renature.co.nz
admin@renature.co.nz
PO Box 331051
Takapuna 0740

Tamaki Pathway

Boardwalk and Bridge

Structural Calculations

Prepared For:

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Project Brief

reNature has been engaged by Auckland Council to provide the engineering professional services for the structural design of a range of timber boardwalks & glulam bridge structures and a retained concrete path for the Tamaki Pathway upgrades.

Design Philosophy

The timber boardwalks and glulam bridges have been designed as simply supported, single span structures. The foundations have been designed as driven timber piles or timber piles in concrete filled holes.

With respect to design loadings and barriers, this structure has been designed in accordance with Standards New Zealand's *Tracks and Outdoor Visitor Structures,* SNZ HB 8630:2004. The Handbook refer to numerous Standards including NZS 4203 *General Structural Design Loadings for Buildings* (now superseded by AS/NZS 1170 *Structural Design Actions*), NZS 3109 *Concrete Construction*, and NZS 3602 *Timber and wood based products for use in Building*. Refer to page 5 of HB 8630.

The following codes have also been used on designing this structure:

☒ NZS 3404: Steel Structures Standard
☒ NZS AS 1720: Timber Structures Standard
☐ NZS 3101: Concrete Structures Standard
☐ AS/NZS 1170: Structural Design Actions

Compliance with the New Zealand Building Code

SNZ HB8630 has been developed as an alternative means of achieving compliance with the New Zealand Building Code. This Handbook has been developed to provide solutions with respect to the loadings, durability, access, and safety barrier requirements which are more appropriate to outdoor visitor structures.

Amendment 8 to B1 Structure of the Building Code (Acceptable Solutions and Verification Methods) in December 2008 stated, "For the design of outdoor visitor structures as defined in SNZ HB 8630: 2004, the imposed actions must be as given by that publication with references to NZS 4203 replaced by equivalent references to AS/NZS 1170."

B1: Structure		Alternative Solution: HB 8630: 2004
☒	Table 6	Visitor group factor
☒	Table 7	Consequence of failure factor
☒	Table 8	Basic live loads
☐	Table 9	Basic live loads for restricted load structures
☒	Table 10	Basic live loads for barriers

B2: Durability		Alternative Solution: HB 8630: 2004
☒	Table 12	Timber components
☒	Table 13	Protection of timber fixings

☒	Table 14	Protection of steel components
☐	Table 15	Protection of cable structure hardware

D1: Access Routes		Alternative Solution: HB 8630: 2004
☒	Table 17	Minimum access widths
☒	Table 18	Maximum structure gradients
☐	Table 19	Stairway classification

F4: Safety from Falling		Alternative Solution: HB 8630: 2004
☒	Table 20	Fall height calculations
☒	Table 21	Fall surface assessment
☒	Table 22	Barrier types for given effective fall height in relation to visitor group

1.0 2.0m Wide Boardwalk - 200 × 50 Joists

Requirements

- For use on TP2
- UR user group
- 2.0m wide

HB 8630 – Design Details

		Notes:
Structure	Boardwalk	2.0m wide
Structure Type	Access	
Site User Group	UR (Urban Residential)	K_{VG} = 1.0
Fall Surface Category	Favourable	
Effective Fall Height (H_E)	H_{eff} < 3.0m	K_{FF} = 0.9
Basic Design Load	3.60 kPa	4.0kPa × 1.0 × 0.9
Concentrated Load	1.8 kN	SNZ HB 8630 3.5.1
Barrier Type	Type 'B' both sides	SNZ HB 8630 3.21.1
Basic Barrier Design Load	0.75 kN/m	SNZ HB 8630 3.6.1
Corrosion Zone	Zone D	
Design Lateral Loading	10% of Basic Design Load	
Foundations	Driven timber piles	C3.9 HB 8630: *"It is recognised that outdoor visitor structures are basic non-habitable buildings. They will sometimes be located on unstable ground and subject to natural hazards."*

1.1 Decking Planks

Try 150 × 50 G8 Timber decking planks with 25mm by 7mm R-Grip wet pour inserts

Bending M^* = PL / 4

1.5 × 1.8 kN × 0.67m / 4

0.45 kN

$\phi M = \phi \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 1 \times 0.85 \times 1 \times 1 \times 14.0 \text{ MPa} \times 0.04623 \times 10^{-3}$

0.44 kNm

→ 0.45 / 0.44 = 1.02 ~ 1 OK

Use 150 × 50 G8 Timber decking planks with R-Grip wet pour inserts, max span 0.67m fixed with 2/ 100 × 4mm FH nails per joist

1.2 Joists

Try 4/ 200 × 50 G8 joists

Dead Load

G	decking	6 × 0.05 × 2.1	0.63 kN/m
	joists	6 × 4 × 0.05 × 0.20	0.24 kN/m
	blocking	6 × 0.05 × 0.20 × 1.8 / 1.5	0.07 kN/m
	barrier	2 × 0.20	0.40 kN/m
	fixings	*bolts, tie bars, washer etc.*	0.05 kN/m
			w_G = 1.39 kN/m

Live Load

Q 4.0 kPa × 2.0 m × 0.9 (k_{FF}) × 1.0 (k_{VG}) w_Q = 7.20 kN/m

ULS udl $1.2\ w_G + 1.5\ w_Q$

1.2 × 1.39 kN/m + 1.5 × 7.20 kN/m w^* = 12.47 kN/m

per joist $^1/_4$ × 12.47 kN/m w_{JOIST}^* = 3.12 kN/m

Bending

$M^* = w_{JOIST}^* L^2 / 8$

3.12 kN/m × $(2.8m)^2$ / 8

3.06 kNm

ø	0.8	
k_1	0.94	*NZS AS 1720.1 Table 2.3*
k_4	0.85 (20% MC)	*NZS AS 1720.1 2.4.2.3*
g_{31}	1.0	
g_{32}	1.24	
s	667mm	
L	2800mm	
k_9	1.13	*NZS AS 1720.1 2.4.5*
ρ_b	0.76	*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25\ (d / b)\ (L_{ay} / d)^{0.5}$	*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25\ (200 / 50)\ (1500 / 200)^{0.5}$	
	13.7	
$\rho_b S_1$	10.4	
k_{12}	0.98	*NZS AS 1720.1 3.2.4*

øM = $\phi \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.94 \times 0.85 \times 1.13 \times 0.98 \times 14.0$ MPa $\times (50 \times 200^2 / 6)$

3.30 kNm

→ 3.06 / 3.30 = 0.93 < 1 OK

Shear

V* = $^1/_2\ w_{JOIST}{*}\ L$

$^1/_2$ 3.12 kN/m × 2.8m

4.37 kN

øV = $\phi \times k_1 \times k_4 \times f_S \times ⅔\ b \times d$

$0.8 \times 0.94 \times 0.85 \times 3.7$ MPa $\times (⅔ \times 0.05$ m $\times 0.20$ m)

15.77 kN

→ 4.37 / 15.77 = 0.28 < 1 OK

Short Term Deflection

SLS udl $w_G + \psi_s w_Q$

1.39 kN/m + 1.0 × 7.20 kN/m w_s = 8.59 kN/m

per joist = $w_s / 4$ $w_{s\ beam}$ = 2.15 kN/m

Δ_s = $^5/_{384}\ (wL^4 / EI)$

$^5/_{384}\ (2.15 \times (2.80)^4$ / 6.7 GPa $\times (0.05 \times 0.20^3) / 12)$

7.70mm

→ 7.70 / (2800 / 200) = 0.55 < 1 OK

Δ_{1kN} = $^1/_{48}\ (PL^3 / EI)$

$^1/_{48}\ (1.0 / 2 \times (2.80)^3$ / 6.7 GPa $\times (0.05 \times 0.20^3) / 12)$

0.51mm

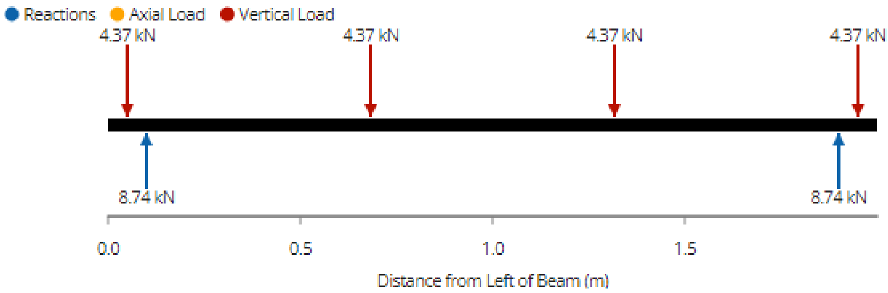
→ 0.51 / 2.00 = 0.26 < 1 OK

Use 4/ 200 × 50 G8 joists with max 2.8m span
With 200 × 50 G8 blocking at max 1500 centres

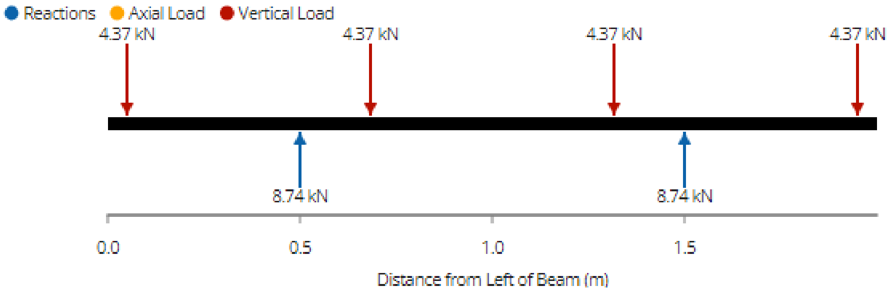
1.3 Bearers

Try 200 × 50 H5 bearer

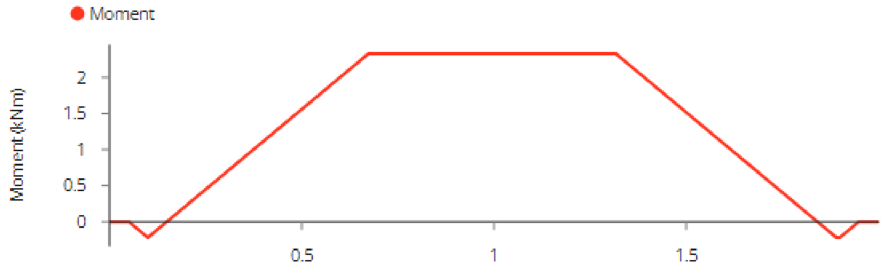
Case 1: 1.8m pile centres



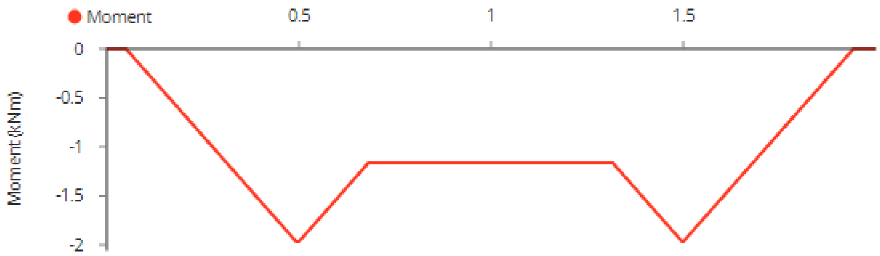
Case 2: 1.0m pile cetres



Bending



M* = 2.33 kNm



M* = 1.97 kNm

ρ_b	0.76	*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25\ (d / b)\ (L_{ay} / d)^{0.5}$	*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25\ (200 / 50)\ (1800 / 200)^{0.5}$	
	15.0	
$\rho_b S_1$	11.4	
k_{12}	0.93	*NZS AS 1720.1 3.2.4*

$\text{ø}M =$ $\text{ø} \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.94 \times 0.7 \times 1.0 \times 0.93 \times 14.0\text{ MPa} \times (50 \times 200^2 / 6)$

3.07 kNm

→ 2.33 / 3.07 = 0.76 < 1 OK

Shear

$V^* =$ 4.37 kN

$\text{ø}V =$ $\text{ø} \times k_1 \times k_4 \times f_S \times \frac{2}{3} b \times d$

$0.8 \times 0.94 \times 0.85 \times 3.7\text{ MPa} \times (\frac{2}{3} \times 0.05\text{ m} \times 0.20\text{ m})$

15.77 kN

→ 4.37 / 15.77 = 0.28 < 1 OK

Check bearing of joists on bearers

$N^* =$ V^*

4.37 kN

$\text{ø}N_{d,p} =$ $\text{ø} \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.94 \times 0.7 \times 1.20 \times 6.9\text{ MPa} \times 2{,}500\text{mm}^2$

10.90 kN

→ 4.37 / 10.90 = 0.40 < 1 OK

Use 200 × 50 H5 bearers

1.4 Piles

Try 150 SED H5 piles with 30mm notch

Check Bearing between Bearer and Pile

$N^*_b =$ 8.74 kN

$^2/_3$ Chord length 80mm

k_7 1.15 *NZS AS 1720.1 Table 2.6*

$\text{ø}N_{d,p} =$ $\text{ø} \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.8 \times 0.7 \times 1.15 \times 6.9\text{ MPa} \times 2{,}516\text{mm}^2$

8.94 kN

→ 8.74 / 8.94 = 0.98 < 1 OK

Use 150mm SED piles notched 30mm with 2/ M12 SS Eng bolts

1.5 Foundations

Unfactored Load

$w_s =$ 8.59 kN/m

$N_B^* =$ w_s L / 2

8.59 kN/m × 2.8m / 2

12.03 kN

In reference to geotechnical report LTA23155, the following conditions have been assumed:

- 540 kPa Ultimate Geotechnical End Bearing Capacity;
- 30 kPa Ultimate Geotechnical Skin Friction, to be ignored for the upper 1.5m of pile length;
- Lateral load resistance may be based upon cu = 40 kPa below depths of 1.5m;
- Strength reduction factors of 0.5 and 0.6 for static and seismic load cases respectively should be applied to the ultimate capacities given above.

