

Job No.: EHB 850**Address:** 149 Butson Road, Athol, Southland, New Zealand**Date:** 30/05/2024**Latitude:** -45.488639**Longitude:** 168.711392**Elevation:** 432.5 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	1.74 KPa	Roof Snow Load	1.22 KPa
Earthquake Zone	2	Subsoil Category	D	Exposure Zone	B
Importance Level	2	Ultimate wind & Earthquake ARI	500 Years	Max Height	4.4 m
Wind Region	NZ2	Terrain Category	2.0	Design Wind Speed	48.74 m/s
Wind Pressure	1.43 KPa	Lee Zone	NO	Ultimate Snow ARI	150 Years
Wind Category	Very High	Earthquake ARI	500		

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 3.70 m $C_{p,e} = -0.9$ $p_e = -1.15$ KPa $p_{net} = -1.15$ KPa

For roof $C_{p,e}$ from 3.70 m To 7.40 m $C_{p,e} = -0.5$ $p_e = -0.64$ KPa $p_{net} = -0.64$ 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 14.40 m $C_{p,e} = 0.7$ $p_e = 0.90$ KPa $p_{net} = 1.33$ KPa

For side wall $C_{p,e}$ from 0 m To 3.70 m $C_{p,e} =$ $p_e = -0.83$ KPa $p_{net} = -0.83$ KPa

Maximum Upward pressure used in roof member Design = 1.15 KPa

Maximum Downward pressure used in roof member Design = 0.69 KPa

Maximum Wall pressure used in Design = 1.33 KPa

Maximum Racking pressure used in Design = 1.32 KPa

Design Summary**Purlin Design**

Purlin Spacing = 900 mm

Purlin Span = 4650 mm

Try Purlin 250x50 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 = 0.97

K8 Upward = 0.66 S1 Downward = 12.68 S1 Upward = 20.27

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

Capacity Checks

M _{1.35D}	0.82 Kn-m	Capacity	3.40 Kn-m	Passing Percentage	414.63 %
M _{1.2D+1.5L 1.2D+S_n 1.2D+W_nD_n}	3.7 Kn-m	Capacity	4.53 Kn-m	Passing Percentage	122.43 %
M _{0.9D-W_nUp}	-2.25 Kn-m	Capacity	-3.83 Kn-m	Passing Percentage	170.22 %
V _{1.35D}	0.71 Kn	Capacity	12.06 Kn	Passing Percentage	1698.59 %

Pole Shed App Ver 01 2022

V _{1.2D+1.5L 1.2D+Sn 1.2D+WnDn}	3.18 Kn	Capacity	16.08 Kn	Passing Percentage	505.66 %
V _{0.9D-WnUp}	-1.94 Kn	Capacity	-20.10 Kn	Passing Percentage	1036.08 %

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 = 7.22 mm Limit by Woolcock et al, 1999 Span/360 = 12.78 mm

Deflection under Dead and Service Wind = 10.16 mm Limit by Woolcock et al, 1999 Span/250 = 30.67 mm

Reactions

Maximum downward = 3.18 kn Maximum upward = -1.94 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 = 9450 mm Try Rafter 2x450x63 LVL13

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 = 6.68 S₁ Upward = 6.68

Shear Capacity of timber = 5.3 MPa Bending Capacity of timber = 48 MPa NZS3603 Amt 4, table 2.3

Capacity Checks

M _{1.35D}	18.08 Kn-m	Capacity	91.56 Kn-m	Passing Percentage	506.42 %
M _{1.2D+1.5L 1.2D+Sn 1.2D+WnDn}	81.44 Kn-m	Capacity	122.08 Kn-m	Passing Percentage	149.90 %
M _{0.9D-WnUp}	-49.56 Kn-m	Capacity	-152.6 Kn-m	Passing Percentage	307.91 %
V _{1.35D}	7.65 Kn	Capacity	96.64 Kn	Passing Percentage	1263.27 %
V _{1.2D+1.5L 1.2D+Sn 1.2D+WnDn}	34.47 Kn	Capacity	128.86 Kn	Passing Percentage	373.83 %
V _{0.9D-WnUp}	-20.98 Kn	Capacity	-161.08 Kn	Passing Percentage	767.78 %

Deflections

Modulus of Elasticity = 11000 MPa NZS3603 Amt 4, Table 2.3

k₂ for Long Term Loads = 2

Deflection under Dead and Live Load = 13.62 mm Limit by Woolcock et al, 1999 Span/360 = 26.67 mm

Deflection under Dead and Service Wind = 21.31 mm Limit by Woolcock et al, 1999 Span/250 = 64.00 mm

