File: 16627
23 August 2023
Revision: 1

RETAINING WALL DESIGN

932 Whangarei Heads Road, Whangarei

(Rahuikuri A2C Block)

1.0 Introduction

RS Eng Ltd (RS Eng) has been engaged by Steve Morris to complete a geotechnical investigation of his property (Rahuikuri A2C Block) for the design of soldier piles, to mitigate the risk of potential slope instability affecting the existing building, due to its limited setback from the steep slopes.

2.0 Site Description

This 0.42ha property is located on the southern side of Whangarei Heads Road, approximately 780m east of its intersection with Pepi Road. The property sits on an elevated plateau feature at the foot of a dominant spur to the northwest. A dwelling exists atop the plateau near the crest of the steep slopes. The property slopes gently to the northwest before dropping off steeply to the south. Ground coverage is currently mown lawn with the slope bush clad.

Figure 1: Rahuikuri A2C Block *(Source: RS ENG GIS).*

3.0 Desk Study

3.1 Site Geology

The GNS 1:250,000 scale New Zealand Geology Web Map indicates that the property is located within an area that is underlain by Waipapa Group, which has been described as follows: *"Volcaniclastic sandstone and argillite with tectonically included basalt, chert and siliceous argillite."*

4.0 Field Investigation

Two Engineers from this office visited the property on 19 April 2023 to undertake a walkover inspection three Scala Penetrometer tests and three hand augers.

The walkover inspection observed a cut approximately 1.5m high and 10m long between the dwelling and the crest of the cliff. Fill was noted in the cut face. A recent slope failure had occurred on the steep slopes near the southwestern corner of the dwelling.

The hand augers were dug to a maximum depth of 2.3m BGL (below ground level). Shear Vane readings were taken at regular intervals throughout the hand augers, observing In Situ Shear Strengths from 100kPa up to and exceeding 195kPa in natural ground and generally less than 100kPa and as low as 28kPa in fill material. Soil and rock descriptions are in general accordance with the New Zealand Geotechnical Society guideline.

The Scala Penetrometer tests were performed at the base of HA01 and at the surface on the cut platform in natural ground, achieving a minimum of 7 blows/100mm between 1.5-2.1m, increasing in density with depth.

5.0 Subsoil Conditions

Interpretation of subsurface conditions is based on the investigations shown on the drawings in Appendix A. The conditions are summarised below.

- 0.3-1.1m of fill was encountered at the surface (where not recently cut), consisting of high plasticity, organic clay with minor silt.
- 0.2m of buried topsoil was encountered below fill.
- Extremely weak, completely weathered Greywacke was encountered below buried topsoil between 0.55m-1.3mBGL, to an observed depth of 2.35mBGL. Completely weathered Greywacke consisted of non-plastic, well graded, silty, sandy gravel with trace clay, and low plasticity, clayey silt with minor sand and trace gravel.
- Groundwater was not encountered during investigations and is expected to be greater than 10m due to the relative permeability of the rock mass.

6.0 Soldier Pile Design

The proposed soldier piles are aimed to provide lateral restrain to the buildings founding soils and rock, should the existing landslide regress, or a future landslide occurs.

RS Eng has designed design the solider piles, based on a potential regression of the existing slope to a 35° line of influence from the lowest part of the adjacent slope. Due to the position of the building in relation to the slope, the potential retained depth reduces from west to east. For efficiency, we have designed three pile types, accounting for the reduced potential maximum retained height.

6.1 Geotechnical Parameters

The design soil parameters for the various materials/units are presented in Table 1 below. These are based on the previous RS Eng report, the previous investigations, and our experience in similar materials.

Table 1: Assessed Retaining Wall Design Parameters

Parameter	Residual Soil/Earth Fill	Weathered Rock
Soil Density (kN/m³)	19	22
Friction Angle (°)	30	35
Undrained Cohesion (kPa)	100	100

6.2 Groundwater

Hydrostatic pressures were taken as nil in the design. Elevated groundwater is not likely within the Waipapa Group Greywacke due to the jointed nature of the rock mass and its relatively high hydraulic conductivity.

6.3 Seismic Loading

Based on a site subsoil Class C and a 1 in 500 year return period design event, a peak ground acceleration of 0.19g was adopted. The design peak ground acceleration was calculated based on the recommendations of MBIE Module 6, being k_h=0.09g (α_{max}=0.19,g A_{topo}=1.2, Wd=0.5).

6.4 Surcharge Loading

The retaining walls have been designed using a permanent surcharge load of 12.5kPa to represent existing building loads and the soil surcharge.

6.5 Methods of Analysis

Analysis of the proposed retaining walls was completed using the methods of NZBC B1/VM4.

6.6 Results

The calculations are included in Appendix C. All cases achieved the design criteria.

The design drawings are included in Appendix E.

7.0 Stormwater

All stormwater should be collected from roofs and paved surfaces and discharged in a controlled manner. RS Eng recommends stormwater is discharged to the north, away from the steep slopes. No stormwater shall be discharged in an uncontrolled manner. As much as reasonably practical, all stormwater/runoff shall be discharged/diverted away from the steep slopes.

8.0 Construction Monitoring and Producer Statements

During the soldier piles construction, RS Eng shall undertake construction monitoring and the contactor shall complete quality assurance in accordance with Table 2 below.

Any works not inspected will be excluded from future producer statements (PS4) to be issued by RS Eng. In any event, where doubt exists regarding inspections, this office should be contacted for advice, and provided with reasonable notice of inspections.

Table 2: Summary of Geotechnical Construction Monitoring and Testing

Stage	Observations	Specification / Acceptance Criteria	Observation / Testing by:
Retaining Walls	Setout	Positioned correctly	Surveyor
	Foundation excavations	Confirm assumed design soil/rock conditions	RS Eng (100%)
	Wall construction	Correct materials / layout	Contractor to keep records of materials installed. RS Eng periodic observations (50%)

9.0 Limitations

This report has been prepared solely for the benefit of our client. The purpose is to provide details of the soldier pile wall design enclosed. The reliance by other parties on the information, opinions or recommendations contained therein shall, without our prior review and agreement in writing, do so at their own risk.

Recommendations and opinions in this report are based on data obtained as previously detailed. The nature and continuity of subsoil conditions away from the test locations are inferred and it should be appreciated that actual conditions could vary from those assumed. If during the construction process, conditions are encountered that differ from the inferred conditions on which the report has been based, RS Eng should be contacted immediately.

Construction site safety is the responsibility of the builder/contractor. The recommendations included herein should not be construed as direction of the contractor's methods, construction sequencing or procedures. RS Eng can provide recommendations if specifically engaged to, upon request.

Prepared/Approved by:

Matthew Jacobson
Director
NZDE(Civil), BE(Hons)(Civil), CPEng, CMEngNZ

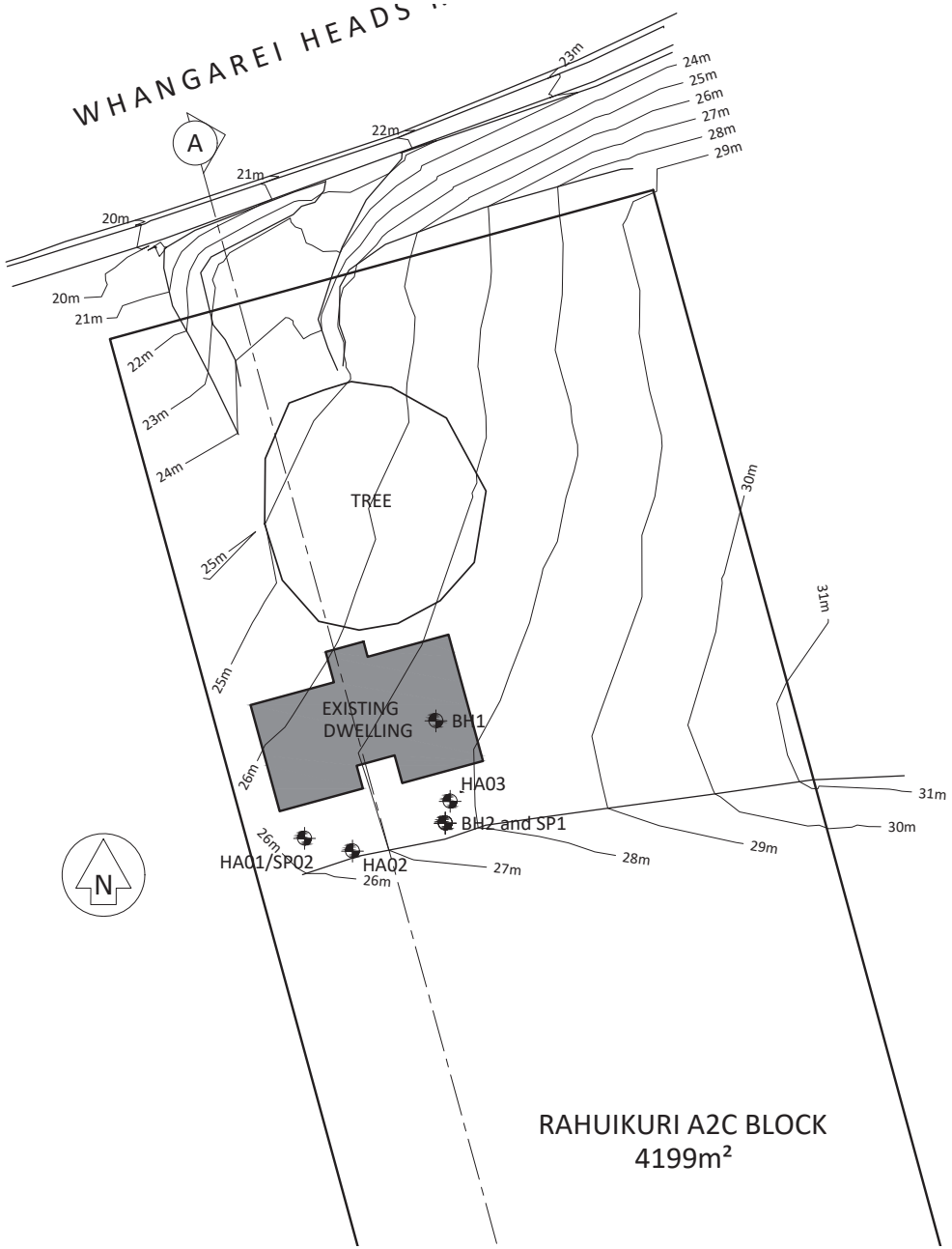
Reviewed by:

