Memorandum

ARUP

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Subject	Centenary Building Retention Design		

1 Introduction

This memo records the criteria, design inputs and results for the retention structural design for the Centenary Building at Cranbrook School.

2 Retention Design

The plan below describes the sections analysed and provides references for this memo.

The retention for the Centenary building is designed with secant retaining walls. The lateral support of the wall varies across the site, between both temporary and permanent ground anchors and internal propping. Refer to drawings CB-ST-0960-270 to CB-ST-0960-277 for the various construction sequences across the site.

The table below describes the main areas of the site, describing the retention system in the temporary and permanent conditions and highlighting the constraints.

	Ref Elevations	Temporary retention	Permanent Retention	Constraints
	SW 1, 2, 3	• Secant piled Walls + Temporary ground anchors (stressed) – to Sand • Internal Propping (East)	• Composite floor slabs prop secant walls at Levels 01, 03 and 04 • Diaphragm floor slabs distribute the lateral load back to the cores and shear walls.	• Property boundary typically 1200mm from the centre of the secant wall • Proximity to Rose Bay Avenue and limitations on allowable lateral defections considering in ground services under Rose Bay Avenue • Trees to be retained.
	SW 4, 5	• Secant piled walls + temporary ground anchors (stressed) - to Sand	• Monolithic RC buttresses tie in to the secant wall	• Proximity to the property boundary • Limitations on allowable lateral deflections of the building structure (H/500)
	SW 12	• Cantilever secant piled walls	• Cantilever secant piled walls	• Proximity to the property boundary • Limitations on allowable lateral defections considering in ground services under Rose Bay Avenue • Differential settlement imposed on Perkins foundations • Architectural aspirations - landscaping
	SW 6, 7, 8	• Series secant piled walls + 1 no. top temporary sand anchor and beneath up to 5 no. permanent ground anchors (stressed) - to rock	• Series secant piled walls + permanent ground anchors (stressed) - to rock	• Differential settlement imposed on Perkins foundations – limited to 25mm • Construction sequence - existing ground profile • Proximity of the property boundary (ground anchors)
	SW 9	• Secant piled walls + permanent ground anchors (stressed) - to rock • 2m high gravity retaining wall (cantilever)	• Secant piled walls + permanent ground anchors (stressed) – to rock • 2m high gravity retaining wall (cantilever)	• Construction sequence – steep slope of the existing ground • Trees and existing Cranbrook stairs to be retained
	SW 10, 11	• Batter existing ground and rock cut to excavation level (GL WA to WC) • Cantilever secant piled walls	• Cantilever secant piled walls	• Integration with landscaping • Location of the Rock shelfs unknown • Trees to be retained

3 Geotechnical Parameters

3.1 Geotechnical reports

The design has been based on the information provided in the geotechnical investigation reports prepared by Douglas and Partners Pty Ltd. The results and interpretation of the encountered subsurface profile has been summarised in the most recent report dated February 2018 (Project Ref: 84944.02, Document No: R.001).

3.2 Ground profile

The typical soil profile comprises of poorly compacted sandy fill, underlain by aeolian sands of very loose to loose density on first contact, improving with depth to medium dense to very dense. sandstone bedrock of low to medium strength is encountered below the sands. The bedrock surface varies significantly across the site from RL29 over the western portion of the site to RL7 over the eastern portion of the site.

The geotechnical parameters for the soil units have been derived from a combination of SPT, CPT and consistency/ density information from the existing boreholes and CPTs, using established empirical correlations.

The sandstone bedrock, where encountered, has been classified according to Pells et al classification. The classification is based on the logging of the bedrock, point load index tests, and UCS testing. The bedrock strength parameters have been adopted based on the inferred rock strength, degree of weathering and the nature of the discontinuities encountered.

3.2.1 Standard penetration tests

Standard penetration tests were conducted in the majority of the boreholes. The standard penetration number ‘N’ is a useful guide for assessment of subsoil conditions, provided the results are interpreted correctly. It is noted that all equations and correlations related to the standard penetration numbers are approximate. Soil is not homogeneous, therefore a wide variation in the N value may be obtained. A summary table is provided below presents the range of SPT N values encountered. Also a plot of the SPT N results across the site are provided in the Figure opposite.

Material	SPT 'N'				Number of Results
	Min	Max	Average	Median	
Sandy Filling	1	14	4.9	4	13
Very Loose Sand	2	4	2.5	2	11
Loose Sand	5	10	7.8	8	11
Medium Dense Sand	12	30	21.3	21	43
Dense Sand	31	48	38.4	38	29
Very Dense Sand	55	76	62	55	3

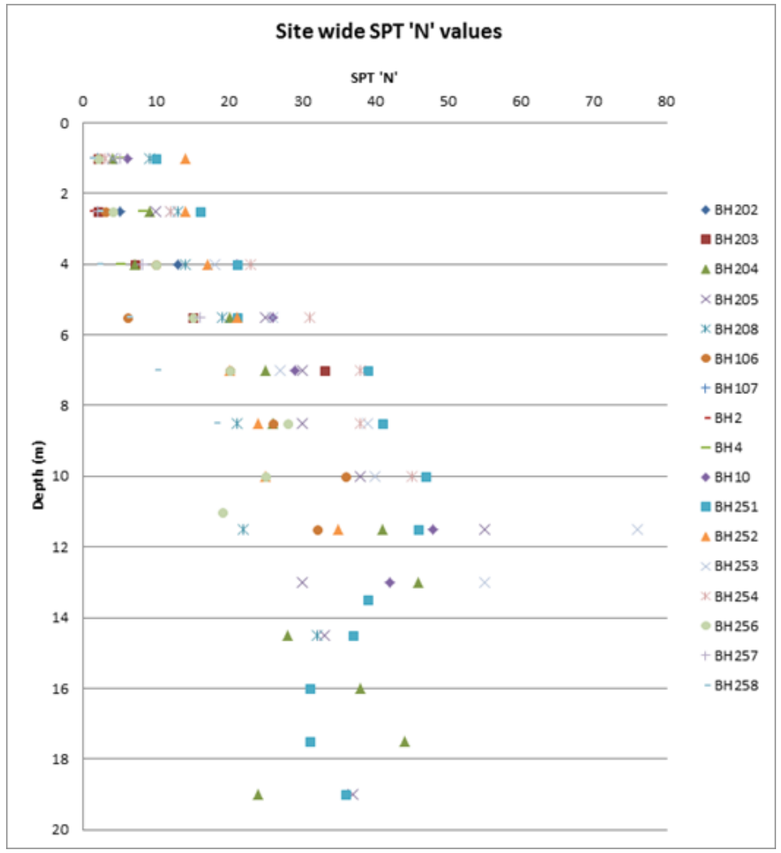


Figure: Graph of SPT values across the site

3.3 Summary of material parameters

The adopted material parameters for the project are summarised in the table below. These are based on all relevant borehole and CPT data across the site area.

Material	Unit	Range			
		Bulk Density (kN/m³)	Friction Angle (°) deg	Cohesion (kPa)	Youngs Modulus (MPa)
Fill	Sandy Filling	15 - 17	28	0	5 - 15
Aeolian Sands	Very Loose Sand	15	28	0	5 - 10
	Loose Sand	17	28 - 30	0	10 - 25
	Medium Dense Sand	18 - 20	30 - 33	0	25 - 40
	Dense Sand	19 - 21	35	0	60 - 100
	Very Dense Sand	21	38	0	100 - 120
Sandstone	Class V Sandstone	20	30	20	50
	Class IV Sandstone	23	30	50	300 - 350
	Class III Sandstone	23	35	200	500 - 800
	Class II Sandstone	24	35	500	1500

4 Geotechnical design of retention system

4.1 Analysis

The retaining wall design has used soil-structure interaction analyses and the modelling of construction sequences. The retaining wall design was carried out using Plaxis 2D, a finite element numerical modelling package. Hardening Soil model was adopted for modelling the sand units, while traditional Mohr Coulomb was used for the Sandstone units. The Hardening Soil model accounts for the stress-dependency of the stiffness moduli and was selected to more realistically model the stiffer response of the material units during unloading. A loading to unloading stiffness ratio of 3 has been applied to the analysis.

As the subsurface profile is all granular with relatively high permeability, all excess pore pressures will dissipate rapidly hence the strength will always be based on drained properties, and therefore all calculations have been carried out using effective stress parameters.

Active and passive earth pressure coefficients used in drained analysis are based on the effective angle of friction of the material, assuming a mobilised wall friction of $\delta = 0.67\phi'$.

The earth pressure which acts on the retaining wall depends on the initial or at-rest state of stress of the ground. For undisturbed soil, the ratio of horizontal to vertical stress at rest depends on the type of soil, its geological origin, changes in ground strain or groundwater regime due to natural or artificial causes and the temporary loads which may have acted on the ground surface.

The values of K_0 for the site has been derived using the Jaky (1944) approach.

$K_0 = 1 - \sin\phi$

Additional in-situ stress in sandstone has been ignored.

An additional 0.5m has been adopted, as a minimum value, to account for accidental over dig when assessing retention stability. For retention embedded in sand, a passive resistance reduction has been carried out to determine the minimum pile embedment to achieve global retention stability. Further, for retention embedded in sand, basal stability has been assessed to achieve a Factor of Safety of 2 or better.

4.2 Groundwater

Based on Water Table Douglas Partners memo ‘Groundwater Monitoring Results’ issued on 13.04.18 the groundwater table appears to be located at or just above the soil/rock interface. Further, based on the monitoring period, the groundwater does not appear to be influence by rainfall. Therefore, the water table is assumed to be at the top of the rock. As such, a hydrostatic water pressure has not been adopted in the analysis. However, water mounding, over the bottom third of retained soil, has been considered as part of the design.

The design has considered the retention to be fully drained both in the short term during construction and in the long term.

4.3 Ground anchors

The allowable bond stresses adopted for the design are summarised below, and shall be verified by preliminary anchor testing.

Material	Unit	Allowable Bond Stress (kPa)
Sand	Medium Dense Sand or better	Varies from 75 to 200
Sandstone	Class III	500

Ground anchors bonded into rock have been designed as permeant anchors while anchors bonded in sand have been designed as temporary anchors. Reference should be made to both the permanent and temporary anchor specification.

Anchors in rock have been designed in accordance to the requirements of 5100.3, and included checks for rock to grout, grout to steel and cone pull out. Rock anchors have generally been inclined at 45° below the horizontal to encounter rock within the site boundaries. The free length has been extended from the wall face to beyond any likely failure surfaces.

Anchors in sand have been designed in accordance to the requirements of 5100.3 and 4678. Sand anchors have been inclined at 20° below the horizontal, and the free length extending beyond a 45° line projected up from the pile toe.

The project anchor specification outlines the required validation testing and construction requirements.

4.4 Seismic Site Classifications

Seismic ground assessment is to AS 1170.4 Clause 4.4.1, based on the encountered ground conditions the following site classification has been adopted;

Site Class: C_e. – Shallow soil

4.5 Earthquake loading

Seismic design has been carried out according to the requirements of AS5100.2 and AS1170.4. Based on a structure classification, EDC II in accordance with AS1170.4 Table 2.1, the seismic design takes into account forces from static earth pressures, seismically induced lateral earth pressures and additional forces arising from wall and backfill inertia effects. The effects of vertical acceleration have been omitted. The calculation of seismically induced lateral earth pressures has been in accordance with accepted engineering principles such as the pseudo-static Mononobe-Okabe method.

5 Retention Structural Design

The following section describes the structural design of the primary retention design and the adopted parameters in the analysis.

5.1 Permanent anchor retention system

The permanent anchor retention design consists of piled walls supported by permanent rock anchors. To assist with constructability of the wall adjacent to the steep embankment, the intent is to construct a smaller diameter secant piled wall 725mm from the face of the existing Perkin's building. The smaller diameter piled wall is designed to be supported by temporary sand anchors. The existing ground is then excavated to RL 31m to allow a 900mm diameter secant piled wall to be construed at this lower level. The 900mm diameter wall is supported by a series of permanent rock anchors over the excavation height.

