



**Job No.:** EHB 169**Address:** 17 Calder Way, Invercargill, New Zealand**Date:** 16/05/2024**Latitude:** -46.403107**Longitude:** 168.429637**Elevation:** 18 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	4.2 m
Wind Region	NZ4	Terrain Category	2.2	Design Wind Speed	39.92 m/s
Wind Pressure	0.96 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  $C_{p,i} = 0.938$

For roof  $C_{p,e}$  from 0 m To 3.6 m  $C_{p,e} = -0.9$   $p_e = -0.48$  KPa  $p_{net} = -0.93$  KPa

For roof  $C_{p,e}$  from 3.6 m To 7.2 m  $C_{p,e} = -0.5$   $p_e = -0.27$  KPa  $p_{net} = -0.72$  KPa

For wall Windward  $C_{p,i} = 0.6983$  side Wall  $C_{p,i} = -0.6467$

For wall Windward and Leeward  $C_{p,e}$  from 0 m To 13.2 m  $C_{p,e} = 0.7$   $p_e = 0.6$  KPa  $p_{net} = 1.27$  KPa

For side wall  $C_{p,e}$  from 0 m To 3.6 m  $C_{p,e} =$   $p_e = -0.56$  KPa  $p_{net} = 0.11$  KPa

Maximum Upward pressure used in roof member Design = 0.93 KPa

Maximum Downward pressure used in roof member Design = 0.84 KPa

Maximum Wall pressure used in Design = 1.27 KPa

Maximum Racking pressure used in Design = 1.03 KPa

**Design Summary****Purlin Design**

Purlin Spacing = 800 mm

Purlin Span = 4650 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 = 0.77 S1 Downward = 11.27 S1 Upward = 18.02

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

**Capacity Checks**

$M_{1.35D}$	0.73 Kn-m	Capacity	2.23 Kn-m	Passing Percentage	<b>305.48 %</b>
$M_{1.2D+1.5L 1.2D+S_n 1.2D+W_nD_n}$	2.46 Kn-m	Capacity	2.97 Kn-m	Passing Percentage	<b>120.73 %</b>
$M_{0.9D-W_nUp}$	-1.52 Kn-m	Capacity	-2.86 Kn-m	Passing Percentage	<b>188.16 %</b>
$V_{1.35D}$	0.63 Kn	Capacity	9.65 Kn	Passing Percentage	<b>1531.75 %</b>

Pole Shed App Ver 01 2022

V <sub>1.2D+1.5L 1.2D+Sn 1.2D+WnDn</sub>	2.12 Kn	Capacity	12.86 Kn	Passing Percentage	<b>606.60 %</b>
V <sub>0.9D-WnUp</sub>	-1.31 Kn	Capacity	-16.08 Kn	Passing Percentage	<b>1227.48 %</b>

**Deflections**

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

k<sub>2</sub> for Long Term Loads = 2

Deflection under Dead and Live Load = 12.53 mm Limit by Woolcock et al, 1999 Span/240 = 19.17 mm

Deflection under Dead and Service Wind = 19.21 mm Limit by Woolcock et al, 1999 Span/100 = 46.00 mm

**Reactions**

Maximum downward = 2.12 kn Maximum upward = -1.31 kn

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

**Rafter Design Internal**

Internal Rafter Load Width = 4800 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)

K<sub>1</sub> Short term = 1 K<sub>1</sub> Medium term = 0.8 K<sub>1</sub> Long term = 0.6 K<sub>4</sub> = 1 K<sub>5</sub> = 1 K<sub>8</sub> Downward = 1.00

K<sub>8</sub> Upward = 1.00 S<sub>1</sub> Downward = 6.81 S<sub>1</sub> Upward = 6.81

