARI	50 Years
Wind Category	Very 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 $C_{p,i} = 0.6624$

For roof $C_{p,e}$ from 0 m To 3.55 m $C_{p,e} = -0.9$ $p_e = -0.56$ KPa $p_{net} = -1.06$ KPa

For roof $C_{p,e}$ from 3.55 m To 7 m $C_{p,e} = -0.5$ $p_e = -0.31$ KPa $p_{net} = -0.81$ KPa

For wall Windward $C_{p,i} = 0.6624$ side Wall $C_{p,i} = 0.5803$

For wall Windward and Leeward $C_{p,e}$ from 0 m To 10.8 m $C_{p,e} = 0.7$ $p_e = 0.69$ KPa $p_{net} = 1.38$ KPa

For side wall $C_{p,e}$ from 0 m To 3.55 m $C_{p,e} =$ $p_e = -0.64$ KPa $p_{net} = 0.05$ KPa

Maximum Upward pressure used in roof member Design = 1.06 KPa

Maximum Downward pressure used in roof member Design = 0.89 KPa

Maximum Wall pressure used in Design = 1.38 KPa

Maximum Racking pressure used in Design = 1.27 KPa

Design Summary**Purlin Design**

Purlin Spacing = 800 mm

Purlin Span = 3450 mm

Try Purlin 150x50 SG8 Dry

Moisture Condition = Dry (Moisture in timber is less than 16% and 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 = 0.73 S1 Downward = 9.63 S1 Upward = 18.72

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

Capacity Checks

M _{1.35D}	0.4 Kn-m	Capacity	1.26 Kn-m	Passing Percentage	315.00 %
M _{1.2D+1.5L 1.2D+S_n 1.2D+W_nD_n}	1.42 Kn-m	Capacity	1.68 Kn-m	Passing Percentage	118.31 %
M _{0.9D-W_nUp}	-0.99 Kn-m	Capacity	-1.54 Kn-m	Passing Percentage	121.26 %
V _{1.35D}	0.47 Kn	Capacity	7.24 Kn	Passing Percentage	1540.43 %

Pole Shed App Ver 01 2022

V _{1.2D+1.5L 1.2D+Sn 1.2D+WnDn}	1.64 Kn	Capacity	9.65 Kn	Passing Percentage	588.41 %
V _{0.9D-WnUp}	-1.15 Kn	Capacity	-12.06 Kn	Passing Percentage	1048.70 %

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 = 8.86 mm Limit by Woolcock et al, 1999 Span/240 = 14.17 mm

Deflection under Dead and Service Wind = 13.96 mm Limit by Woolcock et al, 1999 Span/100 = 34.00 mm

Reactions

Maximum downward = 1.64 kn Maximum upward = -1.15 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 = 3600 mm Internal Rafter Span = 5350 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

M _{1.35D}	4.35 Kn-m	Capacity	10.08 Kn-m	Passing Percentage	231.72 %
M _{1.2D+1.5L 1.2D+Sn 1.2D+WnDn}	15.33 Kn-m	Capacity	13.44 Kn-m	Passing Percentage	87.67 %
M _{0.9D-WnUp}	-10.75 Kn-m	Capacity	-16.8 Kn-m	Passing Percentage	156.28 %
V _{1.35D}	3.25 Kn	Capacity	28.94 Kn	Passing Percentage	890.46 %
V _{1.2D+1.5L 1.2D+Sn 1.2D+WnDn}	11.46 Kn	Capacity	38.6 Kn	Passing Percentage	336.82 %
V _{0.9D-WnUp}	-8.04 Kn	Capacity	-48.24 Kn	Passing Percentage	600.00 %

Deflections

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

k₂ for Long Term Loads = 2

Deflection under Dead and Live Load = 9.53 mm Limit by Woolcock et al, 1999 Span/240 = 22.92 mm

Deflection under Dead and Service Wind = 16.68 mm Limit by Woolcock et al, 1999 Span/100 = 55.00 mm

Reactions

Maximum downward = 11.46 kn Maximum upward = -8.04 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

$K_{11} = 14.9$ $f_{pj} = 12.9$ Mpa for Rafter with effective thickness = 100 mm

For Parallel to grain loading

$K_{11} = 2.0$ $f_{ej} = 36.1$ Mpa for Pole with effective thickness = 100 mm

Capacity under short term loads = 21.67 Kn > -8.04 Kn

Rafter Design External

External Rafter Load Width = 1800 mm

External Rafter Span = 5328 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

