

Job No.: EHB 211-1
Latitude: -46.418876

Address: 19 Norwood Street, Invercargill, New Zealand
Longitude: 168.39318

Date: 14/06/2024
Elevation: 14 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	2	Ultimate wind & Earthquake ARI	500 Years	Max Height	3.1 m
Wind Region	NZ4	Terrain Category	3.0	Design Wind Speed	38.91 m/s
Wind Pressure	0.91 KPa	Lee Zone	NO	Ultimate Snow ARI	150 Years
Wind Category	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 = Gable Enclosed

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

For roof $C_{p,e}$ from 0 m To 2.90 m $C_{p,e} = -0.9$ $p_e = -0.74$ KPa $p_{net} = -0.74$ KPa

For roof $C_{p,e}$ from 2.90 m To 5.80 m $C_{p,e} = -0.5$ $p_e = -0.41$ KPa $p_{net} = -0.41$ 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 6.40 m $C_{p,e} = 0.7$ $p_e = 0.57$ KPa $p_{net} = 0.84$ KPa

For side wall $C_{p,e}$ from 0 m To 2.90 m $C_{p,e} =$ $p_e = -0.53$ KPa $p_{net} = -0.53$ KPa

Maximum Upward pressure used in roof member Design = 0.74 KPa

Maximum Downward pressure used in roof member Design = 0.43 KPa

Maximum Wall pressure used in Design = 0.84 KPa

Maximum Racking pressure used in Design = 0.82 KPa

Design Summary

Purlin Design

Purlin Spacing = 900 mm

Purlin Span = 2650 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 = 0.84 S1 Downward = 9.63 S1 Upward = 16.37

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

Capacity Checks

$M_{1.35D}$	0.27 Kn-m	Capacity	1.26 Kn-m	Passing Percentage	466.67 %
$M_{1.2D+1.5L 1.2D+S_n 1.2D+W_nD_n}$	0.97 Kn-m	Capacity	1.68 Kn-m	Passing Percentage	173.20 %
$M_{0.9D-W_nUp}$	-0.41 Kn-m	Capacity	-1.77 Kn-m	Passing Percentage	59.20 %
$V_{1.35D}$	0.40 Kn	Capacity	7.24 Kn	Passing Percentage	1810.00 %

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V _{1.2D+1.5L 1.2D+Sn 1.2D+WnDn}	1.11 Kn	Capacity	9.65 Kn	Passing Percentage	869.37 %
V _{0.9D-WnUp}	-0.61 Kn	Capacity	-12.06 Kn	Passing Percentage	1977.05 %

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 = 3.41 mm	Limit by Woolcock et al, 1999 Span/360 = 7.22 mm
Deflection under Dead and Service Wind = 4.06 mm	Limit by Woolcock et al, 1999 Span/250 = 17.33 mm

Reactions

Maximum downward = 1.11 kn Maximum upward = -0.61 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 = 2800 mm Internal Rafter Span = 3050 mm Try Rafter 2x610x45 LVL11

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 = 11.05 S₁ Upward = 11.05

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

Capacity Checks

M _{1.35D}	1.10 Kn-m	Capacity	90.18 Kn-m	Passing Percentage	8198.18 %
M _{1.2D+1.5L 1.2D+Sn 1.2D+WnDn}	3.03 Kn-m	Capacity	120.24 Kn-m	Passing Percentage	3968.32 %
M _{0.9D-WnUp}	-1.68 Kn-m	Capacity	-150.28 Kn-m	Passing Percentage	8945.24 %
V _{1.35D}	1.44 Kn	Capacity	88.28 Kn	Passing Percentage	6130.56 %
V _{1.2D+1.5L 1.2D+Sn 1.2D+WnDn}	3.97 Kn	Capacity	117.7 Kn	Passing Percentage	2964.74 %
V _{0.9D-WnUp}	-2.20 Kn	Capacity	-147.14 Kn	Passing Percentage	6688.18 %

Deflections

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

k₂ for Long Term Loads = 2

Deflection under Dead and Live Load = 0.06 mm	Limit by Woolcock et al, 1999 Span/360 = 8.89 mm
Deflection under Dead and Service Wind = 0.08 mm	Limit by Woolcock et al, 1999 Span/250 = 21.33 mm

Reactions

Maximum downward = 3.97 kn Maximum upward = -2.20 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