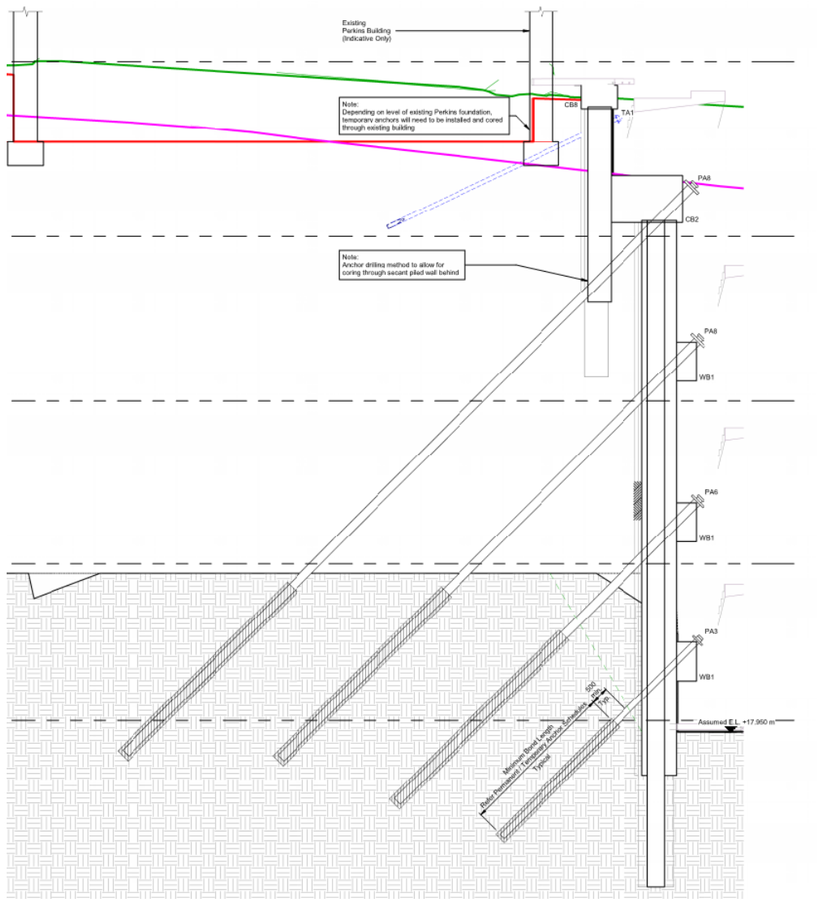


Figure: Typical section of the permanent retention design

5.2 Temporary Anchor Retention Design

The retention system design adjacent to Rose Bay Avenue, on the East of the site, uses temporary ground anchors to support a secant piled wall. The proximity to the road means permanent ground anchors are not an option here as the bond length would extend beyond the site boundary.

A secant piled wall is installed with temporary ground anchors supporting the piles during the excavation. The structure is constructed, bottom-up and tied back in to the piles. Once the structure is completed the ground anchors are de-stressed and the lateral loads imposed onto the retention system are supported by the building structure.

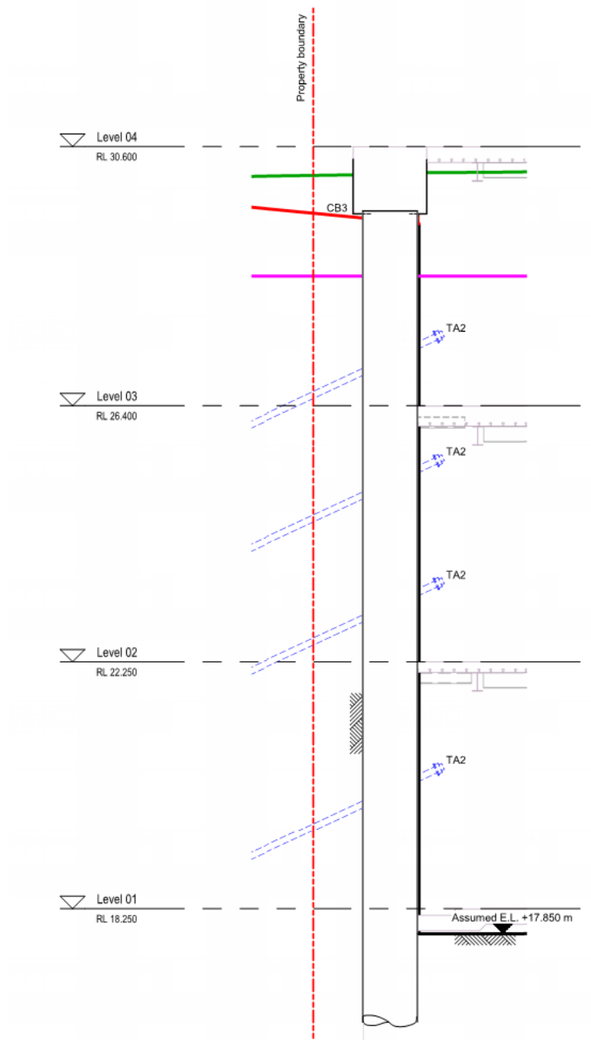


Figure: Typical section of the temporary retention design

5.3 Structural design parameters

5.3.1 Pile stiffness

During the analysis of the various retention wall designs, the concrete grade for the reinforced (hard) piles has been taken as 50MPa and 25MPa for the unreinforced (soft) piles.

During the construction sequence the properties of the concrete will vary depending on loading and time. The following concrete properties have been adopted.

- Short term Concrete Young's modulus: E_{ST} = 32800 MPa.
- Long term Concrete Young's modulus E_{LT} = 70% E_{ST} = 22960MPa

As lateral loading is imposed on to the retaining walls the concrete will crack, which reduces the stiffness. An iterative process has been carried out to asses bending, cracking and resulting stiffness of the pile. Taking an initial pile bending moment of M_{SLS} = ~330kNm (from FREW analysis) with pile reinforcement = 1.5%, the appropriate section modulus (I value) is reduced to 75%I.

- Hence long-term properties used in the analysis = 50% E_{ST}I.

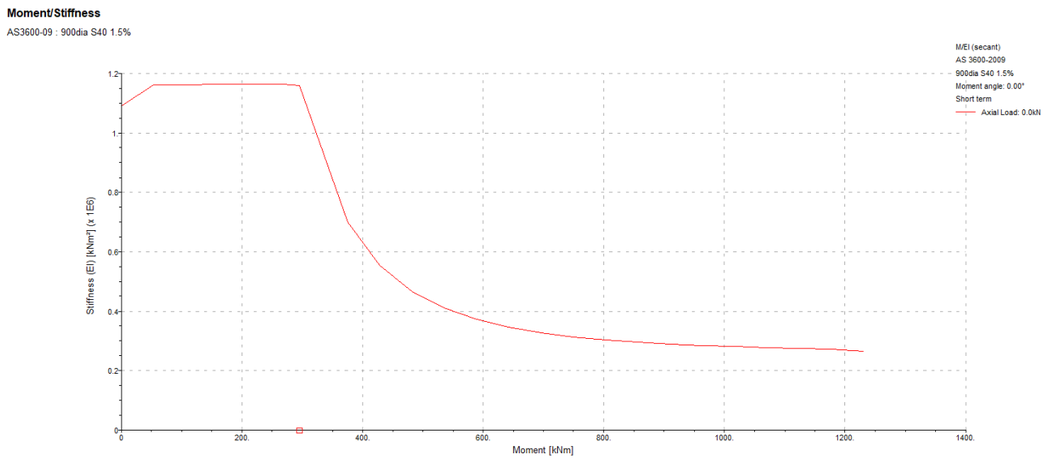


Figure: Moment stiffness interaction for 900 dia pile (typ) showing 75% I cracking

5.3.2 Surcharge loading

The plan below highlights the surcharge loading that has been considered in the design:

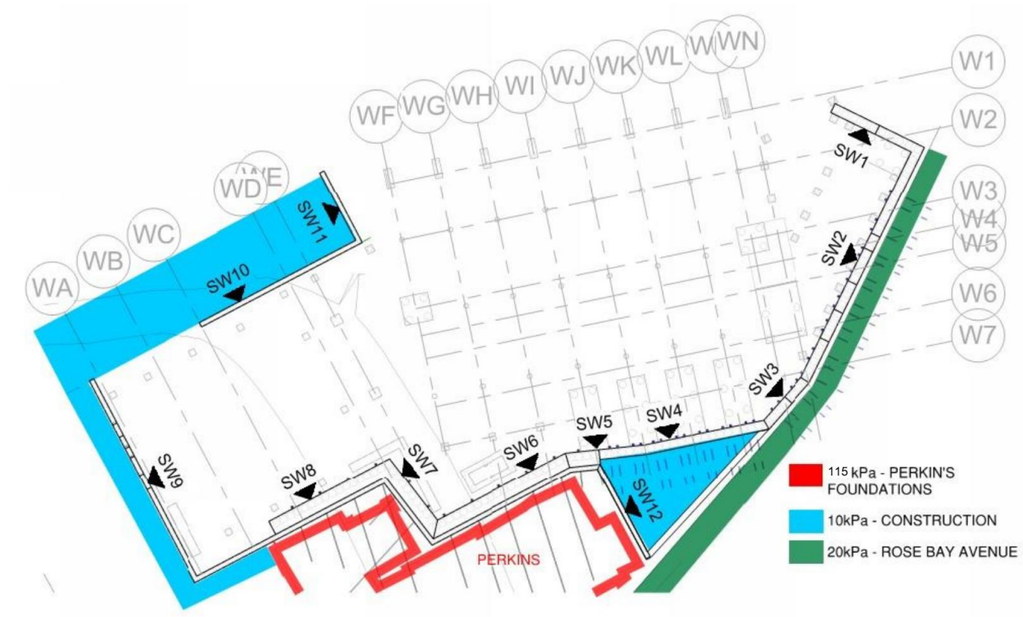


Figure: Magnitude of surcharge the retaining walls have been designed for

Perkin's is an existing heritage building on the site. The information provided to date has reported the original construction is of 3 skin masonry. Note, the existing drawings do not detail the wall build up, however intrusive testing has begun and initial findings support this construction build up.

The following assumptions have been made to calculate a surcharge loading to use in the retention analysis.

3 layers masonry: 110mm solid brick, 60mm cavity, internal wall 240mm solid brickwork.
Masonry density = 20 kN/m^3.
Height = 13m
Footing width = 700mm
Surcharge = **115kPa** (considering allowance for window penetrations)

The base level of the strip foundations for Perkin's has been assumed to be 0.5m below the existing ground level. Note, investigations on site have found that the footing levels vary between 0.5m to 3.0m below the existing ground level. It is therefore conservative to assume the footings are 0.5m below existing ground level. It has been noted to the Client and Contractor that there is the risk of the temporary ground anchors locally penetrating the existing footings of Perkin's.

6 Movements

A technical Memo 01 rev 02 *" Centenary Building – Impact Assessment on adjacent structures*" (dated 8/10/2018) summaries the assessment and criteria for the allowable settlement for Perkin's foundations and the services running adjacent to Rose Bay Avenue.

The table below summarises the total predicted displacements for each piled wall section that was analysed. Refer to drawing CB-ST-0960-152 for wall types and location references.

