APPENDIX D

WALLAP Output (R&E Geotechnical Consultants)

PROJECT	Grove Lodge, London NW3	R&E Geotechnical Consultants Ltd
TITLE	Bored Pile Retaining Walls	Design Cover Sheet

Reference No.	Revision No.	Date of Previous Design (if revision)	Page 1 of 61
RE1366 des 001	0		

Activity	Initials	Signature	Date
Design By	mrf		07/07/15
Verified By	njb		07/07/15

Design Input

Southern Testing *Site Investigation Report* reference J11827 dated July 2014.
Ground Engineering *Ground Investigation Report* reference C13390A dated February 2014.

Marked up sketches received by email, appended for ease of reference.

ULS analysis performed to BS EN 1997-1 (Design Approach 1, Combination 2 most onerous) with factored soil strengths, surcharges and accidental overdig to determine lengths for stability.

BS EN 1997-1 is a limit state design with FoS ≥1 required for factored inputs.

SLS analysis carried out to give estimated deflections and unfactored moments.

The unplanned overdig is part of the design process and should not be carried out.

Soft secant piles ignored, treated effectively as contiguous.

Design Output

8m bored lengths - Sections 1-1 & 3-3.

10m bored lengths - Section 2-2.

450mm diameter at 600mm centres, 8B20 reinforcement cage with B8 links at 200mm centres.

13mm maximum calculated deflection, see summary pages

Summary of analysis is presented on sheets 3-4, 19-20, 37-38 & 53.

Worst case waling load of 119kN/m ULS, 58kN/m SLS.

Propped throught in temporary condition. Propped by basement and ground floor slabs in permanent condition, except Section 1-1 which cantilevers above basement slab.

Revision	By	Date	Ver	Date	Description

Reference

Ground Profile

Made Ground: From existing ground levels to 125.2mOD.

Sand & Gravel: From 125.2mOD to 121.6mOD.

Claygate: From 121.6mOD to toe of piles.

Groundwater: Encountered at 123.75mOD in SI. In SLS analysis, raised to 124.75mOD long term. In ULS analysis, 124.75mOD short term, raised to ground level long term.

Live Surcharge: 10kPa throughout (factored by 1.3 in ULS analysis).

Dead Surcharges: 20kN/m as indicated in Section 2-2, 125kN/m assumed from Admiral House in Section 3-3. Bund in Section 1-1 represented as equivilent surcharge.

Made Ground			ULS Earth Pressure Coefficients:			
			ka:	0.382		
Bulk Density:	19.0kN/m3		ko:	0.550		
Submerged Density:	20.0kN/m3		kp:	3.062		
Elastic Modulus =	5MPa + 4MPa/m depth					
			SLS Earth Pressure Coefficients:			
Shear Strength:	23.89°	ULS	ka:	0.313		
	28°	SLS	ko:	0.550		
			kp:	3.868		

Sand & Gravel			ULS Earth Pressure Coefficients:			
			ka:	0.305		
Bulk Density:	19.0kN/m3		ko:	0.550		
Submerged Density:	20.0kN/m3		kp:	4.211		
Elastic Modulus =	20MPa + 5MPa/m depth					
			SLS Earth Pressure Coefficients:			
Shear Strength:	28.35°	ULS	ka:	0.243		
	34°	SLS	ko:	0.500		
			kp:	5.675		

Claygate			ULS Earth Pressure Coefficients:			
			ka:	0.396	kac:	1.482
Bulk Density:	20.0kN/m3		ko:	1.000		
Submerged Density:	20.0kN/m3		kp:	2.915	kpc:	4.699
Elastic Modulus =	20MPa + 5MPa/m depth					
			SLS Earth Pressure Coefficients:			
Shear Strength:	22.18°, c' 4kPa	ULS	ka:	0.326	kac:	1.322
	27°, c' 5kPa	SLS	ko:	1.000		
			kp:	3.647	kpc:	5.195

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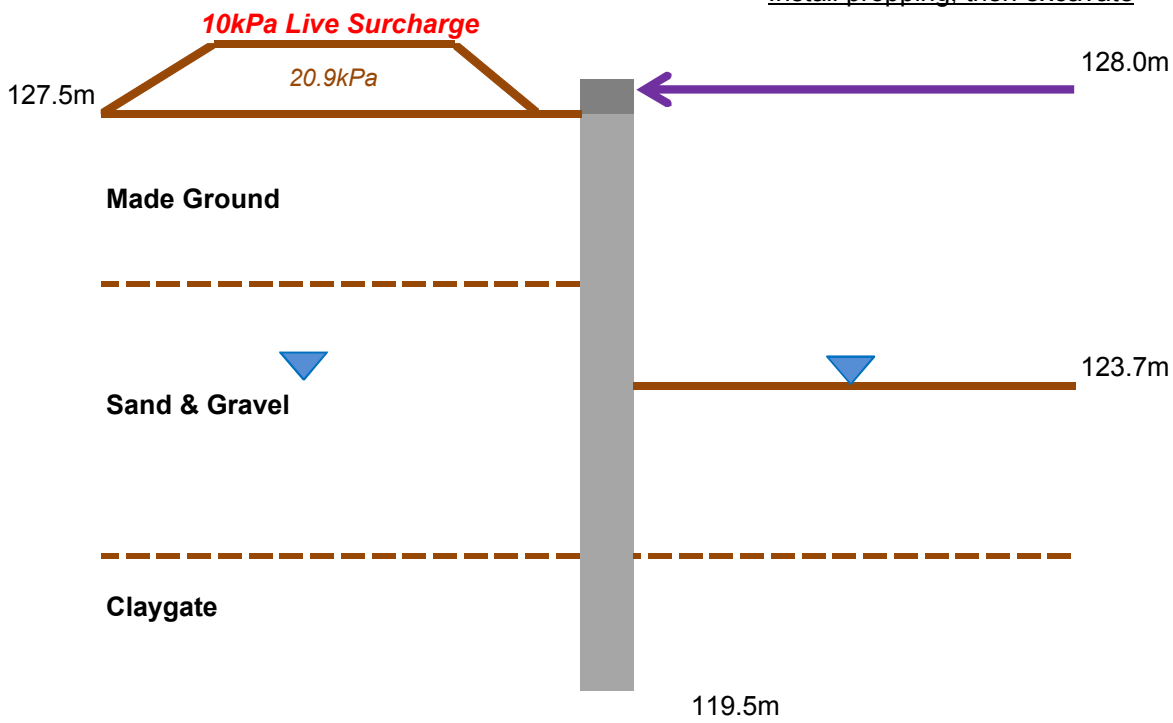
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Bored Pile Retaining Walls
mrf	07/07/15	njb	07/07/15	RE1366 des 001	3 of 61	

Reference

Summary of Analysis
Section 1-1
Install propping, then excavate



Excavation Level	123.7m	OD planned
	123.32m	OD with accidental overdig
Retained Level	127.5m	OD
Top of Pile Level	127.5m	OD
Toe Level	119.5m	OD
Wall Depth	8.0	m
Factor of safety	1.10	> 1.0 for factored strengths with overdig (ULS)
	3.22	Burland & Potts (SLS)
Maximum Moment	146	kNm (ULS)
	51	kNm (SLS)
Waling Load	56	kN/m (ULS)
	25	kN/m (SLS)
Deflection	4	mm

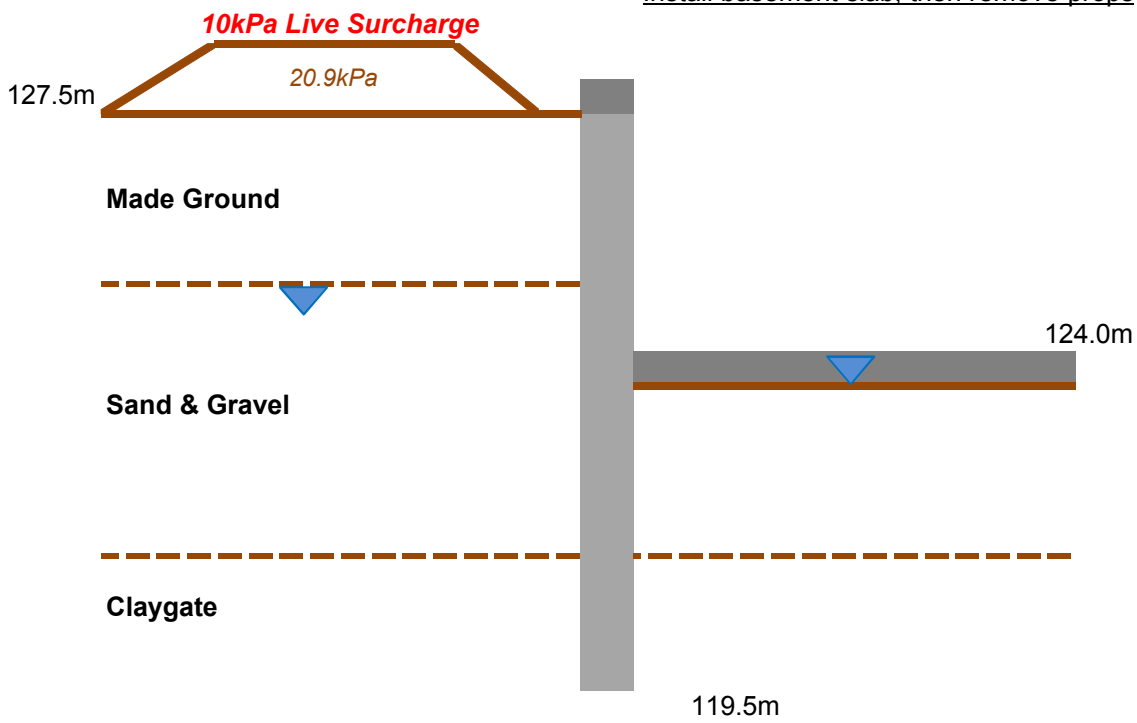
R&E Geotechnical Consultants Ltd						Grove Lodge, London NW3
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Bored Pile Retaining Walls
mrf	07/07/15	njb	07/07/15	RE1366 des 001	4 of 61	