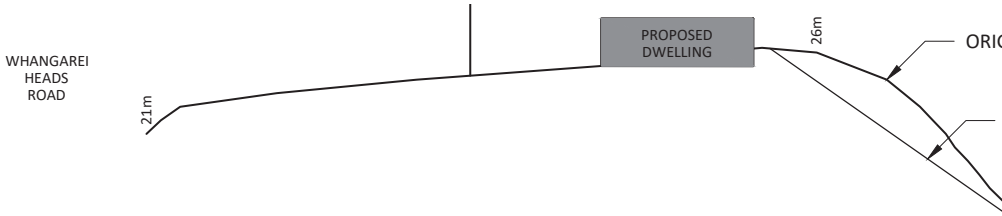
David Platt
Geotechnical Team Leader
NZDE(Civil), MEngNZ

RS Eng Ltd

Appendix A

Drawings





SECTION A-A 1:500

Appendix B

Subsurface Investigations

RS Eng Ltd
09 438 3273
office@RSEng.co.nz
2 Seaview Road,
Whangarei 0110

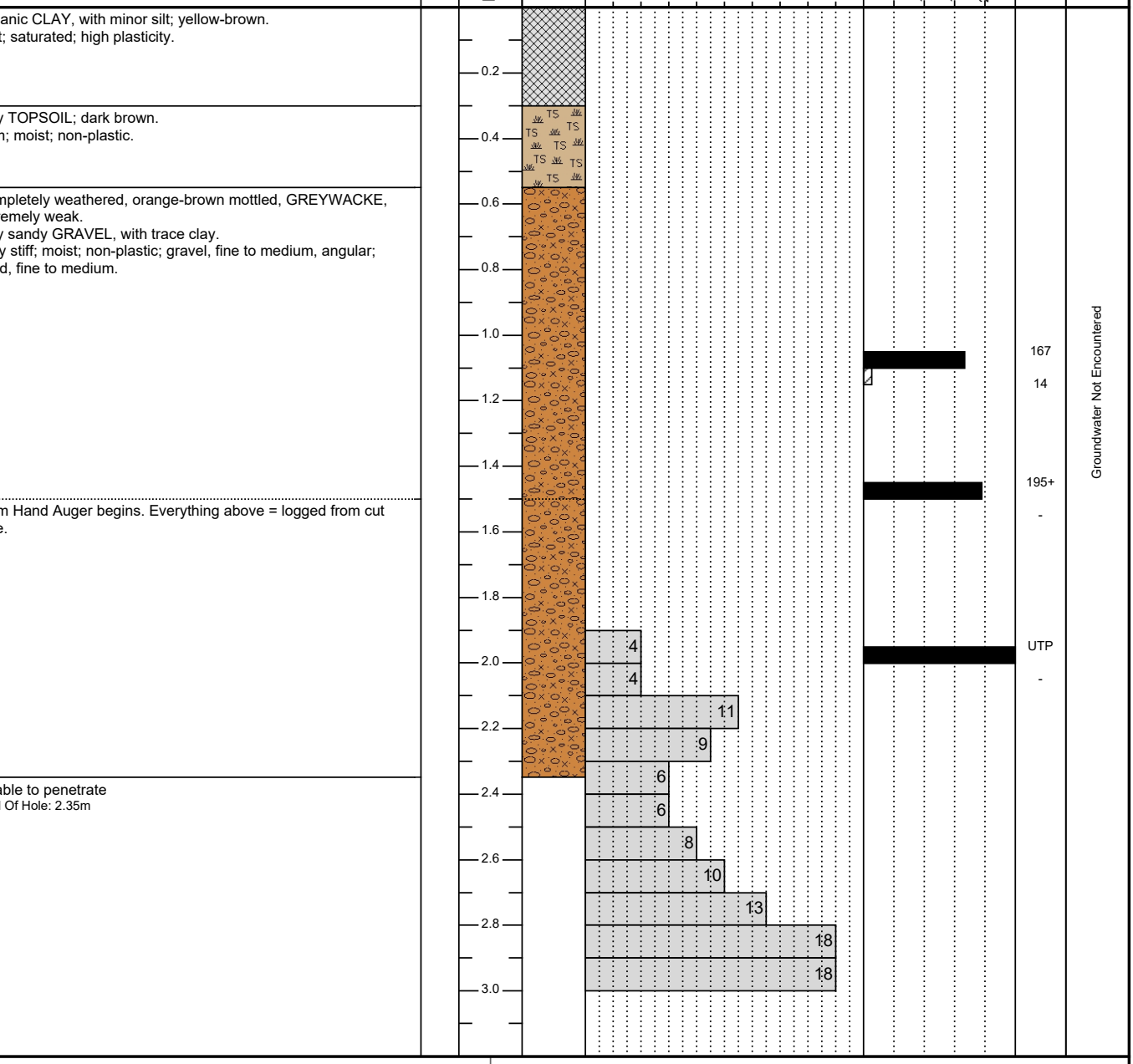
HAND AUGER LOG

HOLE NO.: HA01/SP02

CLIENT: Morris Steven
PROJECT: Geotechnical Investigations
JOB NO.: 16627

SITE LOCATION: 932 Whangarei Heads Road
CO-ORDINATES: 1730622mE, 6039559mN
ELEVATION: 25.3m
START DATE: 19/04/2023
END DATE: 19/04/2023
LOGGED BY: BL

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)
FILL	Organic CLAY, with minor silt; yellow-brown. Soft; saturated; high plasticity.		0.0 – 0.2
TS	Silty TOPSOIL; dark brown. Firm; moist; non-plastic.		0.2 – 0.4
Waipapa Gr	Completely weathered, orange-brown mottled, GREYWACKE, extremely weak. Silty sandy GRAVEL, with trace clay. Very stiff; moist; non-plastic; gravel, fine to medium, angular; sand, fine to medium.		0.4 – 1.5
	1.5m Hand Auger begins. Everything above = logged from cut face.		1.5 – 2.35
	Unable to penetrate End Of Hole: 2.35m		2.35



WATER: Groundwater Not Encountered

PHOTO(S)

REMARKS

HA performed at the base of 1.5m existing cut. 0-1.5m logged from cut face. SP performed at base of HA.

WATER

- ▼ Standing Water Level
- ▷ Out flow
- ◁ In flow

INVESTIGATION TYPE

- ☑ Hand Auger
- ☐ Test Pit

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HAND AUGER LOG

HOLE NO.: HA02

CLIENT: Morris Steven
PROJECT: Geotechnical Investigations
JOB NO.: 16627

SITE LOCATION: 932 Whangarei Heads Road
CO-ORDINATES: 1730628mE, 6039557mN
ELEVATION: 24.4m
START DATE: 19/04/2023
END DATE: 19/04/2023
LOGGED BY: BL

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 0mm)	VANE SHEAR STRENGTH (kPa) Vane: GEO415	Values	WATER
FILL	Organic CLAY, with minor silt; yellow-brown. Soft; saturated; high plasticity.		0.0				28 8	Groundwater Not Encountered
	0.6m minor fine, angular gravel, becoming firm.		0.6				84 28	
TS	Silty TOPSOIL; dark brown. Firm; moist; non-plastic.		1.0	TS			98 17	
Waipapa Gr	Completely weathered, orange-brown mottled, GREYWACKE, extremely weak. Clayey SILT, with minor sand, with trace gravel. Very stiff; moist; low plasticity; sand, fine to medium; gravel, fine.		1.4				112 14	
	1.5m Hand Auger begins. Everything above = logged from cut face		1.5					
	Target Depth End Of Hole: 2.00m		2.0				195+ -	

SCALA PENETROMETER: 2 4 6 8 10 12 14 16 18
VANE SHEAR STRENGTH (kPa): 50 100 150 200
DEPTH (m): 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0

PHOTO(S)

REMARKS

HA performed at the base of 1.5m existing cut.