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

Factor of Safety = 0.7

For Perpendicular to grain loading

$K_{11} = 12.6$ fpj = 22.7 Mpa for Rafter with effective thickness = 90 mm

For Parallel to grain loading

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

Capacity under short term loads = 29.11 Kn > -2.20 Kn

Rafter Design External

External Rafter Load Width = 1400 mm

External Rafter Span = 3056 mm

Try Rafter 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_1 Medium term = 0.8 K_1 Long term = 0.6 $K_4 = 1$ $K_5 = 1$ K_8 Downward = 1.00

K_8 Upward = 1.00 S_1 Downward = 11.27 S_1 Upward = 11.27

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

Capacity Checks

$M_{1.35D}$	0.55 Kn-m	Capacity	2.23 Kn-m	Passing Percentage	405.45 %
$M_{1.2D+1.5L \ 1.2D+S_n \ 1.2D+W_nD_n}$	1.52 Kn-m	Capacity	2.97 Kn-m	Passing Percentage	195.39 %
$M_{0.9D-W_nUp}$	-0.84 Kn-m	Capacity	-3.72 Kn-m	Passing Percentage	442.86 %
$V_{1.35D}$	0.72 Kn	Capacity	9.65 Kn	Passing Percentage	1340.28 %
$V_{1.2D+1.5L \ 1.2D+S_n \ 1.2D+W_nD_n}$	1.99 Kn	Capacity	12.86 Kn	Passing Percentage	646.23 %
$V_{0.9D-W_nUp}$	-1.10 Kn	Capacity	-16.08 Kn	Passing Percentage	1461.82 %

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 = 3.19 mm

Limit by Woolcock et al, 1999 Span/360 = 8.89 mm

Deflection under Dead and Service Wind = 3.80 mm

Limit by Woolcock et al, 1999 Span/250 = 21.33 mm

Reactions

Maximum downward = 1.99 kn Maximum upward = -1.10 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

$K_{11} = 14.9$ fpj = 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) = -14.70 kn > -1.10 Kn

Single Shear Capacity under short term loads = -10.84 Kn > -1.10 Kn

Girt Design Front and Back

Girt's Spacing = 1300 mm

Girt's Span = 2800 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 = 0.82 S_1 Downward = 9.63 S_1 Upward = 16.99

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

Capacity Checks

$M_{Wind+Snow}$	1.07 Kn-m	Capacity	1.71 Kn-m	Passing Percentage	159.81 %
$V_{0.9D-WnUp}$	1.53 Kn	Capacity	12.06 Kn	Passing Percentage	788.24 %

Deflections

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

Deflection under Snow and Service Wind = 16.23 mm

Limit by Woolcock et al, 1999 Span/250 = 11.20 mm

Sag during installation = 3.73 mm

Reactions

Maximum = 1.53 kn

Girt Design Sides

Girt's Spacing = 600 mm

Girt's Span = 3200 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 = 0.76 S_1 Downward = 9.63 S_1 Upward = 18.16

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

Capacity Checks

$M_{Wind+Snow}$	0.65 Kn-m	Capacity	1.60 Kn-m	Passing Percentage	246.15 %
$V_{0.9D-WnUp}$	0.81 Kn	Capacity	12.06 Kn	Passing Percentage	1488.89 %

Deflections

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

Deflection under Snow and Service Wind = 12.78 mm

Limit by Woolcock et al. 1999 Span/100 = 12.80 mm

Sag during installation = 6.36 mm

Reactions

Maximum = 0.81 kn

Middle Pole Design

Geometry

175 UNI H5	Dry Use	Height	3050 mm
Area	24041 mm ²	As	18030.46875 mm ²
Ix	46015259 mm ⁴	Zx	525889 mm ³
Iy	46015259 mm ⁴	Zx	525889 mm ³
Lateral Restraint	3400 mm c/c		

Loads

Total Area over Pole = 8.96 m²

Dead	2.24 Kn	Live	2.24 Kn
Wind Down	3.85 Kn	Snow	5.64 Kn
Moment wind	2.75 Kn-m	Moment snow	1.30 Kn-m
Phi	0.8	K8	0.70
K1 snow	0.8	K1 Dead	0.6
K1 wind	1		

Material

Shaving	Steaming	Normal	Dry Use
fb =	34.325 MPa	fs =	2.96 MPa
fc =	18 MPa	fp =	7.2 MPa
ft =	20.75 MPa	E =	8793 MPa