Location	Predicted total displacements
SW1A	Max 900mm dia. = 29mm
SW2A	Max 900mm dia. = 4mm (E), 6mm (N)
SW2B	Max 900mm dia. = 20mm
SW2C	Max 900mm dia. = 21mm
SW4	Before destressing anchors = 24mm After distressing anchors = 31mm
SW5	Before destressing anchors = 22mm After distressing anchors = 28mm
SW6 – Rock RL14m	Max 900mm dia. = 16mm Max 600mm dia. = 17mm Under Perkins foundation= 21mm
SW6 – Rock RL14m- Lift Pit	Max 900mm dia. = 21mm Max 600mm dia. = 20mm Under Perkins foundation= 24mm
SW6 – Rock RL 20m	Max 900mm dia. = 15mm Max 600mm dia. = 15mm Under Perkins foundation= 19mm
SW8 – Rock RL22	Max 900mm dia. = 8mm Max 600mm dia. = 7mm Under Perkins foundation= 13mm
SW8 – Rock RL26	Max 900mm dia. = 6mm Max 600mm dia. = 8mm Under Perkins foundation= 14mm
SW8 – Rock RL29	Max 600mm dia. = 13mm Under Perkins foundation= 20mm
SW8b – Rock RL29 – No Perkins	Max 600mm dia. = 6mm
SW9	Max 450mm dia. = 6mm
SW10	Max 600mm dia. = 24mm
SW11	Top 600mm dia. = 31mm
SW12	Top 600mm dia. = <20mm (N), <20mm (M)
SW13	Top 600mm dia. = <20mm (S), =<20mm (M)

Note, the predicted settlements under the Perkins foundations assume that Perkins foundations are 0.5m below the existing ground level.

The contours plotted on the following plans illustrate the vertical and horizontal components of the total displacement predicted in the current analysis. The vertical component of the total displacements is the estimated settlement at the level of the existing building's foundation and at the existing ground surface level. The (-) sign of the horizontal displacement indicate movement into the excavation.

6.1 Monitoring

The monitoring strategy proposed is intended to capture the impact of the most onerous stages of construction work on the Perkins Buildings, surrounding pavements, and third-party assets on and around the site.

Ground movements will be induced during piling and excavation works. The table below list out the type of instruments proposed to monitor these movements during construction and the life of the building. Reference should also be made to drawing CB-ST-0960-142 Monitoring Layout, for further details on the instrumentation location and frequency of monitoring.

Instrumentation	Purpose	Location
Surface settlement pins	Monitor surface settlement	Installed along Rosebay avenue, following existing buried services.
In Place inclinometers	Monitor lateral ground movements due to excavation	Installed within piles and extending down a minimum of 3m below bulk excavation level.
Tiltmeters	Monitor deflection of the building, both normal and parallel to the wall	Installed on Perkins and Cranbrook House
Survey	Survey monitoring in x, y, and z axes	Survey monitoring of Perkins, Cranbrook House and the shoring wall at 10m horizontal spacings and at every anchor level as minimum.

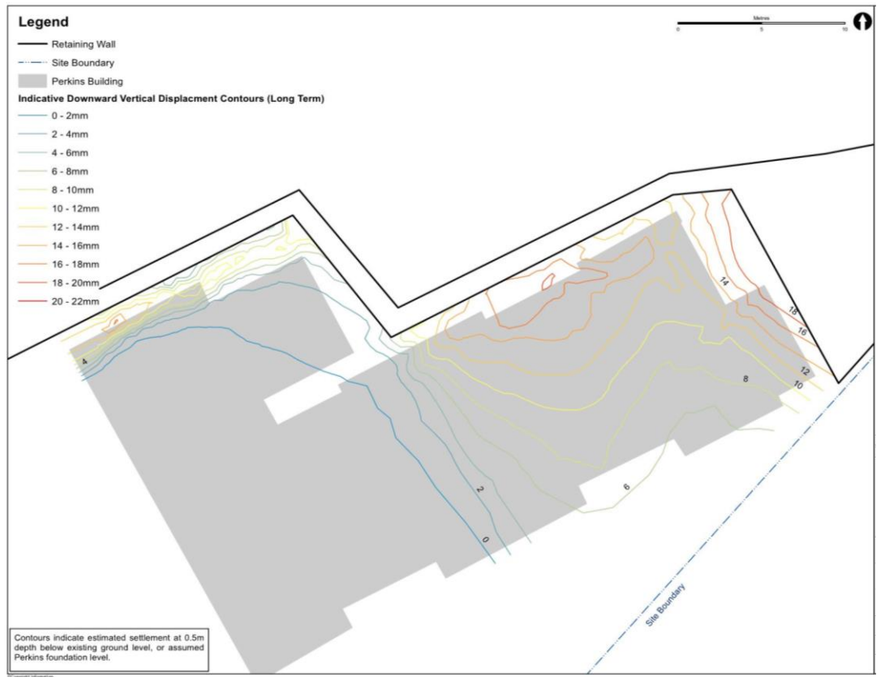


Figure: The predicted vertical settlement at Perkins foundation level (Assumed 0.5m below existing ground level)

Figure: The predicted vertical settlement at existing ground level.

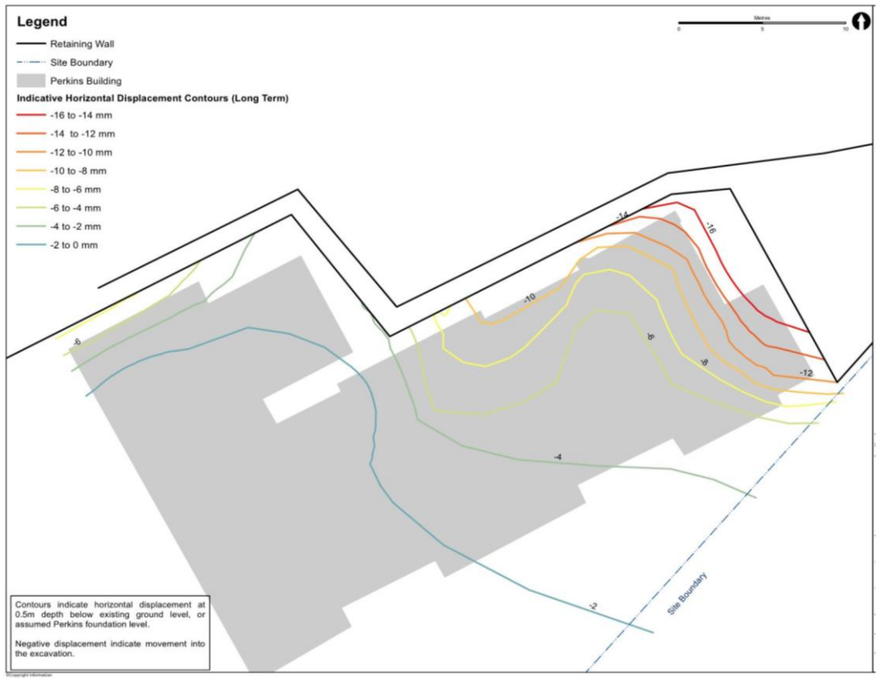
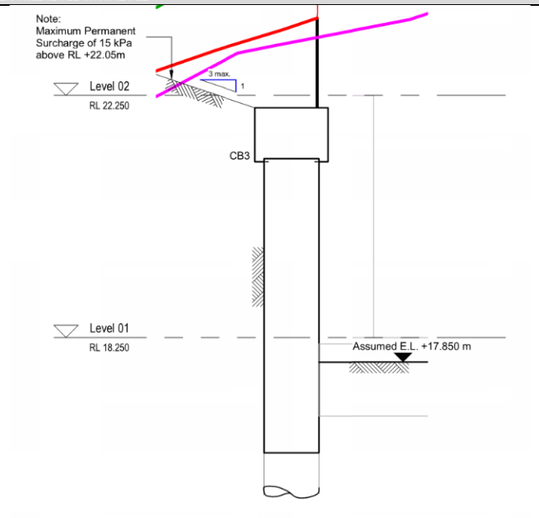
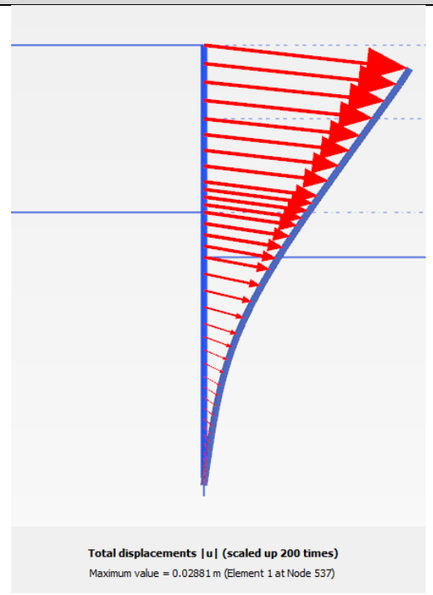
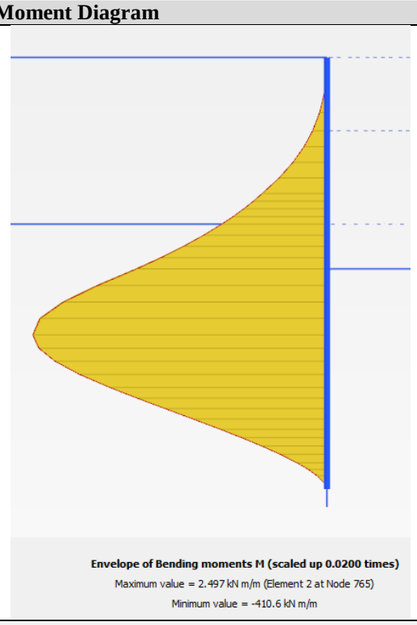
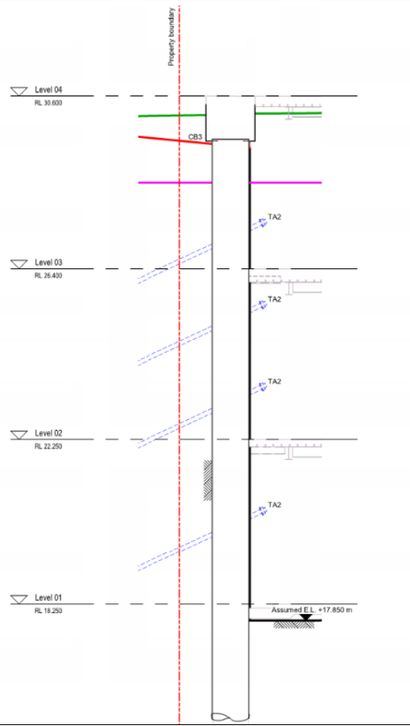
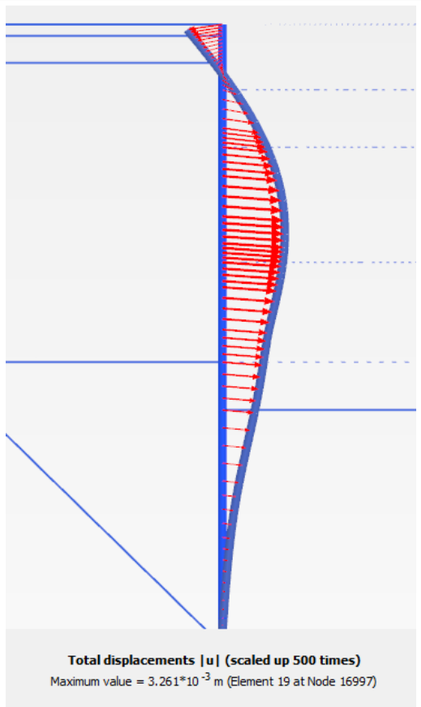
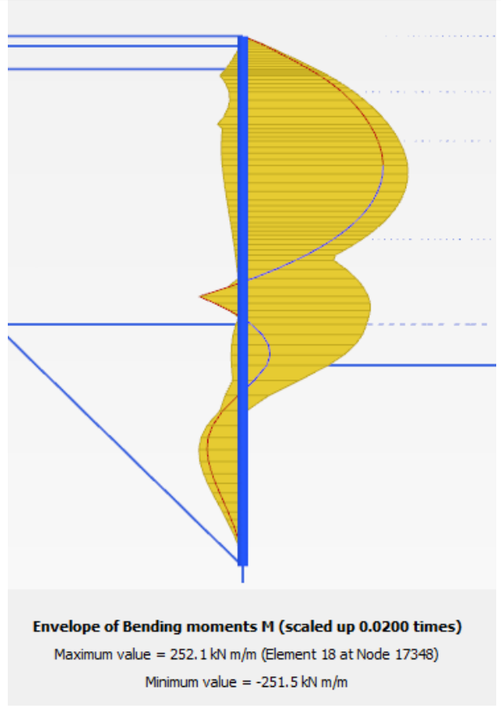


Figure: The predicted horizontal displacement at Perkins foundation level (Assumed 0.5m below existing ground level)

Figure: The predicted horizontal displacement at existing ground level.