WATER

- Standing Water Level
- Out flow
- In flow

INVESTIGATION TYPE

- [x] Hand Auger
- [ ] Test Pit

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HAND AUGER LOG

HOLE NO.: HA03

CLIENT: Morris Steven
PROJECT: Geotechnical Investigations

JOB NO.: 16627

SITE LOCATION: 932 Whangarei Heads Road
CO-ORDINATES: 1730635mE, 6039559mN
ELEVATION: 26.5m

START DATE: 19/04/2023
END DATE: 19/04/2023
LOGGED BY: BL

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 0mm)	VANE SHEAR STRENGTH (kPa) Vane: GEO415	Values	WATER
FILL	Organic CLAY, with minor silt; yellow-brown. Soft; saturated; high plasticity.		0.0 – 0.5				151	Groundwater Not Encountered
TS	Silty TOPSOIL; dark brown. Firm; moist; non-plastic.		0.5 – 0.8	TS			22	
	Void		0.8 – 1.0	VOID				
Waipapa Gr	Completely weathered, orange-brown mottled, GREYWACKE, extremely weak. Clayey SILT, with minor sand, with trace gravel. Very stiff; moist; low plasticity; sand, fine to medium; gravel, fine.		1.0 – 2.0				63 21 195+ -	
	Target Depth End Of Hole: 2.00m		2.0				195+ -	

Scala penetrometer: 2, 4, 6, 8, 10, 12, 14, 16, 18 (Blows / 0mm)
Vane shear strength (kPa): 50, 100, 150, 200

PHOTO(S)

REMARKS

HA performed and logged from cut platform.

WATER

- Standing Water Level
- Out flow
- In flow

INVESTIGATION TYPE

- [x] Hand Auger
- [ ] Test Pit

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HAND AUGER LOG

HOLE NO.: SP01

CLIENT: Morris Steven
PROJECT: Geotechnical Investigations
JOB NO.: 16627

SITE LOCATION: 932 Whangarei Heads Road
CO-ORDINATES: 1730630mE, 6039560mN
ELEVATION: 26.9m
START DATE: 19/04/2023
END DATE: 19/04/2023
LOGGED BY: BL

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 100mm)	VANE SHEAR STRENGTH (kPa) Vane: Values	WATER
	SP performed at the base of 1.5m cut.		0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4				Groundwater Not Encountered
	End Of Hole: 2.30m		1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0		8, 13, 15, 13, 13, 15, 29 >>, 25 >>		

SCALA PENETROMETER (Blows / 100mm): 2 4 6 8 10 12 14 16 18
VANE SHEAR STRENGTH (kPa) Vane: 50 100 150 200

PHOTO(S)

REMARKS

WATER
- Standing Water Level
- Out flow
- In flow

INVESTIGATION TYPE
- Hand Auger
- Test Pit

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HAND AUGER LOG

HOLE NO.: SP03

CLIENT: Morris Steven
PROJECT: Geotechnical Investigations
JOB NO.: 16627

SITE LOCATION: 932 Whangarei Heads Road
CO-ORDINATES: 1730636mE, 6039561mN
ELEVATION: 27.6m
START DATE: 19/04/2023
END DATE: 19/04/2023
LOGGED BY: BL

UNIT	MATERIAL DESCRIPTION (See Classification & Symbology sheet for details)	SAMPLES	DEPTH (m)	LEGEND	SCALA PENETROMETER (Blows / 100mm)	VANE SHEAR STRENGTH (kPa)	WATER
	SP performed at the base of 1.5m cut.		0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4				
	End Of Hole: 2.90m		1.6, 1.8, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0		1, 1, 8, 10, 13, 9, 18, 14, 20, 20, 21 >>		Groundwater Not Encountered

Scala Penetrometer (Blows / 100mm): 2 4 6 8 10 12 14 16 18
Vane Shear Strength (kPa) — Vane: 50 100 150 200 — Values

PHOTO(S)

REMARKS

WATER
- Standing Water Level
- Out flow
- In flow

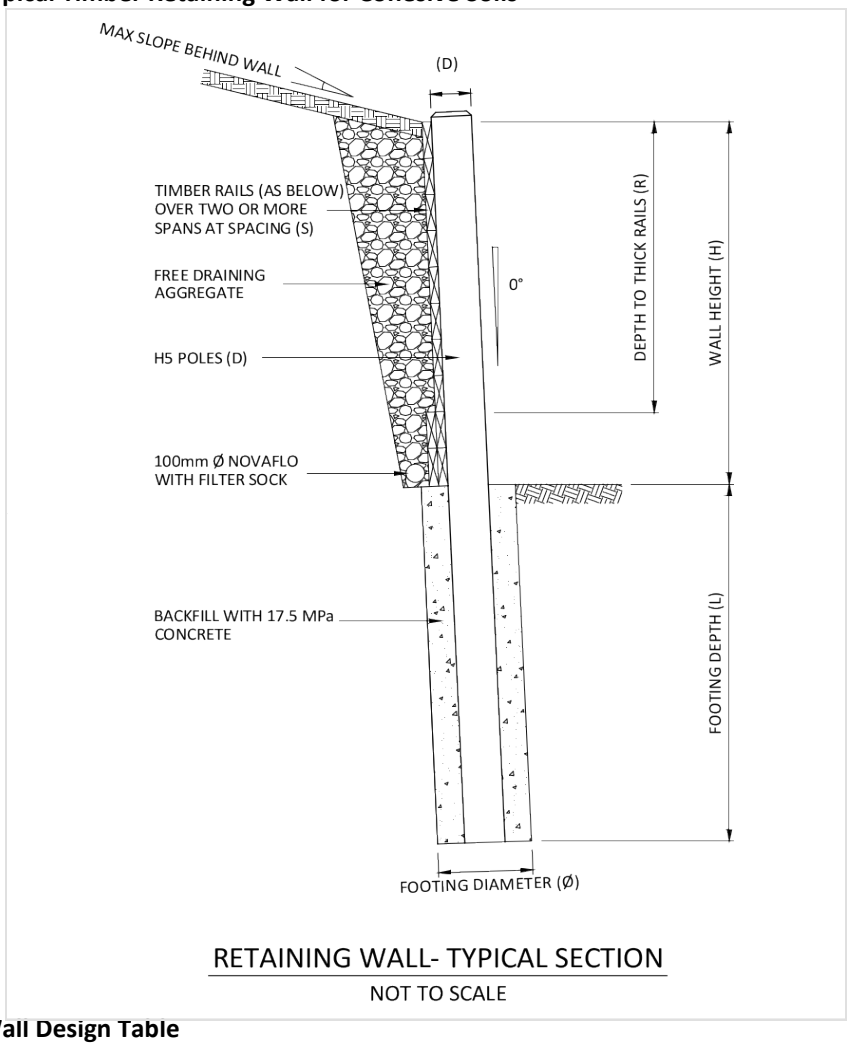
INVESTIGATION TYPE
- Hand Auger
- Test Pit

Appendix C

Calculations

PROJECT	Soldier Piles	Page No.	1
		Job No.	16627
		Calculated by:	MJ
CLIENT	S Morris	Checked by:	
		Date	15/08/2023

Design of Typical Timber Retaining Wall for Cohesive Soils



RETAINING WALL- TYPICAL SECTION

NOT TO SCALE

Retaining Wall Design Table

Max Wall Height	Pole Size	Min Footing Depth	Footing Diameter	Depth to Thick Rails	Pole Spacing	Rail Size
(H)	(D)	(L)	(Ø)	(R)	(S)	
3.5m	600ø RC	6.0m	0.60m	-	1.5m	200x50 RS
2.7m	400SED HD	5.0m	0.75m	0.3m	1.5m	200x50 RS
2.1m	325SED HD	4.0m	0.60m	0.3m	1.5m	200x50 RS

Notes:

Safety from falling barrier required for walls over 1.0m high where access unrestricted

PROJECT Soldier Piles

CLIENT S Morris

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Checked by:	0
Date	15/08/2023

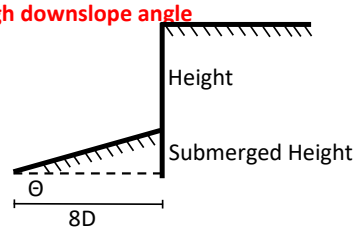
Design of Typical Timber Retaining Wall for Cohesive Soils

1.0 Site Parameters

Location		Northland
Subsoil Class		Class C
Performance Requirement Case	Case	3
Importance Level	IL	2
		ULS

Design Wall Parameters **Consider modelling in Wallap due to high downslope angle**

Height	H	3.5	m
Downslope Angle	Θ	0	deg
Allowance for Creep	creep	0.0	m
Submerged height	h	0.0	m
Retained Height	H_W	3.5	m
Ground Slope Behind Wall	i	0	deg
Rake on Wall	β	0	deg
Pole Spacing	S	1.5	m
Wall Friction Angle	δ	0	deg