Try 150 SED H5 driven timber piles

$N_B =$ $q_{ULS} \times A_{BASE}$

$0.5 \times 540 \text{ kPa} \times (\pi \times 0.15^2) / 4$

4.77 kN

$N_s =$ $q_{skin} \times A_{skin}$

$0.5 \times 30 \text{ kPa} \times (\pi \times 0.15 \times 1.5)$

10.60 kN

øN = $N_B + N_s$

4.77 kN + 10.60 kN

15.37 kN

→ 12.03 / 15.37 = 0.78 < 1 OK

$N_H =$ $3 \times N_B^*$

3 × 12.03 kN

36.1 kN

Check lateral and seismic loads

Lateral load

$Q_L =$ Q × 0.1 *(10% of design live load)*

(1.5 × 4.0 kPa) × 2.0m × 2.8m / 2 × 0.1

1.68 kN

Earthquake Load

Conservative assumption, take W = G

G_L = G × 0.5 *(50% of dead load)*

(1.2 × 1.39 kN/m) × 2.8m / 2 × 0.5

1.17 kN

(lateral load resistance assumed only below 1.5m due to cohesion only – conservative approach)

P_p = ø × cu × (D – 1.5m) × d

0.5 × 40 kPa × (3.0m – 1.5m) × 0.15m

4.50 kN

→ 1.68 / 4.50 = 0.37 < 1 OK

Use 150 SED H5 driven timber piles
driven to achieve min. 37 kN ultimate bearing capacity using Hiley formula
Min. 3000 pile embedment depth (min. 1500 into good ground)

1.6 Baluster posts

Try 100 × 100 G8 @ 1.0m centres

Barrier height 1100 mm

w = 0.75 kN/m *NZS HB 8630 3.6.1*

L = 1.0 m *max spacing between posts (centres)*

h = 1.2 m *height top rail to upper bolt*

Z_{EFF} = $b_{EFF} \times d_{EFF}^2$ /6 *reduced Z due to bolt hole and taper by location of upper bolt hole*

= (100mm – 14mm) × $(100mm)^2$ / 6

= 143,333mm^3

Bending

M* = w × k_{FF} × L × h

1.5 × 0.75 kN/m × 0.9 × 1.0m × 1.2m

1.21 kNm

S_1 = 1.25 (d / b) $(L_{ay} / d)^{0.5}$

1.25 (100 / 100) $(1200 / 100)^{0.5}$

4.33

ρ_b = 0.76

k_{12} = 1.0

øM = ø × k_1 × k_4 × k_9 × k_{12} × f_b × Z

0.8 × 0.97 × 0.85 × 1.0 × 1.0 × 14.0 MPa × (143,333) × 10^{-6}

1.32 kNm

→ 1.21 / 1.32 = 0.92 < 1 OK

Fixing $N^* = M^* / d$

1.21 / 0.15

8.07 kN

Check compression under 50×50 washer

$øN = ø \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.97 \times 0.85 \times 1.0 \times 6.9\ \text{MPa} \times (0.05\text{m} \times 0.05\ \text{m} - \pi \times (0.012\text{m})^2 / 4)$

11.33 kN

→ 8.07 / 11.33 = 0.71 < 1 OK

Posts: 100 × 100mm, at max 1000 mm centres
Fix with 2/ M12 SS Eng bolts at min 150mm centres

1.7 Top Rail

Try 140 × 45 G8 dressed top rail with 20mm radius to top edges

Bending $M_{UDL}^* = w^* \times L^2 / 8$ *with udl from SNZ HB 8630 3.6.1*

$(1.5 \times 0.75\ \text{kN/m}) \times 1.0^2 / 8$

0.14 kNm

$øM = ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.97 \times 0.85 \times 1.0 \times 1.0 \times 14.0\ \text{MPa} \times (0.14 \times 0.045^2 / 6)$

0.44 kNm

→ 0.14 / 0.44 = 0.32 < 1 OK

Fixing $V_{PL}^* = 1.5 \times 0.5$ kN *Assume point load at fixing location*

0.75 kN

by inspection OK

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140 x 45 G8 dressed top rail with 20mm radius to top edges.
Fix with 2/ 14G × 100 SS bugle head batten screws.

2.0 2.0m Wide Boardwalk – 2-200 × 50 Joists

Requirements

- For use on TP2
- UR user group
- 2.0m wide

HB 8630 – Design Details

		Notes:
Structure	Boardwalk	2.0m wide
Structure Type	Access	
Site User Group	UR (Urban Residential)	K_{VG} = 1.0
Fall Surface Category	Favourable	
Effective Fall Height (H_E)	H_{eff} < 3.0m	K_{FF} = 0.9
Basic Design Load	3.60 kPa	4.0kPa × 1.0 × 0.9
Concentrated Load	1.8 kN	SNZ HB 8630 3.5.1
Barrier Type	Type 'B' both sides	SNZ HB 8630 3.21.1
Basic Barrier Design Load	0.75 kN/m	SNZ HB 8630 3.6.1
Corrosion Zone	Zone D	
Design Lateral Loading	10% of Basic Design Load	
Foundations	Driven timber piles	C3.9 HB 8630: *"It is recognised that outdoor visitor structures are basic non-habitable buildings. They will sometimes be located on unstable ground and subject to natural hazards."*

2.1 Decking Planks

Try 150 × 50 G8 Timber decking planks with 25mm by 7mm R-Grip wet pour inserts

Bending $M^* =$ PL / 4

1.5 × 1.8 kN × 0.67m / 4

0.45 kN

$\phi M =$ $\phi \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 1 \times 0.85 \times 1 \times 1 \times 14.0 \text{ MPa} \times 0.04623 \times 10^{-3}$

0.44 kNm

→ 0.45 / 0.44 = 1.02 ~ 1 OK

Use 150 × 50 G8 Timber decking planks with R-Grip wet pour inserts, max span 0.67m fixed with 2/ 100 × 4mm FH nails per joist

2.2 Joists

Try 4/ 2-200 × 50 G8 joists

Dead Load

G	decking	6 × 0.05 × 2.1	0.63 kN/m
	joists	6 × 8 × 0.05 × 0.20	0.48 kN/m
	blocking	6 × 0.05 × 0.20 × 1.6 / 1.5	0.06 kN/m
	barrier	2 × 0.20	0.40 kN/m
	fixings	*bolts, tie bars, washer etc.*	0.05 kN/m
			w_G = 1.62 kN/m

Live Load

Q 4.0 kPa × 2.0 m × 0.9 (k_{FF}) × 1.0 (k_{VG}) w_Q = 7.20 kN/m

ULS udl $1.2\ w_G + 1.5\ w_Q$

1.2 × 1.62 kN/m + 1.5 × 7.20 kN/m w^* = 12.74 kN/m

per joist $^1/_4$ × 12.74 kN/m w_{JOIST}^* = 3.19 kN/m

Bending

$M^* = w_{JOIST}^*\ L^2 / 8$

3.19 kN/m × $(4.2\text{m})^2$ / 8

7.03 kNm

ø	0.8	
k_1	0.94	*NZS AS 1720.1 Table 2.3*
k_4	0.85 (20% MC)	*NZS AS 1720.1 2.4.2.3*
g_{31}	1.14	
g_{32}	1.31	
s	667mm	
L	4200mm	
k_9	1.26	*NZS AS 1720.1 2.4.5*
ρ_b	0.76	*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25\ (d / b)\ (L_{ay} / d)^{0.5}$	*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25\ (200 / 100)\ (1500 / 200)^{0.5}$	
	6.85	
$\rho_b S_1$	5.20	
k_{12}	1.00	*NZS AS 1720.1 3.2.4*

$\phi M =$ $\phi \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.94 \times 0.85 \times 1.26 \times 1.00 \times 14.0$ MPa $\times (100 \times 200^2 / 6)$

7.52 kNm

→ 7.03 / 7.52 = 0.93 < 1 OK

Shear

$V^* =$ $^1/_2\ w_{JOIST} * L$

$^1/_2$ 3.19 kN/m × 4.2m

6.70 kN

$\phi V =$ $\phi \times k_1 \times k_4 \times f_S \times \frac{2}{3}\, b \times d$

$0.8 \times 0.94 \times 0.85 \times 3.7$ MPa $\times (\frac{2}{3} \times 0.10$ m $\times 0.20$ m$)$

31.54 kN

→ 6.70 / 31.5 = 0.21 < 1 OK

Short Term Deflection

SLS udl $w_G + \psi_s w_Q$

1.62 kN/m + 1.0 × 7.20 kN/m $w_s =$ 8.82 kN/m

per joist = $w_s / 4$ $w_{s\ beam}$ = 2.21 kN/m

$\Delta_s =$ $^5/_{384}\ (wL^4 / EI)$

$^5/_{384}\ (2.21 \times (4.20)^4 / 6.7$ GPa $\times (0.10 \times 0.20^3) / 12)$

20.0mm

→ 20.0 / (4200 / 200) = 0.95 < 1 OK

$\Delta_{1kN} =$ $^1/_{48}\ (PL^3 / EI)$

$^1/_{48}\ (1.0 / 2 \times (4.20)^3 / 6.7$ GPa $\times (0.10 \times 0.20^3) / 12)$

1.73mm

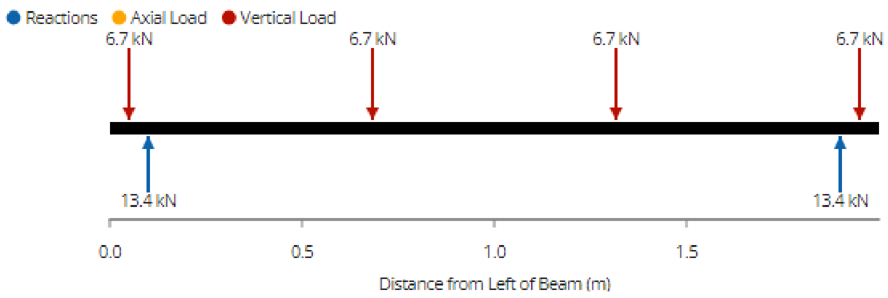
→ 1.73 / 2.00 = 0.87 < 1 OK

Use 4/ 2-200 × 50 G8 joists with max 4.2m span
With 200 × 50 G8 blocking at max 1500 centres

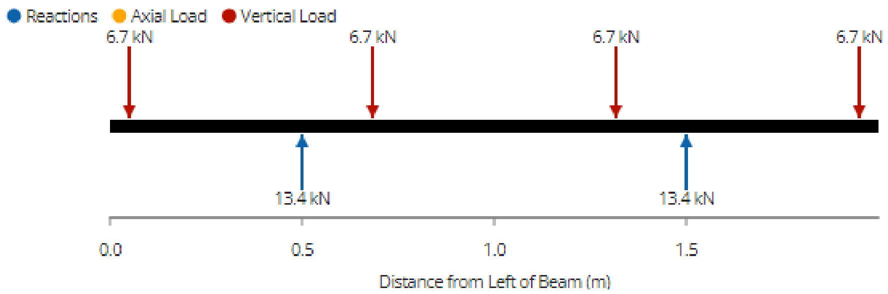
2.3 Bearers

Try 200 × 75 H5 bearer

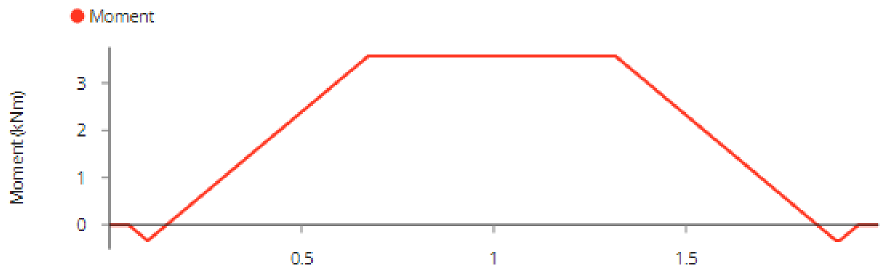
Case 1: 1.8m pile centres



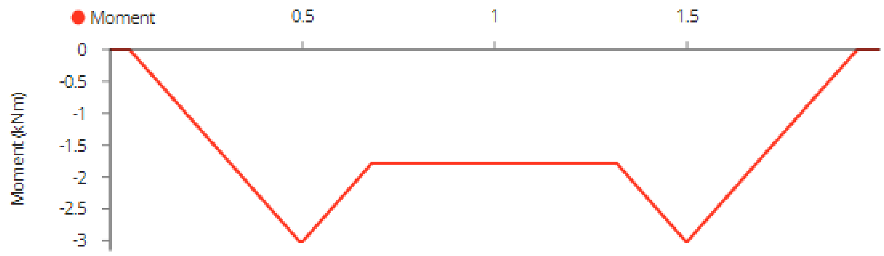
Case 2: 1.0m pile cetres



Bending



M* = 3.57 kNm



M* = 3.02 kNm

ρ_b	0.76	*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25\ (d / b)\ (L_{ay} / d)^{0.5}$	*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25\ (200 / 75)\ (1800 / 200)^{0.5}$	
	10.0	
$\rho_b S_1$	7.60	
k_{12}	1.0	*NZS AS 1720.1 3.2.4*

$\phi M =$ $\phi \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$
$0.8 \times 0.94 \times 0.7 \times 1.0 \times 1.00 \times 14.0$ MPa $\times (75 \times 200^2 / 6)$
3.68 kNm

→ 3.57 / 3.68 = 0.97 < 1 OK

Shear

$V^* =$ 6.70 kN

$\phi V =$ $\phi \times k_1 \times k_4 \times f_S \times \frac{2}{3} b \times d$
$0.8 \times 0.94 \times 0.85 \times 3.7$ MPa $\times (\frac{2}{3} \times 0.075$ m $\times 0.20$ m)
23.65 kN

→ 6.70 / 23.65 = 0.28 < 1 OK

Check bearing of joists on bearers

$N^* =$ V^*
6.70 kN

$\phi N_{d,p} =$ $\phi \times k_1 \times k_4 \times k_7 \times f_p \times A_p$
$0.8 \times 0.94 \times 0.7 \times 1.15 \times 6.9$ MPa $\times$ 7,500mm^2
31.3 kN

→ 6.70 / 31.3 = 0.21 < 1 OK

Use 200 × 75 H5 bearers

2.4 Piles

Try 200 SED H5 piles with 50mm notch

Check Bearing between Bearer and Pile

$N^*_b =$ 13.4 kN

$^2/_3$ Chord length 115.5mm
k_7 1.11 *NZS AS 1720.1 Table 2.6*

$\phi N_{d,p} =$ $\phi \times k_1 \times k_4 \times k_7 \times f_p \times A_p$
$0.8 \times 0.8 \times 0.7 \times 1.11 \times 6.9$ MPa $\times$ 6,142mm^2
21.07 kN

→ 13.4 / 21.07 = 0.64 < 1 OK

Use 200mm SED piles notched 50mm with 2/ M12 SS Eng bolts

2.5 Foundations

Unfactored Load

$w_s =$ 8.82 kN/m

$N_B^* =$ w_s L / 2
8.82 kN/m × 4.2m / 2
18.52 kN

Refer to Section 1.5 for geotechnical assumptions.