Reactions

Maximum downward = 34.47 kn Maximum upward = -20.98 kn

Rafter to Pole Connection check

Bolt Size = M16 Number of Bolts = 3

Calculations as per NZS 3603:1993 Amend 2005 clause 4.4

Joint Group for Rafters = J2 Joint Group for Pole = J5

Minimum Bolt edge, end and spacing for Load perpendicular to grains = 80 mm

Factor of Safety = 0.7

For Perpendicular to grain loading

$K_{11} = 12.6 \text{ fpj} = 22.7 \text{ Mpa}$ for Rafter with effective thickness = 126 mm

For Parallel to grain loading

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

Capacity under short term loads = 77.63 Kn > -20.98 Kn

Rafter Design External

External Rafter Load Width = 2400 mm

External Rafter Span = 4651 mm

Try Rafter 240x45 LVL11

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 = 13.82 S_1 Upward = 13.82

Shear Capacity of timber = 5 MPa Bending Capacity of timber = 38 MPa NZS3603 Amt 4, table 2.3

Capacity Checks

$M_{1.35D}$	2.19 Kn-m	Capacity	7.41 Kn-m	Passing Percentage	338.36 %
$M_{1.2D+1.5L \ 1.2D+S_n \ 1.2D+W_nD_n}$	9.86 Kn-m	Capacity	9.89 Kn-m	Passing Percentage	100.30 %
$M_{0.9D-W_nUp}$	-6.00 Kn-m	Capacity	-12.36 Kn-m	Passing Percentage	206.00 %
$V_{1.35D}$	1.88 Kn	Capacity	17.37 Kn	Passing Percentage	923.94 %
$V_{1.2D+1.5L \ 1.2D+S_n \ 1.2D+W_nD_n}$	8.48 Kn	Capacity	23.16 Kn	Passing Percentage	273.11 %
$V_{0.9D-W_nUp}$	-5.16 Kn	Capacity	-28.94 Kn	Passing Percentage	560.85 %

Deflections

Modulus of Elasticity = 9900 MPa NZS3603 Amt 4, Table 2.3

k_2 for Long Term Loads = 2

Deflection under Dead and Live Load = 9.70 mm

Limit by Woolcock et al, 1999 Span/360 = 13.33 mm

Deflection under Dead and Service Wind = 13.66 mm

Limit by Woolcock et al, 1999 Span/250 = 32.00 mm

Reactions

Maximum downward = 8.48 kn Maximum upward = -5.16 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 = J2 Joint Group for Pole = J5

Factor of Safety = 0.7

For Perpendicular to grain loading

$K_{11} = 12.6 \text{ fpj} = 22.7 \text{ Mpa}$ for Rafter with effective thickness = 45 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) = -28.35 kn > -5.16 Kn

Single Shear Capacity under short term loads = -14.56 Kn > -5.16 Kn

Girt Design Front and Back

Girt's Spacing = 1300 mm

Girt's Span = 2400 mm

Try Girt 200x50 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 = 0.75 S_1 Downward = 11.27 S_1 Upward = 18.41

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

Capacity Checks

$M_{Wind+Snow}$	1.24 Kn-m	Capacity	2.79 Kn-m	Passing Percentage	225.00 %
$V_{0.9D-WnUp}$	2.07 Kn	Capacity	16.08 Kn	Passing Percentage	776.81 %

Deflections

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

Deflection under Snow and Service Wind = 6.41 mm

Limit by Woolcock et al, 1999 Span/250 = 9.60 mm

Sag during installation = 2.01 mm

Reactions

Maximum = 2.07 kn

Girt Design Sides

Girt's Spacing = 900 mm

Girt's Span = 2400 mm

Try Girt 200x50 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 = 0.75 S_1 Downward = 11.27 S_1 Upward = 18.41

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

Capacity Checks

$M_{Wind+Snow}$	0.86 Kn-m	Capacity	2.79 Kn-m	Passing Percentage	324.42 %
$V_{0.9D-WnUp}$	1.44 Kn	Capacity	16.08 Kn	Passing Percentage	1116.67 %

Deflections

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

Deflection under Snow and Service Wind = 4.44 mm

Limit by Woolcock et al. 1999 Span/100 = 9.60 mm

Sag during installation = 2.01 mm

Reactions

Maximum = 1.44 kn

Middle Pole Design

Geometry

250 SED H5 (Minimum 275 dia. at Floor Level)	Dry Use	Height	3400 mm
Area	54091 mm ²	As	40568.5546875 mm ²
Ix	232952248 mm ⁴	Zx	1774874 mm ³
Iy	232952248 mm ⁴	Zx	1774874 mm ³
Lateral Restraint	3400 mm c/c		