Design Retained Soil Parameters

Soil Density	γ	19	kN/m³
Effective Stress Angle	ϕ	30	deg

Design Foundation Soil Parameters

Undrained Soil Strength	Su	90	kPa
Strength Reduction Factor for Soils	Φ	0.5	

Design Wall Surcharge

Permanent Surcharge	S_G	16.0	kPa
Variable Surcharge	S_Q	0.0	kPa
Construction Surcharge	S_{CON}	0.0	kPa

Seismic Parameters

Topographic Amplification Factor	A_{topo}	1.2	
Return Period	R	1.0	
Wall Displacement Factor	W_d	0.5	
Peak horizontal ground acceleration	a_{max}	0.15	g
Design horizontal acceleration	k_h	0.1	g
	θ	5	deg

Table 5.1, Module 6

$$a_{max} = C_{0,1000}\frac{R}{1.3}fg$$

$$k_h = a_{max}A_{topo}W_d$$

$$\theta = \tan^{-1}k_h$$

2.0 Pressure Coefficients

Ka	0.33
Ko	0.50
Kp	3
Kae	0.39
Kpe	0.39

Coefficient Chosen: **Ko**

$$K_A = \frac{cos^2(\emptyset+\beta)}{\cos(\delta-\beta)cos^2(-\beta)[1+\sqrt{\frac{\sin(\emptyset+\delta)\sin(\emptyset-i)}{\cos(\delta-\beta)\cos(-i-\beta)}}]^2}$$

$$K_{AE} = \frac{cos^2(\emptyset-\theta+\beta)}{cos\theta cos^2\beta\cos(\delta+\beta+\theta)[1+\sqrt{\frac{\sin(\emptyset+\delta)\sin(\emptyset-\theta-i)}{\cos(\delta+\beta+\theta)\cos(i-\beta)}}]^2}$$

$$K_{PE} = \frac{cos^2(\emptyset-\theta+\beta)}{cos\theta cos^2\beta\cos(\delta-\beta+\theta)[1+\sqrt{\frac{\sin(\emptyset+\delta)\sin(\emptyset-\theta+i)}{\cos(\delta-\beta+\theta)\cos(i-\beta)}}]^2}$$

PROJECT Soldier Piles

CLIENT S Morris

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Design of Typical Timber Retaining Wall for Cohesive Soils

3.0 Loading:

		Characteristic	Static	Earthquake	Construction
Soil Pressure	Fe	87.3	130.9	67.8	87.3
Permanent Surcharge	G	42.0	50.4	32.6	42.0
Variable Surcharge	Q	0.0	0.0	0.0	0.0
	Sum (kN)	129.3	181.3	100.4	129.3
	Average LF	1	1.4	1.0	1

$$P_{soil} = \frac{1}{2} L F K_{chosen} \gamma H_w{}^2 S$$

$$P_{sur} = L F K_{chosen} S_s H_w S$$

4.0 Bending Moments:

		Moment (kNm)	M/K1
Characteristic	M_C	175.3	292.2
Static	M_S	240.9	401.6
Earthquake	M_{EQ}	136.1	136.1
Construction	M_{CON}	175.3	175.3

$$M = P_{soil}\frac{H_w}{3} + P_{sur}\frac{H_w}{2}$$

Design Bending Moment (Pole)	M*	240.9	kNm	Critical Moment: Static
Design Bending Moment (Footing)	M*	240.9	kNm	Critical Moment: Static

Pole Data:

Strength Reduction Factor	Ø	0.8
Load Duration Factor	K_1	0.6
Shaving Factor	K_{20}	0.85
Steaming Factor	K_{21}	0.85
Strength in Bending	f_b	52 MPa

$$Z_{req} = \frac{M}{\emptyset K_1 K_{20} K_{21} f_b}$$

$$SED_{req} = D_{req} - 6_E{}^{-3} H_w \qquad D_{req} = \sqrt[3]{\frac{32 Z_{req}}{\pi}}$$

Type of Log Chosen: SED HD

SED HD size required= 493 mm

Pole Size Chosen: 450SED HD

5.0 Choose Footing Depth

Footing Diameter	D	0.6	m
Spacing Factor	S_{fact}	0.63	
Total Force on Wall	P	181.3	kN
Height of Total Force on Wall	H	1.33	m
Depth to Effective Soil	F_0	0.90	m
Required Depth of Footing	L	5.77	m

$$H_{cap} = \Phi 9 S_u B \sqrt{\begin{matrix}(L+2H+F_0)^2 \\ +(L-F_0)^2 \\ -(L+2H+F_{0)}\end{matrix}}$$

F_0 Manual Entry (m)

Footing Depth Chosen (m) 6.00

6.0 Check Rails

Choose Rail Size: 200x50 RS

Choose Timber Grade: No. 1 Framing

Ensure rails are continuous over more than one span.

Strength of Single Rail ϕM_n 0.30 kNm

$$\Phi M_n = \frac{\Phi k_1 f_b d b^2}{6}$$

Maximum unrestrained depth for single depth 0.27 m

$$depth = \frac{\Phi M_n 10}{L F K_{chosen} (\gamma + S_S) d S^2}$$

PROJECT Soldier Piles

CLIENT S Morris

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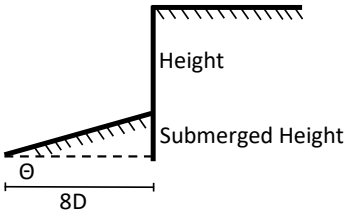
Design of Typical Timber Retaining Wall for Cohesive Soils

1.0 Site Parameters

Location		Northland	
Subsoil Class		Class C	
Performance Requirement Case	Case	3	
Importance Level	IL	2	
		ULS	

Design Wall Parameters

Height	H	2.7	m
Downslope Angle	Θ	0	deg
Allowance for Creep	creep	0.0	m
Submerged height	h	0.0	m
Retained Height	H_W	2.7	m
Ground Slope Behind Wall	i	0	deg
Rake on Wall	β	0	deg
Pole Spacing	S	1.5	m
Wall Friction Angle	δ	0	deg



Design Retained Soil Parameters

Soil Density	γ	19	kN/m³
Effective Stress Angle	ϕ	30	deg

Design Foundation Soil Parameters

Undrained Soil Strength	Su	80	kPa
Strength Reduction Factor for Soils	Φ	0.5	

Design Wall Surcharge

Permanent Surcharge	S_G	16.0	kPa
Variable Surcharge	S_Q	0.0	kPa
Construction Surcharge	S_{CON}	0.0	kPa

Seismic Parameters

Topographic Amplification Factor	A_{topo}	1.2	
Return Period	R	1.0	
Wall Displacement Factor	W_d	0.5	
Peak horizontal ground acceleration	a_{max}	0.15	g
Design horizontal acceleration	k_h	0.1	g
	θ	5	deg

Table 5.1, Module 6

$$a_{max} = C_{0,1000}\frac{R}{1.3}fg$$

$$k_h = a_{max}A_{topo}W_d$$

$$\theta = \tan^{-1}k_h$$

2.0 Pressure Coefficients

Ka	0.33
Ko	0.50
Kp	3
Kae	0.39
Kpe	0.39

Coefficient Chosen: **Ko**

$$K_A = \frac{cos^2(\emptyset+\beta)}{\cos(\delta-\beta)cos^2(-\beta)[1+\sqrt{\frac{\sin(\emptyset+\delta)\sin(\emptyset-i)}{\cos(\delta-\beta)\cos(-i-\beta)}}]^2}$$

$$K_{AE} = \frac{cos^2(\emptyset-\theta+\beta)}{cos\theta cos^2\beta\cos(\delta+\beta+\theta)[1+\sqrt{\frac{\sin(\emptyset+\delta)\sin(\emptyset-\theta-i)}{\cos(\delta+\beta+\theta)\cos(i-\beta)}}]^2}$$

$$K_{PE} = \frac{cos^2(\emptyset-\theta+\beta)}{cos\theta cos^2\beta\cos(\delta-\beta+\theta)[1+\sqrt{\frac{\sin(\emptyset+\delta)\sin(\emptyset-\theta+i)}{\cos(\delta-\beta+\theta)\cos(i-\beta)}}]^2}$$

PROJECT Soldier Piles

CLIENT S Morris

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Calculated by:	MJ
Checked by:	0/01/1900
Date	15/08/2023

Design of Typical Timber Retaining Wall for Cohesive Soils

3.0 Loading:

		Characteristic	Static	Earthquake	Construction
Soil Pressure	Fe	51.9	77.9	40.3	51.9
Permanent Surcharge	G	32.4	38.9	25.2	32.4
Variable Surcharge	Q	0.0	0.0	0.0	0.0
	Sum (kN)	84.3	116.8	65.5	84.3
	Average LF	1	1.4	1.0	1

$$P_{soil} = \frac{1}{2} LFK_{chosen}\gamma {H_w}^2 S$$

$$P_{sur} = LFK_{chosen} S_s H_w S$$

4.0 Bending Moments:

		Moment (kNm)	M/K1
Characteristic	M_C	90.5	150.8
Static	M_S	122.6	204.3
Earthquake	M_{EQ}	70.2	70.2
Construction	M_{CON}	90.5	90.5

$$M = P_{soil}\frac{H_w}{3} + P_{sur}\frac{H_w}{2}$$

Design Bending Moment (Pole)	M*	122.6	kNm	Critical Moment: Static
Design Bending Moment (Footing)	M*	122.6	kNm	Critical Moment: Static