Reference

Summary of Analysis

Section 1-1

Install basement slab, then remove props



Retained Level	127.5m	OD
Top of Pile Level	127.5m	OD
Toe Level	119.5m	OD
Wall Depth	8.0	m
Factor of safety	V.High, wall tending to rotate into retained side	
	6.14	Burland & Potts (SLS)
Maximum Moment	110	kNm (ULS)
	61	kNm (SLS)
Base Slab Load	204	kN/m (ULS)
	79	kN/m (SLS)
Deflection	13	mm

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	127.50	1 Made Ground	1 Made Ground
2	125.20	2 Sand & Gravel	2 Sand & Gravel
3	121.60	3 dr Claygate	3 dr Claygate

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made Ground	19.00a	5000	0.550	OC	0.382	3.062	0.0d
	(127.50)	20.00b	(4000)		(0.200)	(1.453)	(4.848)	
2	Sand & Gr..	19.00a	20000	0.500	OC	0.305	4.211	
	(125.20)	20.00b	(5000)		(0.200)	(0.000)	(0.000)	
3	dr Claygate	20.00	20000	1.000	OC	0.396	2.915	4.000d
	(121.60)		(4000)		(0.200)	(1.482)	(4.700)	

Note: (a) and (b) are Bulk Densities above and below the water table

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	23.04	0.660	0.00	23.04	0.660	0.00
2	Sand & Gravel	28.35	0.660	0.00	28.35	0.660	0.00
3	dr Claygate	22.17	0.660	0.00	22.17	0.660	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	124.75	124.75

Automatic water pressure balancing at toe of wall : Yes

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	124.75	124.75	0.0	1	123.32	123.32	0.0
2	1	127.50	127.50	0.0	1	123.70	123.70	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 119.50
Maximum finite element length = 0.50 m
Youngs modulus of wall E = 2.5000E+07 kN/m2
Moment of inertia of wall I = 3.3500E-03 m4/m run
E.I = 83750 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	128.00	6.00	0.015000	2.000E+08	10.00	0.00	0	No
2	124.00	1.00	0.300000	2.000E+07	10.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	127.50	1.00(A)	20.00	5.00	20.90	=	N/A	N/A
2	127.50	0.30(A)	20.00	20.00	13.00	=	N/A	N/A
3	123.70	-0.00(P)	20.00	20.00	6.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 127.50
2	Change EI of wall to 83750 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
3	Apply surcharge no.2 at elevation 127.50 No analysis at this stage
4	Install strut or anchor no.1 at elevation 128.00
5	Apply water pressure profile no.1 No analysis at this stage
6	Excavate to elevation 123.32 on PASSIVE side
7	Fill to elevation 123.70 on PASSIVE side with soil type 1
8	Install strut or anchor no.2 at elevation 124.00
9	Apply surcharge no.3 at elevation 123.70 No analysis at this stage
10	Remove strut or anchor no.1 at elevation 128.00
11	Apply water pressure profile no.2

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 8.000 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

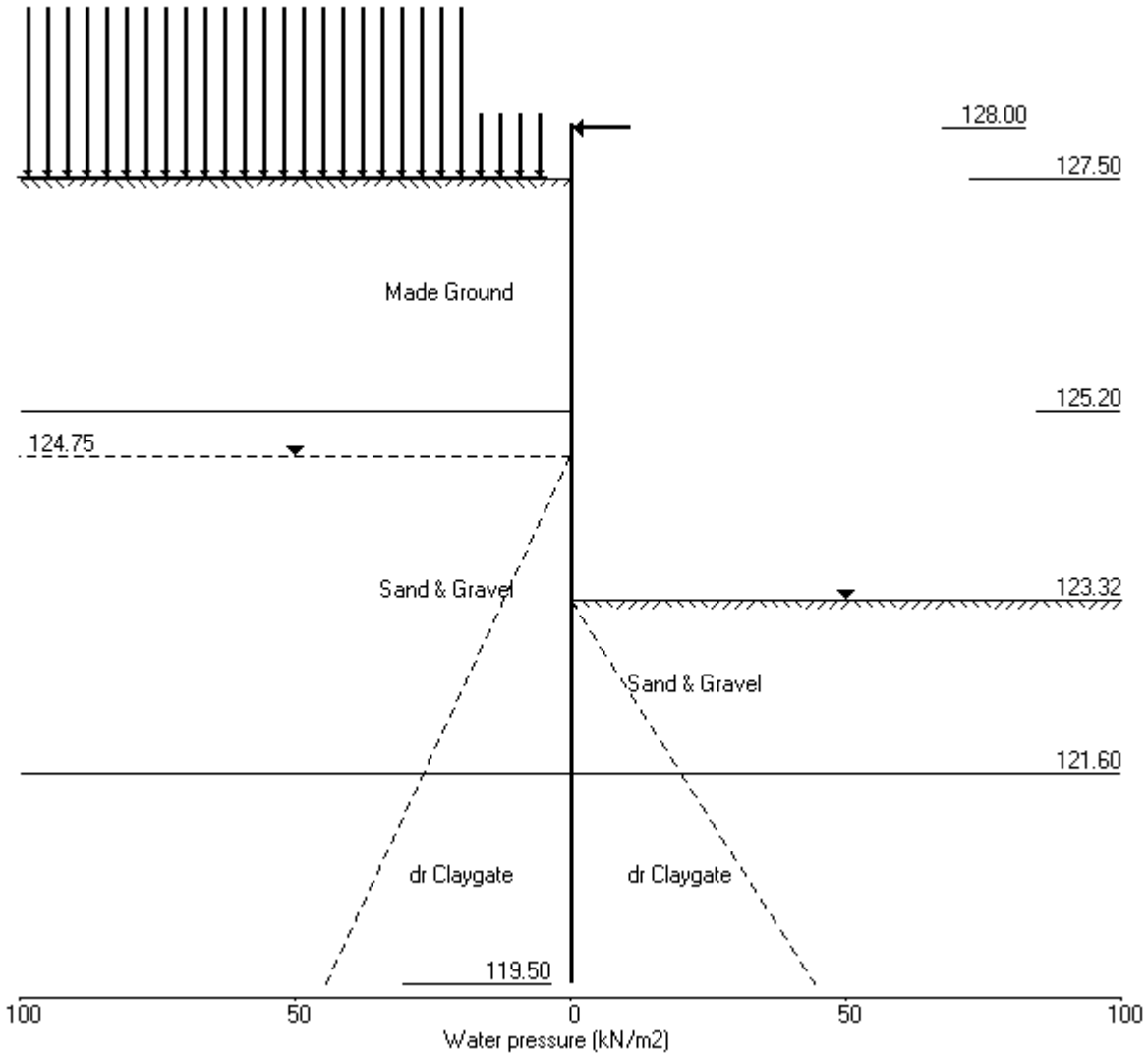
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 127.50	No	No	No
2	Change EI of wall to 83750kN.m2/m run	No	No	No
3	Apply surcharge no.2 at elev. 127.50	No	No	No
4	Install strut no.1 at elev. 128.00	No	No	No
5	Apply water pressure profile no.1	No	No	No
6	Excav. to elev. 123.32 on PASSIVE side	Yes	No	No
7	Fill to elev. 123.70 on PASSIVE side	No	No	No
8	Install strut no.2 at elev. 124.00	No	No	No
9	Apply surcharge no.3 at elev. 123.70	No	No	No
10	Remove strut no.1 at elev. 128.00	No	No	No
11	Apply water pressure profile no.2	Yes	No	No