Capacities

PhiNcx Wind	241.67 Kn	PhiMnx Wind	10.08 Kn-m	PhiVnx Wind	42.70 Kn
PhiNcx Dead	145.00 Kn	PhiMnx Dead	6.05 Kn-m	PhiVnx Dead	25.62 Kn
PhiNcx Snow	193.34 Kn	PhiMnx Snow	8.06 Kn-m	PhiVnx Snow	34.16 Kn

Checks

$(M_x/\Phi M_{nx}) + (N/\Phi N_{cx}) = 0.32 < 1$ OK

$(M_x/\Phi M_{nx})^2 + (N/\Phi N_{cx}) = 0.12 < 1$ OK

Deflection at top under service lateral loads = 9.03 mm < 20.33 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 =	1300 mm	Pile embedment length
f1 =	2325 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

Loads

Moment Wind =	2.75 Kn-m	Moment Snow =	Kn-m
Shear Wind =	1.18 Kn	Shear Snow =	1.30 Kn

Pile Properties

Safety Factory	0.55	
Hu =	5.40 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	7.57 Kn-m	Ultimate Moment Capacity of Pile

Checks

Applied Forces/Capacities = 0.36 < 1 OK

End Pole Design

Geometry For End Bay Pole

Geometry

150 UNI H5	Dry Use	Height	2900 mm
Area	17663 mm ²	As	13246.875 mm ²
Ix	24837891 mm ⁴	Zx	331172 mm ³
Iy	24837891 mm ⁴	Zy	331172 mm ³
Lateral Restraint	mm c/c		

Loads

Total Area over Pole = 4.48 m²

Dead	1.12 Kn	Live	1.12 Kn
Wind Down	1.93 Kn	Snow	2.82 Kn
Moment Wind	1.38 Kn-m	Moment snow	0.65 Kn-m
Phi	0.8	K8	0.70
K1 snow	0.8	K1 Dead	0.6
K1wind	1		

Material

Shaving	Steaming	Normal	Dry Use
fb =	34.325 MPa	fs =	2.96 MPa
fc =	18 MPa	fp =	7.2 MPa
ft =	20.75 MPa	E =	8793 MPa

Capacities

PhiNcx Wind	178.81 Kn	PhiMnx Wind	6.39 Kn-m	PhiVnx Wind	31.37 Kn
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PhiNcx Dead	107.29 Kn	PhiMnx Dead	3.84 Kn-m	PhiVnx Dead	18.82 Kn
PhiNcx Snow	143.05 Kn	PhiMnx Snow	5.11 Kn-m	PhiVnx Snow	25.09 Kn

Checks

$$(M_x/\Phi M_{nx}) + (N/\Phi N_{cx}) = 0.25 < 1 \text{ OK}$$

$$(M_x/\Phi M_{nx})^2 + (N/\Phi N_{cx}) = 0.08 < 1 \text{ OK}$$

$$\text{Deflection at top under service lateral loads} = 8.48 \text{ mm} < 20.61 \text{ mm}$$

Ds =	0.6 mm	Pile Diameter
L =	1300 mm	Pile embedment length
f1 =	2325 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

Loads

$$\text{Total Area over Pole} = 4.48 \text{ m}^2$$

Moment Wind =	1.38 Kn-m	Moment Snow =	0.65 Kn-m
Shear Wind =	0.59 Kn	Shear Snow =	0.65 Kn

Pile Properties

Safety Factory	0.55	
Hu =	5.40 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	7.57 Kn-m	Ultimate Moment Capacity of Pile

Checks

$$\text{Applied Forces/Capacities} = 0.18 < 1 \text{ OK}$$

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 =	2325 mm	Distance at which the shear force is applied
f2 =	0 mm	Distance of top soil at rest pressure

Loads

Moment Wind =	1.38 Kn-m	Moment Snow =	0.65 Kn-m
Shear Wind =	0.59 Kn	Shear Snow =	0.65 Kn

Pile Properties

Safety Factory	0.55
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Hu =	5.40 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	7.57 Kn-m	Ultimate Moment Capacity of Pile

Checks

Applied Forces/Capacities = $0.18 < 1$ 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 π x Dia of Pile(0.6) x Height of Pile(1300)

Skin Friction = 13.65 Kn

Weight of Pile + Pile Skin Friction = 17.68 Kn

Uplift on one Pile = 4.61 Kn

Uplift is ok