Pole Data:

Strength Reduction Factor	Ø	0.8
Load Duration Factor	K_1	0.6
Shaving Factor	K_{20}	0.85
Steaming Factor	K_{21}	0.85
Strength in Bending	f_b	52 MPa

$$Z_{req} = \frac{M}{\emptyset K_1 K_{20} K_{21} f_b}$$

$$SED_{req} = D_{req} - 6_E{}^{-3} H_w \qquad D_{req} = \sqrt[3]{\frac{32 Z_{req}}{\pi}}$$

Type of Log Chosen:	**SED HD**
Pole Size Chosen:	**400SED HD**

SED HD size required= 394 mm

5.0 Choose Footing Depth

Footing Diameter	D	0.75	m
Spacing Factor	S_{fact}	0.50	
Total Force on Wall	P	116.8	kN
Height of Total Force on Wall	H	1.05	m
Depth to Effective Soil	F_0	1.13	m

$$H_{cap} = \Phi 9 S_u B \sqrt{\begin{matrix}(L+2H+F_0)^2 \\ +(L-F_0)^2 \\ -(L+2H+F_{0)}\end{matrix}}$$

F_0 Manual Entry (m)	

Required Depth of Footing L 4.99 m

Footing Depth Chosen (m)	**5.00**

6.0 Check Rails

Choose Rail Size:	200x50 RS
Choose Timber Grade:	No. 1 Framing

Ensure rails are continuous over more than one span.

Strength of Single Rail ϕM_n 0.30 kNm

$$\Phi M_n = \frac{\Phi k_1 f_b d b^2}{6}$$

Maximum unrestrained depth for single depth 0.27 m

$$depth = \frac{\Phi M_n 10}{LFK_{chosen}(\gamma + S_S) d S^2}$$

Accept a 400SED HD pole in a 0.75m diameter hole 5.0m deep for a maximum retained height of 2.7m. Below a depth of .27m use 200x75 rails or double thickness of 200x50 well spiked together.

PROJECT Soldier Piles

CLIENT S Morris

Page No.	6
Job No.	16627
Calculated by:	MJ
Checked by:	0
Date	15/08/2023

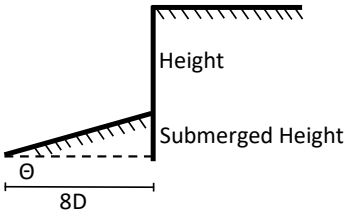
Design of Typical Timber Retaining Wall for Cohesive Soils

1.0 Site Parameters

Location		Northland
Subsoil Class		Class C
Performance Requirement Case	Case	3
Importance Level	IL	2
		ULS

Design Wall Parameters

Height	H	2.1	m
Downslope Angle	Θ	0	deg
Allowance for Creep	creep	0.0	m
Submerged height	h	0.0	m
Retained Height	H_W	2.1	m
Ground Slope Behind Wall	i	0	deg
Rake on Wall	β	0	deg
Pole Spacing	S	1.5	m
Wall Friction Angle	δ	0	deg



Design Retained Soil Parameters

Soil Density	γ	19	kN/m³
Effective Stress Angle	ϕ	30	deg

Design Foundation Soil Parameters

Undrained Soil Strength	Su	70	kPa
Strength Reduction Factor for Soils	Φ	0.5	

Design Wall Surcharge

Permanent Surcharge	S_G	16.0	kPa
Variable Surcharge	S_Q	0.0	kPa
Construction Surcharge	S_{CON}	0.0	kPa

Seismic Parameters

Topographic Amplification Factor	A_{topo}	1.0	
Return Period	R	1.0	
Wall Displacement Factor	W_d	0.5	
Peak horizontal ground acceleration	a_{max}	0.15	g
Design horizontal acceleration	k_h	0.1	g
	θ	4	deg

Table 5.1, Module 6

$$a_{max} = C_{0,1000}\frac{R}{1.3}fg$$

$$k_h = a_{max}A_{topo}W_d$$

$$\theta = \tan^{-1}k_h$$

2.0 Pressure Coefficients

Ka	0.33
Ko	0.50
Kp	3
Kae	0.38
Kpe	0.38

Coefficient Chosen: **Ko**

$$K_A = \frac{cos^2(\emptyset+\beta)}{\cos(\delta-\beta)cos^2(-\beta)[1+\sqrt{\frac{\sin(\emptyset+\delta)\sin(\emptyset-i)}{\cos(\delta-\beta)\cos(-i-\beta)}}]^2}$$

$$K_{AE} = \frac{cos^2(\emptyset-\theta+\beta)}{cos\theta cos^2\beta\cos(\delta+\beta+\theta)[1+\sqrt{\frac{\sin(\emptyset+\delta)\sin(\emptyset-\theta-i)}{\cos(\delta+\beta+\theta)\cos(i-\beta)}}]^2}$$

$$K_{PE} = \frac{cos^2(\emptyset-\theta+\beta)}{cos\theta cos^2\beta\cos(\delta-\beta+\theta)[1+\sqrt{\frac{\sin(\emptyset+\delta)\sin(\emptyset-\theta+i)}{\cos(\delta-\beta+\theta)\cos(i-\beta)}}]^2}$$

PROJECT Soldier Piles

CLIENT S Morris

Page No.	7
Job No.	16627
Calculated by:	MJ
Checked by:	0/01/1900
Date	15/08/2023

Design of Typical Timber Retaining Wall for Cohesive Soils

3.0 Loading:

		Characteristic	Static	Earthquake	Construction
Soil Pressure	Fe	31.4	47.1	23.8	31.4
Permanent Surcharge	G	25.2	30.2	19.1	25.2
Variable Surcharge	Q	0.0	0.0	0.0	0.0
	Sum (kN)	56.6	77.4	42.8	56.6
	Average LF	1	1.4	1.0	1

$$P_{soil} = \frac{1}{2} L F K_{chosen} \gamma H_w{}^2 S$$

$$P_{sur} = L F K_{chosen} S_s H_w S$$

4.0 Bending Moments:

		Moment (kNm)	M/K1
Characteristic	M_C	48.5	80.8
Static	M_S	64.7	107.9
Earthquake	M_{EQ}	36.7	36.7
Construction	M_{CON}	48.5	48.5

$$M = P_{soil}\frac{H_w}{3} + P_{sur}\frac{H_w}{2}$$

Design Bending Moment (Pole)	M*	64.7	kNm	Critical Moment: Static
Design Bending Moment (Footing)	M*	64.7	kNm	Critical Moment: Static

Pole Data:

Strength Reduction Factor	Ø	0.8
Load Duration Factor	K_1	0.6
Shaving Factor	K_{20}	0.85
Steaming Factor	K_{21}	0.85
Strength in Bending	f_b	52 MPa

$$Z_{req} = \frac{M}{\emptyset K_1 K_{20} K_{21} f_b}$$

$$SED_{req} = D_{req} - 6_E{}^{-3} H_w \qquad D_{req} = \sqrt[3]{\frac{32 Z_{req}}{\pi}}$$

Type of Log Chosen:	**SED HD**
Pole Size Chosen:	**325SED HD**

SED HD size required= 319 mm

5.0 Choose Footing Depth

Footing Diameter	D	0.6	m
Spacing Factor	S_{fact}	0.63	
Total Force on Wall	P	77.4	kN
Height of Total Force on Wall	H	0.84	m
Depth to Effective Soil	F_0	0.90	m

$$H_{cap} = \Phi 9 S_u B \sqrt{\begin{matrix}(L+2H+F_0)^2 \\ +(L-F_0)^2 \\ -(L+2H+F_{0)}\end{matrix}}$$

F_0 Manual Entry (m)	

Required Depth of Footing L 3.88 m

Footing Depth Chosen (m)	**4.00**

6.0 Check Rails

Choose Rail Size:	200x50 RS
Choose Timber Grade:	No. 1 Framing

Ensure rails are continuous over more than one span.

Strength of Single Rail ϕM_n 0.30 kNm

$$\Phi M_n = \frac{\Phi k_1 f_b d b^2}{6}$$

Maximum unrestrained depth for single depth 0.28 m

$$depth = \frac{\Phi M_n 10}{L F K_{chosen} (\gamma + S_S) d S^2}$$

Accept a 325SED HD pole in a 0.6m diameter hole 4.0m deep for a maximum retained height of 2.1m. Below a depth of .28m use 200x75 rails or double thickness of 200x50 well spiked together.

Appendix D

Producer Statement Design – PS1

PRODUCER STATEMENT – PS1A DESIGN

[NOT TO BE USED IN CONJUNCTION WITH A BUILDING CONSENT APPLICATION]

JOB NUMBER:	16627
ISSUED BY: *(Engineering Design Firm)*	RS Eng
TO: *(Client)*	Steven Morris
TO BE SUPPLIED TO: *(Regulatory Authority)*	Whangarei District Council
IN RESPECT OF: *(Description of Works to be constructed/carried out)*	SED Soldier Piles (the "Works")
AT: *(Address)*	932 Whangarei Heads Road, Parua Bay, Whangarei
LEGAL DESCRIPTION	Rahuikuri A2C Block

We have been engaged by Steven Morris to provide:

SED Soldier Piles

In this document SED means "Specific Engineering Design".