7 Results

This section summarises the key results for each retention section analysed.

Retention section	Deflection Plot	Pile bending Moment Diagram	Comments
			**SW1** 900mm dia piles @ 1100mm c/c spacing Temporary Design: cantilever secant piled wall Permanent Design: cantilever secant piled wall Surcharge = 10kPa Deflections Max 900mm dia = 29mm (LT) Bending Moments (ULS) 900mm dia pile = 700kNm
			**SW2a** 900mm dia piles @ 1300mm c/c Temporary Design Temporary sand anchors: 3 rows @ 2m c/c and temporary struts Permanent Design: Secant piled wall propped by the permanent structure Anchor prestress = 150kN Road surcharge = 20kPa Deflections Max 900mm dia = 4mm Bending Moments (ULS) 900mm dia pile = 550kNm

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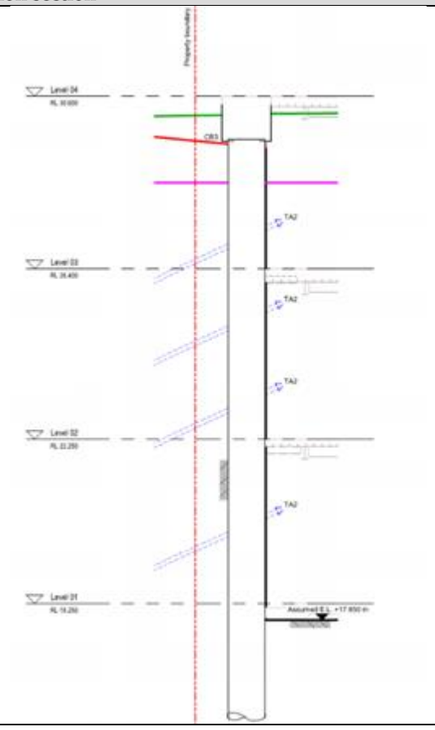
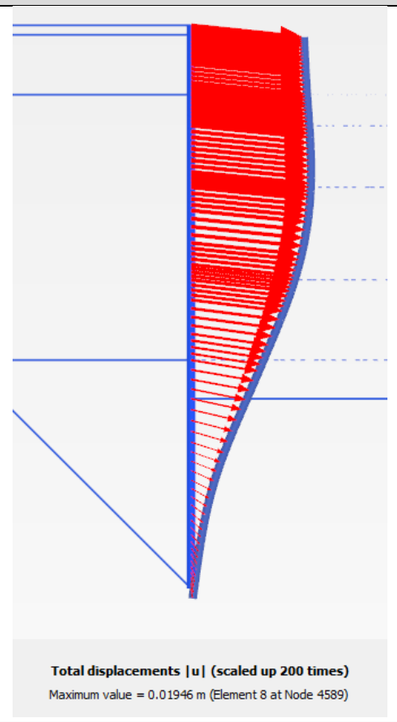
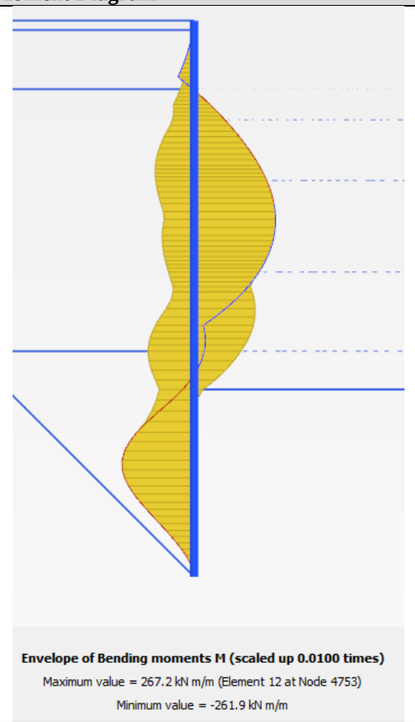
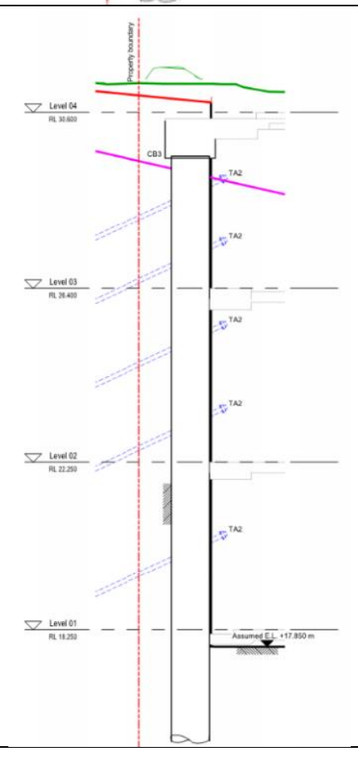
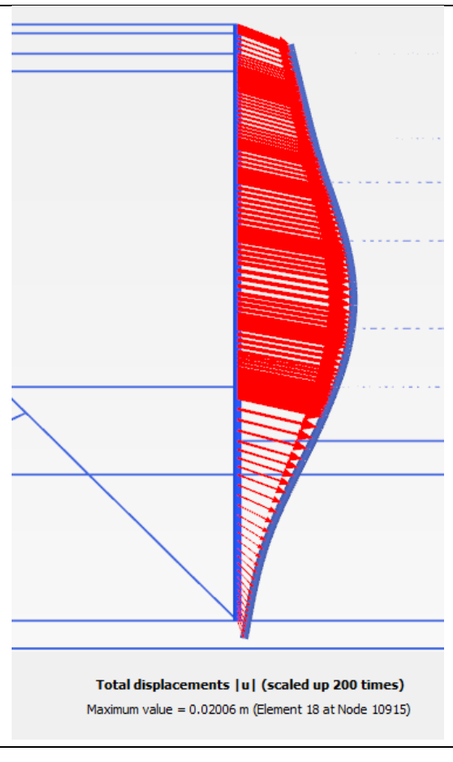
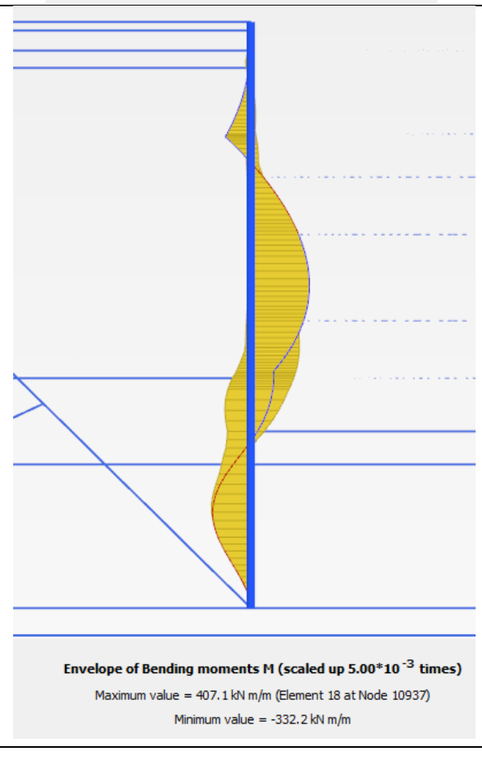
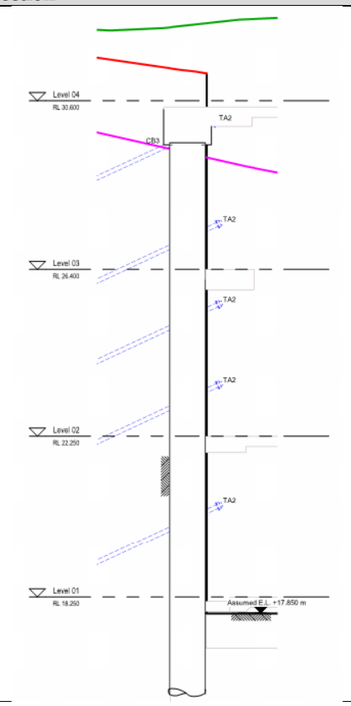
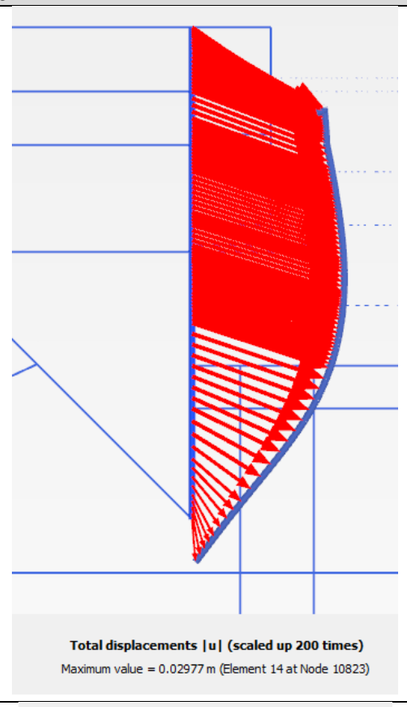
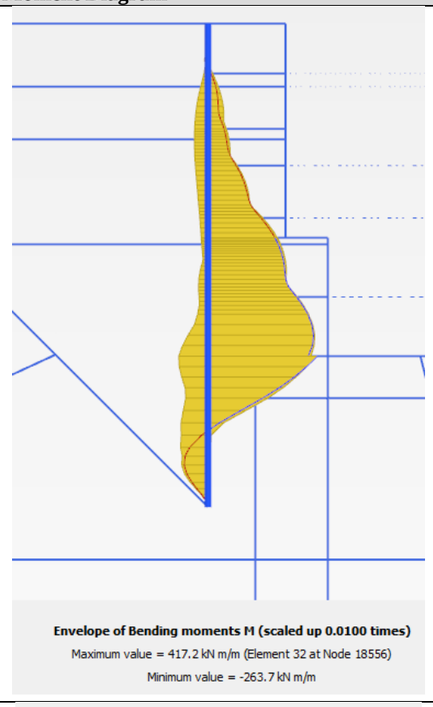
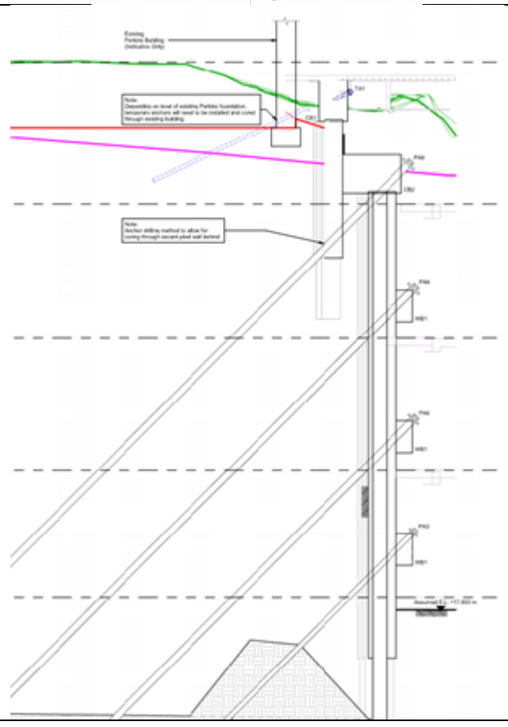
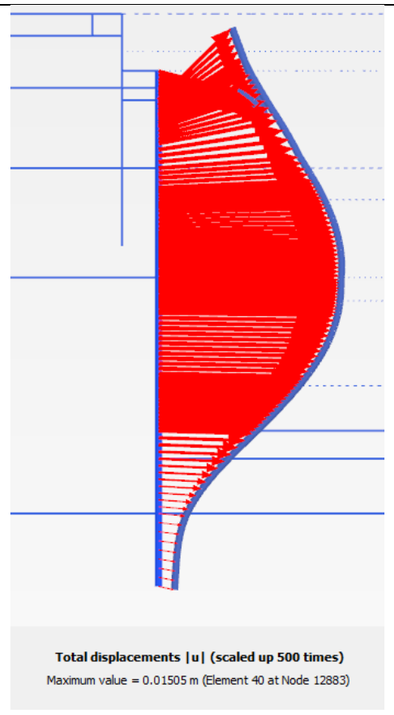
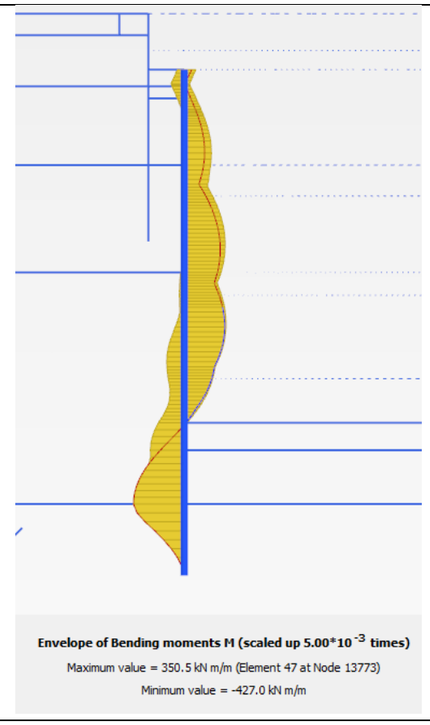
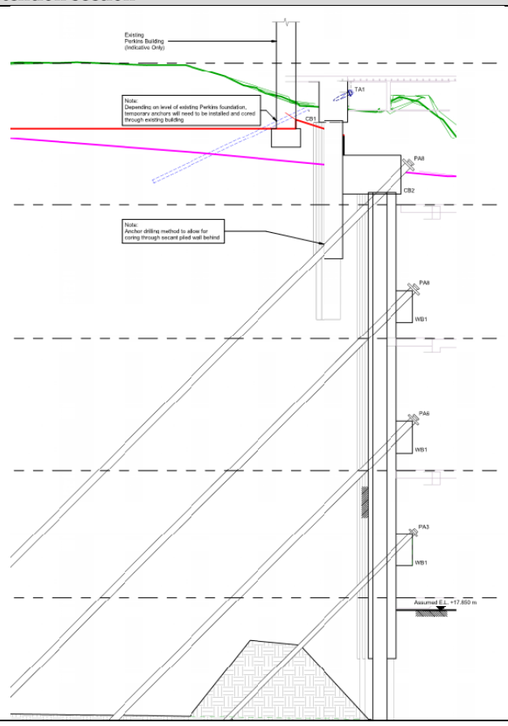
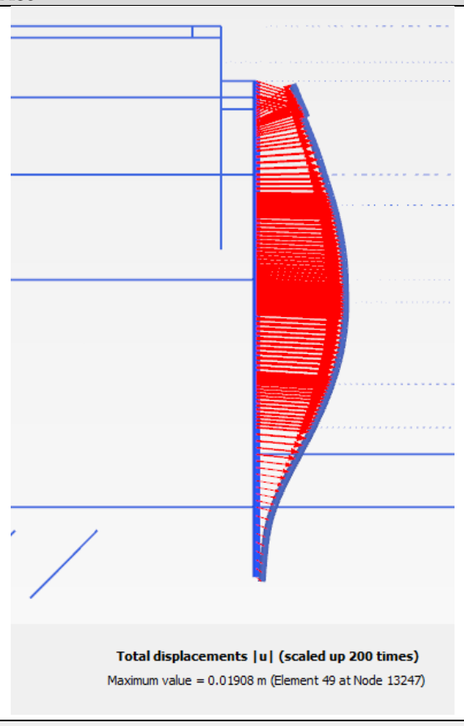
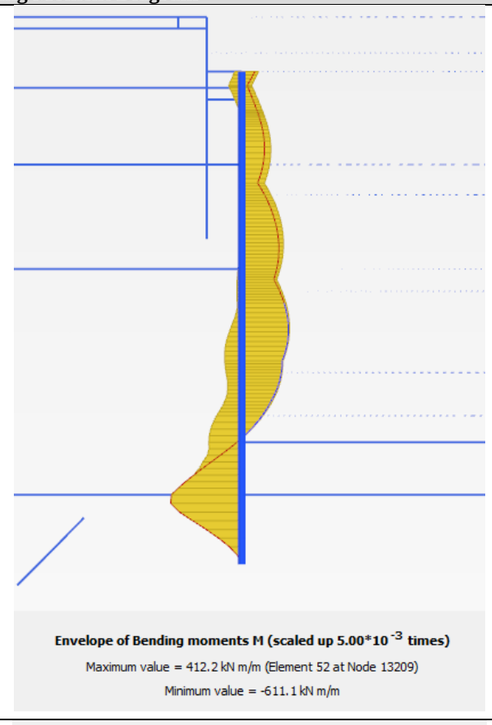
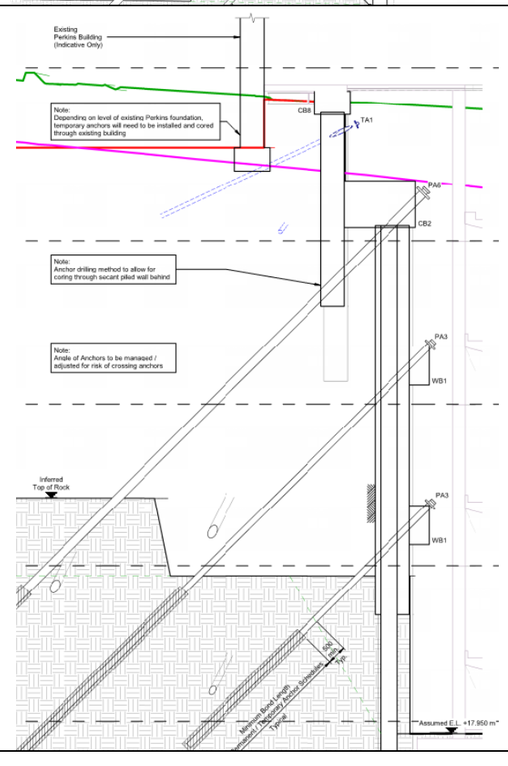
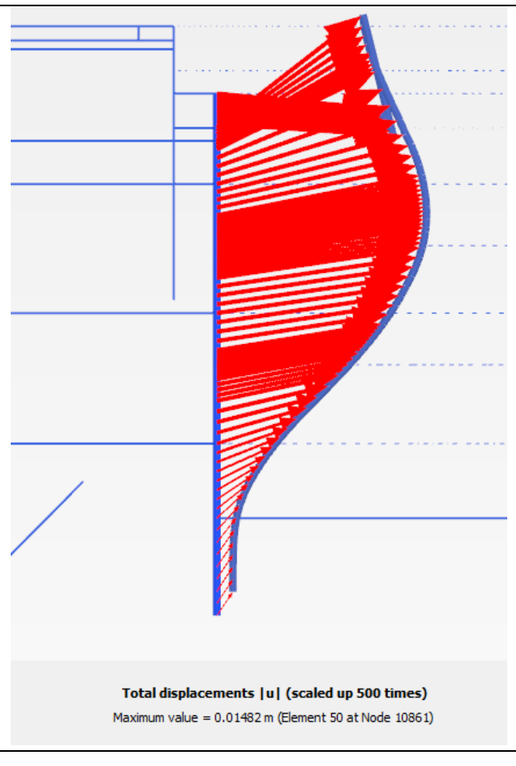
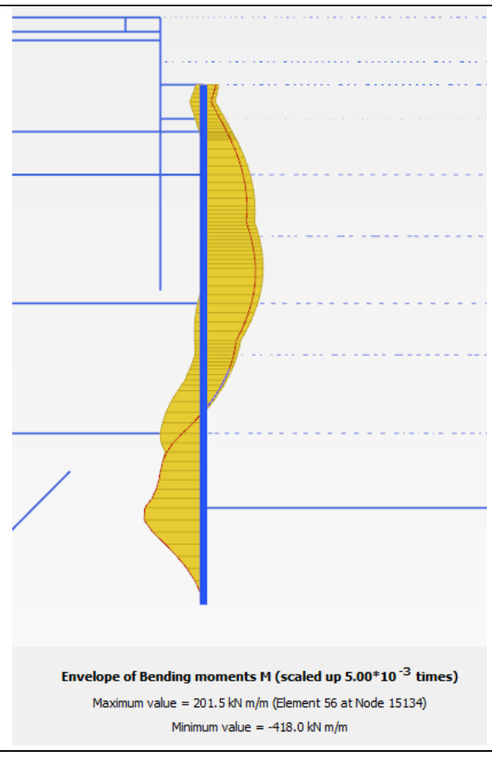
Retention section	Deflection Plot	Pile bending Moment Diagram	Comments
			**SW2b** 900mm dia piles @ 1300mm c/c Temporary Design Temporary sand anchors: 3 rows @ 2m c/c Permanent Design: Secant piled wall propped by the permanent structure Anchor prestress = 150kN Road surcharge = 20kPa Deflections Max 900mm dia = 20mm Bending Moments (ULS) 900mm dia pile =550kNm
			**SW2c** 900mm dia piles @ 1300mm c/c Temporary Design Temporary sand anchors: 3 rows Permanent Design: Secant piled wall propped by the permanent structure Anchor prestress = 150kN Road surcharge = 20kPa Deflections Max 900mm dia = 21mm Bending Moments (ULS) 900mm dia pile =840kNm

