

**Job No.:** EHB 855

**Address:** LOT 1 90 Millwood Glen, Invercargill, New Zealand

**Date:** 8/2/2022

**Latitude:** -46.403034

**Longitude:** 168.429613

**Elevation:** 20 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 ARI	100 Years	Max Height	4.25 m
Wind Region	NZ4	Terrain Category	2.0	Design Wind Speed	42.77 m/s
Wind Pressure	1.1 KPa	Lee Zone	NO	Ultimate ARI	100 Years
Wind Category	High				

### Pressure Coefficients and Pressures

Shed Type = Gable Open

For roof  $C_{p,i} = -0.45$

For roof  $C_{p,e}$  from 0 m To 5 m  $C_{p,e} = -0.66$   $p_e = -0.37$  KPa  $p_{net} = -0.81$  KPa

For roof  $C_{p,e}$  from 5 m To 10 m  $C_{p,e} = -0.5$   $p_e = -0.27$  KPa  $p_{net} = -0.71$  KPa

For wall Windward  $C_{p,i} = 0.58$  side Wall  $C_{p,i} = -0.3$

For wall Windward and Leeward  $C_{p,e}$  from 0 m To 18 m  $C_{p,e} = 0.7$   $p_e = 0.62$  KPa  $p_{net} = 1.24$  KPa

For side wall  $C_{p,e}$  from 0 m To 4.25 m  $C_{p,e} =$   $p_e = -0.58$  KPa  $p_{net} = 0.44$  KPa

Maximum Upward pressure used in roof member Design = 0.81 KPa

Maximum Downward pressure used in roof member Design = 0.80 KPa

Maximum Wall pressure used in Design = 1.24 KPa

Maximum Racking pressure used in Design = 0.99 KPa

### Design Summary

#### Purlin Design

Purlin Spacing = 900 mm

Purlin Span = 4300 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)

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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 <sub>1.35D</sub>	0.7 Kn-m	Capacity	2.39 Kn-m	Passing Percentage	<b>341.43 %</b>
M <sub>1.2D+1.5L 1.2D+Sn 1.2D+WnDn</sub>	2.29 Kn-m	Capacity	3.18 Kn-m	Passing Percentage	<b>138.86 %</b>
M <sub>0.9D-WnUp</sub>	-1.22 Kn-m	Capacity	-1.88 Kn-m	Passing Percentage	<b>154.10 %</b>
V <sub>1.35D</sub>	0.65 Kn	Capacity	9.65 Kn	Passing Percentage	<b>1484.62 %</b>
V <sub>1.2D+1.5L 1.2D+Sn 1.2D+WnDn</sub>	2.13 Kn	Capacity	12.86 Kn	Passing Percentage	<b>603.76 %</b>
V <sub>0.9D-WnUp</sub>	-1.13 Kn	Capacity	-16.08 Kn	Passing Percentage	<b>1423.01 %</b>

**Deflections**

Modulus of Elasticity = 8000 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 = 9.01 mm      Limit by AS1170.0 Table C1 Span/250 = 17.20 mm

Deflection under Dead and Service Wind = 13.52 mm      Limit by AS1170.0 Table C1 Span/120 = 35.83 mm

**Reactions**

Maximum downward = 2.13 kn    Maximum upward = -1.13 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 = 9850 mm      Try Rafter 2x360x63 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 = 5.90    S1 Upward = 5.90

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

**Capacity Checks**

M <sub>1.35D</sub>	18.42 Kn-m	Capacity	70.4 Kn-m	Passing Percentage	<b>382.19 %</b>
M <sub>1.2D+1.5L 1.2D+Sn 1.2D+WnDn</sub>	60.03 Kn-m	Capacity	93.86 Kn-m	Passing Percentage	<b>156.36 %</b>

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M <sub>0.9D-WnUp</sub>	-31.93 Kn-m	Capacity	-117.34 Kn-m	Passing Percentage	<b>367.49 %</b>
V <sub>1.35D</sub>	7.48 Kn	Capacity	77.32 Kn	Passing Percentage	<b>1033.69 %</b>
V <sub>1.2D+1.5L 1.2D+Sn 1.2D+WnDn</sub>	24.38 Kn	Capacity	103.08 Kn	Passing Percentage	<b>422.81 %</b>
V <sub>0.9D-WnUp</sub>	-12.97 Kn	Capacity	-128.86 Kn	Passing Percentage	<b>993.52 %</b>

**Deflections**

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

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

Deflection under Dead and Live Load = 29.36 mm      Limit by AS1170.0 Table C1 Span/250 = 40.00 mm

Deflection under Dead and Service Wind = 48.93 mm      Limit by AS1170.0 Table C1 Span/120 = 83.33 mm

**Reactions**

Maximum downward = 24.38 kn    Maximum upward = -12.97 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<sub>11</sub> = 12.6 fpj = 22.7 Mpa for Rafter with effective thickness = 126 mm