The design carried out by RS Eng has been prepared in accordance with the following compliance documents, regulatory requirements and/or standards and guidelines ('Compliance Documents'):

✓ Building Code Clause No(s): B1/VM4

The proposed work covered by this producer statement is described in the drawings listed in the attached Schedule, together with the specifications, and other documents set out in the attached Schedule.

On behalf of RS Eng, and subject to:

I believe on reasonable grounds that:

- the elements of the Works that have been designed by RS Eng, if constructed in accordance with the drawings, specifications, and other documents provided or listed in the attached Schedule, will comply with the relevant provisions of the Compliance Documents listed above and that:
- the persons who have undertaken the design have the necessary competency to do so.

I also recommend the following level of construction monitoring: CM2

I, Matthew Jacobson, am:

- CPEng number 1161533
- and hold the following qualifications: B.E. (Hons)

RS Eng holds a current policy of Professional Indemnity Insurance no less than $200,000.

✓ RS Eng is a member of ACE New Zealand.

SIGNED BY: Matthew Jacobson

(Signature):  Date: 23/08/2023

ON BEHALF OF: RS Eng

Note: This statement has been prepared solely for Whangarei District Council and shall not be relied upon by any other person or entity. Any liability in relation to this statement accrues to RS Eng only. As a condition of reliance on this statement, Whangarei District Council accepts that the total maximum amount of liability of any kind arising from this statement and all other statements provided to Whangarei District Council in relation to the Works, whether in tort or otherwise, is limited to the sum of $200,000.

SCHEDULE TO PS1A

Please include an itemised list of all referenced documents, drawings, or other supporting materials in relation to this producer statement below:

- Certificate of Design Work
- Geotechnical Report: RS Eng - Geotechnical Design Report - 23/08/2023 - RS16627

Appendix E

Drawings

WHANGAREI HEADS ROAD

932 Whangarei Heads Road
Parua Bay
Rahuikuri A2C Block
0.4199ha

Lot 2
DP 107135

Rahuikuri A2D2 Block

Actual dwelling position (surveyed) - shown solid and hatched

Actual deck position (surveyed)

19.5m long Soldier Pile Wall.
Refer to Sheet 2 for details on different Wall types.

5xPoles Type 1
3xPoles Type 2
6xPoles Type 3
19.5m long Soldier Pile Wall
Piles @ 1.5m crs
1.0m

30.0
27.5
25.0
22.5

0 1:25 2.5 3.75 5
PLAN 1:250

NOTES:

- All services should be located on-site prior to commencement of works.
- All works to comply with all relevant local authority by-laws and council regulations where applicable.
- Contractors to confirm all dimensions on site prior to commencing any work.
- Do not scale off drawings.
- These drawings are to be read in conjunction with specifications - plans take precedence.
- If any part of these documents are unclear, please contact RSEng Ltd.
- This plan is copyright to RSEng Ltd and should not be reproduced without prior permission.

Contours are shown at 0.5m crs.
Contours are derived from LiDAR (2018) and are shown at OTP64 Vertical Datum.

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2 Seaview Road,
Whangarei 0110

Title
EXISTING DWELLING AND SLIP
SLIP REMEDIAL DESIGN
SOLDIER PILE WALL DESIGN

Client
STEVEN MORRIS

Location
932 WHANGAREI HEADS ROAD
PARUA BAY

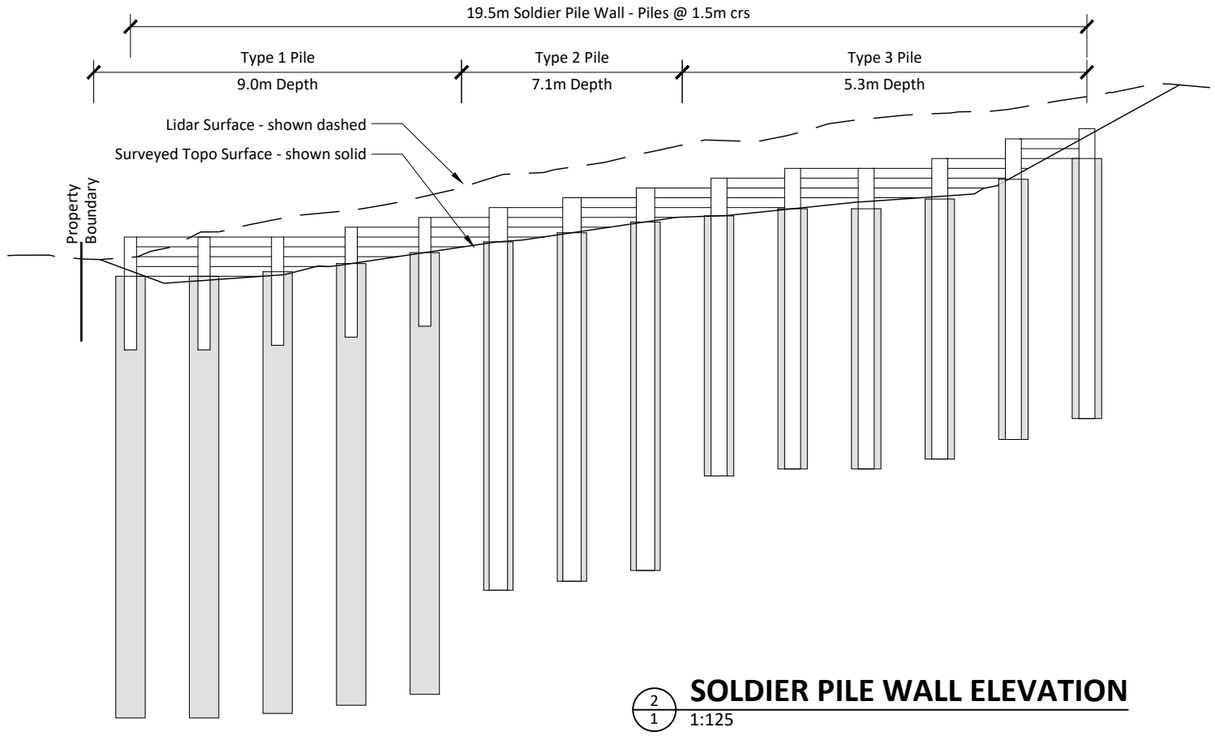
Date	Rev	Notes
04/08/2023	A	Building Consent Exemption

RS Eng Ltd
Consulting Engineers
This drawing is in accordance with our calculations where applicable.

per .....
Chartered Professional Engineer

Scale	Original	Rev
1:250	A3	A

Drawn	Approved	File #	Sheet
NW	MJ	16627	1



2/1 SOLDIER PILE WALL ELEVATION
1:125

NOTES:

- All services should be located on-site prior to commencement of works.
- All works to comply with all relevant local authority by-laws and council regulations where applicable.
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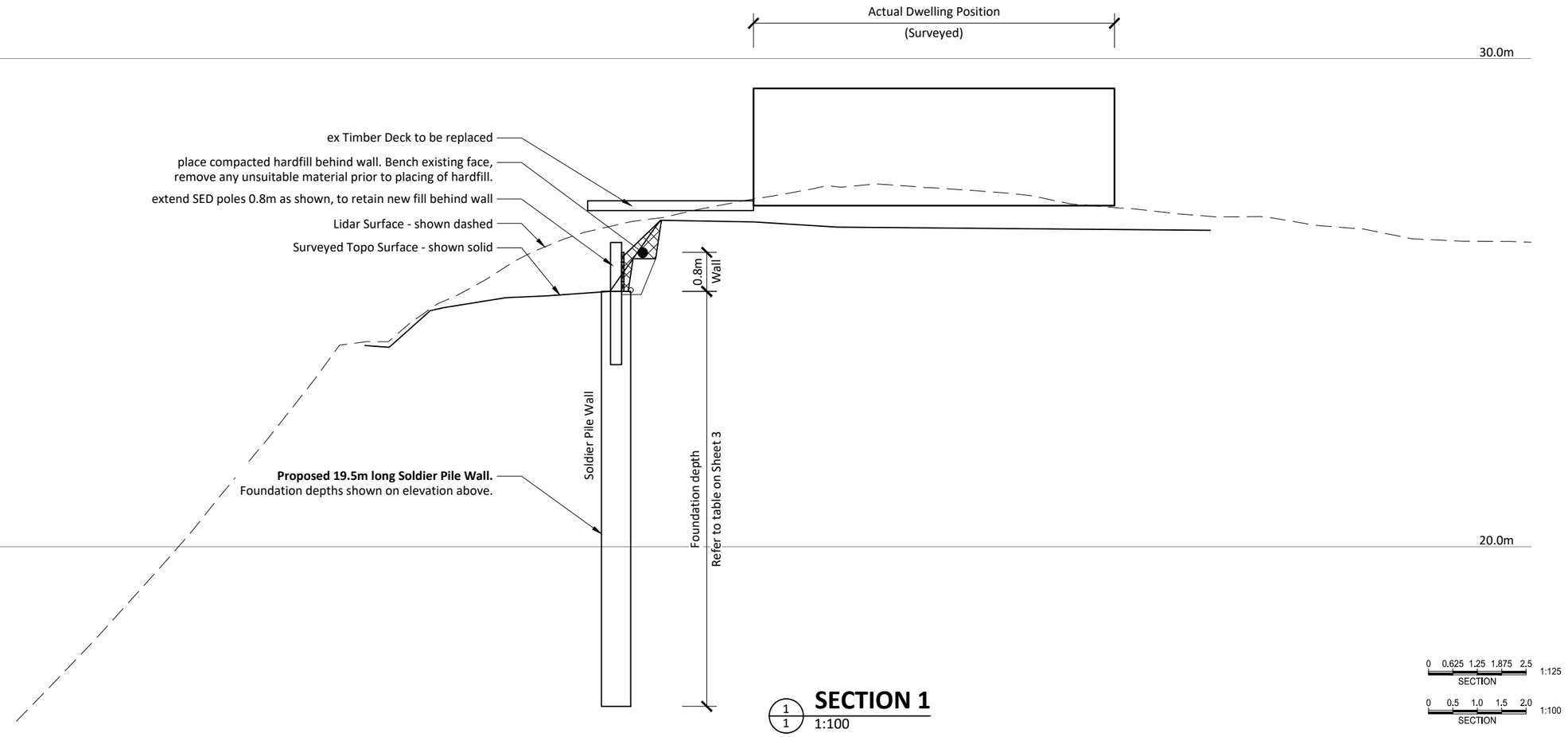
Refer to Sheet 3 for typical foundation type details