Units: kN,m

Stage No.6 Excav. to elev. 123.32 on PASSIVE side



Units: kN,m

Stage No. 6 Excavate to elevation 123.32 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 119.50 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
6	127.50	123.32	128.00	1.099	n/a	120.15	3.17

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

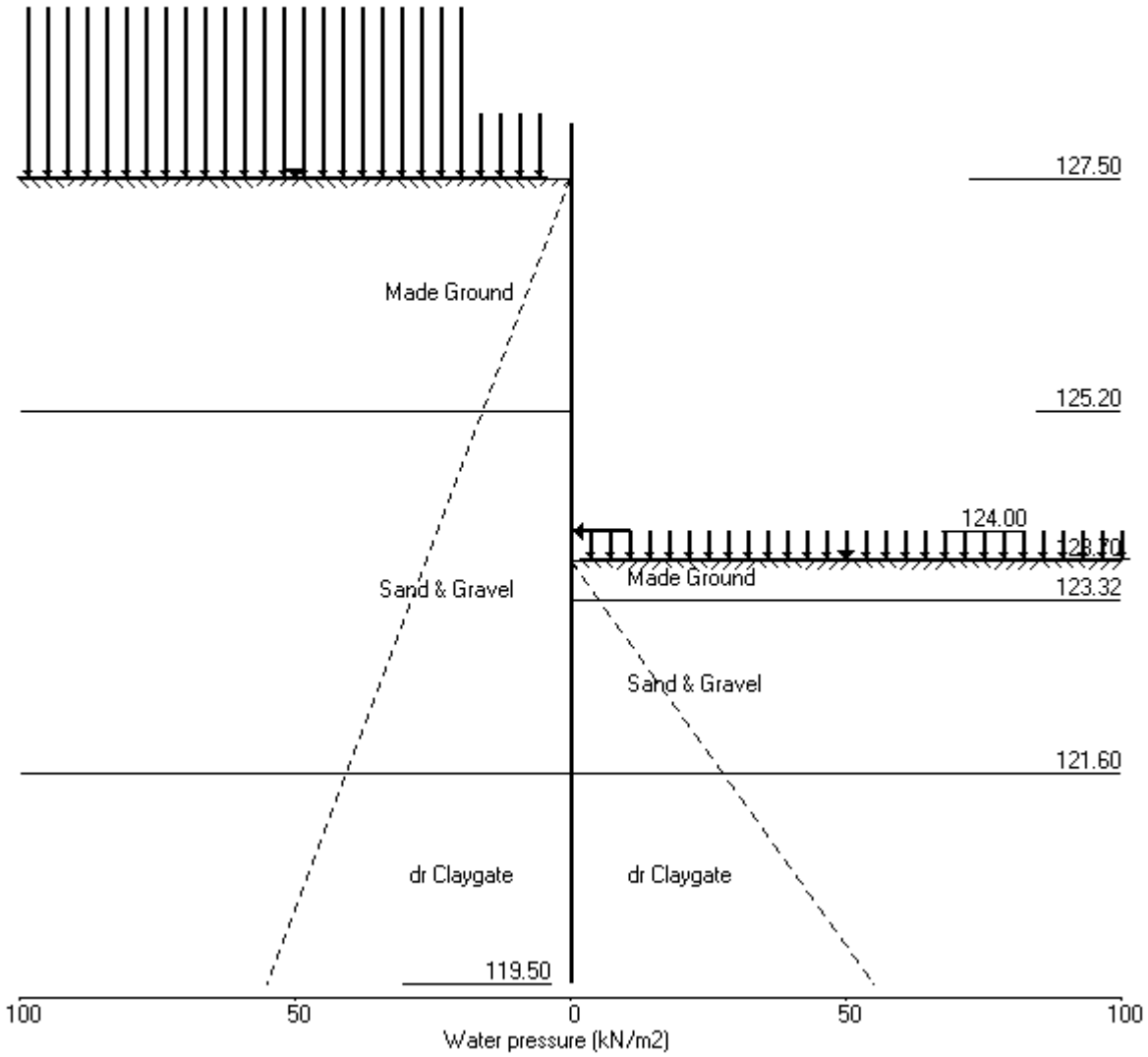
*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	128.00	0.00	0.002	-4.84E-03	-55.6	0.0	55.6
2	127.50	0.00	0.004	-4.76E-03	-55.6	-27.8	
3	127.00	5.81	0.006	-4.51E-03	-54.1	-55.3	
4	126.50	11.87	0.008	-4.10E-03	-49.7	-81.3	
5	126.00	17.21	0.010	-3.55E-03	-42.5	-104.5	
6	125.60	21.09	0.012	-3.02E-03	-34.8	-120.0	
7	125.20	24.69	0.013	-2.42E-03	-25.6	-132.1	
		19.70	0.013	-2.42E-03	-25.6	-132.1	
8	124.75	22.74	0.014	-1.68E-03	-16.1	-141.5	
9	124.38	27.47	0.014	-1.04E-03	-6.7	-145.8	
10	124.00	32.11	0.015	-3.92E-04	4.5	-146.3	
11	123.70	35.78	0.015	1.26E-04	14.7	-143.4	
12	123.32	40.38	0.014	7.58E-04	29.1	-135.2	
13	122.91	26.01	0.014	1.38E-03	42.8	-120.2	
14	122.50	11.59	0.013	1.92E-03	50.5	-100.9	
15	122.05	-4.30	0.012	2.40E-03	52.1	-77.5	
16	121.60	-20.24	0.011	2.76E-03	46.6	-55.1	
		-10.69	0.011	2.76E-03	46.6	-55.1	
17	121.30	-15.06	0.010	2.94E-03	42.7	-41.6	
18	121.00	-18.82	0.009	3.06E-03	37.6	-29.6	
19	120.50	-23.81	0.008	3.19E-03	27.0	-13.5	
20	120.00	-27.32	0.006	3.24E-03	14.2	-3.3	
21	119.50	-29.49	0.005	3.25E-03	0.0	-0.0	

At elev. 128.00 Strut force = 333.6 kN/strut = 55.6 kN/m run

Units: kN,m

Stage No.11 Apply water pressure profile no.2



Units: kN,m

Stage No. 11 Apply water pressure profile no.2

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 119.50 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
11	127.50	123.70	124.00	Conditions not suitable for FoS calc.			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	128.00	0.00	0.031	4.28E-03	0.0	0.0	
2	127.50	0.00	0.029	4.28E-03	0.0	0.0	
3	127.00	8.13	0.027	4.28E-03	2.0	0.4	
4	126.50	16.50	0.025	4.27E-03	8.2	2.8	
5	126.00	24.17	0.023	4.23E-03	18.4	9.3	
6	125.60	29.89	0.021	4.16E-03	29.2	18.8	
7	125.20	35.35	0.019	4.04E-03	42.2	33.0	
		31.41	0.019	4.04E-03	42.2	33.0	
8	124.75	36.74	0.017	3.80E-03	57.6	55.4	
9	124.38	41.06	0.016	3.49E-03	72.1	79.6	
10	124.00	45.31	0.015	3.07E-03	88.3	109.7	204.3
		45.31	0.015	3.07E-03	-116.0	109.7	
11	123.70	53.91	0.014	2.74E-03	-101.1	77.0	
		49.96	0.014	2.74E-03	-101.1	77.0	
12	123.32	56.29	0.013	2.47E-03	-80.9	42.1	
		57.21	0.013	2.47E-03	-80.9	42.1	
13	122.91	60.68	0.012	2.33E-03	-56.8	13.7	
14	122.50	55.48	0.011	2.31E-03	-33.0	-5.3	
15	122.05	42.33	0.010	2.37E-03	-11.0	-15.1	
16	121.60	26.13	0.009	2.45E-03	4.4	-16.3	
		14.72	0.009	2.45E-03	4.4	-16.3	
17	121.30	9.70	0.008	2.51E-03	8.1	-14.4	
18	121.00	4.69	0.007	2.56E-03	10.3	-11.6	
19	120.50	-3.31	0.006	2.61E-03	10.6	-6.3	
20	120.00	-10.76	0.005	2.63E-03	7.1	-1.8	
21	119.50	-17.63	0.003	2.64E-03	0.0	-0.0	

At elev. 124.00 Strut force = 204.3 kN/strut = 204.3 kN/m run

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	127.50	1 Made Ground	1 Made Ground
2	125.20	2 Sand & Gravel	2 Sand & Gravel
3	121.60	3 dr Claygate	3 dr Claygate