Try 200 SED H5 driven timber piles

$N_B =$ $q_{ULS} \times A_{BASE}$
0.5 × 540 kPa × (π × 0.20^2) / 4
8.48 kN

$N_s =$ $q_{skin} \times A_{skin}$
0.5 × 30 kPa × (π × 0.20 × 1.5)
14.14 kN

øN = $N_B + N_s$
8.48 kN + 14.14 kN
22.62 kN

→ 18.52 / 22.62 = 0.82 < 1 OK

$N_H =$ 3 × N_B^*
3 × 18.52 kN
55.6 kN

Check lateral and seismic loads

Lateral load

$Q_L =$ Q × 0.1 *(10% of design live load)*
(1.5 × 4.0 kPa) × 2.0m × 4.2m / 2 × 0.1
2.52 kN

Earthquake Load

Conservative assumption, take W = G

$G_L =$ G × 0.5 *(50% of dead load)*
(1.2 × 1.62 kN/m) × 4.2m / 2 × 0.5
2.04 kN

(lateral load resistance assumed only below 1.5m due to cohesion only – conservative approach)

P_p = ø × cu × (D – 1.5m) × d
0.5 × 40 kPa × (3.0m – 1.5m) × 0.20m
6.00 kN

→ 2.52 / 6.00 = 0.42 < 1 OK

Use 200 SED H5 driven timber piles
driven to achieve min. 56 kN ultimate bearing capacity using Hiley formula
Min. 3000 pile embedment depth (min. 1500 into good ground)

2.6 Baluster posts

Refer to Section 1.6 for detailed checks.

Posts: 100 × 100mm, at max 1000 mm centres
Fix with 2/ M12 SS Eng bolts at min 150mm centres

2.7 Top Rail

Refer to Section 1.7 for detailed checks.

---

140 x 45 G8 dressed top rail with 20mm radius to top edges.
Fix with 2/ 14G × 100 SS bugle head batten screws.

3.0 6m Timber Bridge

Requirements

- For use on TP2
- UR user group
- 2.0m wide

HB 8630 – Design Details

		Notes:
Structure	Timber Bridge	2.0m wide
Structure Type	Access	
Site User Group	UR (Urban Residential)	K_{VG} = 1.0
Fall Surface Category	Favourable	
Effective Fall Height (H_E)	H_{eff} < 3.0m	K_{FF} = 0.9
Basic Design Load	3.6 kPa	4.0kPa × 1.0 × 0.9
Concentrated Load	1.8 kN	SNZ HB 8630 3.5.1
Barrier Type	Type 'B' both sides	SNZ HB 8630 3.21.1
Basic Barrier Design Load	0.75 kN/m	SNZ HB 8630 3.6.1
Corrosion Zone	Zone D	
Design Lateral Loading	10% of Basic Design Load	
Foundations	Driven timber piles	C3.9 HB 8630: *"It is recognised that outdoor visitor structures are basic non-habitable buildings. They will sometimes be located on unstable ground and subject to natural hazards."*

3.1 Decking Planks

Try 150 × 50 G8 Timber decking planks with 25mm by 7mm R-Grip wet pour inserts

Bending $M^* =$ PL / 4

1.5 × 1.8 kN × 0.67m / 4

0.45 kN

$øM =$ $ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 1 \times 0.85 \times 1 \times 1 \times 14.0 \text{ MPa} \times 0.04623 \times 10^{-3}$

0.44 kNm

→ 0.45 / 0.44 = 1.02 ~ 1 OK

Use 150 × 50 G8 Timber decking planks with R-Grip wet pour inserts, max span 0.67m fixed with 2/ 100 × 4mm FH nails per joist

3.2 Joists

Try 4/ 2-300 × 50 G8 joists

Dead Load

G	decking	6 × 0.05 × 2.1	0.63 kN/m
	joists	6 × 8 × 0.05 × 0.30	0.72 kN/m
	blocking	6 × 0.05 × 0.30 × 1.6 / 1.5	0.10 kN/m
	barrier	2 × 0.20	0.40 kN/m
	fixings	*bolts, tie bars, washer etc.*	0.05 kN/m
			w_G = 1.90 kN/m

Live Load

Q 4.0 kPa × 2.0 m × 0.9 (k_{FF}) × 1.0 (k_{VG}) w_Q = 7.20 kN/m

ULS udl $1.2\, w_G + 1.5\, w_Q$

1.2 × 1.90 kN/m + 1.5 × 7.20 kN/m w^* = 13.08 kN/m

per joist $^1/_4$ × 13.08 kN/m w_{JOIST}^* = 3.27 kN/m

Bending

$M^* = w_{JOIST}^* L^2 / 8$

3.27 kN/m × $(6.4\text{m})^2$ / 8

16.74 kNm

ø	0.8	
k_1	0.94	*NZS AS 1720.1 Table 2.3*
k_4	0.85 (20% MC)	*NZS AS 1720.1 2.4.2.3*
g_{31}	1.14	
g_{32}	1.31	
s	667mm	
L	6400mm	
k_9	1.27	*NZS AS 1720.1 2.4.5*
ρ_b	0.76	*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25\,(d / b)\,(L_{ay} / d)^{0.5}$	*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25\,(300 / 100)\,(1500 / 300)^{0.5}$	
	8.38	
$\rho_b S_1$	6.37	
k_{12}	1.00	*NZS AS 1720.1 3.2.4*

$\varnothing M = \varnothing \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.94 \times 0.85 \times 1.27 \times 1.00 \times 14.0$ MPa $\times (100 \times 300^2 / 6)$

17.05 kNm

→ 16.74 / 17.04 = 0.98 < 1 OK

Shear

$V^* = {}^1/_2\, w_{JOIST} * L$

${}^1/_2$ 3.27 kN/m × 6.4m

10.46 kN

$\varnothing V = \varnothing \times k_1 \times k_4 \times f_S \times {}^2/_3\, b \times d$

0.8 × 0.94 × 0.85 × 3.7 MPa × (⅔ × 0.10 m × 0.30 m)

47.31 kN

→ 10.46 / 47.31 = 0.22 < 1 OK

Short Term Deflection

SLS udl $w_G + \psi_s w_Q$

1.90 kN/m + 1.0 × 7.20 kN/m w_s = 9.10 kN/m

per joist = $w_s / 4$ $w_{s\ beam}$ = 2.28 kN/m

$\Delta_s = {}^5/_{384} (wL^4 / EI)$

${}^5/_{384} (2.28 \times (6.4)^4 / 6.7\ \text{GPa} \times (0.10 \times 0.30^3) / 12)$

33.0mm

→ 33.0 / (6400 / 200) = 1.03 ~ 1 OK

$\Delta_{1kN} = {}^1/_{48} (PL^3 / EI)$

${}^1/_{48} (1.0 / 2 \times (6.4)^3 / 6.7\ \text{GPa} \times (0.10 \times 0.30^3) / 12)$

1.81mm

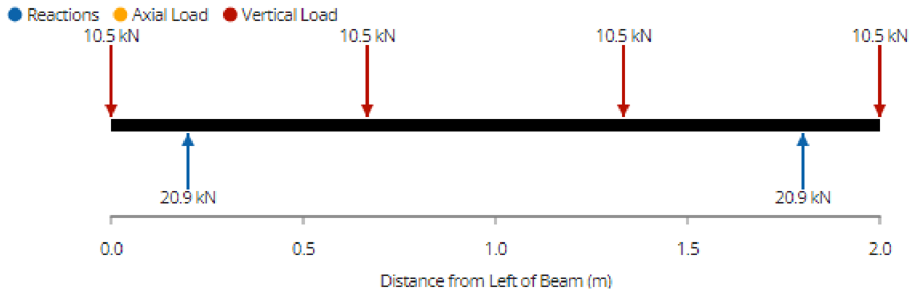
→ 1.81 / 2.00 = 0.92 < 1 OK

Use 4/ 2-300 × 50 G8 joists with max 6.4m span
With 300 × 50 G8 blocking at max 1500 centres

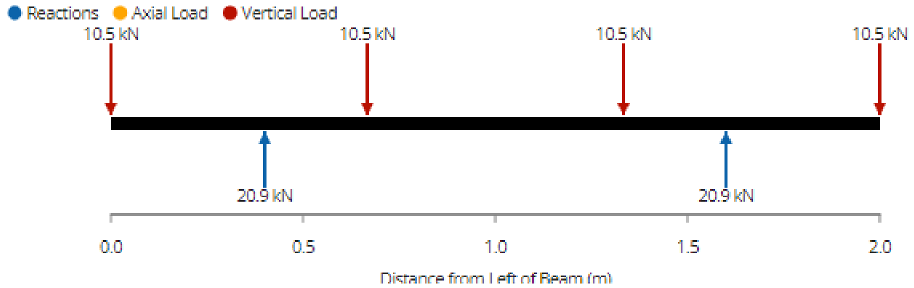
3.3 Bearers

Try 2/ 200 × 50 H6 bearers

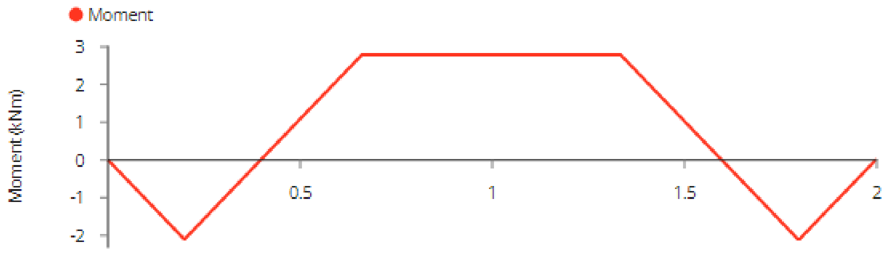
Case 1: 1.6m pile centres



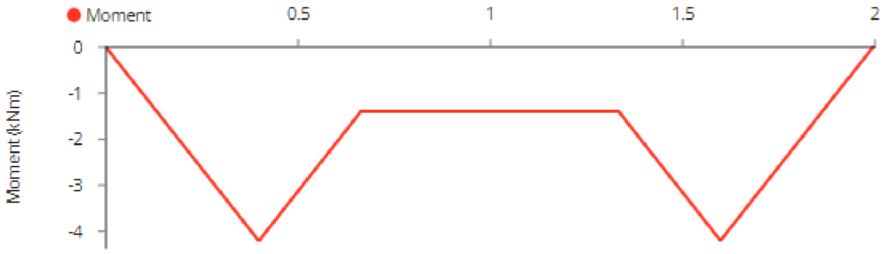
Case 2: 1.2m pile cetres



Bending



$M^* =$ 2.79 kNm



$M^* =$ 4.18 kNm

ρ_b	0.76	*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25\ (d / b)\ (L_{ay} / d)^{0.5}$	*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25\ (200 / 50)\ (1600 / 200)^{0.5}$	
	14.14	
$\rho_b S_1$	10.75	
k_{12}	0.96	*NZS AS 1720.1 3.2.4*

$\phi M =$ $\phi \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.94 \times 0.7 \times 1.0 \times 0.96 \times 14.0$ MPa $\times 2 \times (50 \times 200^2 / 6)$

4.72 kNm

→ 4.18 / 4.72 = 0.89 < 1 OK

Shear

$V^* =$ 10.46 kN

$\phi V =$ $\phi \times k_1 \times k_4 \times f_S \times \frac{2}{3}\, b \times d$

$0.8 \times 0.94 \times 0.85 \times 3.7$ MPa $\times 2 \times (\frac{2}{3} \times 0.05$ m $\times 0.20$ m)

31.53 kN

→ 10.46 / 31.53 = 0.33 < 1 OK

Check bearing of joists on bearers

$N^* =$ V^*

10.46 kN

$\phi N_{d,p} =$ $\phi \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.94 \times 0.7 \times 1.20 \times 6.9$ MPa $\times 2 \times 5{,}000\text{mm}^2$

43.59 kN

→ 10.46 / 43.59 = 0.24 < 1 OK

Use 2/ 200 × 50 H5 bearers

3.4 Piles

Try 200 SED H5 piles notched 50mm

Check Bearing between Bearer and Pile

$N^*_b =$ 20.9 kN

$^2/_3$ Chord length 115.5mm

k_7 1.11 *NZS AS 1720.1 Table 2.6*

$\phi N_{d,p} =$ $\phi \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.8 \times 0.7 \times 1.11 \times 6.9$ MPa $\times 2 \times 6{,}142\text{mm}^2$

42.14 kN

→ 20.9 / 42.14 = 0.50 < 1 OK

Use 200mm SED piles notched 50mm with 2/ M12 SS Eng bolts

3.5 Foundations

Unfactored Load

w_s = 9.10 kN/m

N_B* = w_s L / 4

9.10 kN/m × 6.4m / 4

14.6 kN

Refer to Section 1.5 for geotechnical assumptions.

Try 200 SED H5 driven timber piles

N_B = q_{ULS} × A_{BASE}

0.5 × 540 kPa × (π × 0.20^2) / 4

8.48 kN

N_s = q_{skin} × A_{skin}

0.5 × 30 kPa × (π × 0.20 × 1.5)

14.14 kN

øN = N_B + N_s

8.48 kN + 14.14 kN

22.62 kN

→ 14.6 / 22.62 = 0.65 < 1 OK

N_H = 3 × N_B*

3 × 14.6 kN

43.8 kN

Check lateral and seismic loads

Lateral load

Q_L = Q × 0.1 *(10% of design live load)*

(1.5 × 4.0 kPa) × 2.0m × 6.4m / 2 × 0.1

3.84 kN

Earthquake Load

Conservative assumption, take W = G

G_L = G × 0.5 *(50% of dead load)*

(1.2 × 1.90 kN/m) × 6.4m / 2 × 0.5

3.65 kN

(lateral load resistance assumed only below 1.5m due to cohesion only – conservative approach)

P_p = ø × cu × (D – 1.5m) × d

0.5 × 40 kPa × (3.0m – 1.5m) × 0.20m

6.00 kN

→ 3.84 / 6.00 = 0.64 < 1 OK

Use 200 SED H5 driven timber piles
driven to achieve min. 44 kN ultimate bearing capacity using Hiley formula
Min. 3000 pile embedment depth (min. 1500 into good ground)

3.6 Baluster posts

Refer to Section 1.6 for detailed checks.