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

**Capacity Checks**

M <sub>1.35D</sub>	3.83 Kn-m	Capacity	10.08 Kn-m	Passing Percentage	<b>263.19 %</b>
M <sub>1.2D+1.5L 1.2D+Sn 1.2D+WnDn</sub>	12.94 Kn-m	Capacity	13.44 Kn-m	Passing Percentage	<b>103.86 %</b>
M <sub>0.9D-WnUp</sub>	-8.00 Kn-m	Capacity	-16.8 Kn-m	Passing Percentage	<b>210.00 %</b>
V <sub>1.35D</sub>	3.52 Kn	Capacity	28.94 Kn	Passing Percentage	<b>822.16 %</b>
V <sub>1.2D+1.5L 1.2D+Sn 1.2D+WnDn</sub>	11.90 Kn	Capacity	38.6 Kn	Passing Percentage	<b>324.37 %</b>
V <sub>0.9D-WnUp</sub>	-7.36 Kn	Capacity	-48.24 Kn	Passing Percentage	<b>655.43 %</b>

**Deflections**

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

k<sub>2</sub> for Long Term Loads = 2

Deflection under Dead and Live Load = 5.695 mm Limit by Woolcock et al, 1999 Span/240 = 18.75 mm

Deflection under Dead and Service Wind = 9.705 mm Limit by Woolcock et al, 1999 Span/100 = 45.00 mm

**Reactions**

Maximum downward = 11.90 kn Maximum upward = -7.36 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 > -7.36 Kn

### Rafter Design External

External Rafter Load Width = 2400 mm

External Rafter Span = 2927 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

$M_{1.35D}$	0.87 Kn-m	Capacity	4.72 Kn-m	Passing Percentage	<b>542.53 %</b>
$M_{1.2D+1.5L \ 1.2D+S_n \ 1.2D+W_nD_n}$	2.93 Kn-m	Capacity	6.30 Kn-m	Passing Percentage	<b>215.02 %</b>
$M_{0.9D-W_nUp}$	-1.81 Kn-m	Capacity	-7.87 Kn-m	Passing Percentage	<b>434.81 %</b>
$V_{1.35D}$	1.19 Kn	Capacity	14.47 Kn	Passing Percentage	<b>1215.97 %</b>
$V_{1.2D+1.5L \ 1.2D+S_n \ 1.2D+W_nD_n}$	4.00 Kn	Capacity	19.30 Kn	Passing Percentage	<b>482.50 %</b>
$V_{0.9D-W_nUp}$	-2.48 Kn	Capacity	-24.12 Kn	Passing Percentage	<b>972.58 %</b>

### 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 = 1.43 mm

Limit by Woolcock et al, 1999 Span/240 = 12.92 mm

Deflection under Dead and Service Wind = 2.19 mm

Limit by Woolcock et al, 1999 Span/100 = 31.00 mm

### Reactions

Maximum downward = 4.00 kn    Maximum upward = -2.48 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

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

Eccentric Load check

$V = \phi_i \times k_1 \times k_4 \times k_5 \times f_s \times b \times d_s \dots\dots\dots (\text{Eq 4.12}) = -25.20 \text{ kn} > -2.48 \text{ Kn}$

Single Shear Capacity under short term loads = -10.84 Kn > -2.48 Kn

### Intermediate Design Front and Back

Intermediate Spacing = 2400 mm

Intermediate Span = 2851 mm

Try Intermediate 2x200x50 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 = 1.00

$K_8$  Upward = 1.00     $S_1$  Downward = 11.27     $S_1$  Upward = 0.63

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

#### Capacity Checks

$M_{\text{Wind+Snow}}$	3.10 Kn-m	Capacity	7.46 Kn-m	Passing Percentage	<b>240.65 %</b>
$V_{0.9D-WnUp}$	4.34 Kn	Capacity	-32.16 Kn	Passing Percentage	<b>741.01 %</b>

#### Deflections

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

Deflection under Snow and Service Wind = 12.44 mm

Limit by Woolcock et al, 1999 Span/100 = 28.51 mm

#### Reactions

Maximum = 4.34 kn

### Girt Design Front and Back

Girt's Spacing = 1300 mm

Girt's Span = 2400 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 = 0.87     $S_1$  Downward = 9.63     $S_1$  Upward = 15.73