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made Ground	19.00a	5000	0.550	OC	0.313	3.868	0.0d
	(127.50)	20.00b	(4000)		(0.200)	(1.293)	(5.395)	
2	Sand & Gr..	19.00a	20000	0.500	OC	0.243	5.675	
	(125.20)	20.00b	(5000)		(0.200)	(0.000)	(0.000)	
3	dr Claygate	20.00	20000	1.000	OC	0.326	3.647	5.000d
	(121.60)		(4000)		(0.200)	(1.322)	(5.195)	

Note: (a) and (b) are Bulk Densities above and below the water table

Additional soil parameters associated with Ka and Kp

-------- Soil type -------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	28.00	0.600	0.00	28.00	0.500	0.00
2	Sand & Gravel	34.00	0.540	0.00	34.00	0.500	0.00
3	dr Claygate	27.00	0.600	0.00	27.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	123.75	123.75

Automatic water pressure balancing at toe of wall : Yes

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	123.75	123.75	0.0	1	123.70	123.70	0.0
2	1	124.75	124.75	0.0	1	123.70	123.70	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 119.50
Maximum finite element length = 0.50 m
Youngs modulus of wall E = 2.5000E+07 kN/m2
Moment of inertia of wall I = 3.3500E-03 m4/m run
E.I = 83750 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	128.00	6.00	0.015000	2.000E+08	10.00	0.00	0	No
2	124.00	1.00	0.300000	2.000E+07	10.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	127.50	1.00(A)	20.00	5.00	20.90	=	N/A	N/A
2	127.50	0.30(A)	20.00	20.00	10.00	=	N/A	N/A
3	123.70	-0.00(P)	20.00	20.00	6.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 127.50
2	Change EI of wall to 83750 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
3	Apply surcharge no.2 at elevation 127.50 No analysis at this stage
4	Install strut or anchor no.1 at elevation 128.00
5	Apply water pressure profile no.1 No analysis at this stage
6	Excavate to elevation 123.70 on PASSIVE side
7	Install strut or anchor no.2 at elevation 124.00
8	Apply surcharge no.3 at elevation 123.70 No analysis at this stage
9	Remove strut or anchor no.1 at elevation 128.00
10	Apply water pressure profile no.2

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Burland-Potts
Factor on passive for calculating wall depth = 1.80

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 8.000 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

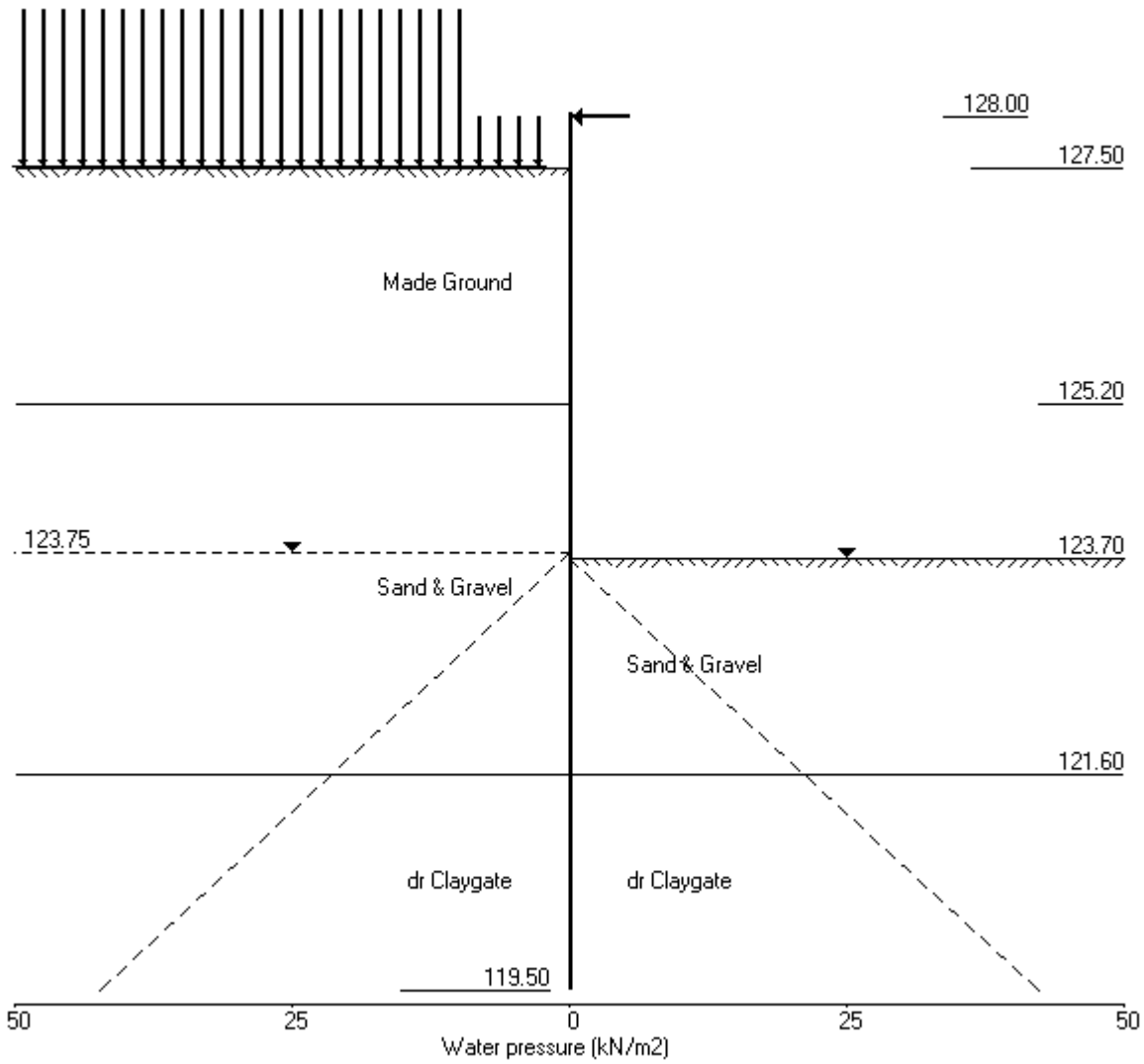
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 127.50	No	No	No
2	Change EI of wall to 83750kN.m2/m run	No	No	No
3	Apply surcharge no.2 at elev. 127.50	No	No	No
4	Install strut no.1 at elev. 128.00	No	No	No
5	Apply water pressure profile no.1	No	No	No
6	Excav. to elev. 123.70 on PASSIVE side	Yes	No	No
7	Install strut no.2 at elev. 124.00	No	No	No
8	Apply surcharge no.3 at elev. 123.70	No	No	No
9	Remove strut no.1 at elev. 128.00	No	No	No
10	Apply water pressure profile no.2	Yes	No	No

Units: kN,m

Stage No.6 Excav. to elev. 123.70 on PASSIVE side



Units: kN,m

Stage No. 6 Excavate to elevation 123.70 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Burland-Potts method

Factor of safety on nett available passive

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 119.50 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.800 Toe elev.	Wall Penetr -ation
6	127.50	123.70	128.00	3.224	n/a	121.43	2.27