$M_{1.35D}$	2.16 Kn-m	Capacity	4.72 Kn-m	Passing Percentage	218.52 %
$M_{1.2D+1.5L \ 1.2D+S_n \ 1.2D+W_nD_n}$	7.60 Kn-m	Capacity	6.30 Kn-m	Passing Percentage	82.89 %
$M_{0.9D-W_nUp}$	-5.33 Kn-m	Capacity	-7.87 Kn-m	Passing Percentage	147.65 %
$V_{1.35D}$	1.62 Kn	Capacity	14.47 Kn	Passing Percentage	893.21 %
$V_{1.2D+1.5L \ 1.2D+S_n \ 1.2D+W_nD_n}$	5.71 Kn	Capacity	19.30 Kn	Passing Percentage	338.00 %
$V_{0.9D-W_nUp}$	-4.00 Kn	Capacity	-24.12 Kn	Passing Percentage	603.00 %

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 = 10.59 mm

Limit by Woolcock et al, 1999 $\text{Span}/240 = 22.92$ mm

Deflection under Dead and Service Wind = 16.68 mm

Limit by Woolcock et al, 1999 $\text{Span}/100 = 55.00$ mm

Reactions

Maximum downward = 5.71 kn Maximum upward = -4.00 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

$K_{11} = 14.9$ $f_{pj} = 12.9$ Mpa for Rafter with effective thickness = 50 mm

For Parallel to grain loading

$K_{11} = 2.0$ $f_{c,j} = 36.1$ Mpa for Pole with effective thickness = 100 mm

Eccentric Load check

$V = \phi_i \times k_1 \times k_4 \times k_5 \times f_s \times b \times d_s \dots\dots\dots$ (Eq 4.12) = -25.20 kn > -4.00 Kn

Single Shear Capacity under short term loads = -10.84 Kn > -4.00 Kn

Intermediate Design Sides

Intermediate Spacing = 2750 mm

Intermediate Span = 3675 mm

Try Intermediate 2x250x50 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 $K_4 = 1$ $K_5 = 1$ K_8 Downward = 0.97

K_8 Upward = 1.00 S_1 Downward = 12.68 S_1 Upward = 0.81

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

Capacity Checks

$M_{Wind+Snow}$	3.20 Kn-m	Capacity	11.66 Kn-m	Passing Percentage	364.38 %
$V_{0.9D-WnUp}$	3.49 Kn	Capacity	40.2 Kn	Passing Percentage	1151.86 %

Deflections

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

Deflection under Snow and Service Wind = 21.17 mm

Limit by Woolcock et al, 1999 Span/100 = 36.75 mm

Reactions

Maximum = 3.49 kn

Girt Design Front and Back

Girt's Spacing = 750 mm

Girt's Span = 3600 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 = 0.95 S_1 Downward = 9.63 S_1 Upward = 13.62

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

Capacity Checks

$M_{Wind+Snow}$	1.68 Kn-m	Capacity	1.99 Kn-m	Passing Percentage	118.45 %
$V_{0.9D-WnUp}$	1.86 Kn	Capacity	12.06 Kn	Passing Percentage	648.39 %

Deflections

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

Deflection under Snow and Service Wind = 34.99 mm

Limit by Woolcock et al, 1999 Span/100 = 36.00 mm

Sag during installation = 10.18 mm

Reactions

Maximum = 1.86 kn

Girt Design Sides

Girt's Spacing = 900 mm

Girt's Span = 2750 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)

K1 Short term = 1 K4 =1 K5 =1 K8 Downward =1.00

K8 Upward =0.82 S1 Downward =9.63 S1 Upward =16.84

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

Capacity Checks

M _{Wind+Snow}	1.17 Kn-m	Capacity	1.73 Kn-m	Passing Percentage	147.86 %
V _{0.9D-WnUp}	1.71 Kn	Capacity	12.06 Kn	Passing Percentage	705.26 %

Deflections

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

Deflection under Snow and Service Wind = 14.30 mm

Limit by Woolcock et al. 1999 Span/100 = 27.50 mm

Sag during installation =3.47 mm

Reactions

Maximum = 1.71 kn

Middle Pole Design

Geometry

175 SED H5 (Minimum 200 dia. at Floor Level)	Dry Use	Height	3800 mm
Area	27598 mm ²	As	20698.2421875 mm ²
I _x	60639381 mm ⁴	Z _x	646820 mm ³
I _y	60639381 mm ⁴	Z _y	646820 mm ³
Lateral Restraint	3400 mm c/c		

Loads

Total Area over Pole = 19.8 m²

Dead	4.95 Kn	Live	4.95 Kn
Wind Down	17.62 Kn	Snow	12.47 Kn
Moment wind	9.58 Kn-m	Moment snow	2.21 Kn-m
Phi	0.8	K8	0.76
K1 snow	0.8	K1 Dead	0.6
K1 wind	1		