For Parallel to grain loading

K<sub>11</sub> = 2.0 fcj = 36.1 Mpa for Pole with effective thickness = 100 mm

Capacity under short term loads = 29.11 Kn > -12.97 Kn

**Rafter Design External**

External Rafter Load Width = 2250 mm      External Rafter Span = 4966 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<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 = 0.94

K8 Upward =0.94    S1 Downward =13.93    S1 Upward =13.93

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>	2.34 Kn-m	Capacity	4.72 Kn-m	Passing Percentage	<b>201.71 %</b>
M <sub>1.2D+1.5L 1.2D+S<sub>n</sub> 1.2D+W<sub>n</sub>D<sub>n</sub></sub>	7.63 Kn-m	Capacity	6.30 Kn-m	Passing Percentage	<b>82.57 %</b>
M <sub>0.9D-W<sub>n</sub>Up</sub>	-4.06 Kn-m	Capacity	-7.87 Kn-m	Passing Percentage	<b>193.84 %</b>
V <sub>1.35D</sub>	1.89 Kn	Capacity	14.47 Kn	Passing Percentage	<b>765.61 %</b>
V <sub>1.2D+1.5L 1.2D+S<sub>n</sub> 1.2D+W<sub>n</sub>D<sub>n</sub></sub>	6.15 Kn	Capacity	19.30 Kn	Passing Percentage	<b>313.82 %</b>
V <sub>0.9D-W<sub>n</sub>Up</sub>	-3.27 Kn	Capacity	-24.12 Kn	Passing Percentage	<b>737.61 %</b>

#### Deflections

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

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

Deflection under Dead and Live Load = 9.04 mm      Limit by AS1170.0 Table C1 Span/250 = 20.00 mm

Deflection under Dead and Service Wind = 13.56 mm      Limit by AS1170.0 Table C1 Span/120 = 41.67 mm

#### Reactions

Maximum downward =6.15 kn    Maximum upward = -3.27 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<sub>11</sub> = 14.9 f<sub>pj</sub> = 12.9 Mpa for Rafter with effective thickness = 50 mm

For Parallel to grain loading

K<sub>11</sub> = 2.0 f<sub>cj</sub> = 36.1 Mpa for Pole with effective thickness = 100 mm

Eccentric Load check

V = phi x k<sub>1</sub> x k<sub>4</sub> x k<sub>5</sub> x f<sub>s</sub> x b x d<sub>s</sub> ..... (Eq 4.12) = -25.20 kn > -3.27 Kn

Single Shear Capacity under short term loads = -10.84 Kn > -3.27 Kn

## Intermediate Design Sides

Intermediate Spacing = 2500 mm      Intermediate Span = 3450 mm      Try Intermediate 2x150x50 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 = 1.00      S1 Downward = 9.63      S1 Upward = 0.60

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>	2.31 Kn-m	Capacity	4.72 Kn-m	Passing Percentage	<b>204.33 %</b>
V <sub>0.9D-WnUp</sub>	2.67 Kn-m	Capacity	24.12 Kn-m	Passing Percentage	<b>903.37 %</b>

### Deflections

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

Deflection under Snow and Service Wind = 64.96 mm      Limit by AS1170.0 Table C1 Span/120 = 28.75 mm

### Reactions

Maximum = 2.67 kn

## Girt Design Front and Back

Girt's Spacing = 900 mm      Girt's Span = 4500 mm      Try Intermediate 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 = 0.60      S1 Downward = 9.63      S1 Upward = 21.54

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>	1.41 Kn-m	Capacity	1.41 Kn-m	Passing Percentage	<b>100.00 %</b>
V <sub>0.9D-WnUp</sub>	1.26 Kn-m	Capacity	12.06 Kn-m	Passing Percentage	<b>957.14 %</b>

### Deflections

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Modulus of Elasticity = 8000 MPa NZS3603 Amt 4, Table 2.3

Deflection under Snow and Service Wind = 39.94 mm      Limit by AS1170.0 Table C1 Span/120 = 37.50 mm  
Sag during installation = 20.82 mm

**Reactions**

Maximum = 1.26 kn

**Middle Pole Design**

**Geometry**

150 SED H5 (Minimum 200 dia. at Floor Level)	Dry Use	Height	3300 mm
Area	31400 mm <sup>2</sup>	As	23550 mm <sup>2</sup>
I <sub>x</sub>	78500000 mm <sup>4</sup>	Z <sub>x</sub>	785000 mm <sup>3</sup>
I <sub>y</sub>	78500000 mm <sup>4</sup>	Z <sub>y</sub>	785000 mm <sup>3</sup>
Lateral Restraint	3300 mm c/c		