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

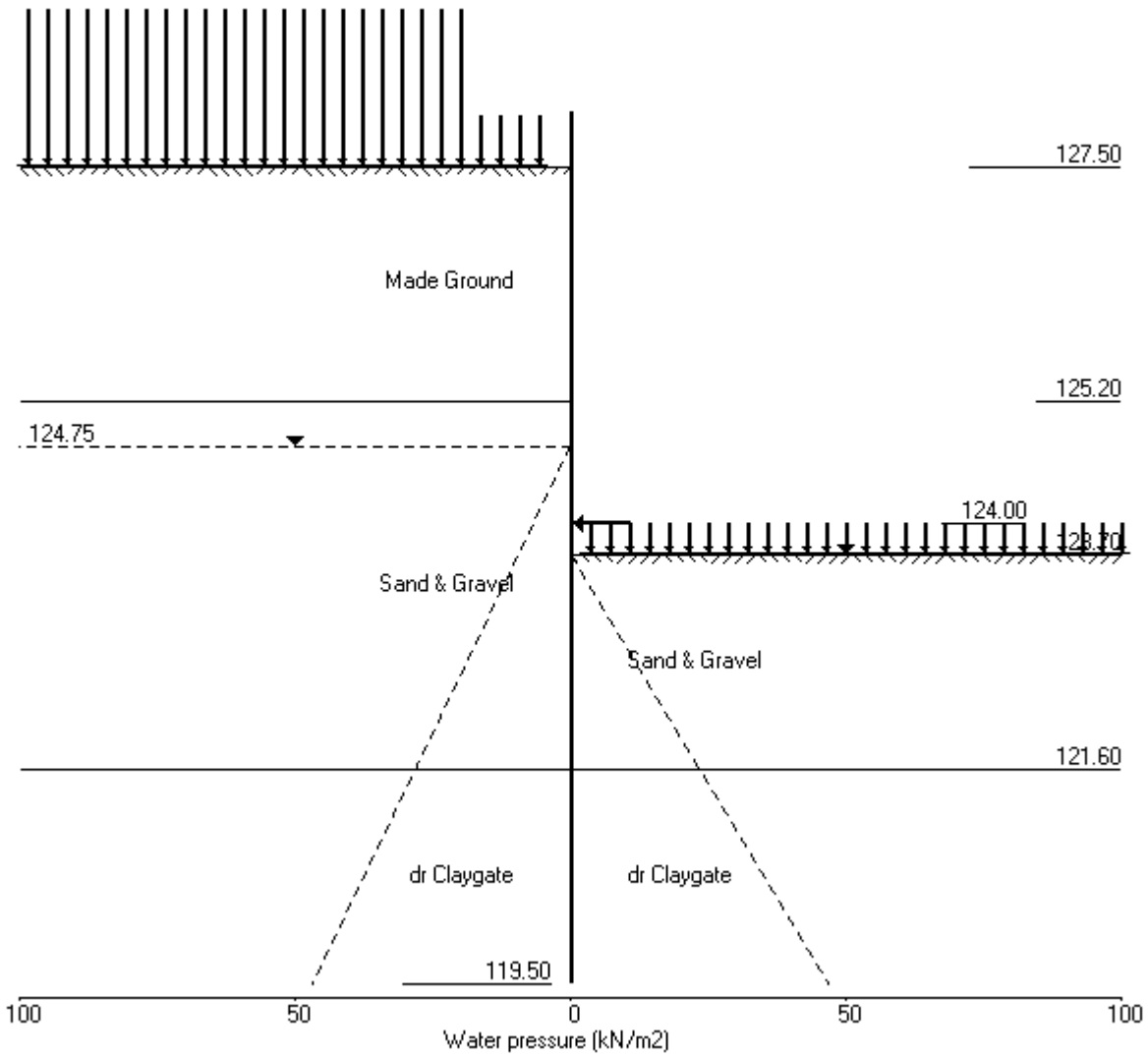
*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	128.00	0.00	0.001	-1.36E-03	-24.9	-0.0	24.9
2	127.50	0.00	0.002	-1.32E-03	-24.9	-12.4	
3	127.00	4.40	0.002	-1.21E-03	-23.8	-24.6	
4	126.50	9.11	0.003	-1.03E-03	-20.4	-35.7	
5	126.00	13.38	0.003	-7.98E-04	-14.8	-44.6	
6	125.60	16.50	0.003	-5.75E-04	-8.8	-49.3	
7	125.20	19.42	0.004	-3.37E-04	-1.6	-51.4	
		15.11	0.004	-3.37E-04	-1.6	-51.4	
8	124.75	17.52	0.004	-6.47E-05	5.7	-50.6	
9	124.38	19.44	0.004	1.52E-04	12.7	-47.1	
10	124.00	21.30	0.004	3.49E-04	20.3	-41.0	
11	123.75	22.51	0.004	4.63E-04	25.8	-35.2	
12	123.70	23.14	0.004	4.84E-04	26.9	-33.9	
13	123.35	4.25	0.003	6.04E-04	31.7	-23.4	
14	123.00	-14.67	0.003	6.80E-04	29.9	-12.4	
15	122.50	-28.68	0.003	7.15E-04	19.1	1.2	
16	122.05	-26.22	0.002	6.94E-04	6.7	7.5	
17	121.60	-23.30	0.002	6.54E-04	-4.4	7.9	
		-1.14	0.002	6.54E-04	-4.4	7.9	
18	121.30	-0.52	0.002	6.29E-04	-4.7	6.5	
19	121.00	0.25	0.002	6.08E-04	-4.7	5.1	
20	120.50	1.90	0.001	5.84E-04	-4.2	2.7	
21	120.00	4.06	0.001	5.73E-04	-2.7	0.9	
22	119.50	6.78	0.001	5.71E-04	0.0	0.0	

At elev. 128.00 Strut force = 149.2 kN/strut = 24.9 kN/m run

Units: kN,m

Stage No.10 Apply water pressure profile no.2



Units: kN,m

Stage No. 10 Apply water pressure profile no.2

STABILITY ANALYSIS of Fully Embedded Wall according to Burland-Potts method

Factor of safety on nett available passive

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 119.50 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.800 Toe elev.	Wall Penetr -ation
10	127.50	123.70	124.00	6.137	n/a	***	***

Legend: *** Result not found

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

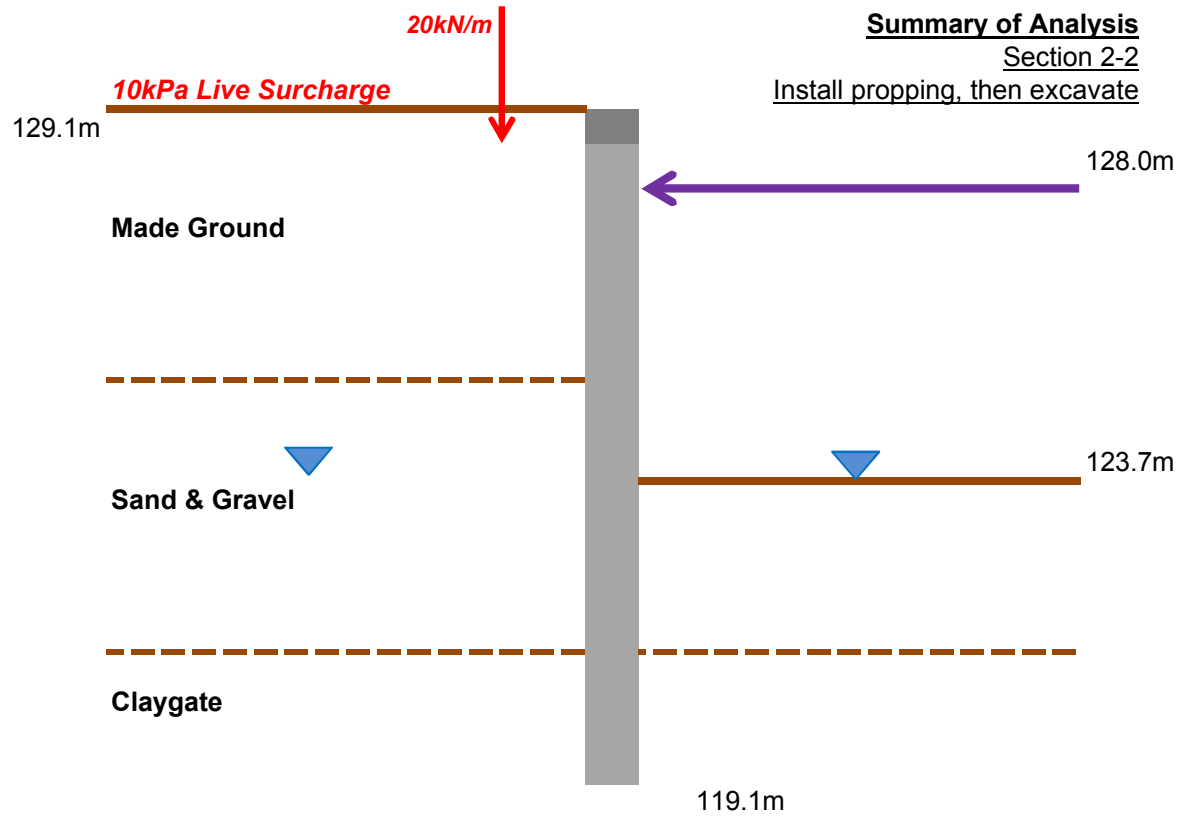
*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	128.00	0.00	0.013	2.38E-03	0.0	-0.0	
2	127.50	0.00	0.012	2.38E-03	0.0	0.0	
3	127.00	4.80	0.010	2.38E-03	1.2	0.3	
4	126.50	9.53	0.009	2.37E-03	4.8	1.7	
5	126.00	13.80	0.008	2.35E-03	10.6	5.5	
6	125.60	16.88	0.007	2.31E-03	16.8	10.9	
7	125.20	19.73	0.006	2.23E-03	24.1	19.0	
		15.56	0.006	2.23E-03	24.1	19.0	
8	124.75	17.80	0.005	2.10E-03	31.6	31.5	
9	124.38	22.11	0.004	1.92E-03	39.1	44.7	
10	124.00	26.53	0.004	1.69E-03	48.2	61.1	78.8
		26.53	0.004	1.69E-03	-30.7	61.1	
11	123.75	30.58	0.003	1.51E-03	-23.5	54.2	
12	123.70	31.54	0.003	1.48E-03	-22.0	53.1	
		29.78	0.003	1.48E-03	-22.0	53.1	
13	123.35	16.67	0.003	1.27E-03	-13.8	46.8	
14	123.00	0.61	0.002	1.09E-03	-10.8	42.6	
15	122.50	-11.04	0.002	8.54E-04	-13.4	37.8	
16	122.05	-7.92	0.002	6.71E-04	-17.7	31.3	
17	121.60	-5.44	0.001	5.28E-04	-20.7	22.5	
		9.24	0.001	5.28E-04	-20.7	22.5	
18	121.30	9.39	0.001	4.58E-04	-17.9	16.7	
19	121.00	9.52	0.001	4.07E-04	-15.1	11.7	
20	120.50	9.76	0.001	3.56E-04	-10.2	5.3	
21	120.00	10.18	0.001	3.35E-04	-5.3	1.4	
22	119.50	10.88	0.001	3.31E-04	0.0	-0.0	