Loads

Total Area over Pole = 23.04 m²

Dead	5.76 Kn	Live	5.76 Kn
Wind Down	15.90 Kn	Snow	28.11 Kn
Moment wind	22.94 Kn-m	Moment snow	9.16 Kn-m
Phi	0.8	K8	0.97
K1 snow	0.8	K1 Dead	0.6
K1 wind	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	751.80 Kn	PhiMnx Wind	49.75 Kn-m	PhiVnx Wind	96.07 Kn
PhiNcx Dead	451.08 Kn	PhiMnx Dead	29.85 Kn-m	PhiVnx Dead	57.64 Kn
PhiNcx Snow	601.44 Kn	PhiMnx Snow	39.80 Kn-m	PhiVnx Snow	76.85 Kn

Checks

$(M_x/\Phi M_{nx}) + (N/\Phi N_{cx}) = 0.52 < 1$ OK

$(M_x/\Phi M_{nx})^2 + (N/\Phi N_{cx}) = 0.27 < 1$ OK

Deflection at top under service lateral loads = 22.36 mm < 22.67 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 =	$(1 + \sin(30)) / (1 - \sin(30))$				

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Geometry For Middle Bay Pole

Ds =	0.6 mm	Pile Diameter
L =	1900 mm	Pile embedment length
f1 =	3300 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

Loads

Moment Wind =	22.94 Kn-m	Moment Snow =	Kn-m
Shear Wind =	6.95 Kn	Shear Snow =	9.16 Kn

Pile Properties

Safety Factory	0.55	
Hu =	11.75 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	23.46 Kn-m	Ultimate Moment Capacity of Pile

Checks

Applied Forces/Capacities = 0.98 < 1 OK

End Pole Design

Geometry For End Bay Pole

Geometry

200 SED H5 (Minimum 225 dia. at Floor Level)	Dry Use	Height	4200 mm
Area	35448 mm ²	As	26585.7421875 mm ²
Ix	100042702 mm ⁴	Zx	941578 mm ³
Iy	100042702 mm ⁴	Zy	941578 mm ³
Lateral Restraint	mm c/c		

Loads

Total Area over Pole = 11.52 m²

Dead	2.88 Kn	Live	2.88 Kn
Wind Down	7.95 Kn	Snow	14.05 Kn
Moment Wind	7.65 Kn-m	Moment snow	3.05 Kn-m
Phi	0.8	K8	0.68
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	348.02 Kn	PhiMnx Wind	18.64 Kn-m	PhiVnx Wind	62.96 Kn
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PhiNcx Dead	208.81 Kn	PhiMnx Dead	11.19 Kn-m	PhiVnx Dead	37.77 Kn
PhiNcx Snow	278.42 Kn	PhiMnx Snow	14.91 Kn-m	PhiVnx Snow	50.36 Kn

Checks

$$(M_x/\Phi M_{nx}) + (N/\Phi N_{cx}) = 0.48 < 1 \text{ OK}$$

$$(M_x/\Phi M_{nx})^2 + (N/\Phi N_{cx}) = 0.24 < 1 \text{ OK}$$

$$\text{Deflection at top under service lateral loads} = 22.41 \text{ mm} < 29.26 \text{ mm}$$

Ds =	0.6 mm	Pile Diameter
L =	1900 mm	Pile embedment length
f1 =	3300 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

Loads

$$\text{Total Area over Pole} = 11.52 \text{ m}^2$$

Moment Wind =	7.65 Kn-m	Moment Snow =	3.05 Kn-m
Shear Wind =	2.32 Kn	Shear Snow =	3.05 Kn

Pile Properties

Safety Factory	0.55	
Hu =	11.75 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	23.46 Kn-m	Ultimate Moment Capacity of Pile

Checks

$$\text{Applied Forces/Capacities} = 0.33 < 1 \text{ OK}$$

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 =	1900 mm	Pile embedment length
f1 =	3300 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

Loads

Moment Wind =	7.65 Kn-m	Moment Snow =	3.05 Kn-m
Shear Wind =	2.32 Kn	Shear Snow =	3.05 Kn

Pile Properties

Safety Factory	0.55
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Hu =	11.75 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	23.46 Kn-m	Ultimate Moment Capacity of Pile

Checks

Applied Forces/Capacities = 0.33 < 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(1900) x Ks(1.5) x 0.5 x tan(30) x Pi x Dia of Pile(0.6) x Height of Pile(1900)

Skin Friction = 29.16 Kn

Weight of Pile + Pile Skin Friction = 32.97 Kn

Uplift on one Pile = 21.31 Kn

Uplift is ok