Wall Type	1	2	3
Pile	Reinforced Concrete	400SED	325SED
Depth	9.0m	7.1m	5.3m
Hole Ø	600mm	600mm	600mm
Concrete	35MPa	20MPa	20MPa
Reinforcing	12/HD20 R10 w/ 150mm	-	-
Rails	Double Rails	Double Rails	Double Rails



1/1 SECTION 1
1:100

0 0.625 1.25 1.875 2.5 SECTION 1:125

0 0.5 1.0 1.5 2.0 SECTION 1:100

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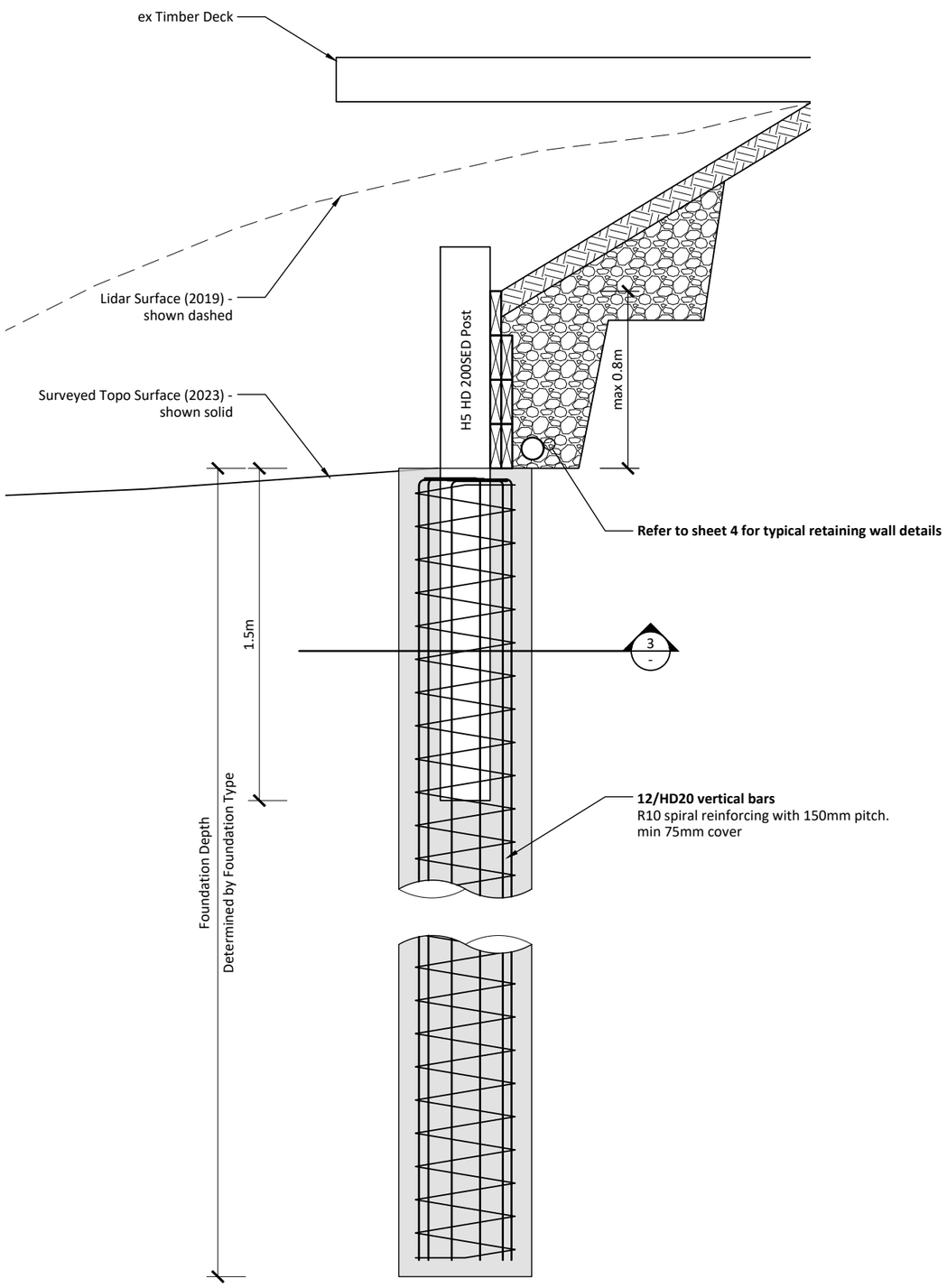
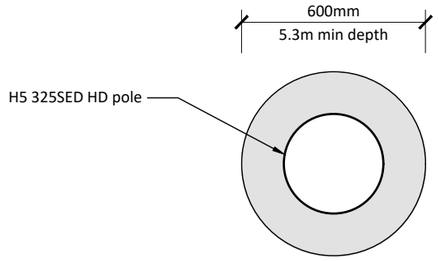
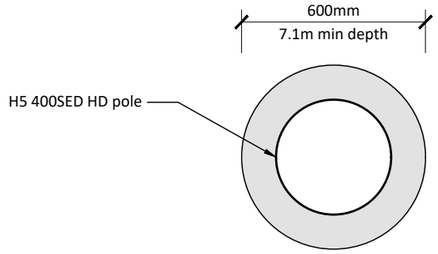


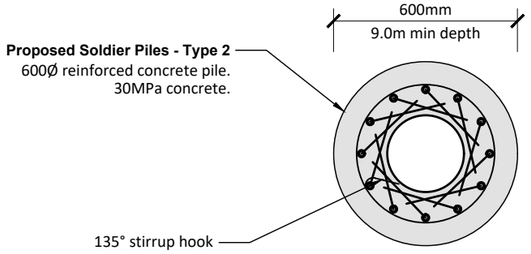
SOLDIER PILE WALL (TYPE 1) - TYPICAL SECTION
1:125



SOLDIER PILE FOUNDATION TYPE 3
1:20



SOLDIER PILE FOUNDATION TYPE 2
1:20



All spiral stirrups to be terminated with a 135° hook or be welded. Lap splices are not acceptable.