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

#### Capacity Checks

$M_{\text{Wind+Snow}}$	1.19 Kn-m	Capacity	1.83 Kn-m	Passing Percentage	<b>153.78 %</b>
$V_{0.9D-WnUp}$	1.98 Kn	Capacity	12.06 Kn	Passing Percentage	<b>609.09 %</b>

#### Deflections

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

Deflection under Snow and Service Wind = 11.33 mm

Limit by Woolcock et al, 1999 Span/100 = 24.00 mm

Sag during installation = 2.01 mm

#### Reactions

Maximum = 1.98 kn

#### Girt Design Sides

Girt's Spacing = 1300 mm

Girt's Span = 3100 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 =0.97    S1 Downward =9.63    S1 Upward =12.64

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

#### Capacity Checks

M <sub>Wind+Snow</sub>	1.98 Kn-m	Capacity	2.04 Kn-m	Passing Percentage	<b>103.03 %</b>
V <sub>0.9D-WnUp</sub>	2.56 Kn	Capacity	12.06 Kn	Passing Percentage	<b>471.09 %</b>

#### Deflections

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

Deflection under Snow and Service Wind = 31.53 mm

Limit by Woolcock et al. 1999 Span/100 = 31.00 mm

Sag during installation =5.60 mm

#### Reactions

Maximum = 2.56 kn

#### Middle Pole Design

##### Geometry

200 SED H5 (Minimum 225 dia. at Floor Level)	Dry Use	Height	3900 mm
Area	35448 mm <sup>2</sup>	As	26585.7421875 mm <sup>2</sup>
I <sub>x</sub>	100042702 mm <sup>4</sup>	Z <sub>x</sub>	941578 mm <sup>3</sup>
I <sub>y</sub>	100042702 mm <sup>4</sup>	Z <sub>y</sub>	941578 mm <sup>3</sup>
Lateral Restraint	3900 mm c/c		

#### Loads

Total Area over Pole = 21.6 m<sup>2</sup>

Dead	5.40 Kn	Live	5.40 Kn
Wind Down	18.14 Kn	Snow	13.61 Kn
Moment wind	10.87 Kn-m	Moment snow	3.02 Kn-m
Phi	0.8	K8	0.75
K1 snow	0.8	K1 Dead	0.6
K1 wind	1		

#### Material

Peeling	Steaming	Normal	Dry Use
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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	383.29 Kn	PhiMnx Wind	20.53 Kn-m	PhiVnx Wind	62.96 Kn
PhiNcx Dead	229.98 Kn	PhiMnx Dead	12.32 Kn-m	PhiVnx Dead	37.77 Kn
PhiNcx Snow	306.63 Kn	PhiMnx Snow	16.43 Kn-m	PhiVnx Snow	50.36 Kn

**Checks**

$(M_x/\Phi M_{nx}) + (N/\Phi N_{cx}) = 0.61 < 1$  OK

$(M_x/\Phi M_{nx})^2 + (N/\Phi N_{cx}) = 0.36 < 1$  OK

Deflection at top under service lateral loads = 27.02 mm < 39.00 mm

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

**Assumed Soil Properties**

Gamma	18 Kn/m <sup>3</sup>	Friction angle	30 deg	Cohesion	0 Kn/m <sup>3</sup>
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 =	1450 mm	Pile embedment length
f1 =	3150 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

**Loads**

Moment Wind =	10.87 Kn-m	Moment Snow =	Kn-m
Shear Wind =	3.45 Kn	Shear Snow =	3.02 Kn

**Pile Properties**

Safety Factory	0.55	
Hu =	5.91 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	10.99 Kn-m	Ultimate Moment Capacity of Pile

**Checks**

Applied Forces/Capacities = 0.99 < 1 OK

**End Pole Design**

**Geometry For End Bay Pole**

**Geometry**

175 SED H5 (Minimum 200 dia. at Floor Level)	Dry Use	Height	3900 mm
Area	27598 mm <sup>2</sup>	As	20698.2421875 mm <sup>2</sup>