**Loads**

Total Area over Pole = 22.5 m<sup>2</sup>

Dead	5.63 Kn	Live	5.63 Kn
Wind	18.00 Kn	Snow	14.18 Kn
Moment wind	Kn-m	Moment snow	4.29 Kn-m
Phi	0.8	K <sub>8</sub>	0.84
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	378.83 Kn	PhiM <sub>nx</sub> Wind	19.10 Kn-m	PhiV <sub>nx</sub> Wind	55.77 Kn
PhiN <sub>cx</sub> Dead	227.30 Kn	PhiM <sub>nx</sub> Dead	11.46 Kn-m	PhiV <sub>nx</sub> Dead	33.46 Kn
PhiN <sub>cx</sub> Snow	303.06 Kn	PhiM <sub>nx</sub> Snow	15.28 Kn-m	PhiV <sub>nx</sub> Snow	44.61 Kn

**Checks**

$$(M_x/\phi M_{nx}) + (N/\phi N_{cx}) = 0.87 < 1 \text{ OK}$$

$$(M_x/\phi M_{nx})^2 + (N/\phi N_{cx}) = 0.70 < 1 \text{ OK}$$

$$\text{Deflection at top under service lateral loads} = 40.81 \text{ mm} < 44.00 \text{ mm}$$

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

### **Soil Properties**

Gamma 18 Kn/m<sup>3</sup>      Friction angle 30 deg      Cohesion 0 Kn/m<sup>3</sup>

$$K_0 = (1 - \sin(30)) / (1 + \sin(30))$$

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

### **Geometry For Middle Bay Pole**

Ds = 600 mm      Pile Diameter  
L = 1650 mm      Pile embedment length  
f1 = 3188 mm      Distance at which the shear force is applied  
f2 = 0 mm      Distance of top soil at rest pressure

### **Loads**

Moment Wind = 15.05 Kn-m      Moment Snow = Kn-m  
Shear Wind = 4.72 Kn      Shear Snow = 4.29 Kn

### **Pile Properties**

Safety Factory 0.55  
Hu = 8.27 Kn      Ultimate Lateral Strength of the Pile, Short pile  
Mu = 15.76 Kn-m      Ultimate Moment Capacity of Pile

### **Checks**

$$\text{Applied Forces/Capacities} = 0.95 < 1 \text{ OK}$$

## **End Pole Design**

### **Geometry For End Bay Pole**

Ds = 600 mm      Pile Diameter  
L = 1300 mm      Pile embedment length  
f1 = 3188 mm      Distance at which the shear force is applied  
f2 = 0 mm      Distance of top soil at rest pressure

**Loads**

Total Area over Pole = 5.625 m<sup>2</sup>

Moment Wind =	5.02 Kn-m	Moment Snow =	1.43 Kn-m
Shear Wind =	1.57 Kn	Shear Snow =	1.43 Kn

**Pile Properties**

Safety Factory	0.55	
Hu =	4.36 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	8.13 Kn-m	Ultimate Moment Capacity of Pile

**Checks**

Applied Forces/Capacities = 0.62 < 1 OK

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

**Soil Properties**

Gamma	18 Kn/m <sup>3</sup>	Friction angle	30 deg	Cohesion	0 Kn/m <sup>3</sup>
K <sub>0</sub> =	$(1 - \sin(30)) / (1 + \sin(30))$				
K <sub>p</sub> =	$(1 + \sin(30)) / (1 - \sin(30))$				

**Geometry For End Bay Pole**

Ds =	600 mm	Pile Diameter
L =	1300 mm	Pile embedment length
f <sub>1</sub> =	3188 mm	Distance at which the shear force is applied
f <sub>2</sub> =	0 mm	Distance of top soil at rest pressure

**Loads**

Moment Wind =	5.02 Kn-m	Moment Snow =	1.43 Kn-m
Shear Wind =	1.57 Kn	Shear Snow =	1.43 Kn

**Pile Properties**

Safety Factory	0.55	
Hu =	4.36 Kn	Ultimate Lateral Strength of the Pile, Short pile
Mu =	8.13 Kn-m	Ultimate Moment Capacity of Pile

**Checks**



Applied Forces/Capacities =  $0.62 < 1$  OK

## **Uplift Check**

Density of Concrete =  $24 \text{ Kn/m}^3$

Density of Timber Pole =  $5 \text{ Kn/m}^3$

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

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

Formula to calculate Skin Friction = Safety factor ( $0.55$ )  $\times$  Density of Soil( $18$ )  $\times$  Height of Pile( $1650$ )  $\times$   $K_s$ ( $1.5$ )  $\times$   $\tan(30)$   $\times$   $\pi \times$  Dia of Pile( $0.6$ )  $\times$  Height of Pile( $1650$ )

Skin Friction =  $21.99 \text{ Kn}$

Weight of Pile + Pile Skin Friction =  $26.54 \text{ Kn}$

Uplift on one Pile =  $13.16 \text{ Kn}$

Uplift is ok