Posts: 100 × 100mm, at max 1000 mm centres
Fix with 2/ M12 SS Eng bolts at min 150mm centres

3.7 Top Rail

Refer to Section 1.7 for detailed checks.

---

140 x 45 G8 dressed top rail with 20mm radius to top edges.
Fix with 2/ 14G × 100 SS bugle head batten screws.

4.0 2m Wide Boardwalk – 2-300 × 50 Joists

Requirements

- For use on TP1, TP3 & TP10
- UR user group
- 2.0m wide

HB 8630 – Design Details

		Notes:
Structure	Boardwalk	2.0m wide
Structure Type	Access	
Site User Group	UR (Urban Residential)	K_{VG} = 1.0
Fall Surface Category	Favourable	
Effective Fall Height (H_E)	H_{eff} > 3.0m	K_{FF} = 1.0
Basic Design Load	4.00 kPa	4.0kPa × 1.0 × 1.0
Concentrated Load	1.8 kN	SNZ HB 8630 3.5.1
Barrier Type	Type 'A' both sides	SNZ HB 8630 3.21.1
Basic Barrier Design Load	0.75 kN/m	SNZ HB 8630 3.6.1
Corrosion Zone	Zone D	
Design Lateral Loading	10% of Basic Design Load	
Foundations	Driven timber piles	C3.9 HB 8630: *"It is recognised that outdoor visitor structures are basic non-habitable buildings. They will sometimes be located on unstable ground and subject to natural hazards."*

4.1 Decking Planks

Try 150 × 50 G8 Timber decking planks with 25mm by 7mm R-Grip wet pour inserts

Bending $M^* =$ PL / 4

1.5 × 1.8 kN × 0.67m / 4

0.45 kN

$øM =$ $ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 1 \times 0.85 \times 1 \times 1 \times 14.0$ MPa $\times 0.04623 \times 10^{-3}$

0.44 kNm

→ 0.45 / 0.44 = 1.02 ~ 1 OK

Use 150 × 50 G8 Timber decking planks with R-Grip wet pour inserts, max span 0.67m fixed with 2/ 100 × 4mm FH nails per joist

4.2 Joists

Try 4/ 2-300 × 50 G8 joists

Dead Load

G	decking	6 × 0.05 × 2.3	0.69 kN/m
	joists	6 × 8 × 0.05 × 0.30	0.72 kN/m
	trimmer joists	6 × 2 × 0.05 × 0.30	0.18 kN/m
	blocking	6 × 0.05 × 0.30 × 1.8 / 1.5	0.11 kN/m
	barrier	2 × 0.30	0.60 kN/m
	fixings	*bolts, tie bars, washer etc.*	0.05 kN/m
			w_G = 2.35 kN/m

Live Load

Q   4.0 kPa × 2.0 m × 1.0 (k_{FF}) × 1.0 (k_{VG}) w_Q = 8.00 kN/m

ULS udl $1.2\,w_G + 1.5\,w_Q$

1.2×2.35 kN/m + 1.5×8.00 kN/m w^* = 14.82 kN/m

per joist $^1/_4 \times 14.82$ kN/m w_{JOIST}^* = 3.71 kN/m

Bending

$M^* = w_{JOIST}^* L^2 / 8$

3.71 kN/m × (6.0m)^2 / 8

16.70 kNm

ø	0.8	
k_1	0.94	*NZS AS 1720.1 Table 2.3*
k_4	0.85 (20% MC)	*NZS AS 1720.1 2.4.2.3*
g_{31}	1.14	
g_{32}	1.31	
s	667mm	
L	6000mm	
k_9	1.27	*NZS AS 1720.1 2.4.5*
ρ_b	0.76	*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25\,(d / b)\,(L_{ay} / d)^{0.5}$	*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25\,(300 / 100)\,(1500 / 300)^{0.5}$	
	8.39	
$\rho_b S_1$	6.37	
k_{12}	1.00	*NZS AS 1720.1 3.2.4*

$\phi M =$ $\phi \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.94 \times 0.85 \times 1.27 \times 1.00 \times 14.0$ MPa $\times (100 \times 300^2 / 6)$

17.05 kNm

→ 16.70 / 17.05 = 0.98 < 1 OK

Shear

$V^* =$ $^1/_2\ w_{JOIST} * L$

$^1/_2$ 3.71 kN/m × 6.0m

11.1 kN

$\phi V =$ $\phi \times k_1 \times k_4 \times f_S \times ⅔\ b \times d$

$0.8 \times 0.94 \times 0.85 \times 3.7$ MPa × (⅔ × 0.10 m × 0.30 m)

47.3 kN

→ 11.1 / 47.3 = 0.24 < 1 OK

Short Term Deflection

SLS udl $w_G + \psi_s w_Q$

2.35 kN/m + 1.0 × 8.00 kN/m $w_s =$ 10.35 kN/m

per joist = $w_s / 4$ $w_{s\ beam}$ = 2.59 kN/m

$\Delta_s =$ $^5/_{384}\ (wL^4 / EI)$

$^5/_{384}\ (2.59 \times (6.00)^4 / 6.7\ \text{GPa} \times (0.10 \times 0.30^3) / 12)$

29.0mm

→ 29.0 / (6000 / 200) = 0.97 < 1 OK

$\Delta_{1kN} =$ $^1/_{48}\ (PL^3 / EI)$

$^1/_{48}\ (1.0 / 2 \times (6.00)^3 / 6.7\ \text{GPa} \times (0.10 \times 0.30^3) / 12)$

1.49mm

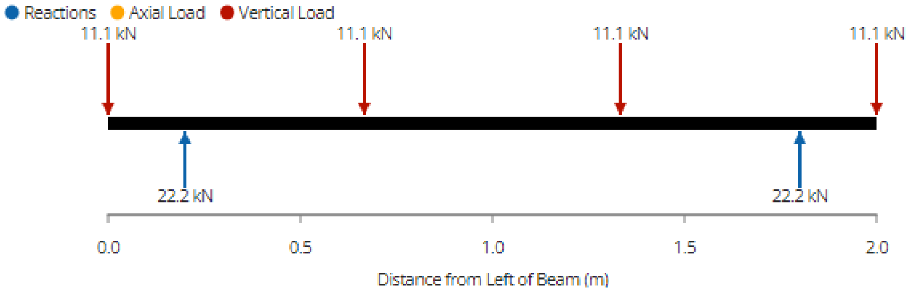
→ 1.49 / 2.00 = 0.75 < 1 OK

Use 4/ 2-300 × 50 G8 joists with max 6.0m span
With 300 × 50 G8 blocking at max 1500 centres

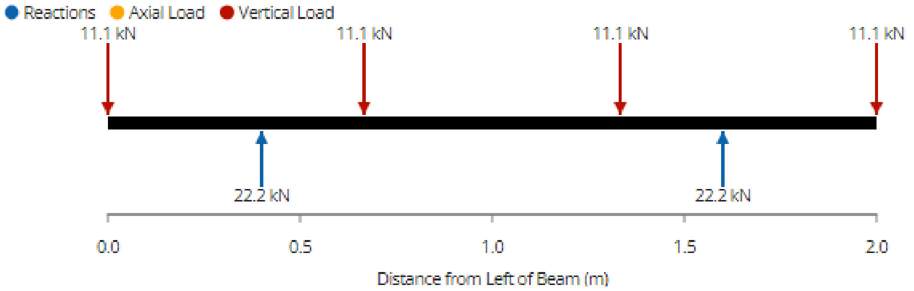
4.3 Bearers

Try 250 × 75 H5 bearer

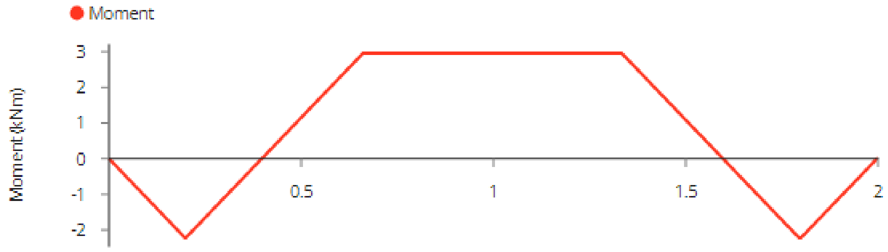
Case 1: 1.6m pile centres



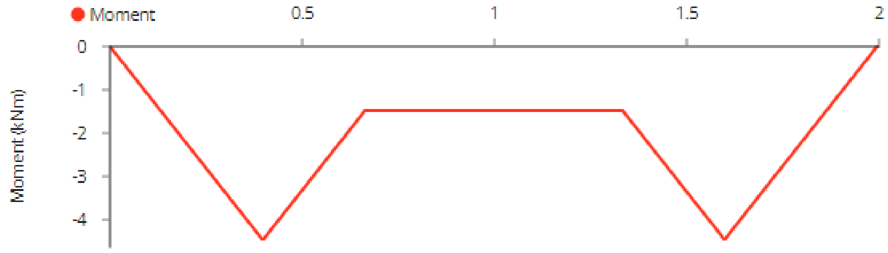
Case 2: 1.2m pile cetres



Bending



$M^* =$ 2.96 kNm



$M^* =$ 4.44 kNm

ρ_b	0.76	*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25\ (d / b)\ (L_{ay} / d)^{0.5}$	*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25\ (250 / 75)\ (1600 / 250)^{0.5}$	
	10.54	
$\rho_b S_1$	8.01	
k_{12}	1.00	*NZS AS 1720.1 3.2.4*

$\text{øM} = \quad ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.94 \times 0.7 \times 1.0 \times 1.00 \times 14.0\ \text{MPa} \times (75 \times 250^2 / 6)$

5.76 kNm

→ 4.44 / 5.76 = 0.77 < 1 OK

Shear

$V^* = \quad 11.1\ \text{kN}$

$\text{øV} = \quad ø \times k_1 \times k_4 \times f_S \times \tfrac{2}{3}\, b \times d$

$0.8 \times 0.94 \times 0.85 \times 3.7\ \text{MPa} \times (\tfrac{2}{3} \times 0.075\ \text{m} \times 0.25\ \text{m})$

29.6 kN

→ 11.1 / 29.6 = 0.38 < 1 OK

Check bearing of joists on bearers

$N^* = \quad V^*$

11.1 kN

$\text{ø}N_{d,p} = ø \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.94 \times 0.7 \times 1.15 \times 6.9\ \text{MPa} \times 7{,}500\text{mm}^2$

31.3 kN

→ 11.1 / 31.3 = 0.35 < 1 OK

Use 250 × 75 H5 bearers

4.4 Piles

Try 200 SED H5 piles notched 50mm

Check Bearing between Bearer and Pile

$N^*_b = \quad 22.2\ \text{kN}$

$^2/_3$ Chord length 115.5mm

k_7 1.11 *NZS AS 1720.1 Table 2.6*

$\text{ø}N_{d,p} = ø \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.8 \times 0.7 \times 1.11 \times 6.9\ \text{MPa} \times 6{,}142\text{mm}^2$

21.1 kN

→ 22.2 / 21.1 = 1.05 ~ 1 OK

Use 200mm SED piles notched 50mm with 2/ M12 SS Eng bolts

4.5 Foundations

Unfactored Load

$w_s =$ 10.35 kN/m

$N_B{}^* =$ w_s L / 2

10.35 kN/m × 6.0m / 2

31.1 kN

Refer to Section 1.5 for geotechnical assumptions.

Try 200 SED H5 driven timber piles

$N_B =$ $q_{ULS} \times A_{BASE}$

0.5×540 kPa $\times (\pi \times 0.20^2) / 4$

8.48 kN

$N_s =$ $q_{skin} \times A_{skin}$

0.5×30 kPa $\times (\pi \times 0.20 \times 2.5)$

23.57 kN

$øN =$ $N_B + N_s$

8.48 kN + 23.57 kN

32.05 kN

→ 31.1 / 32.05 = 0.97 < 1 OK

$N_H =$ $3 \times N_B{}^*$

3 × 31.1 kN

93.3 kN

Try 200 SED H5 timber piles in 450mmØ concrete filled holes

$A_{BASE} = \pi d^2 / 4$

$\pi \times 0.45^2 / 4$

$0.159m^2$

$\sigma_B =$ $N_B{}^* / A_{BASE}$

31.1 kN / $0.159m^2$

195.6 kN/m^2

→ 195.6 kPa / 270 kPa = 0.72 < 1 OK

Check lateral and seismic loads

Lateral load

$Q_L =$ Q × 0.1 *(10% of design live load)*

(1.5 × 4.0 kPa) × 2.0m × 6.0m / 2 × 0.1

3.60 kN

Earthquake Load

Conservative assumption, take W = G

$G_L =$ G × 0.5 *(50% of dead load)*

(1.2 × 2.35 kN/m) × 6.0m / 2 × 0.5

4.23 kN

(lateral load resistance assumed only below 1.5m due to cohesion only – conservative approach)

Driven timber piles

$P_p =$ ø × cu × (D – 1.5m) × d

0.5 × 40 kPa × (4.0m – 1.5m) × 0.20m

10.0 kN

→ 4.23 / 10.0 = 0.42 < 1 OK

Timber piles in concrete filled holes

$P_p =$ ø × cu × (D – 1.5m) × d

0.5 × 40 kPa × (3.0m – 1.5m) × 0.45m

13.5 kN

→ 4.23 / 13.5 = 0.31 < 1 OK

Use 200 SED H5 driven timber piles
driven to achieve min. 93 kN ultimate bearing capacity using Hiley formula
Min 4000 pile embedment depth (min 2500 into good ground)
OR
Use 200 SED H5 timber piles in 450mmØ 17.5MPa concrete filled holes
Min 3000 pile embedment depth (min. 1500 into good ground)