Pole Shed App Ver 01 2022

Ix	60639381 mm <sup>4</sup>	Zx	646820 mm <sup>3</sup>
Iy	60639381 mm <sup>4</sup>	Zy	646820 mm <sup>3</sup>
Lateral Restraint	mm c/c		

**Loads**

Total Area over Pole = 7.44006613392119 m<sup>2</sup>

Dead	1.86 Kn	Live	1.86 Kn
Wind Down	6.25 Kn	Snow	4.69 Kn
Moment Wind	4.18 Kn-m	Moment snow	1.16 Kn-m
Phi	0.8	K <sub>8</sub>	0.63
K <sub>1</sub> snow	0.8	K <sub>1</sub> Dead	0.6
K <sub>1</sub> wind	1		

**Material**

Peeling	Steaming	Normal	Dry Use
f <sub>b</sub> =	36.3 MPa	f <sub>s</sub> =	2.96 MPa
f <sub>c</sub> =	18 MPa	f <sub>p</sub> =	7.2 MPa
f <sub>t</sub> =	22 MPa	E =	9257 MPa

**Capacities**

PhiN <sub>cx</sub> Wind	250.93 Kn	PhiM <sub>nx</sub> Wind	11.86 Kn-m	PhiV <sub>nx</sub> Wind	49.01 Kn
PhiN <sub>cx</sub> Dead	150.56 Kn	PhiM <sub>nx</sub> Dead	7.12 Kn-m	PhiV <sub>nx</sub> Dead	29.41 Kn
PhiN <sub>cx</sub> Snow	200.75 Kn	PhiM <sub>nx</sub> Snow	9.49 Kn-m	PhiV <sub>nx</sub> Snow	39.21 Kn

**Checks**

$(M_x/\Phi M_{nx}) + (N/\Phi N_{cx}) = 0.39 < 1$  OK

$(M_x/\Phi M_{nx})^2 + (N/\Phi N_{cx}) = 0.16 < 1$  OK

Deflection at top under service lateral loads = 18.41 mm < 41.90 mm

D <sub>s</sub> =	0.6 mm	Pile Diameter
L =	1450 mm	Pile embedment length
f <sub>1</sub> =	3150 mm	Distance at which the shear force is applied
f <sub>2</sub> =	0 mm	Distance of top soil at rest pressure

**Loads**

Total Area over Pole = 7.44006613392119 m<sup>2</sup>

Moment Wind =	4.18 Kn-m	Moment Snow =	1.16 Kn-m
Shear Wind =	1.33 Kn	Shear Snow =	1.16 Kn

**Pile Properties**

Safety Factory	0.55		
H <sub>u</sub> =	5.91 Kn	Ultimate Lateral Strength of the Pile, Short pile	
M <sub>u</sub> =	10.99 Kn-m	Ultimate Moment Capacity of Pile	

**Checks**



Applied Forces/Capacities =  $0.38 < 1$  OK

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

### Assumed Soil Properties

Gamma	18 Kn/m <sup>3</sup>	Friction angle	30 deg	Cohesion	0 Kn/m <sup>3</sup>
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 =	1450 mm	Pile embedment length
f1 =	3150 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

### Loads

Moment Wind =	4.18 Kn-m	Moment Snow =	1.16 Kn-m
Shear Wind =	1.33 Kn	Shear Snow =	1.16 Kn

### Pile Properties

Safety Factory	0.55	
Hu =	5.91 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	10.99 Kn-m	Ultimate Moment Capacity of Pile

### Checks

Applied Forces/Capacities =  $0.38 < 1$  OK

## Uplift Check

Density of Concrete = 24 Kn/m<sup>3</sup>

Density of Timber Pole = 5 Kn/m<sup>3</sup>

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 (1450) x Ks (1.5) x 0.5 x tan(30) x Pi x Dia of Pile (0.6) x Height of Pile (1450)

Skin Friction = 16.98 Kn

Weight of Pile + Pile Skin Friction = 20.75 Kn

Uplift on one Pile = 15.23 Kn

Uplift is ok