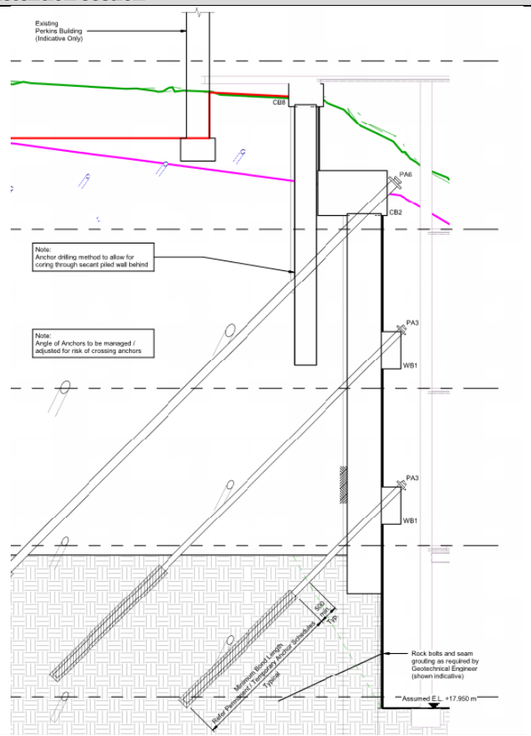
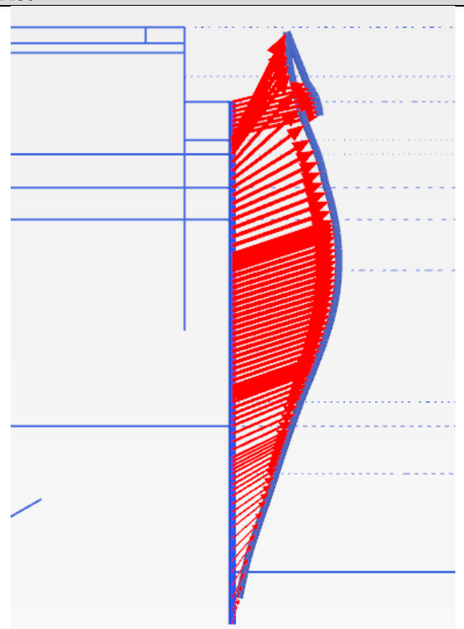
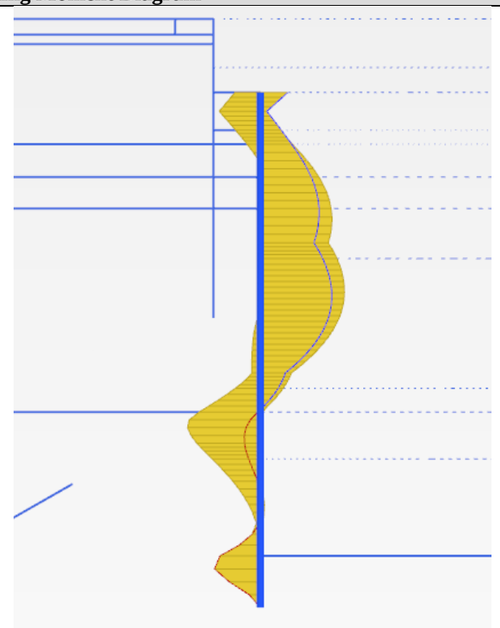
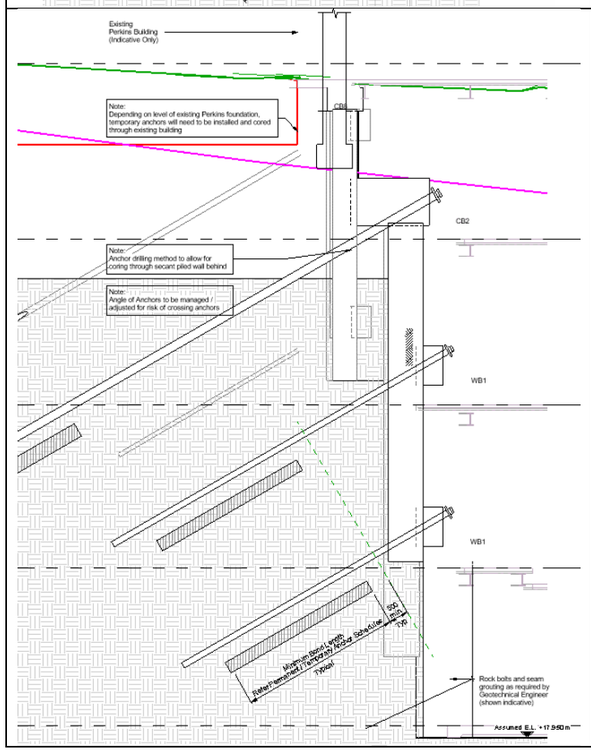
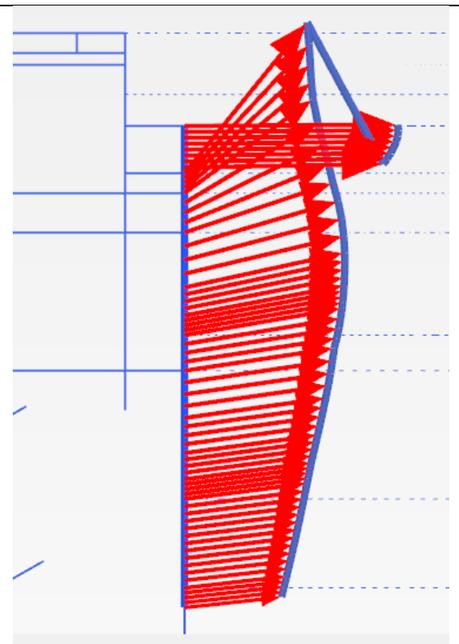
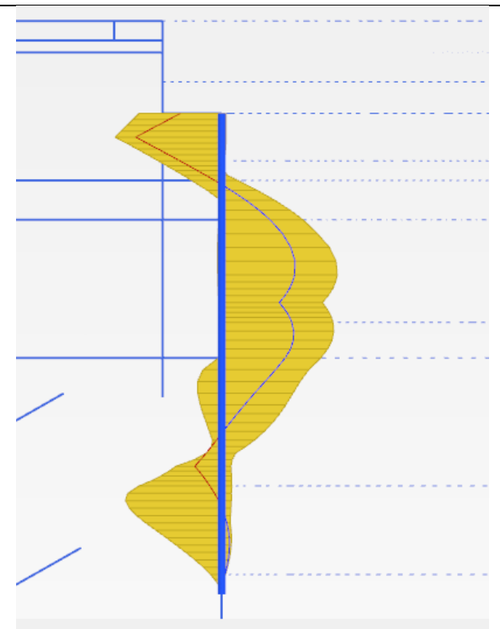
Memorandum