3
-

SOLDIER PILE FOUNDATION TYPE 1
1:20

NOTES:
- All services should be located on-site prior to commencement of works.
- All works to comply with all relevant local authority by-laws and council regulations where applicable.
- Contractors to confirm all dimensions on site prior to commencing any work.
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0 0.125 0.25 0.375 0.5 1:25
SECTION

0 0.1 0.2 0.3 0.4 1:20
SECTION

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EXISTING DWELLING AND SLIP
SLIP INVESTIGATIONS
SLIP REMEDIAL OPTIONS

Client
STEVEN MORRIS

Location
932 WHANGAREI HEADS ROAD
PARUA BAY

Date	Rev	Notes
04/08/2023	A	Building Consent Exemption

RS Eng Ltd
Consulting Engineers
This drawing is in accordance with our calculations where applicable.

per .....
Chartered Professional Engineer

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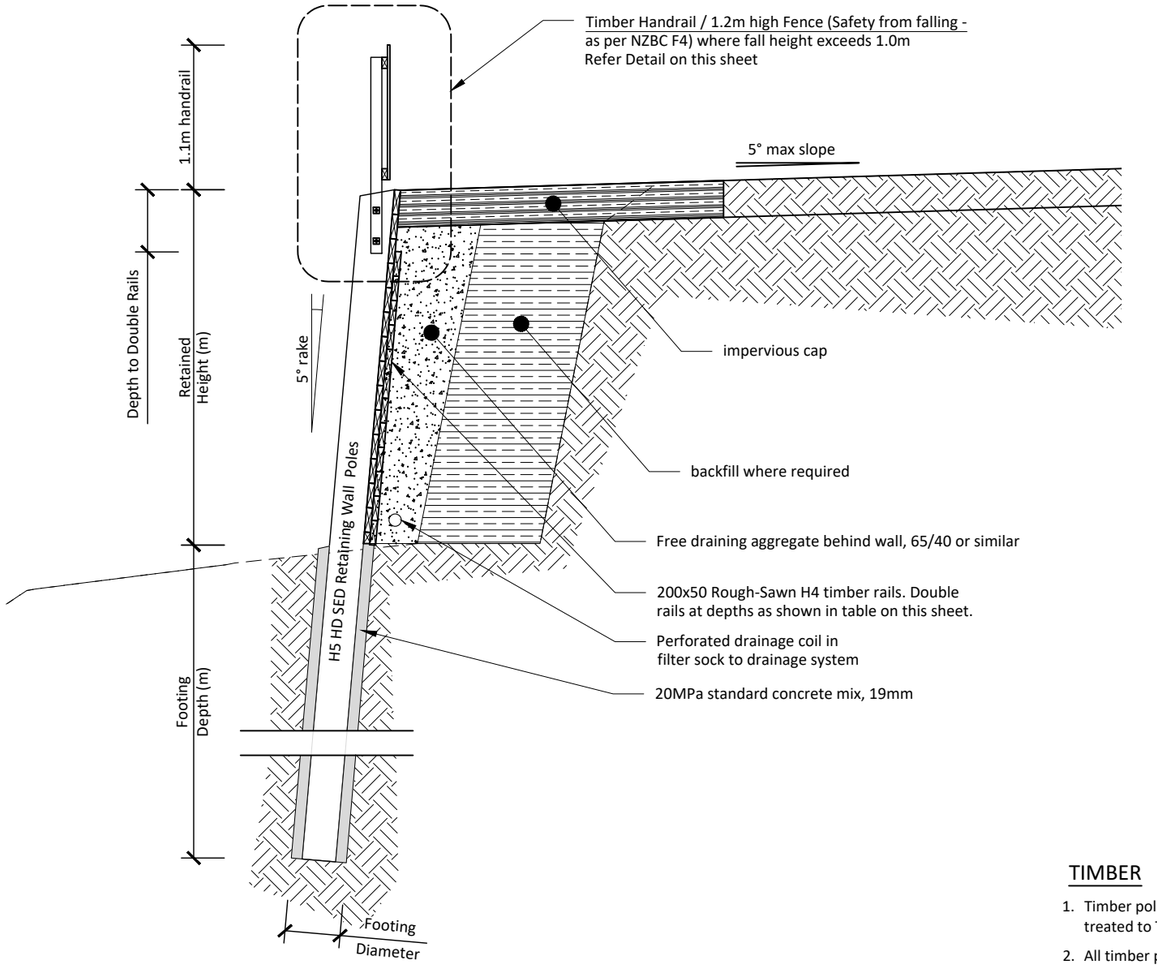
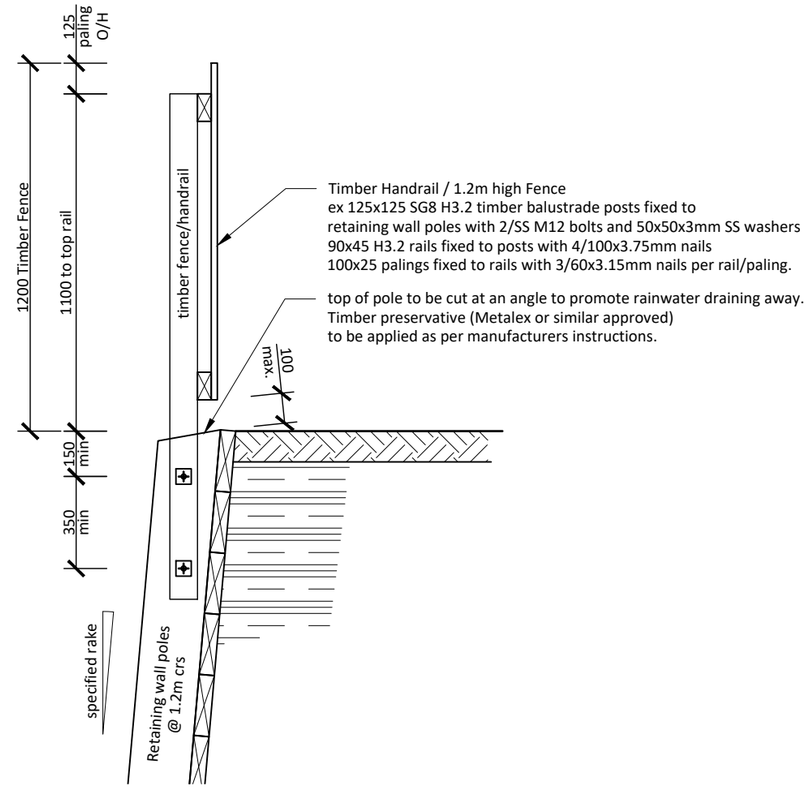


PROPOSED RETAINING WALL - TYPICAL SECTION DETAIL

1:50



RETAINING WALL BARRIER - TYPICAL DETAIL

1:20

GENERAL NOTES

1. General notes shall apply unless noted otherwise on drawings.
2. Verify all dimensions and levels prior to construction of any works.
3. All workmanship and materials shall be accordance with the requirements of current AS and NZS standards, the related by-laws and ordinances of local and government authorities.
4. The contractor shall be responsible for ensuring the safety, stability and integrity of the site, the building works & all other neighboring properties and structures during construction period, including the design and installation of any temporary works as might be required.
5. Do not scale off drawings. If in doubt, contact the engineer.

CONSTRUCTION MONITORING

1. Contractor shall be responsible for reviewing approved building consent documentation and arranging any and all required site visits for construction monitoring purposes by other parties.
2. Before commencing any work, contractor shall make additional enquiries with relevant local authorities to establish site inspection requirements, including identification of all items to be covered by Engineer's Producer Statement.
3. Any item to be covered by Engineer's Producer Statement, must be observed by a Chartered Professional Engineer or their representative.
4. Contractor shall further request Council inspector to make a written note specifying any requirement for engineering observations, at each council inspection.
5. Engineers inspection does not replace council unless prior approval by council.

CONCRETE

1. Concrete for foundation backfill shall be ordinary grade concrete complying with NZS3109 - 'Specification for Concrete', and with a 28 day strength of 20MPa.
2. Concrete shall be placed around poles and well compacted by vibrating. Poles shall be temporarily propped and protected against disturbance for at least two days after placement of concrete.

TIMBER

1. Timber poles shall be peeled radiata pine logs complying with the requirement of NZS3605 - 'Load Bearing Round Timber Piles and Poles' treated to TPA commodity specification H5.
2. All timber poles to be high density (HD).
3. Dimensions of poles are specified as minimum small end diameters. Actual diameters will be greater due to taper and timber grading.
4. Sawn timber in contact with ground shall be radiata pine treated to specification H4.
5. All timber shall have TPA identification brands visible when delivered to the site and shall be protected against damage during storage and handling.

EXCAVATION

1. Deep excavations unsupported during construction may be hazardous particularly when working in confined spaces. Worksafe's Excavation Guide gives recommended safety procedure for such situations. The excavation and earthworks contractor shall take all necessary precautions to protect adequately all persons and property with the potential to be affected by the excavation and earthworks operations.
2. Excavation in stages to allow for temporary support during construction is required. No more than 3.0m of unsupported slope shall exist at any one time unless specified by the Engineer.
3. Excavation for poles shall be taken out by augering to the dimensions detailed, with all surplus soil being disposed of away from the site.
4. Allowance shall be made in positioning augered holes for the slope of the wall and for concrete to surround the poles for the entire depth - min 75mm concrete cover.
5. Poles shall be installed as soon as possible after excavation.
6. Excavation for poles shall be free of water and loose material before concreting. If necessary, the contractor shall allow for hand-cleaning and pumping of excavation.

INSTALLATION

1. Driving of poles is not acceptable as an alternative to augering unless specified by the Engineer.
2. Fixing of horizontal timbers to poles shall utilise galvanised nails as detailed.
3. Timbers shall be laid in position commencing at the bottom of the wall with joints between timbers staggered between the poles

BACKFILLING

1. A perforated drainage coil shall be laid behind the wall and covered in a fine granular material with the invert below the Finished Ground Level and led to a free outlet at a point of safe discharge.
2. Remaining backfill to within 300mm of the top of the wall shall be drained, compacted granular fill not larger than 65mm.
3. The finished surface of backfill shall be sealed against entry of surface water with a layer of topsoil, clay or concrete.

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Location
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PARUA BAY

Date	Rev	Notes
04/08/2023	A	Building Consent Exemption

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Consulting Engineers
This drawing is in accordance with our calculations where applicable.

per .....
Chartered Professional Engineer

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