At elev. 124.00 Strut force = 78.8 kN/strut = 78.8 kN/m run

R&E Geotechnical Consultants Ltd						Grove Lodge, London NW3
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Bored Pile Retaining Walls
mrf	07/07/15	njb	07/07/15	RE1366 des 001	19 of 61	

Reference

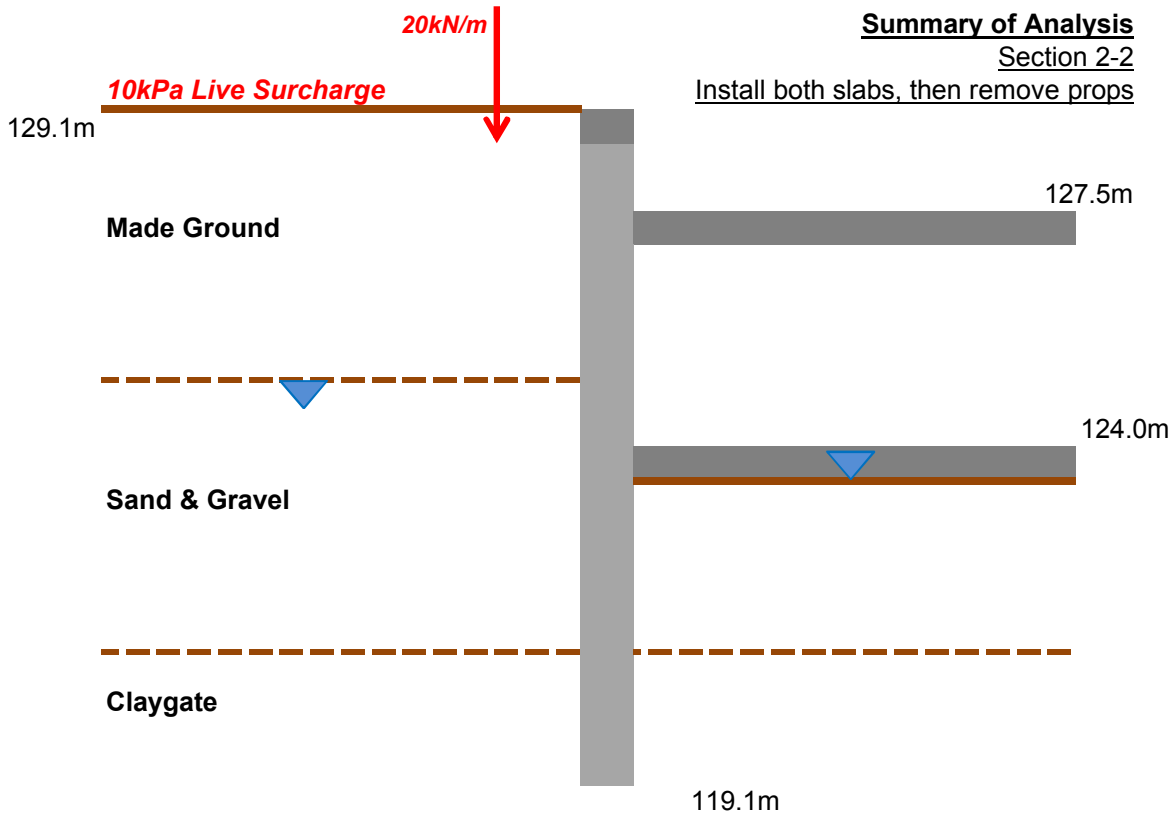


Summary of Analysis
Section 2-2
Install propping, then excavate

Excavation Level	123.7m	OD planned
	123.27m	OD with accidental overdig
Retained Level	129.1m	OD
Top of Pile Level	129.1m	OD
Toe Level	119.1m	OD
Wall Depth	10.0	m
Factor of safety	1.04	> 1.0 for factored strengths with overdig (ULS)
	2.78	Burland & Potts (SLS)
Maximum Moment	213	kNm (ULS)
	78	kNm (SLS)
Waling Load	119	kN/m (ULS)
	58	kN/m (SLS)
Deflection	7	mm

R&E Geotechnical Consultants Ltd						Grove Lodge, London NW3
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Bored Pile Retaining Walls
mrf	07/07/15	njb	07/07/15	RE1366 des 001	20 of 61	

Reference



Summary of Analysis

Section 2-2

Install both slabs, then remove props

Retained Level	129.1m	OD
Top of Pile Level	129.1m	OD
Toe Level	119.1m	OD
Wall Depth	10.0	m
Factor of safety	n/a for multi-propped walls	
Maximum Moment	206	kNm (ULS)
	71	kNm (SLS)
Base Slab Load	40	kN/m (ULS)
	2	kN/m (SLS)
Ground Slab Load	163	kN/m (ULS)
	67	kN/m (SLS)
Deflection	7	mm

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	129.10	1 Made Ground	1 Made Ground
2	125.20	2 Sand & Gravel	2 Sand & Gravel
3	121.60	3 dr Claygate	3 dr Claygate

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made Ground	19.00a	5000	0.550	OC	0.382	3.062	0.0d
	(129.10)	20.00b	(4000)		(0.200)	(1.453)	(4.848)	
2	Sand & Gr..	19.00a	20000	0.500	OC	0.305	4.211	
	(125.20)	20.00b	(5000)		(0.200)	(0.000)	(0.000)	
3	dr Claygate	20.00	20000	1.000	OC	0.396	2.915	4.000d
	(121.60)		(4000)		(0.200)	(1.482)	(4.700)	

Note: (a) and (b) are Bulk Densities above and below the water table

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	23.04	0.660	0.00	23.04	0.660	0.00
2	Sand & Gravel	28.35	0.660	0.00	28.35	0.660	0.00
3	dr Claygate	22.17	0.660	0.00	22.17	0.660	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	124.75	124.75

Automatic water pressure balancing at toe of wall : Yes

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	124.75	124.75	0.0	1	123.27	123.27	0.0
2	1	129.10	129.10	0.0	1	123.70	123.70	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 119.10
Maximum finite element length = 0.40 m
Youngs modulus of wall E = 2.5000E+07 kN/m2
Moment of inertia of wall I = 3.3500E-03 m4/m run
E.I = 83750 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	128.00	6.00	0.015000	2.000E+08	10.00	0.00	0	No
2	124.00	1.00	0.300000	2.000E+07	10.00	0.00	0	No
3	127.50	1.00	0.300000	2.000E+07	10.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	128.43	1.00(A)	20.00	1.00	20.00	=	N/A	N/A
2	129.10	0.30(A)	20.00	20.00	13.00	=	N/A	N/A
3	123.70	-0.00(P)	20.00	20.00	6.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 128.43
2	Change EI of wall to 83750 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
3	Apply surcharge no.2 at elevation 129.10 No analysis at this stage
4	Excavate to elevation 127.34 on PASSIVE side
5	Install strut or anchor no.1 at elevation 128.00
6	Apply water pressure profile no.1 No analysis at this stage
7	Excavate to elevation 123.27 on PASSIVE side
8	Install strut or anchor no.2 at elevation 124.00
9	Fill to elevation 123.70 on PASSIVE side with soil type 1
10	Apply surcharge no.3 at elevation 123.70 No analysis at this stage
11	Install strut or anchor no.3 at elevation 127.50
12	Remove strut or anchor no.1 at elevation 128.00
13	Apply water pressure profile no.2