Retention section	Deflection Plot	Pile bending Moment Diagram	Comments
			**SW 4 – Buttress** 900mm dia piles @ 1300mm c/c Temporary Design Temporary sand anchors: 5 rows @ 2m c/c Permanent Design: Secant piled wall propped by RC buttress Anchor prestress = 150kN Construction surcharge = 10kPa Deflections Max 900mm dia = 31mm Bending Moments (ULS) 900mm dia pile =840kNm
			**SW6** **Rock at RL 14** 600dia @ 1000c/c + 900dia @ 960mm c/c Temporary sand anchor: 150kN prestress Permanent Anchors: 1st and 2nd rows 17 strands. 3rd row 14 strands and 4th row with 8 strands. Anchor prestress: 17 Strands = 1000kN 14 Strands = 800kN 8 Strands = 400kN Perkins surcharge = 115kPa Deflections Under Perkins foundation= 21mm Max 600mm dia = 17mm Max 900mm dia = 16mm Bending Moments (ULS) 900mm dia pile = 800kNm

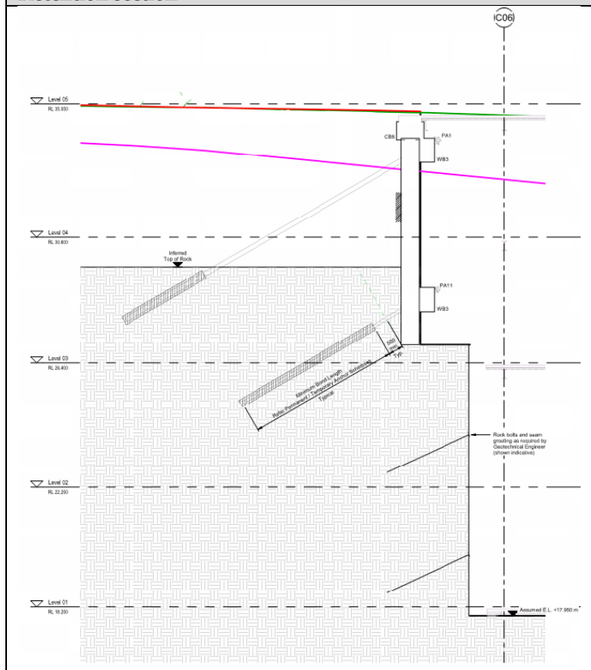
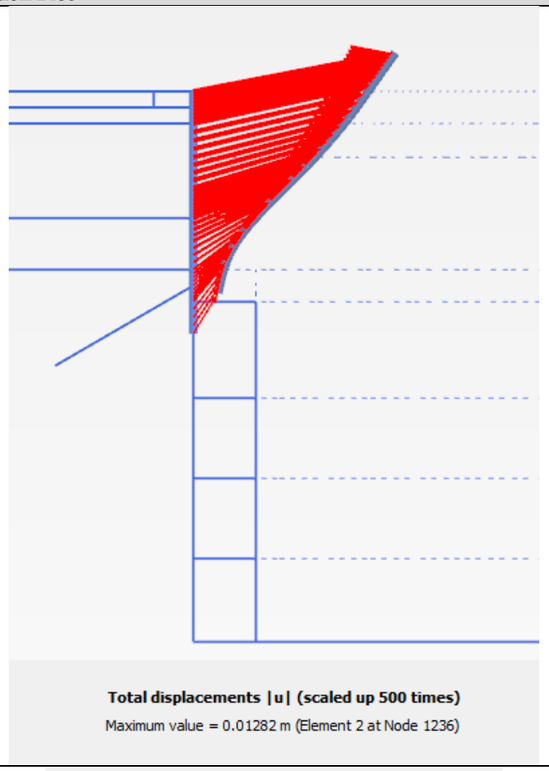
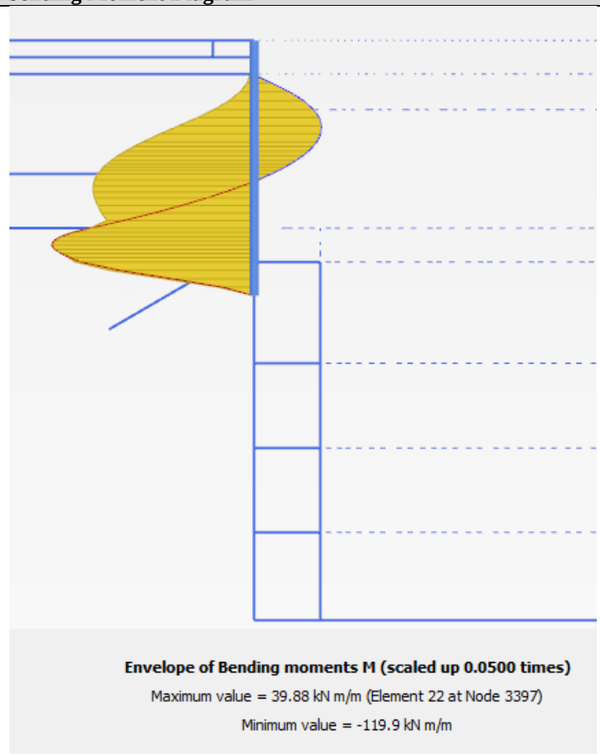
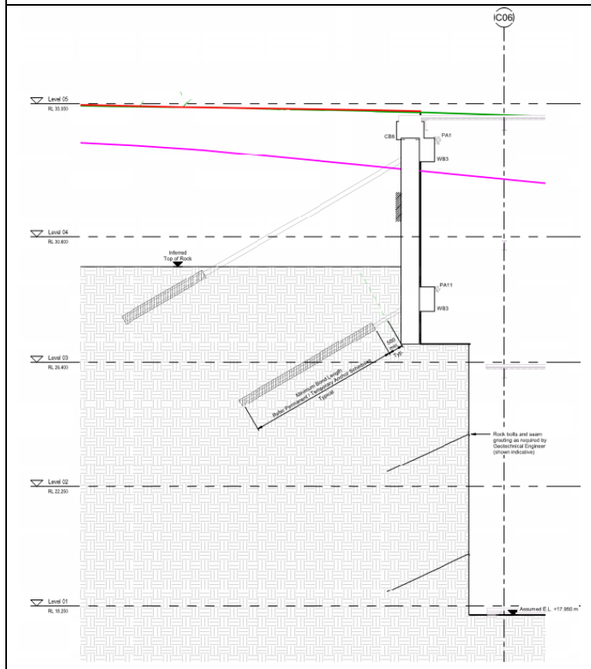
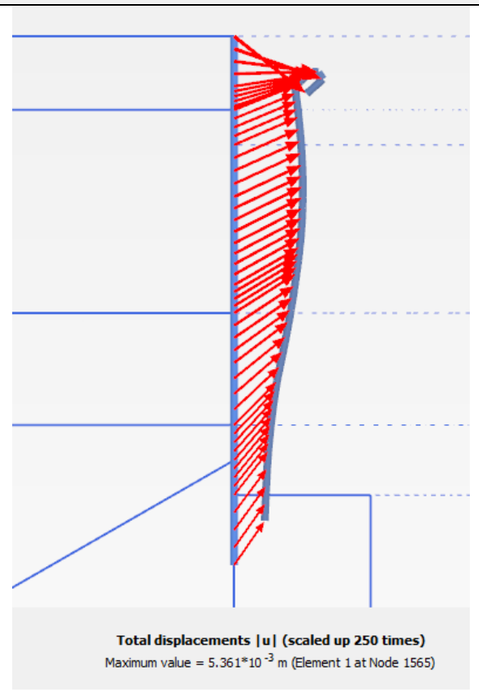
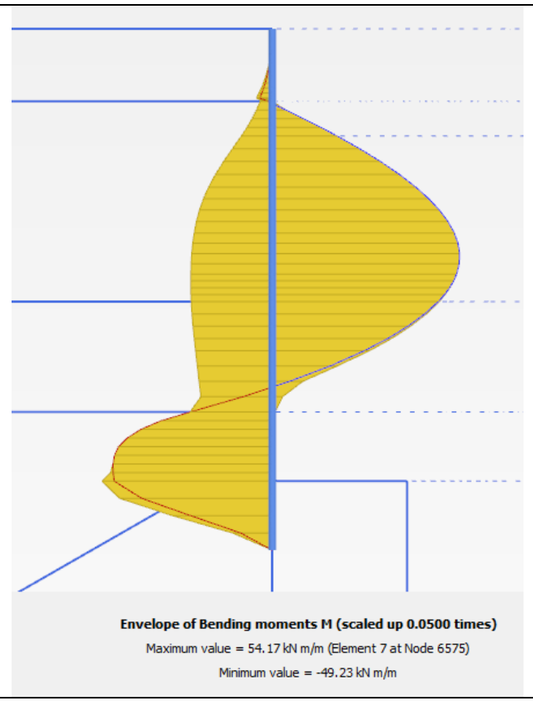
Memorandum