4.6 Baluster posts

Try 90 × 70 G8 dressed posts @ 0.465m centres

Barrier height 1300 mm

w = 0.75 kN/m *NZS HB 8630 3.6.1*

L = 0.465 m *max spacing between posts (centres)*

h = 0.975 m *height handrail/top rail to upper bolt*

$Z_{EFF} = b_{EFF} \times d_{EFF}^2 / 6$ *reduced Z due to bolt hole and taper by location of upper bolt hole*

$= (70mm - 14mm) \times (90mm)^2 / 6$

$= 75{,}600 mm^3$

Bending

$M^* =$ $w \times k_{FF} \times L \times h$

1.5 × 0.75 kN/m × 1.0 × 0.465m × 0.975m

0.51 kNm

$S_1 =$ $1.25\ (d / b)\ (L_{ay} / d)^{0.5}$

$1.25\ (90 / 70)\ (975 / 90)^{0.5}$

5.29

$\rho_b =$ 0.76

$k_{12} =$ 1.0

$øM =$ $ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_b \times Z$

$0.8 \times 0.97 \times 0.85 \times 1.0 \times 1.0 \times 14.0\ \text{MPa} \times (75{,}600) \times 10^{-6}$

0.70 kNm

→ 0.51 / 0.70 = 0.73 < 1 OK

Fixing $N^* =$ M^* / d

0.51 / 0.15

3.40 kN

Check compression under 50×50 washer

$øN =$ $ø \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.97 \times 0.85 \times 1.0 \times 6.9\ \text{MPa} \times (0.05\text{m} \times 0.05\ \text{m} - \pi \times (0.012\text{m})^2 / 4)$

11.33 kN

→ 3.40 / 11.33 = 0.30 < 1 OK

Posts: 90 × 70mm dressed, at 465 mm centres

Fix with 2/ M12 SS Eng bolts through trimmer joist and outer joist at min 150mm centres

Min 200 × 50 blocking and M12 tie bar at max 930 centres, within 150mm of posts

---

4.7 Top Rail

Try 140 × 45 G8 dressed top rail

Bending $M_{UDL}^* = w^* \times L^2 / 8$ *with udl from SNZ HB 8630 3.6.1*

$(1.5 \times 0.75\ \text{kN/m}) \times 0.465^2 / 8$

0.03 kNm

$øM =$ $ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.97 \times 0.85 \times 1.0 \times 1.0 \times 14.0\ \text{MPa} \times (0.14 \times 0.045^2 / 6)$

0.44 kNm

→ 0.03 / 0.44 = 0.07 < 1 OK

Fixing	V_{PL}* = 1.5 × 0.5 kN	*Assume point load at fixing location*
	0.75 kN	

by inspection OK

---

140 x 45 G8 dressed top rail

Fix with 2/ 14G × 100 SS bugle head batten screws.

5.0 3m Wide Boardwalk

Requirements

- For use on TP4, TP8 & TP9
- UR user group
- 3.0m wide

HB 8630 – Design Details

		Notes:
Structure	Boardwalk	3.0m wide
Structure Type	Access	
Site User Group	UR (Urban Residential)	K_{VG} = 1.0
Fall Surface Category	Favourable	
Effective Fall Height (H_E)	H_{eff} > 3.0m	K_{FF} = 1.0
Basic Design Load	4.00 kPa	4.0kPa × 1.0 × 1.0
Concentrated Load	1.8 kN	SNZ HB 8630 3.5.1
Barrier Type	Type 'A' both sides	SNZ HB 8630 3.21.1
Basic Barrier Design Load	0.75 kN/m	SNZ HB 8630 3.6.1
Corrosion Zone	Zone D	
Design Lateral Loading	10% of Basic Design Load	
Foundations	Driven timber piles	C3.9 HB 8630: *"It is recognised that outdoor visitor structures are basic non-habitable buildings. They will sometimes be located on unstable ground and subject to natural hazards."*

5.1 Decking Planks

Try 150 × 50 G8 Timber decking planks with 25mm by 7mm R-Grip wet pour inserts

Bending $M^* =$ PL / 4

1.5 × 1.8 kN × 0.60m / 4

0.41 kN

$øM = ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 1 \times 0.85 \times 1 \times 1 \times 14.0$ MPa $\times 0.04623 \times 10^{-3}$

0.44 kNm

→ 0.41 / 0.44 = 0.93 < 1 OK

Use 150 × 50 G8 Timber decking planks with R-Grip wet pour inserts, max span 0.60m fixed with 2/ 100 × 4mm FH nails per joist

---

5.2 Joists

Try 6/ 2-300 × 50 G8 joists

Dead Load

G	decking	6 × 0.05 × 3.3	0.99 kN/m
	joists	6 × 12 × 0.05 × 0.30	1.08 kN/m
	trimmer joists	6 × 2 × 0.05 × 0.30	0.18 kN/m
	blocking	6 × 0.05 × 0.30 × 2.6 / 1.5	0.16 kN/m
	barrier	2 × 0.30	0.60 kN/m
	fixings	*bolts, tie bars, washer etc.*	0.05 kN/m
			w_G = 3.06 kN/m

Live Load

Q 4.0 kPa × 3.0 m × 1.0 (k_{FF}) × 1.0 (k_{VG}) w_Q = 12.00 kN/m

ULS udl 1.2 w_G + 1.5 w_Q

1.2 × 3.06 kN/m + 1.5 × 12.00 kN/m w^* = 21.67 kN/m

per joist $^1/_6$ × 21.67 kN/m w_{JOIST}^* = 3.61 kN/m

Bending

$M^* = w_{JOIST}^* L^2 / 8$

3.61 kN/m × $(6.2m)^2$ / 8

17.35 kNm

ø	0.8	
k_1	0.94	*NZS AS 1720.1 Table 2.3*
k_4	0.85 (20% MC)	*NZS AS 1720.1 2.4.2.3*
g_{31}	1.14	
g_{32}	1.33	
s	600mm	
L	6200mm	
k_9	1.28	*NZS AS 1720.1 2.4.5*
ρ_b	0.76	*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25 (d / b) (L_{ay} / d)^{0.5}$	*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25 (300 / 100) (1500 / 300)^{0.5}$	
	8.39	
$\rho_b S_1$	6.37	
k_{12}	1.00	*NZS AS 1720.1 3.2.4*

$\phi M =$ $\phi \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.94 \times 0.85 \times 1.28 \times 1.00 \times 14.0$ MPa $\times (100 \times 300^2 / 6)$

17.18 kNm

→ 17.35 / 17.18 = 1.01 ~ 1 OK

Shear

$V^* =$ $^1/_2\ w_{JOIST} * L$

$^1/_2$ 3.61 kN/m × 6.2m

11.2 kN

$\phi V =$ $\phi \times k_1 \times k_4 \times f_S \times \frac{2}{3}\, b \times d$

$0.8 \times 0.94 \times 0.85 \times 3.7$ MPa × (⅔ × 0.10 m × 0.30 m)

47.3 kN

→ 11.2 / 47.3 = 0.24 < 1 OK

Short Term Deflection

SLS udl $w_G + \psi_s w_Q$

3.06 kN/m + 1.0 × 12.00 kN/m $w_s =$ 15.06 kN/m

per joist = $w_s / 6$ $w_{s\ beam}$ = 2.51 kN/m

$\Delta_s =$ $^5/_{384}\ (wL^4 / EI)$

$^5/_{384}\ (2.51 \times (6.20)^4 / 6.7\ \text{GPa} \times (0.10 \times 0.30^3) / 12)$

32.0mm

→ 32.0 / (6200 / 200) = 1.03 ~ 1 OK

$\Delta_{1kN} =$ $^1/_{48}\ (PL^3 / EI)$

$^1/_{48}\ (1.0 / 2 \times (6.20)^3 / 6.7\ \text{GPa} \times (0.10 \times 0.30^3) / 12)$

1.65mm

→ 1.65 / 2.00 = 0.83 < 1 OK

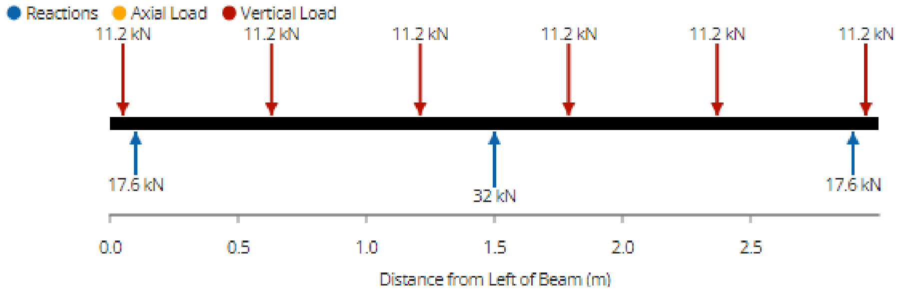
Use 6/ 2-300 × 50 G8 joists with max 6.2m span

With 300 × 50 G8 blocking at max 1500 centres

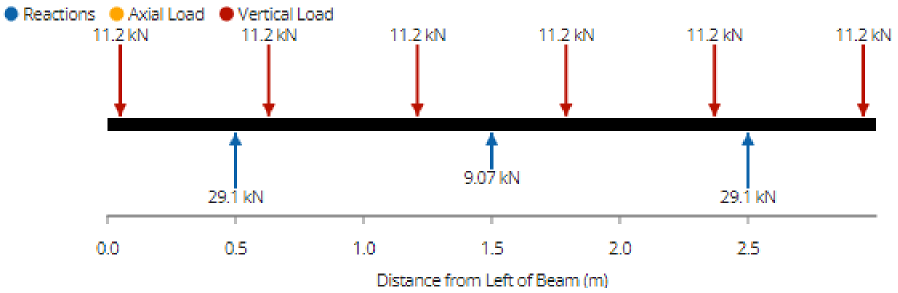
5.3 Bearers

Try 250 × 75 H5 bearer

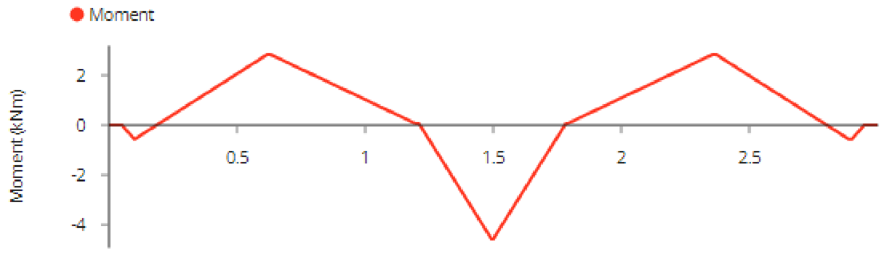
Case 1: 1.4m pile centres



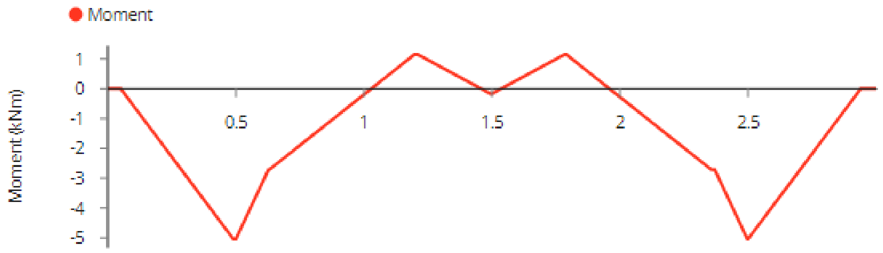
Case 2: 1.0m pile cetres



Bending



M* = 4.57 kNm



M* = 5.04 kNm

ρ_b	0.76	*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25 (d / b) (L_{ay} / d)^{0.5}$	*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25 (250 / 75) (1400 / 250)^{0.5}$	
	9.86	
$\rho_b S_1$	7.49	
k_{12}	1.00	*NZS AS 1720.1 3.2.4*

$\phi M = \phi \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.94 \times 0.7 \times 1.0 \times 1.0 \times 14.0$ MPa $\times (75 \times 250^2 / 6)$

5.78 kNm

→ 5.04 / 5.78 = 0.87 < 1 OK

Check bearing of joists on bearers

$N^* = V^*$

11.2 kN

$\phi N_{d,p} = \phi \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.94 \times 0.7 \times 1.15 \times 6.9$ MPa $\times$ 7,500mm^2

31.3 kN

→ 11.2 / 31.3 = 0.36 < 1 OK

Use 250 × 75 H5 bearers

5.4 Piles

Try 250 SED H5 piles notched 75mm

Check Bearing between Bearer and Pile

$N^*_b = 32.0$ kN

$^2/_3$ Chord length 152.7mm

k_7 1.00 *NZS AS 1720.1 Table 2.6*

$\phi N_{d,p} = \phi \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.8 \times 0.7 \times 1.00 \times 6.9$ MPa $\times$ 12,386mm^2

38.3 kN

→ 32.0 / 38.3 = 0.84 < 1 OK

Use 250mm SED piles notched 75mm with 2/ M12 SS Eng bolts

5.5 Foundations

Unfactored Load

$w_s = 15.06$ kN/m

$w_{s\ beam} = 2.51$ kN/m

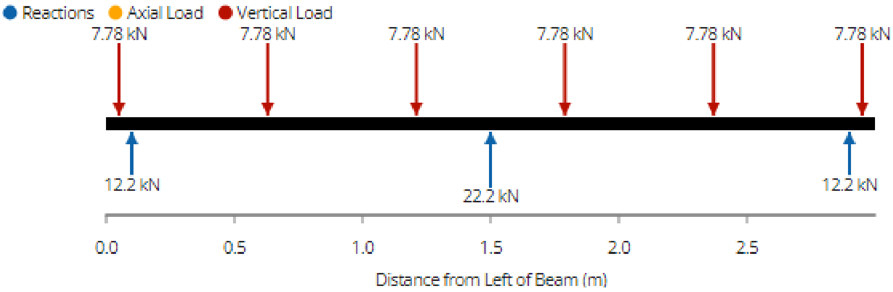
$V^* = {}^1/_2\ w_{JOIST}^* L$

${}^1/_2$ 2.51 kN/m × 6.2m

7.78 kN

Refer to Section 1.5 for geotechnical assumptions.