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

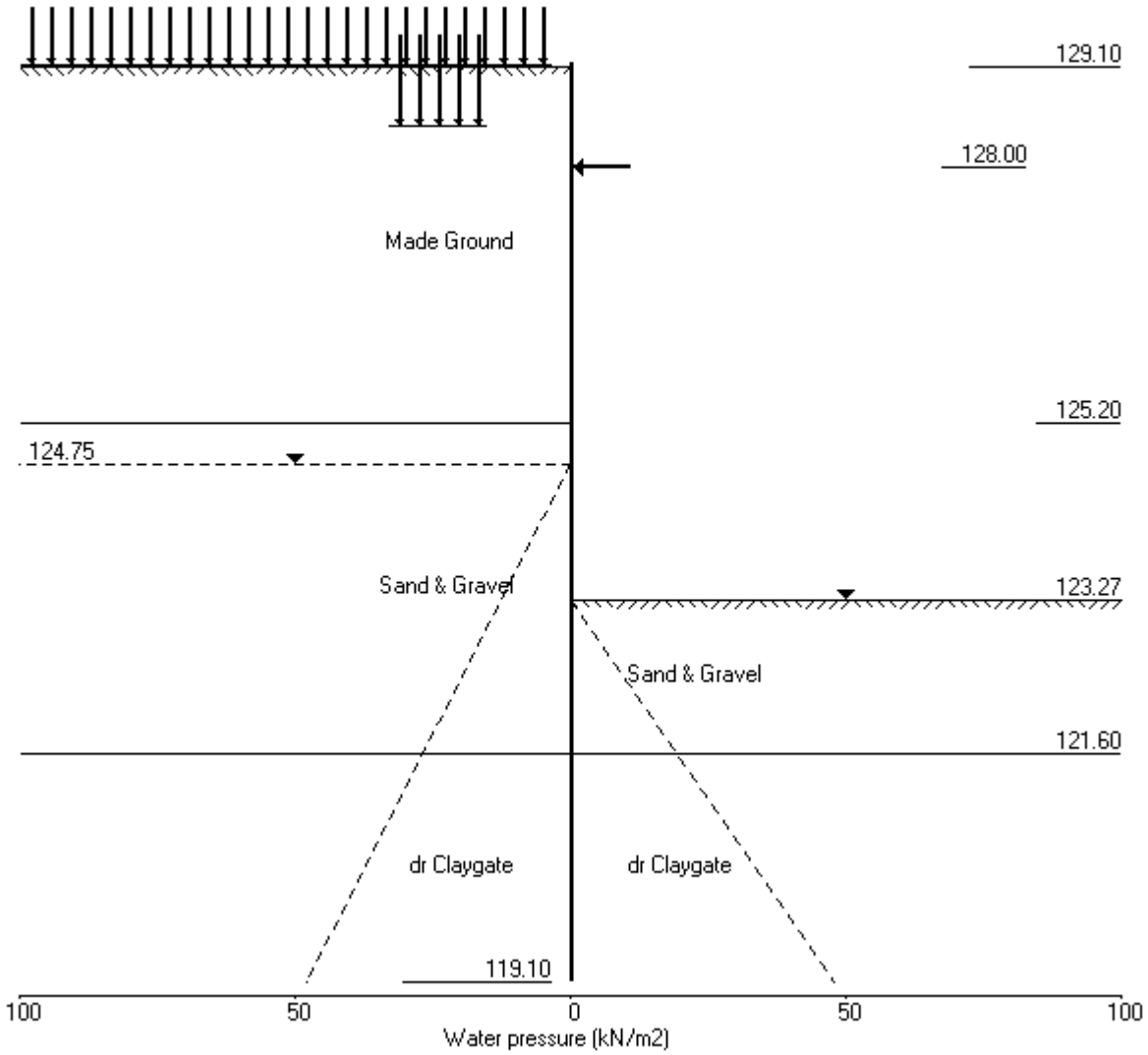
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 128.43	No	No	No
2	Change EI of wall to 83750kN.m2/m run	No	No	No
3	Apply surcharge no.2 at elev. 129.10	No	No	No
4	Excav. to elev. 127.34 on PASSIVE side	No	No	No
5	Install strut no.1 at elev. 128.00	No	No	No
6	Apply water pressure profile no.1	No	No	No
7	Excav. to elev. 123.27 on PASSIVE side	Yes	No	No
8	Install strut no.2 at elev. 124.00	No	No	No
9	Fill to elev. 123.70 on PASSIVE side	No	No	No
10	Apply surcharge no.3 at elev. 123.70	No	No	No
11	Install strut no.3 at elev. 127.50	No	No	No
12	Remove strut no.1 at elev. 128.00	No	No	No
13	Apply water pressure profile no.2	Yes	No	No

Units: kN,m

Stage No.7 Excav. to elev. 123.27 on PASSIVE side



Units: kN,m

Stage No. 7 Excavate to elevation 123.27 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 119.10 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
7	129.10	123.27	128.00	1.043	n/a	119.44	3.83

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

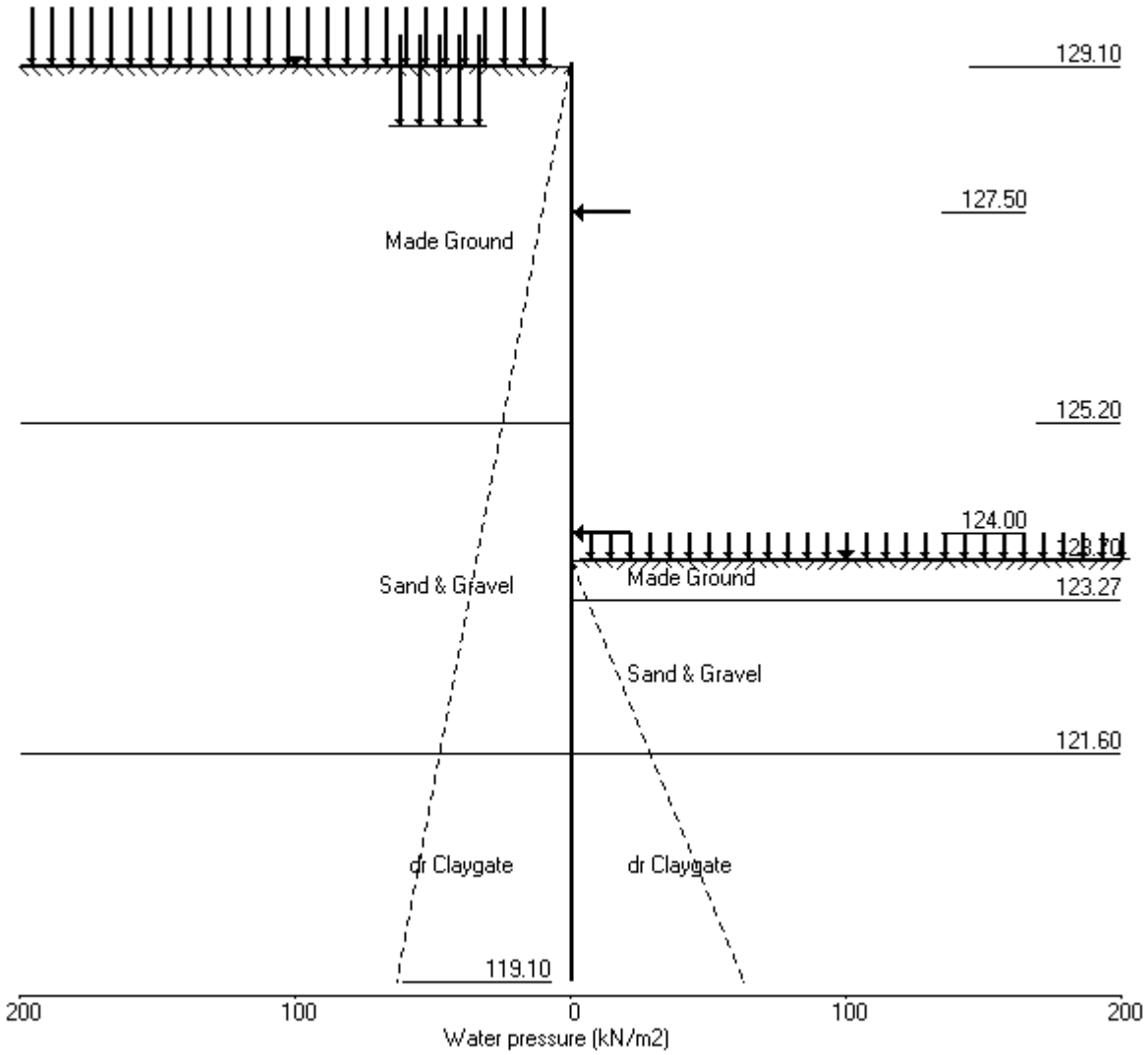
*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	129.10	0.00	-0.000	-7.14E-03	0.0	0.0	
2	128.77	28.19	0.002	-7.14E-03	4.7	0.5	
3	128.43	18.35	0.005	-7.15E-03	12.5	3.3	
4	128.22	9.42	0.006	-7.16E-03	15.5	6.4	
5	128.00	11.49	0.008	-7.18E-03	17.8	10.0	118.8
		11.49	0.008	-7.18E-03	-101.1	10.0	
6	127.75	13.93	0.010	-7.17E-03	-97.9	-14.9	
7	127.50	16.38	0.011	-7.09E-03	-94.1	-38.9	
8	127.34	17.90	0.013	-7.01E-03	-91.4	-53.7	
9	127.07	20.36	0.014	-6.80E-03	-86.2	-77.7	
10	126.80	22.67	0.016	-6.51E-03	-80.4	-100.2	
11	126.40	25.89	0.019	-5.96E-03	-70.7	-129.9	
12	126.00	28.93	0.021	-5.29E-03	-59.7	-156.1	
13	125.60	31.85	0.023	-4.49E-03	-47.5	-177.6	
14	125.20	34.72	0.025	-3.61E-03	-34.2	-194.1	
		27.70	0.025	-3.61E-03	-34.2	-194.1	
15	124.97	28.97	0.025	-3.08E-03	-27.9	-201.1	
16	124.75	30.23	0.026	-2.53E-03	-21.2	-206.6	
17	124.38	34.66	0.027	-1.60E-03	-9.0	-212.4	
18	124.00	39.08	0.027	-6.48E-04	4.8	-213.3	
19	123.70	42.61	0.027	1.09E-04	17.1	-210.1	
20	123.48	45.14	0.027	6.42E-04	26.5	-205.4	
21	123.27	47.67	0.027	1.16E-03	36.5	-198.7	
22	123.04	39.32	0.027	1.70E-03	46.7	-188.9	
23	122.80	30.98	0.026	2.21E-03	54.9	-176.9	
24	122.40	16.76	0.025	3.00E-03	64.5	-152.8	
25	122.00	2.52	0.024	3.67E-03	68.3	-126.1	
26	121.60	-11.74	0.022	4.21E-03	66.5	-98.9	
		-5.89	0.022	4.21E-03	66.5	-98.9	
27	121.20	-15.37	0.020	4.62E-03	62.2	-73.0	
28	120.80	-24.88	0.018	4.91E-03	54.2	-49.6	
29	120.40	-30.62	0.016	5.10E-03	43.1	-28.1	
30	120.00	-32.96	0.014	5.20E-03	30.4	-13.5	
31	119.60	-34.03	0.012	5.24E-03	17.0	-4.1	
32	119.35	-34.09	0.011	5.25E-03	8.5	-1.0	
33	119.10	-33.69	0.010	5.25E-03	0.0	-0.0	