Retention section	Deflection Plot	Pile bending Moment Diagram	Comments
			**SW6** **Rock at RL 14 incl. Lift pit** 600dia @ 1000c/c + 900dia @ 960mm c/c Temporary sand anchor: 150kN prestress Permanent Anchors: 1st and 2nd rows 17 strands. 3rd row 14 strands and 4th row 8 strands. Anchor prestress: 17 Strands = 1000kN 14 Strands = 800kN 8 Strands = 400kN Perkins surcharge = 115kPa Deflections Under Perkins foundation= 24mm Max 600mm dia = 20mm Max 900mm dia = 21mm Bending Moments (ULS) 900mm dia pile = 1000kNm 600mm dia pile = 120kNm
			**SW 6** **Rock at RL 20** 600dia @ 1000c/c + 900dia @ 960mm c/c Temporary sand anchor: 150kN prestress Permanent Anchors: 1st and 2nd rows 14 strands. 3rd row 8 strands. Anchor prestress: 14 Strands = 800kN 8 Strands = 400kN Perkins surcharge = 115kPa Deflections Under Perkins foundation= 19mm Max 600mm dia = 15mm Max 900mm dia = 15mm Bending Moments (ULS) 900mm dia pile = 620kNm 600mm dia pile = 160kNm

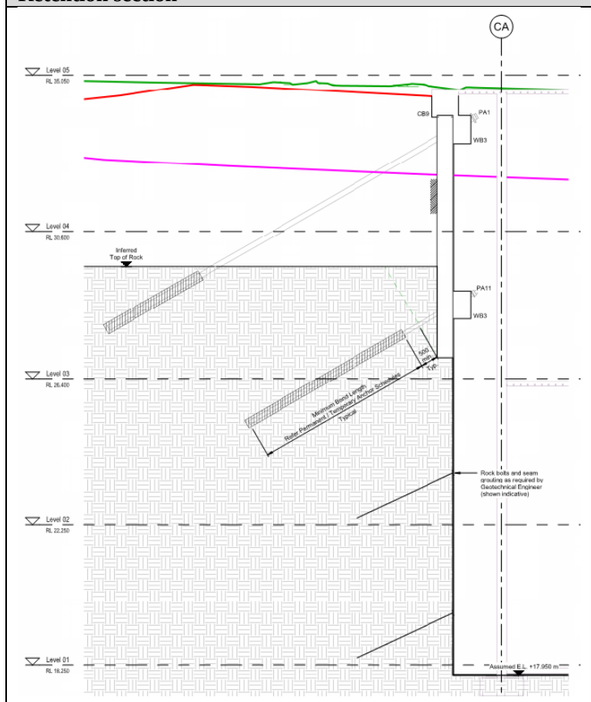
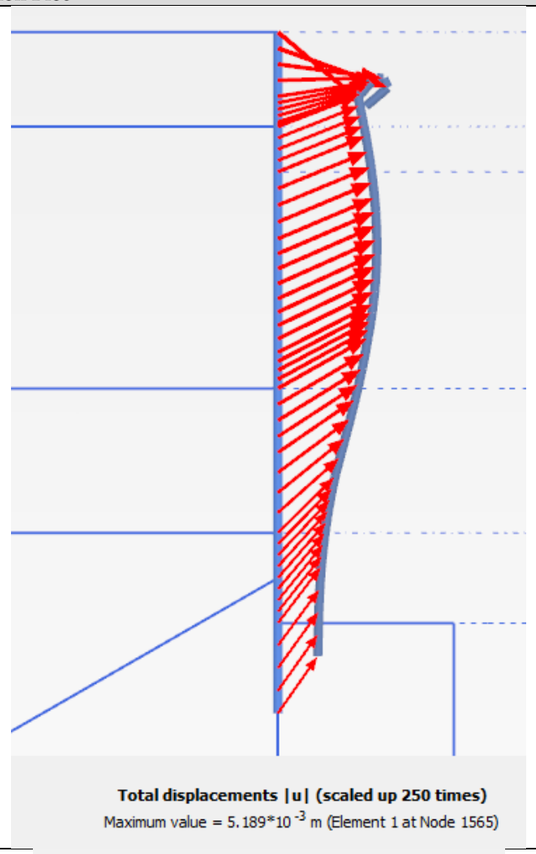
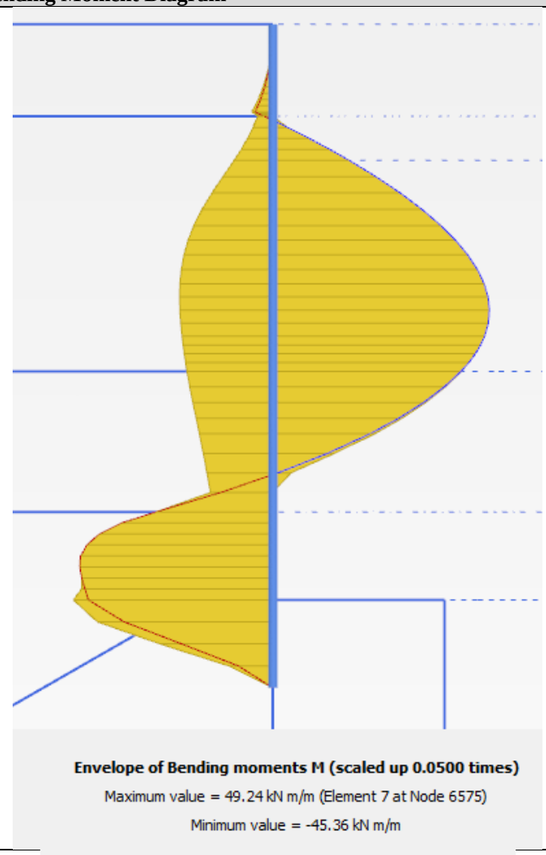
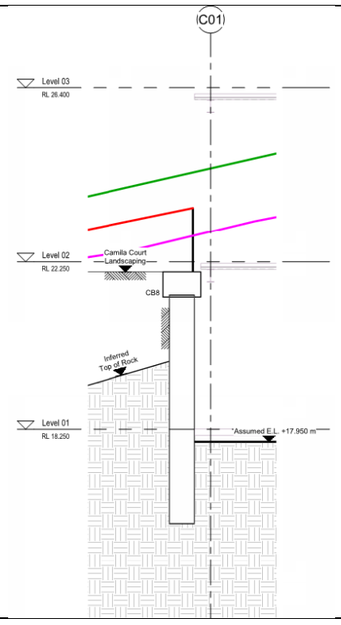
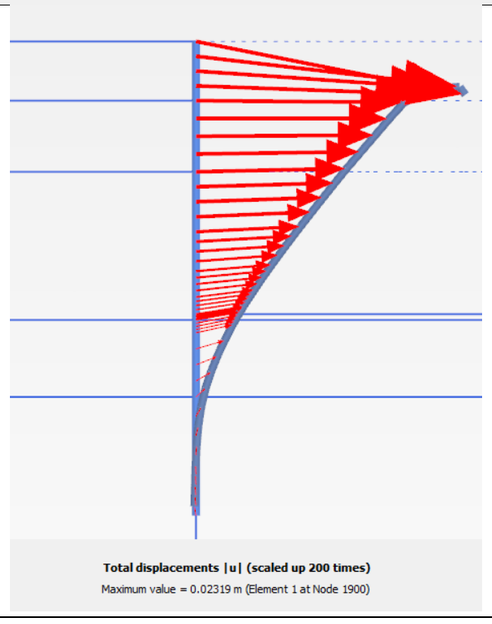
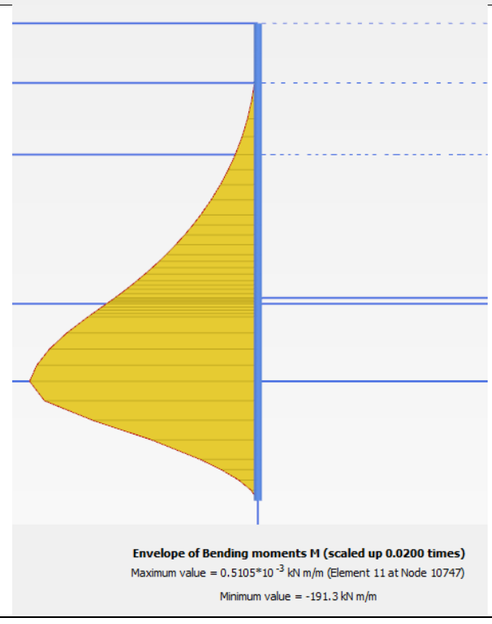
Memorandum

Retention section	Deflection Plot	Pile bending Moment Diagram	Comments
			**SW 8** **Rock at RL 22** 600dia @ 1000c/c + 900dia @ 960mm c/c Temporary sand anchor: 150kN prestress Permanent Anchors: 1st and 2nd rows 14 strands. 3rd row 8 strands. Anchor prestress: 14 Strands = 800kN 8 Strands = 400kN Perkins surcharge = 115kPa Deflections Under Perkins foundation= 13mm Max 600mm dia = 7mm Max 900mm dia = 8mm Bending Moments (ULS) 900mm dia pile = 400kNm 600mm dia pile = 75kNm
			**SW 8** **Rock at RL 26** 600dia @ 1000c/c + 900dia @ 960mm c/c Temporary sand anchor: 150kN prestress Permanent Anchors: 1st row 14 strands. 2nd and 3rd row 8 strands. Anchor prestress: 14 Strands = 800kN 8 Strands = 400kN Perkins surcharge = 115kPa Deflections Under Perkins foundation= 14mm Max 600mm dia = 8mm Max 900mm dia = 6mm Bending Moments (ULS) 900mm dia pile = 220kNm 600mm dia pile = 75kNm