Largest reaction with 1.4m pile centres



N_B* = 22.2 kN per bearer

44.4 kN per pile

Try 250 SED H5 driven timber piles

N_B = $q_{ULS} \times A_{BASE}$

0.5 × 540 kPa × (π × 0.25^2) / 4

13.25 kN

N_s = $q_{skin} \times A_{skin}$

0.5 × 30 kPa × (π × 0.25 × 3.0)

35.34 kN

øN = $N_B + N_s$

13.25 kN + 35.34 kN

48.59 kN

→ 44.4 / 48.59 = 0.91 < 1 OK

N_H = 3 × N_B*

3 × 44.4 kN

133.2 kN

Check lateral and seismic loads

Lateral load

Q_L = Q × 0.1 *(10% of design live load)*

(1.5 × 4.0 kPa) × 3.0m × 6.2m / 3 × 0.1

3.72 kN

Earthquake Load

Conservative assumption, take W = G

G_L = G × 0.5 *(50% of dead load)*

(1.2 × 3.06 kN/m) × 6.2m / 3 × 0.5

3.79 kN

(lateral load resistance assumed only below 1.5m due to cohesion only – conservative approach)

$P_p =$ ø × cu × (D – 1.5m) × d

0.5 × 40 kPa × (4.5m – 1.5m) × 0.25m

15.0 kN

→ 3.79 / 15.0 = 0.25 < 1 OK

Use 250 SED H5 driven timber piles
driven to achieve min. 133 kN ultimate bearing capacity using Hiley formula
Min. 4500 pile embedment depth (min. 3000 into good ground)

5.6 Baluster posts

Try 90 × 70 G8 dressed posts @ 0.465m centres

Barrier height 1300 mm

w = 0.75 kN/m — *NZS HB 8630 3.6.1*

L = 0.465 m — *max spacing between posts (centres)*

h = 0.975 m — *height handrail/top rail to upper bolt*

$Z_{EFF} = b_{EFF} \times d_{EFF}^2 / 6$ — *reduced Z due to bolt hole and taper by location of upper bolt hole*

$= (70mm - 14mm) \times (90mm)^2 / 6$

$= 75{,}600mm^3$

Bending

$M^* =$ $w \times k_{FF} \times L \times h$

1.5 × 0.75 kN/m × 1.0 × 0.465m × 0.975m

0.51 kNm

$S_1 =$ $1.25 (d / b) (L_{ay} / d)^{0.5}$

$1.25 (90 / 70) (975 / 90)^{0.5}$

5.29

$\rho_b =$ 0.76

$k_{12} =$ 1.0

$øM =$ $ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_b \times Z$

$0.8 \times 0.97 \times 0.85 \times 1.0 \times 1.0 \times 14.0 \text{ MPa} \times (75{,}600) \times 10^{-6}$

0.70 kNm

→ 0.51 / 0.70 = 0.73 < 1 OK

Fixing $N^* =$ M^* / d

0.51 / 0.15

3.40 kN

Check compression under 50×50 washer

$\phi N = \phi \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.97 \times 0.85 \times 1.0 \times 6.9\text{ MPa} \times (0.05\text{m} \times 0.05\text{ m} - \pi \times (0.012\text{m})^2 / 4)$

11.33 kN

→ 3.40 / 11.33 = 0.30 < 1 OK

Posts: 90 × 70mm dressed, at 465 mm centres
Fix with 2/ M12 SS Eng bolts through trimmer joist and outer joist at min 150mm centres
Min 200 × 50 blocking and M12 tie bar at max 930 centres, within 150mm of posts

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5.7 Top Rail

Try 140 × 45 G8 dressed top rail

Bending $M_{UDL}^* = w^* \times L^2 / 8$ *with udl from SNZ HB 8630 3.6.1*

$(1.5 \times 0.75\text{ kN/m}) \times 0.465^2 / 8$

0.03 kNm

$\phi M = \phi \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.97 \times 0.85 \times 1.0 \times 1.0 \times 14.0\text{ MPa} \times (0.14 \times 0.045^2 / 6)$

0.44 kNm

→ 0.03 / 0.44 = 0.07 < 1 OK

Fixing $V_{PL}^* = 1.5 \times 0.5\text{ kN}$ *Assume point load at fixing location*

0.75 kN

by inspection OK

---

140 x 45 G8 dressed top rail
Fix with 2/ 14G × 100 SS bugle head batten screws.

6.0 3m Wide Glulam Bridge

Requirements

- For use on TP4
- UR user group
- 3.0m wide

HB 8630 – Design Details

		Notes:
Structure	Glulam Bridge	3.0m wide
Structure Type	Access	
Site User Group	UR (Urban Residential)	K_{VG} = 1.0
Fall Surface Category	Favourable	
Effective Fall Height (H_E)	H_{eff} > 3.0m	K_{FF} = 1.0
Basic Design Load	4.00 kPa	4.0kPa × 1.0 × 1.0
Concentrated Load	1.8 kN	SNZ HB 8630 3.5.1
Barrier Type	Type 'A' both sides	SNZ HB 8630 3.21.1
Basic Barrier Design Load	0.75 kN/m	SNZ HB 8630 3.6.1
Corrosion Zone	Zone D	
Design Lateral Loading	10% of Basic Design Load	
Foundations	Driven timber piles	C3.9 HB 8630: *"It is recognised that outdoor visitor structures are basic non-habitable buildings. They will sometimes be located on unstable ground and subject to natural hazards."*

6.1 Decking Planks

Try 150 × 50 G8 Timber decking planks with 25mm by 7mm R-Grip wet pour inserts

Bending $M^* =$ PL / 4

1.5 × 1.8 kN × 0.68m / 4

0.46 kN

$øM =$ $ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 1 \times 0.85 \times 1 \times 1 \times 14.0\text{ MPa} \times 0.04623 \times 10^{-3}$

0.44 kNm

→ 0.46 / 0.44 = 1.05 ~ 1 OK

Use 150 × 50 G8 Timber decking planks with R-Grip wet pour inserts, max span 0.68m fixed with 2/ 100 × 4mm FH nails per joist

6.2 Beams

Try 5/ 720 × 135 GL10 beams

Dead Load

G	decking	6 × 0.05 × 3.3	0.99 kN/m
	beams	6 × 5 × 0.135 × 0.720	2.92 kN/m
	trimmer joists	6 × 2 × 0.05 × 0.30	0.18 kN/m
	blocking	6 × 0.09 × 0.63 × 2.5 / 1.86	0.46 kN/m
	barrier	2 × 0.30	0.60 kN/m
	fixings	*bolts, tie bars, washer etc.*	0.05 kN/m
			w_G = 5.20 kN/m

Live Load

Q 4.0 kPa × 3.0 m × 1.0 (k_{FF}) × 1.0 (k_{VG}) w_Q = 12.00 kN/m

ULS udl $1.2\,w_G + 1.5\,w_Q$

1.2 × 5.20 kN/m + 1.5 × 12.00 kN/mw* = 24.24 kN/m

per beam $^1/_5$ × 24.24 kN/m w_{BEAM}^* = 4.85 kN/m

Bending

$M^* = w_{BEAM}^* L^2 / 8$

4.85 kN/m × $(16.8\text{m})^2$ / 8

171.1 kNm

ø	0.8		
k_1	0.94		*NZS AS 1720.1 Table 2.3*
k_4	0.91	(18% MC)	*NZS AS 1720.1 2.4.2.3*
k_9	1.0		*NZS AS 1720.1 7.4.3*
r	1.0	(conservative)	*NZS AS 1720.1 Table 7.2(A)*
ρ_b	0.78		*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25\,(d / b)\,(L_{ay} / d)^{0.5}$		*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25\,(720 / 135)\,(1860 / 720)^{0.5}$		
	10.72		
$\rho_b S_1$	8.36		
k_{12}	1.00		*NZS AS 1720.1 3.2.4*

$øM = ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

0.8 × 0.94 × 0.91 × 1.0 × 1.00 × 22.0 MPa × (135 × 720^2 / 6)

175.6 kNm

→ 171.1 / 175.6 = 0.97 < 1 OK

Shear

$V^* = \frac{1}{2} w_{BEAM}{}^* L$

$\frac{1}{2}$ 4.85 kN/m × 16.8m

40.7 kN

$øV = ø \times k_1 \times k_4 \times f_S \times \frac{2}{3} b \times d$

0.8 × 0.94 × 0.91 × 3.7 MPa × (⅔ × 0.135 m × 0.720 m)

102.5 kN

→ 40.7 / 102.5 = 0.40 < 1 OK

Short Term Deflection

SLS udl $w_G + \psi_s w_Q$

5.20 kN/m + 1.0 × 12.00 kN/m w_s = 17.20 kN/m

per beam = $w_s / 5$ $w_{s\ beam}$ = 3.44 kN/m

$\Delta_s = \frac{5}{384} (wL^4 / EI)$

$\frac{5}{384} (3.44 \times (16.8)^4 / 10.0\ GPa \times (0.135 \times 0.720^3) / 12)$

85.0mm

→ 85.0 / (17000 / 200) = 1.00 OK

$\Delta_{1kN} = \frac{1}{48} (PL^3 / EI)$

$\frac{1}{48} (1.0 / 2 \times (16.8)^3 / 10.0\ GPa \times (0.135 \times 0.720^3) / 12)$

1.18mm

→ 1.18 / 2.00 = 0.59 < 1 OK

Creep

SLS udl $j_2 w_G + \psi_l Q$

3.0 × 5.20 kN/m + 0.6 × 12.00 kN/m w_s = 22.80 kN/m

per beam = $w_s / 5$ $w_{s,beam}$ = 4.56 kN/m

$\Delta_s = \frac{5}{384} (wL^4 / EI)$

$\frac{5}{384} (4.56 \times (16.8)^4 / 10.0\ GPa \times (0.135 \times 0.720^3) / 12)$

112.6mm

Use 5/ 720 × 135 GL10 beams with 150mm Pre-camber
Max 16.8m span, max 17.0m pile centres
With 630 × 90 GL8 blocking at max 1860 centres

6.3 Bearers

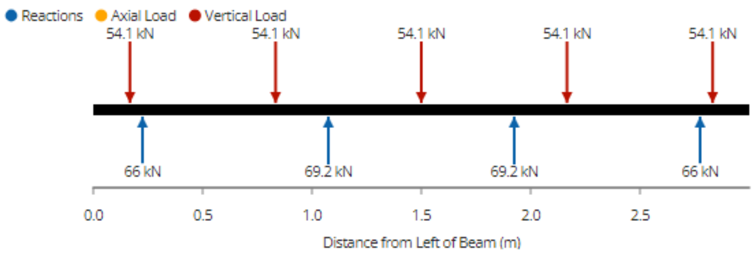
Try 250 × 100 H5 bearer

$N^* =$ $V^* + {}^6/_5\ V_{JOIST}^*$

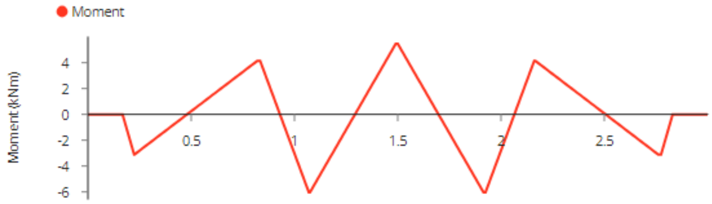
$40.7\ kN + {}^6/_5 \times 11.2\ kN$

$54.1\ kN$

0.85m pile centres



Bending



$M^* =$ 6.04 kNm

ρ_b 0.76 *NZS AS 1720.1 Table ZZ3.1*

S_1 $1.25\ (d\ /\ b)\ (L_{ay}\ /\ d)^{0.5}$ *NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*

$1.25\ (250\ /\ 100)\ (850\ /\ 250)^{0.5}$

5.76

$\rho_b S_1$ 4.38

k_{12} 1.00 *NZS AS 1720.1 3.2.4*

$\varnothing M =$ $\varnothing \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.94 \times 0.7 \times 1.0 \times 1.0 \times 14.0\ MPa \times (100 \times 250^2\ /\ 6)$

7.68 kNm

→ 6.04 / 7.68 = 0.79 < 1 OK

Check bearing of beams on bearers

$N^* =$ 54.1 kN

$\varnothing N_{d,p} =$ $\varnothing \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.94 \times 0.7 \times 1.13 \times 6.9\ MPa \times 13{,}500 mm^2$

55.4 kN

→ 54.1 / 55.4 = 0.98 < 1 OK

Use 250 × 100 H5 bearers

6.4 Piles

Try 250 SED H5 piles notched 100mm

Check Bearing between Bearer and Pile

$N^*_b =$ 69.2 kN

$^2/_3$ Chord length 163.3mm

k_7 1.00 *NZS AS 1720.1 Table 2.6*

$øN_{d,p} = ø \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.8 \times 0.7 \times 1.00 \times 6.9$ MPa $\times$ 18,336mm^2

56.9 kN

Check 2/ M20 bolts

Timber group	J4	
ø	0.8	NZS AS 1720.1 ZZ2.3
b_e	200mm	NZS AS 1720.1 Table 4.9(A) (1)
d_a	20 mm	
k_1	0.86	NZS AS 1720.1 Table 2.3
k_{16}	1.0	
k_{17}	1.0	
n	2	
Q_{sk}	10.65 kN	NZS AS 1720.1 Table 4.10(B)

$øN_{d,j} = ø \times k_1 \times k_{16} \times k_{17} \times n \times Q_{sk}$

$= 0.8 \times 0.86 \times 1.0 \times 1.0 \times 2 \times 10.65$ kN

= 14.7 kN

$øN = øN_{d,p} + øN_{d,j}$

56.9 kN + 14.7 kN

71.6 kN

→ 69.2 / 71.6 = 0.97 < 1 OK

Use 250mm SED piles notched 100mm with 2/ M20 SS Eng bolts

6.5 Foundations

Unfactored Load

$w_s =$ 17.20 kN/m

$w_{s\ beam} =$ 3.44 kN/m

$V^* = \, ^1/_2 \, w_{s\,beam}{}^* \, L$

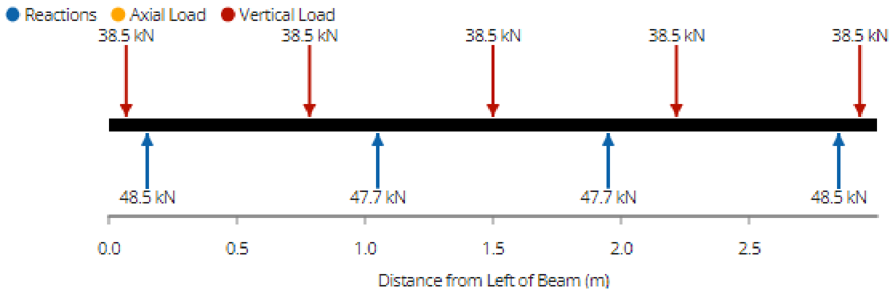
$^1/_2 \; 3.44 \text{ kN/m} \times 17.0\text{m}$

29.2 kN

$N^* = V^* + \, ^6/_5 \, V_{JOIST}{}^*$

$29.2 \text{ kN} + \, ^6/_5 \times 7.78 \text{ kN}$

38.5 kN



$N_B{}^* = 48.5 \text{ kN}$

Refer to Section 1.5 for geotechnical assumptions.