Material

Peeling	Steaming	Normal	Dry Use
---------	----------	--------	---------

Pole Shed App Ver 01 2022

fb =	36.3 MPa	fs =	2.96 MPa
fc =	18 MPa	fp =	7.2 MPa
ft =	22 MPa	E =	9257 MPa

Capacities

PhiNcx Wind	302.65 Kn	PhiMnx Wind	14.30 Kn-m	PhiVnx Wind	49.01 Kn
PhiNcx Dead	181.59 Kn	PhiMnx Dead	8.58 Kn-m	PhiVnx Dead	29.41 Kn
PhiNcx Snow	242.12 Kn	PhiMnx Snow	11.44 Kn-m	PhiVnx Snow	39.21 Kn

Checks

$$(M_x/\Phi M_{nx}) + (N/\Phi N_{cx}) = 0.76 < 1 \text{ OK}$$

$$(M_x/\Phi M_{nx})^2 + (N/\Phi N_{cx}) = 0.54 < 1 \text{ OK}$$

$$\text{Deflection at top under service lateral loads} = 37.37 \text{ mm} < 38.00 \text{ mm}$$

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
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 =	1550 mm	Pile embedment length
f1 =	3075 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

Loads

Moment Wind =	9.58 Kn-m	Moment Snow =	Kn-m
Shear Wind =	3.12 Kn	Shear Snow =	2.21 Kn

Pile Properties

Safety Factory	0.55	
Hu =	7.17 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	13.15 Kn-m	Ultimate Moment Capacity of Pile

Checks

$$\text{Applied Forces/Capacities} = 0.73 < 1 \text{ OK}$$

End Pole Design

Geometry For End Bay Pole

Geometry

150 SED H5 (Minimum 175 dia. at Floor Level)	Dry Use	Height	3800 mm
Area	20729 mm ²	As	15546.6796875 mm ²

Pole Shed App Ver 01 2022

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 = 9.9 m²

Dead	2.48 Kn	Live	2.48 Kn
Wind Down	8.81 Kn	Snow	6.24 Kn
Moment Wind	4.79 Kn-m	Moment snow	1.10 Kn-m
Phi	0.8	K _s	0.52
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 _{cx} Wind	154.24 Kn	PhiM _{nx} Wind	6.32 Kn-m	PhiV _{nx} Wind	36.81 Kn
PhiN _{cx} Dead	92.55 Kn	PhiM _{nx} Dead	3.79 Kn-m	PhiV _{nx} Dead	22.09 Kn
PhiN _{cx} Snow	123.40 Kn	PhiM _{nx} Snow	5.05 Kn-m	PhiV _{nx} Snow	29.45 Kn

Checks

$(M_x/\Phi M_{nx}) + (N/\Phi N_{cx}) = 0.85 < 1$ OK

$(M_x/\Phi M_{nx})^2 + (N/\Phi N_{cx}) = 0.66 < 1$ OK

Deflection at top under service lateral loads = 35.65 mm < 40.90 mm

D _s =	0.6 mm	Pile Diameter
L =	1300 mm	Pile embedment length
f ₁ =	3075 mm	Distance at which the shear force is applied
f ₂ =	0 mm	Distance of top soil at rest pressure

Loads

Total Area over Pole = 9.9 m²

Moment Wind =	4.79 Kn-m	Moment Snow =	1.10 Kn-m
Shear Wind =	1.56 Kn	Shear Snow =	1.10 Kn

Pile Properties

Safety Factor	0.55		
H _u =	4.47 Kn	Ultimate Lateral Strength of the Pile, Short pile	
M _u =	8.07 Kn-m	Ultimate Moment Capacity of Pile	

Checks

Applied Forces/Capacities = $0.59 < 1$ 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 =	3075 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

Loads

Moment Wind =	4.79 Kn-m	Moment Snow =	1.10 Kn-m
Shear Wind =	1.56 Kn	Shear Snow =	1.10 Kn

Pile Properties

Safety Factory	0.55	
Hu =	4.47 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	8.07 Kn-m	Ultimate Moment Capacity of Pile

Checks

Applied Forces/Capacities = $0.59 < 1$ 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 (1550) x Ks (1.5) x 0.5 x tan(30) x Pi x Dia of Pile (0.6) x Height of Pile (1550)

Skin Friction = 19.40 Kn

Weight of Pile + Pile Skin Friction = 23.94 Kn

Uplift on one Pile = 16.53 Kn

Uplift is ok