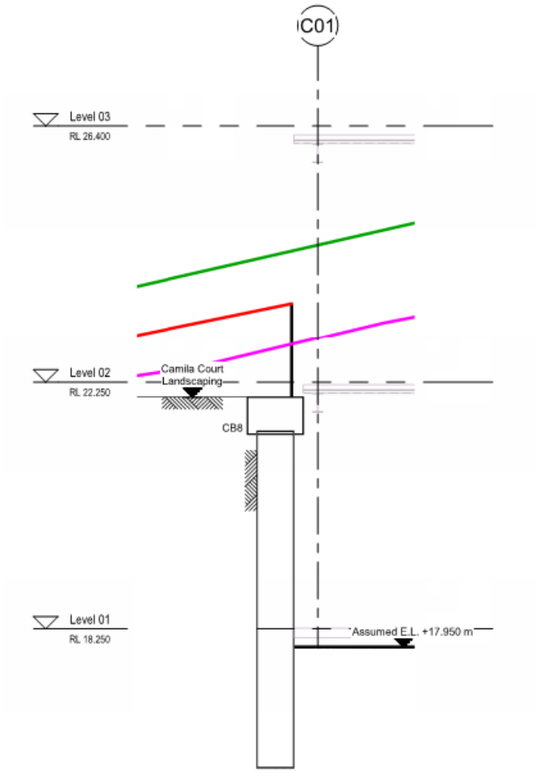
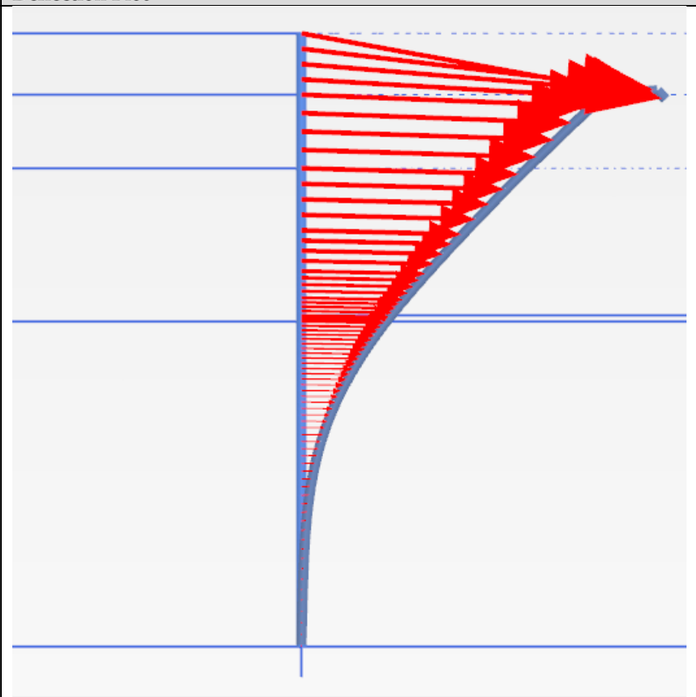
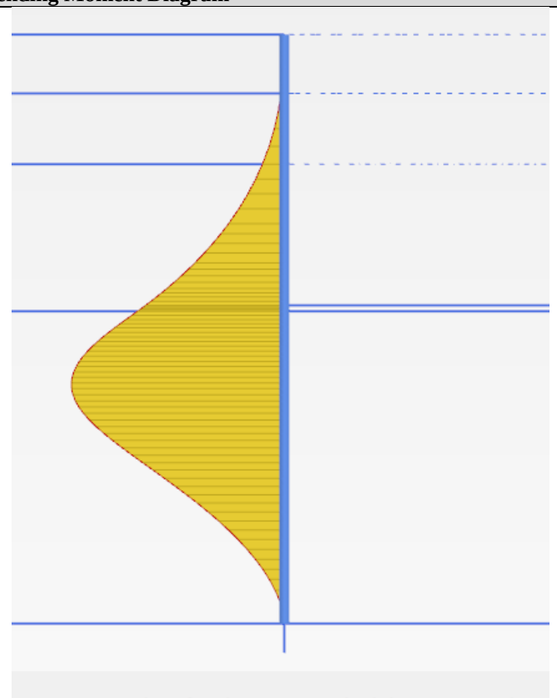
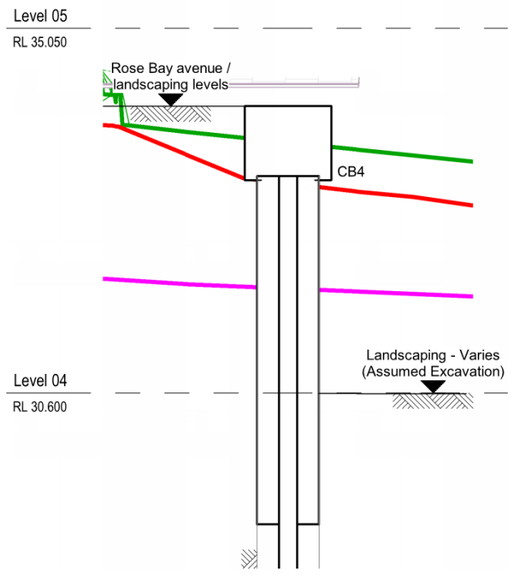
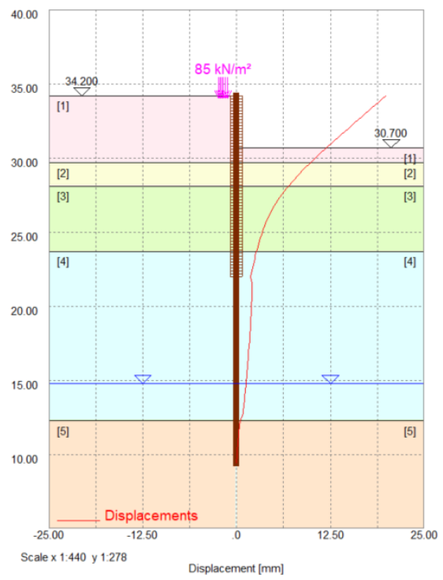
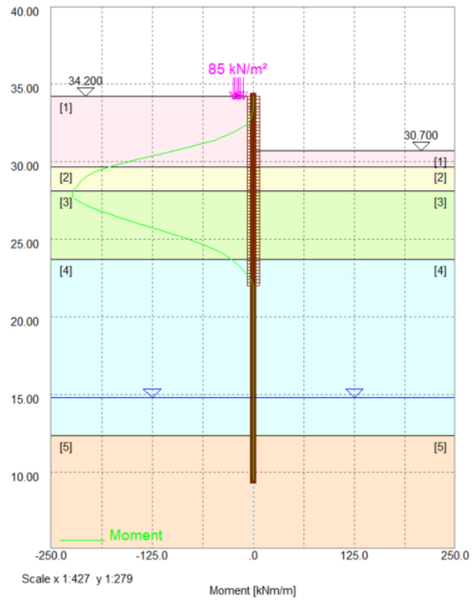
Memorandum

Retention section	Deflection Plot	Pile bending Moment Diagram	Comments
			**SW 8** **Rock at RL 29** 600dia @ 1000c/c Permanent Anchors: 1st row 6 strands, toe bolt Anchor prestress: 6 Strands = 200kN Perkins surcharge = 115kPa Deflections Under Perkins foundation= 20mm Max 600mm dia = 13mm Bending Moments (ULS) 600mm dia pile = 190kNm
			**SW 8b** **Rock at RL 29** 600dia @ 550c/c Permanent Anchors: 1st row 6 strands, toe bolt Anchor prestress: 6 Strands = 200kN Perkins surcharge = N/A Deflections Max 600mm dia = 6mm Bending Moments (ULS) 600mm dia pile = 90kNm

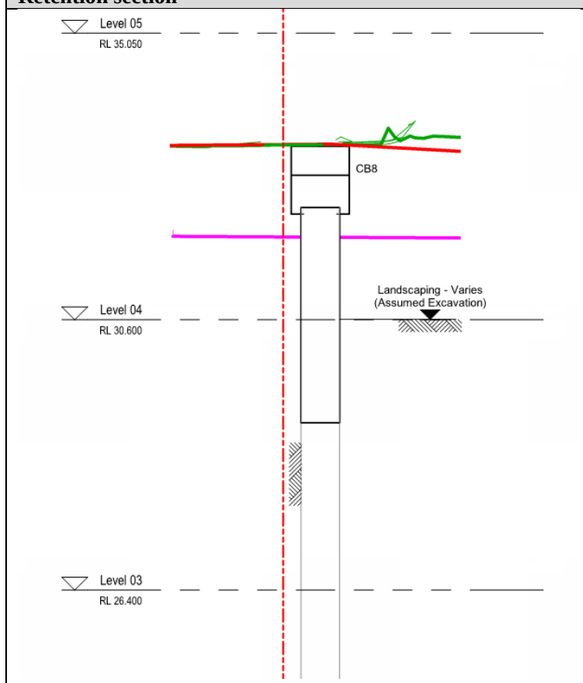
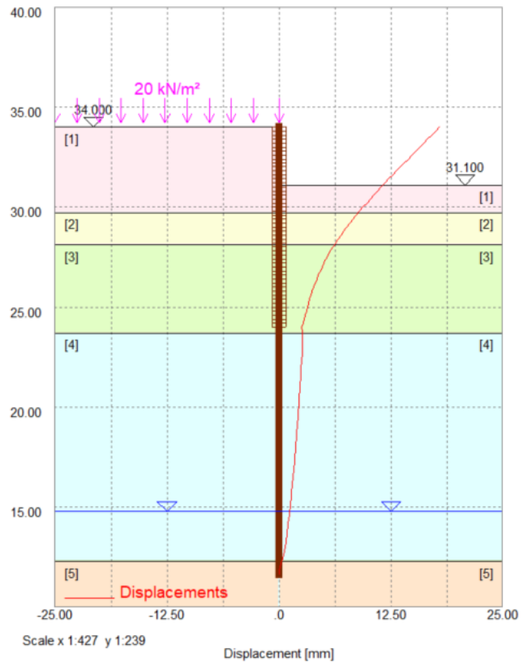
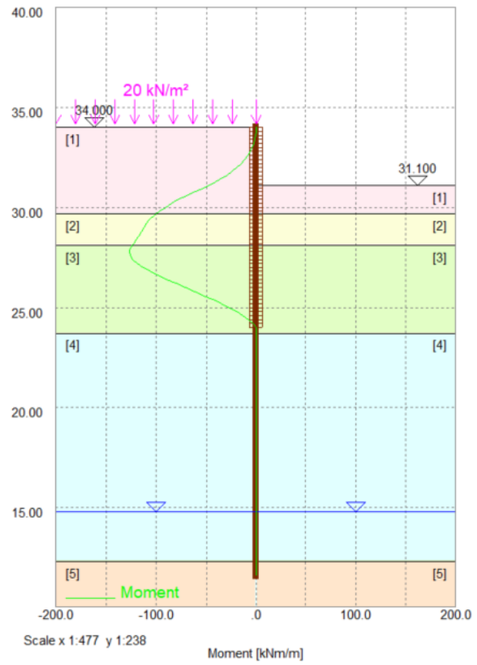
Memorandum

Retention section	Deflection Plot	Pile bending Moment Diagram	Comments
			**SW 9** **Rock at RL 29** 450dia @ 1000c/c Permanent Anchors: 1st row 6 strands, toe bolt Anchor prestress: 6 Strands = 200kN Perkins surcharge = N/A Deflections Max 450mm dia = 6mm Bending Moments (ULS) 450mm dia pile = 80kNm
			**SW 10** **Rock at RL 16** 600dia @ 1000c/c Cantilever secant wall in temporary and permanent condition Perkins surcharge = N/A Deflections Max 600mm dia = 24mm Bending Moments (ULS) 600mm dia pile = 300kNm

Memorandum

Retention section	Deflection Plot	Pile bending Moment Diagram	Comments
			**SW 11** **Rock at RL 12** 600dia @ 1000c/c Cantilever secant wall in temporary and permanent condition Perkins surcharge = N/A Deflections Max 600mm dia = 31mm Bending Moments (ULS) 600mm dia pile = 280kNm
	 STAGE 6 : Pile Stiffness Reduction	 STAGE 6 : Pile Stiffness Reduction	**SW 12** V Wall- Rose Bay 600 dia @ 900 c/c Cantilever secant wall in temporary and permanent condition Perkins surcharge = 115kPa Deflections Lateral movement @ Perkins foundation =< 20mm Max 750mm dia =< 20mm Bending Moments (ULS) 600mm dia pile = 306kNm

Memorandum

Retention section	Deflection Plot	Pile bending Moment Diagram	Comments
	 STAGE 6 : Pile Stiffness Reduction	 STAGE 6 : Pile Stiffness Reduction	**<u>SW 13</u>** V Wall- Rose Bay 600 dia @ 1000 c/c Cantilever secant wall in temporary and permanent condition Perkins surcharge = N/A Deflections Max 600mm dia = <20mm Bending Moments (ULS) 600mm dia pile = 200kNm