Try 250 SED H5 driven timber piles

$N_B = q_{ULS} \times A_{BASE}$

$0.5 \times 540 \text{ kPa} \times (\pi \times 0.25^2) / 4$

13.25 kN

$N_s = q_{skin} \times A_{skin}$

$0.5 \times 30 \text{ kPa} \times (\pi \times 0.25 \times 3.0)$

35.34 kN

$øN = N_B + N_s$

$13.25 \text{ kN} + 35.34 \text{ kN}$

48.6 kN

$\rightarrow$ 48.5 / 48.6 = 1.00 OK

$N_H = 3 \times N_B{}^*$

$3 \times 48.5 \text{ kN}$

145.5 kN

Check lateral and seismic loads

Lateral load

Q_L = Q × 0.1 *(10% of design live load)*

(1.5 × 4.0 kPa) × 3.0m × 17.0m / 4 × 0.1

7.65 kN

Earthquake Load

Conservative assumption, take W = G

G_L = G × 0.5 *(50% of dead load)*

(1.2 × 5.20 kN/m) × 17.0m / 4 × 0.5

13.26 kN

(lateral load resistance assumed only below 1.5m due to cohesion only – conservative approach)

P_p = ø × cu × (D – 1.5m) × d

0.5 × 40 kPa × (4.5m – 1.5m) × 0.25m

15.0 kN

→ 13.26 / 15.0 = 0.88 < 1 OK

Use 250 SED H5 driven timber piles

driven to achieve min. 146 kN ultimate bearing capacity using Hiley formula

Min. 4500 pile embedment depth (min. 3000 into good ground)

6.6 Baluster posts

Try 90 × 70 G8 dressed posts @ 0.465m centres

Barrier height 1300 mm

w = 0.75 kN/m *NZS HB 8630 3.6.1*

L = 0.465 m *max spacing between posts (centres)*

h = 0.975 m *height handrail/top rail to upper bolt*

Z_{EFF} = b_{EFF} × d_{EFF}^2 /6 *reduced Z due to bolt hole and taper by location of upper bolt hole*

= (70mm – 14mm) × $(90mm)^2$ / 6

= 75,600mm^3

Bending

M* = w × k_{FF} × L × h

1.5 × 0.75 kN/m × 1.0 × 0.465m × 0.975m

0.51 kNm

S_1 = 1.25 (d / b) $(L_{ay} / d)^{0.5}$

1.25 (90 / 70) $(975 / 90)^{0.5}$

5.29

ρ_b = 0.76

k_{12} = 1.0

$\phi M = \phi \times k_1 \times k_4 \times k_9 \times k_{12} \times f_b \times Z$
$0.8 \times 0.97 \times 0.85 \times 1.0 \times 1.0 \times 14.0 \text{ MPa} \times (75{,}600) \times 10^{-6}$
0.70 kNm

→ 0.51 / 0.70 = 0.73 < 1 OK

Fixing $N^* = M^* / d$
0.51 / 0.15
3.40 kN

Check compression under 50×50 washer

$\phi N = \phi \times k_1 \times k_4 \times k_7 \times f_p \times A_p$
$0.8 \times 0.97 \times 0.85 \times 1.0 \times 6.9 \text{ MPa} \times (0.05\text{m} \times 0.05 \text{ m} - \pi \times (0.012\text{m})^2 / 4)$
11.33 kN

→ 3.40 / 11.33 = 0.30 < 1 OK

Posts: 90 × 70mm dressed, at 465 mm centres
Fix with 2/ M12 SS Eng bolts through trimmer joist and outer joist at min 150mm centres
Min 200 × 50 blocking and M12 tie bar at max 930 centres, within 150mm of posts

---

6.7 Top Rail

Try 140 × 45 G8 dressed top rail

Bending $M_{UDL}^* = w^* \times L^2 / 8$ *with udl from SNZ HB 8630 3.6.1*
$(1.5 \times 0.75 \text{ kN/m}) \times 0.465^2 / 8$
0.03 kNm

$\phi M = \phi \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$
$0.8 \times 0.97 \times 0.85 \times 1.0 \times 1.0 \times 14.0 \text{ MPa} \times (0.14 \times 0.045^2 / 6)$
0.44 kNm

→ 0.03 / 0.44 = 0.07 < 1 OK

Fixing $V_{PL}^* = 1.5 \times 0.5$ kN *Assume point load at fixing location*
0.75 kN

by inspection OK

---

140 x 45 G8 dressed top rail
Fix with 2/ 14G × 100 SS bugle head batten screws.

7.0 Concord Place Glulam Bridge

Requirements

- UR user group
- 3.0m wide

HB 8630 – Design Details

		Notes:
Structure	Glulam Bridge	3.0m wide
Structure Type	Access	
Site User Group	UR (Urban Residential)	K_{VG} = 1.0
Fall Surface Category	Favourable	
Effective Fall Height (H_E)	H_{eff} > 3.0m	K_{FF} = 1.0
Basic Design Load	4.00 kPa	4.0kPa × 1.0 × 1.0
Concentrated Load	1.8 kN	SNZ HB 8630 3.5.1
Barrier Type	Type 'A' both sides	SNZ HB 8630 3.21.1
Basic Barrier Design Load	0.75 kN/m	SNZ HB 8630 3.6.1
Corrosion Zone	Zone D	
Design Lateral Loading	10% of Basic Design Load	
Foundations	Driven timber piles	C3.9 HB 8630: *"It is recognised that outdoor visitor structures are basic non-habitable buildings. They will sometimes be located on unstable ground and subject to natural hazards."*

7.1 Decking Planks

Try 140 × 45 Vitex decking planks with non-slip surfacing

Bending M* = PL / 4
1.5 × 1.8 kN × 0.9m / 4
0.61 kN

øM = $ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$
$0.8 \times 1 \times 0.85 \times 1 \times 1 \times 55.0\ \text{MPa} \times 0.04725 \times 10^{-3}$
1.77 kNm

→ 0.61 / 1.77 = 0.34 < 1 OK

Use 140 × 45 Vitex decking planks with non-slip surfacing, max span 0.90m
Fixed with 2/ 14g × 75mm SS bugle head batten screws per beam

7.2 Beams

Try 5/ 945 × 180 GL12 beams

Dead Load

G	decking	8 × 0.045 × 3.0	1.08 kN/m
	beams	6 × 5 × 0.180 × 0.945	5.10 kN/m
	blocking	6 × 0.09 × 0.855 × 2.1 / 2.0	0.48 kN/m
	barrier	2 × 0.50	1.00 kN/m
	fixings	*bolts, tie bars, washer etc.*	0.05 kN/m
			w_G = 7.71 kN/m

Live Load

Q 4.0 kPa × 3.0 m × 1.0 (k_{FF}) × 1.0 (k_{VG}) w_Q = 12.00 kN/m

ULS udl $1.2\ w_G + 1.5\ w_Q$

1.2 × 7.71 kN/m + 1.5 × 12.00 kN/m w* = 27.25 kN/m

per beam $^1/_5$ × 27.25 kN/m w_{BEAM}* = 5.45 kN/m

Bending

M* = $w_{JOIST}^* L^2 / 8$

5.45 kN/m × $(21.5\text{m})^2$ / 8

314.9 kNm

ø	0.8		
k_1	0.94		*NZS AS 1720.1 Table 2.3*
k_4	0.91	(18% MC)	*NZS AS 1720.1 2.4.2.3*
k_9	1.0		*NZS AS 1720.1 7.4.3*
r	1.0	(conservative)	*NZS AS 1720.1 Table 7.2(A)*
ρ_b	0.78		*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25\ (d / b)\ (L_{ay} / d)^{0.5}$		*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25\ (945 / 180)\ (2000 / 945)^{0.5}$		
	9.55		
$\rho_b S_1$	7.27		
k_{12}	1.00		*NZS AS 1720.1 3.2.4*

øM = $ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

0.8 × 0.94 × 0.91 × 1.0 × 1.00 × 25.0 MPa × $(180 \times 945^2 / 6)$

343.8 kNm

→ 314.9 / 343.8 = 0.92 < 1 OK

Shear

$V^* = \frac{1}{2} w_{JOIST}^* L$

$\frac{1}{2}$ 5.45 kN/m × 21.5m

58.6 kN

$øV = ø \times k_1 \times k_4 \times f_S \times \frac{2}{3} b \times d$

0.8 × 0.94 × 0.91 × 3.7 MPa × ($\frac{2}{3}$ × 0.180 m × 0.945 m)

287.1 kN

→ 58.6 / 287.1 = 0.20 < 1 OK

Short Term Deflection

SLS udl $w_G + \psi_s w_Q$

7.71 kN/m + 1.0 × 12.00 kN/m w_s = 19.71 kN/m

per beam = w_s / 5 $w_{s\ beam}$ = 3.94 kN/m

$\Delta_s = \frac{5}{384} (wL^4 / EI)$

$\frac{5}{384}$ (3.94 × $(21.5)^4$ / 12.0 GPa × (0.180 × 0.945^3) / 12)

72.2mm

→ 72.2 / (21500 / 200) = 0.67 < 1 OK

$\Delta_{1kN} = \frac{1}{48} (PL^3 / EI)$

$\frac{1}{48}$ (1.0 × $(21.5)^3$ / 12.0 GPa × (0.180 × 0.945^3) / 12)

1.36mm

→ 1.36 / 2.00 = 0.68 < 1 OK

Creep

SLS udl $j_2 w_G + \psi_l Q$

3.0 × 7.71 kN/m + 0.6 × 12.00 kN/m w_s = 30.33 kN/m

per beam = w_s / 5 $w_{s,beam}$ = 6.07 kN/m

$\Delta_s = \frac{5}{384} (wL^4 / EI)$

$\frac{5}{384}$ (6.07 × $(21.5)^4$ / 12.0 GPa × (0.180 × 0.945^3) / 12)

111.2mm

Use 5/ 945 × 180 GL12 beams with 200mm Pre-camber

Max 21.5m span, max 22.0m pile centres

With 855 × 90 GL8 blocking at max 2000 centres

7.3 Plan Bracing

Check lateral and earthquake loading

Lateral Load

Q_L = Q × 0.1 *from SNZ HB 8630 3.7.1*

12.0 kN/m × 0.1 × 22.0m

26.4 kN

Earthquake Load

Conservative assumption, take W = G

G_L = G × 0.5 *50% of dead load*

7.71 kN/m × 0.5 × 22.0m

84.8 kN

Tension N* = 0.5 × G_L × L_{BRACE} / e *Approx. e is centre of beams*

0.5 × 84.8 kN × 3.46 / 2.82

52.0 kN

Try double Multibrace

øN = ø × $k_{1\text{-green factor}}$ × 2 × 18.4 kN

0.8 × 0.85 × 2 × 18.4 kN

25.02 kN

→ 24.21 / 25.02 = 0.97 < 1 OK

Check central 6m:

G_L = G × 0.5 *50% of dead load*

3.34 kN/m × 0.5 × 6.0m

10.02 kN

Tension N* = 0.5 × G_L × L_{BRACE} / e *Approx. e is centre of beams*

0.5 × 10.02 kN × 2.69 / 1.67

8.07 kN

Try single Multibrace

øN = ø × $k_{1\text{-green factor}}$ × 18.4 kN

0.8 × 0.85 × 18.4 kN

12.51 kN

→ 8.07 / 12.51 = 0.65 < 1 OK

Use double Lumberlok Multibrace SS 53 × 0.91mm for outer 6m each side

Use single Lumberlok Multibrace SS 53 × 0.91mm for central 6m

Fix with 11- 45 × 3.15mm SS AG nails to blocking at each end

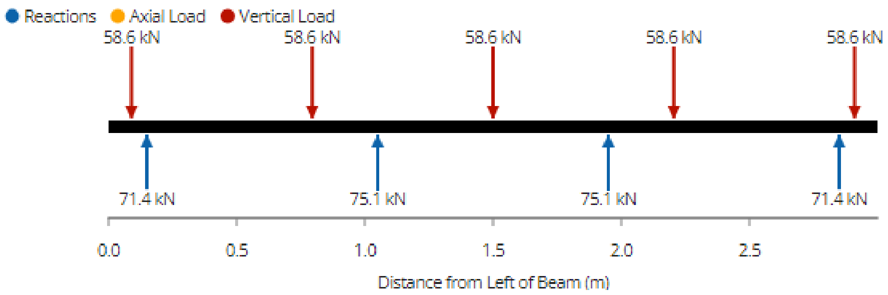
7.4 Bearers

Try 2/ 250 × 75 H5 bearers

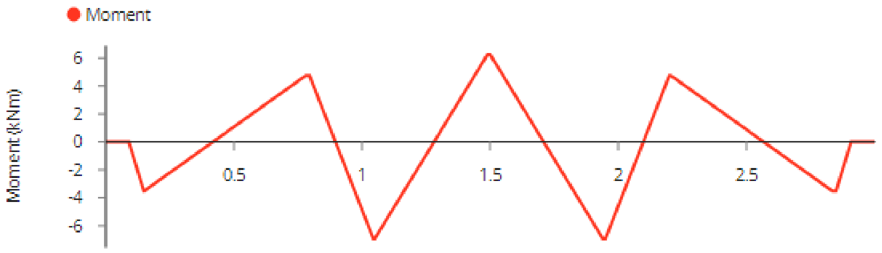
N* = V*

58.6 kN

0.90m pile centres



Bending



M* = 6.93 kNm

ρ_b	0.76	*NZS AS 1720.1 Table ZZ3.1*
S_1	$1.25\ (d / b)\ (L_{ay} / d)^{0.5}$	*NZS AS 1720.1 3.2.3.2 (a) 3.2(4)*
	$1.25\ (250 / 75)\ (850 / 250)^{0.5}$	
	7.68	
$\rho_b S_1$	5.99	
k_{12}	1.00	*NZS AS 1720.1 3.2.4*

øM = $ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.94 \times 0.7 \times 1.0 \times 1.0 \times 14.0\ \text{MPa} \times 2 \times (75 \times 250^2 / 6)$

11.52 kNm

→ 6.93 / 11.52 = 0.60 < 1 OK

Check bearing of beams on bearers

N* = 58.6 kN

$\phi N_{d,p} = \phi \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.94 \times 0.7 \times 1.15 \times 6.9\ \text{MPa} \times 2 \times 13{,}500\text{mm}^2$

112.8 kN

→ 58.6 / 112.8 = 0.52 < 1 OK

Use 2/ 250 × 75 H5 bearers

7.5 Piles

Try 250 SED H5 piles notched 75mm

Check Bearing between Bearer and Pile

$N^*_b =$ 75.1 kN

$^2/_3$ Chord length 152.7mm

k_7 1.00 *NZS AS 1720.1 Table 2.6*

$\phi N_{d,p} = \phi \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.8 \times 0.7 \times 1.00 \times 6.9\ \text{MPa} \times 2 \times 12{,}386\text{mm}^2$

76.6 kN

→ 75.1 / 76.6 = 0.98 < 1 OK

Use 250mm SED piles notched 75mm with 2/ M20 SS Eng bolts

7.6 Foundations

Unfactored Load

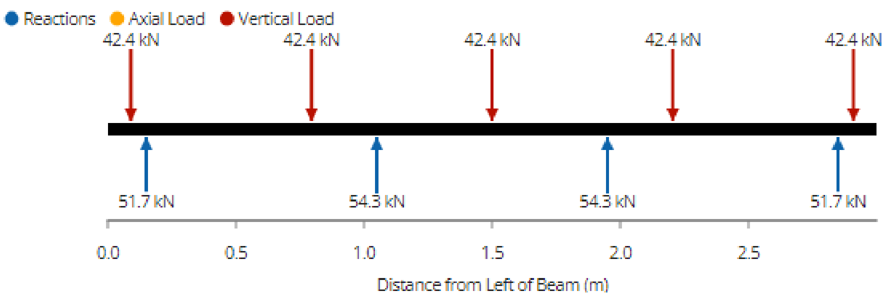
$w_s =$ 19.71 kN/m

$w_{s\ beam} =$ 3.94 kN/m

$V^* = {}^1/_2\, w_{JOIST}{}^* L$

${}^1/_2$ 3.94 kN/m × 21.5m

42.4 kN



$N_B^* =$ 54.3 kN

Refer to Section 1.5 for geotechnical assumptions.

Try 250 SED H5 driven timber piles

$N_B =$ $q_{ULS} \times A_{BASE}$

0.5×540 kPa $\times (\pi \times 0.25^2) / 4$

13.25 kN

$N_s =$ $q_{skin} \times A_{skin}$

0.5×30 kPa $\times (\pi \times 0.25 \times 5.5)$

64.80 kN

$øN =$ $N_B + N_s$

13.25 kN + 64.80 kN

78.1 kN

→ 54.3 / 78.1 = 0.70 < 1 OK

$N_H =$ $3 \times N_B$*

3 × 54.3 kN

162.9 kN

Check lateral and seismic loads

Lateral load

$Q_L =$ Q × 0.1 *(10% of design live load)*

(1.5 × 4.0 kPa) × 3.0m × 22.0m / 4 × 0.1

9.90 kN

Earthquake Load

Conservative assumption, take W = G

$G_L =$ G × 0.5 *(50% of dead load)*

(1.2 × 7.71 kN/m) × 22.0m / 4 × 0.5

25.44 kN

(lateral load resistance assumed only below 1.5m due to cohesion only – conservative approach)

$P_p =$ ø × cu × (D – 1.5m) × d

0.5 × 40 kPa × (7.0m – 1.5m) × 0.25m

27.5 kN

→ 25.44 / 27.5 = 0.93 < 1 OK

Use 250 SED H5 driven timber piles

driven to achieve min. 163 kN ultimate bearing capacity using Hiley formula

Min. 7000 pile embedment depth (min. 5500 into good ground)

7.7 Steel Infill Barrier

Check 65mm × 6mm MS Steel Fins

Barrier height 1100 mm

w =	0.75 kN/m	*NZS HB 8630 3.6.1*
L =	0.10 m	*max spacing between steel fins (centres)*
h =	1.185 m	*height steel capping to upper bolt*
Z_{EFF} =	$b_{EFF} \times d_{EFF}^2 / 6$	
	$6mm \times (65mm)^2 / 6$	
	$4{,}225mm^3$	

Bending

M* =	$w \times k_{FF} \times L \times h$	
	1.5 × 0.75 kN/m × 1.0 × 0.10m × 1.185m	
	0.13 kNm	
$øM_s$ =	$ø \times f_y \times Z_e$	
	$0.9 \times 250\ MPa \times (4{,}225) \times 10^{-6}$	
	0.95 kNm	
		→ 0.13 / 0.95 = 0.14 < 1 OK

α_m =	2.25	*NZS 3404.1, Table 5.6.2*
k_t =	1.0	
k_l =	1.0	
k_r =	1.0	
L_e =	$k_t\ k_l\ k_r\ L$	
	1.0 × 1.0 × 1.0 × 1.185m	
	1.185m	

M_{oa} = $((\pi^2 EI_y / L_e^2) [GJ + (\pi^2 EI_w / L_e^2)])^{0.5}$

$((\pi^2 \times 205\ GPa \times 390mm^3 / (1.185m)^2) [80\ GPa \times 4{,}680mm^4 + (\pi^2 \times 205\ GPa \times 0 / (1.185m)^2)])^{0.5}$

$(561{,}929.1 \times (374.4 + 0))^{0.5}$

14.5 kNm

α_s = $0.6 \times ([(M_s / M_{oa})^2 + 3]^{0.5} - (M_s / M_{oa}))$

$0.6 \times ([(1.06\ kNm / 14.5\ kNm)^2 + 3]^{0.5} - (1.06\ kNm / 14.5\ kNm))$

0.996

$øM_b$ = $ø \times \alpha_m \times \alpha_s \times M_s \leq øM_s$

0.9 × 2.25 × 0.996 × 1.06 kNm ≤ 0.95 kNm

2.14 kNm ≤ 0.95 kNm

→ 0.13 / 0.95 = 0.14 < 1 OK

Check 50mm fillet weld top and bottom 50mm

$V^* =$ 1.5 × 0.75 kN/m × 0.10m
0.11 kN

$øv_w =$ $ø \times 0.6 \times f_{uw} \times t_t \times k_r$
0.60 × 0.6 × 410 MPa × (3mm × sin (45˚)) × 1.00
313 N/mm

$øV_w =$ $øv_w \times L$
313 N/mm × 100mm
31.3 kN

→ 0.11 / 31.3 = 0.004 < 1 OK

Bending

Assume rotation about bottom of weld

$P^* =$ $(V^* \times h) / d$
(0.11 kN × 1.35m) / 0.15m
0.99 kN

$øV_w =$ $øv_w \times L$
313 N/mm × 50mm
15.7 kN

→ 0.99 / 15.7 = 0.06 < 1 OK

Fixing $N^* =$ (w × L × h) / d
(1.5 × 0.75 kN/m × 0.50m × 1.185m) / 0.18m
3.70 kN

Check compression under 50×50 washer

$øN =$ $ø \times k_1 \times k_4 \times k_7 \times f_p \times A_p$
$0.8 \times 0.97 \times 0.85 \times 1.0 \times 6.9\ \text{MPa} \times (0.05\text{m} \times 0.05\ \text{m} - \pi \times (0.012\text{m})^2 / 4)$
11.33 kN

→ 3.70 / 11.33 = 0.33 < 1 OK

Type 'A' Steel Infill barrier with 65 × 6mm steel fins and 6mm steel capping
Fins welded to 250mm × 8mm MS plate with 50mm FWAR top and bottom of plate
Plate fixed to beams with 2/ M12 SS Eng bolts at 180mm spacing, max 500mm centres

8.0 Concrete Path Retaining Wall

Requirements

- 1.0m high
- 3.0m wide concrete path surcharge

HB 8630 – Design Details

		Notes:
Structure	Retaining Wall	1.0m high
Structure Type	Access	
Site User Group	UR (Urban Residential)	K_{VG} = 1.0
Fall Surface Category	Favourable	
Effective Fall Height (H_E)	H_{eff} < 1.5m	K_{FF} = 0.8
Basic Design Load	3.2 kPa	4.0kPa × 1.0 × 0.8
Concentrated Load	1.8 kN	SNZ HB 8630 3.5.1
Corrosion Zone	Zone D	
Design Lateral Loading	10% of Basic Design Load	
Foundations	Timber piles in concrete filled foundations	C3.9 HB 8630: *"It is recognised that outdoor visitor structures are basic non-habitable buildings. They will sometimes be located on unstable ground and subject to natural hazards."*

8.1 Loads and Soil Characteristics

Live load surcharge (Q) = 3.2 kPa

Dead load surcharge (G) = 24 kN/m^3 × 0.125m

3.0 kPa

Total Surcharge = 1.2 G + 1.5 Q

1.2 × 3.0 kPa + 1.5 × 3.2 kPa

8.85 kPa

Assume following characteristics for basecourse and fill:

Basecourse:

γ = 15 kN/m^3

θ = 34˚ *(conservative assumption)*

K_o = 1 – sin θ

1 – sin 34˚

0.44

K_a = tan^2 (45˚ – θ / 2)

tan^2 (45˚ - 34˚ / 2)

0.28

Fill:	γ =	18.5 kN/m^3
	θ =	32°
	K_o =	1 – sin θ
		1 – sin 32°
		0.47
	K_a =	$\tan^2$ (45° – θ / 2)
		$\tan^2$ (45° - 32° / 2)
		0.31
In-Situ Soils	γ =	17.5 kN/m^3
	θ =	30°
	K_p =	$\tan^2$ (45° + θ / 2)
		$\tan^2$ (45° + 30° / 2)
		3.00

Assume load from fill only – conservative assumption.

8.2 Loading Analysis

Active pressure at 0m depth:	$K_o \times S$
	0.47 × 8.85 kPa
	4.16 kPa
Active pressure at 1.0m depth:	4.16 kPa + $K_a \times \gamma \times D$
	4.16 kPa + 0.31 × 18.5 kN/m^3 × 1.0m
	9.90 kPa
Active pressure at 1.9m depth:	4.16 kPa + $K_a \times \gamma \times D$
	4.16 kPa + 0.31 × 18.5 kN/m^3 × 1.9m
	15.06 kPa
Passive pressure at 1.9m depth:	$K_p \times \gamma \times D$
	3.00 × 17.5 kN/m^3 × 0.9m
	47.25 kPa

8.3 Tie Rod

Try M16 SS tie bar at every post (1m centres)

Using 'Simplified Broms Method' to calculate conservative load in tie rod

Check moments about base:

$M_o =$ (4.16 kPa × 1.0m × 1.0m) × 1.4m + (0.5 × (9.90 kPa – 4.16 kPa) × 1.0m × 1.0m) × 1.23m + (9.90 kPa × 0.9m × 0.3m) × 0.45m + (0.5 × (15.06 kPa – 9.90 kPa) × 0.9m × 0.3m) × 0.3m – (0.5 × 47.25 kPa × 0.9m × 0.3m) × 0.3m – T × 1.5m = 0

$M_o =$ 5.82 kNm + 3.53 kNm + 1.20 kNm + 0.21 kNm – 1.91 kNm – 1.5T = 0

T = 8.85 kNm / 1.5m *(assume tie rod max 400mm from top of concrete path)*

5.90 kN

Check compression under 65 × 65 washer

$øN = ø \times k_1 \times k_4 \times k_7 \times f_p \times A_p$

$0.8 \times 0.97 \times 0.85 \times 1.0 \times 6.9\ \text{MPa} \times (0.065\text{m} \times 0.065\ \text{m} - \pi \times (0.016\text{m})^2 / 4)$

18.3 kN

→ 5.90 / 18.3 = 0.32 < 1 OK

8.4 Retaining Boards

Try 150 × 50 H6 retaining boards

Active pressure at 1.0m depth: 9.90 kPa

Line load on retaining board: 9.90 kPa × 0.15m

1.49 kN/m

$M^* = w^* L^2 / 8$

$1.49\ \text{kN/m} \times (1.0\text{m})^2 / 8$

0.19 kNm

$øM = ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.8 \times 0.70 \times 1 \times 1 \times 14.0\ \text{MPa} \times (0.15 \times 0.05^2 / 6)$

0.39 kNm

→ 0.19 / 0.39 = 0.49 < 1 OK

Try 200 × 50 H6 retaining boards

Active pressure at 1.0m depth: 9.90 kPa

Line load on retaining board: 9.90 kPa × 0.20m

1.98 kN/m

$M^* =$ $w^* L^2 / 8$

1.98 kN/m × $(1.0\text{m})^2 / 8$

0.25 kNm

$øM =$ $ø \times k_1 \times k_4 \times k_9 \times k_{12} \times f_B \times Z$

$0.8 \times 0.8 \times 0.70 \times 1 \times 1 \times 14.0$ MPa × $(0.20 \times 0.05^2 / 6)$

0.52 kNm

→ 0.25 / 0.52 = 0.48 < 1 OK

Use 150 SED H6 timber posts in 350mmØ concrete filled holes at max 1000 centres
With 150 × 50 OR 200 × 50 H6 timber retaining boards and M16 SS tie bar

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