At elev. 128.00 Strut force = 712.9 kN/strut = 118.8 kN/m run

Units: kN,m

Stage No.13 Apply water pressure profile no.2



Units: kN,m

Stage No. 13 Apply water pressure profile no.2

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 119.10 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
13	129.10	123.70		More than one strut			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	129.10	0.00	0.001	-6.37E-03	0.0	0.0	
2	128.77	24.87	0.004	-6.37E-03	4.2	0.6	
3	128.43	17.59	0.006	-6.37E-03	11.3	3.0	
4	128.22	15.17	0.007	-6.39E-03	14.8	5.9	
5	128.00	17.91	0.008	-6.41E-03	18.4	9.4	
6	127.75	21.01	0.010	-6.44E-03	23.2	14.6	
7	127.50	24.24	0.012	-6.50E-03	28.9	21.1	162.5
		24.24	0.012	-6.50E-03	-133.6	21.1	
8	127.34	26.41	0.013	-6.52E-03	-129.6	0.0	
9	127.07	30.46	0.014	-6.46E-03	-121.9	-33.9	
10	126.80	34.47	0.016	-6.31E-03	-113.1	-65.7	
11	126.40	40.07	0.019	-5.90E-03	-98.2	-107.5	
12	126.00	45.34	0.021	-5.30E-03	-81.1	-143.5	
13	125.60	50.39	0.023	-4.55E-03	-62.0	-172.3	
14	125.20	55.26	0.025	-3.68E-03	-40.8	-192.9	
		48.21	0.025	-3.68E-03	-40.8	-192.9	
15	124.97	50.60	0.025	-3.15E-03	-29.7	-200.9	
16	124.75	52.96	0.026	-2.61E-03	-18.1	-206.3	
17	124.38	56.67	0.027	-1.68E-03	2.5	-209.3	
18	124.00	60.29	0.027	-7.58E-04	24.4	-204.4	40.2
		60.29	0.027	-7.58E-04	-15.8	-204.4	
19	123.70	63.10	0.027	-2.36E-05	2.7	-206.4	
		56.36	0.027	-2.36E-05	2.7	-206.4	
20	123.48	54.39	0.027	5.03E-04	14.6	-204.6	
21	123.27	52.40	0.027	1.02E-03	26.1	-200.2	
		53.27	0.027	1.02E-03	26.1	-200.2	
22	123.04	50.98	0.027	1.57E-03	38.3	-192.7	
23	122.80	41.09	0.026	2.10E-03	49.1	-182.3	
24	122.40	24.27	0.025	2.91E-03	62.2	-159.8	
25	122.00	7.73	0.024	3.62E-03	68.6	-133.5	
26	121.60	-8.48	0.022	4.19E-03	68.5	-105.9	
		-1.75	0.022	4.19E-03	68.5	-105.9	

(continued)

Stage No.13 Apply water pressure profile no.2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
27	121.20	-12.97	0.021	4.63E-03	65.5	-78.9	
28	120.80	-24.12	0.019	4.95E-03	58.1	-54.0	
29	120.40	-31.48	0.017	5.15E-03	47.0	-30.9	
30	120.00	-35.73	0.015	5.26E-03	33.5	-14.9	
31	119.60	-38.10	0.013	5.31E-03	18.8	-4.6	
32	119.35	-37.65	0.011	5.32E-03	9.3	-1.1	
33	119.10	-36.75	0.010	5.32E-03	0.0	-0.0	

At elev. 127.50 Strut force = 162.5 kN/strut = 162.5 kN/m run
At elev. 124.00 Strut force = 40.2 kN/strut = 40.2 kN/m run

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	129.10	1 Made Ground	1 Made Ground
2	125.20	2 Sand & Gravel	2 Sand & Gravel
3	121.60	3 dr Claygate	3 dr Claygate

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made Ground	19.00a	5000	0.550	OC	0.313	3.868	0.0d
	(129.10)	20.00b	(4000)		(0.200)	(1.293)	(5.395)	
2	Sand & Gr..	19.00a	20000	0.500	OC	0.243	5.675	
	(125.20)	20.00b	(5000)		(0.200)	(0.000)	(0.000)	
3	dr Claygate	20.00	20000	1.000	OC	0.326	3.647	5.000d
	(121.60)		(4000)		(0.200)	(1.322)	(5.195)	

Note: (a) and (b) are Bulk Densities above and below the water table

Additional soil parameters associated with Ka and Kp

Soil type No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	28.00	0.600	0.00	28.00	0.500	0.00
2	Sand & Gravel	34.00	0.540	0.00	34.00	0.500	0.00
3	dr Claygate	27.00	0.600	0.00	27.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	123.75	123.75

Automatic water pressure balancing at toe of wall : Yes

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	123.75	123.75	0.0	1	123.70	123.70	0.0
2	1	124.75	124.75	0.0	1	123.70	123.70	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 119.10
Maximum finite element length = 0.40 m
Youngs modulus of wall E = 2.5000E+07 kN/m2
Moment of inertia of wall I = 3.3500E-03 m4/m run
E.I = 83750 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	128.00	6.00	0.015000	2.000E+08	10.00	0.00	0	No
2	124.00	1.00	0.300000	2.000E+07	10.00	0.00	0	No
3	127.50	1.00	0.300000	2.000E+07	10.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	128.43	1.00(A)	20.00	1.00	20.00	=	N/A	N/A
2	129.10	0.30(A)	20.00	20.00	10.00	=	N/A	N/A
3	123.70	-0.00(P)	20.00	20.00	6.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 128.43
2	Change EI of wall to 83750 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
3	Apply surcharge no.2 at elevation 129.10 No analysis at this stage
4	Excavate to elevation 127.50 on PASSIVE side
5	Install strut or anchor no.1 at elevation 128.00
6	Apply water pressure profile no.1 No analysis at this stage
7	Excavate to elevation 123.70 on PASSIVE side
8	Install strut or anchor no.2 at elevation 124.00
9	Apply surcharge no.3 at elevation 123.70 No analysis at this stage
10	Install strut or anchor no.3 at elevation 127.50
11	Remove strut or anchor no.1 at elevation 128.00
12	Apply water pressure profile no.2

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Burland-Potts
Factor on passive for calculating wall depth = 1.80

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

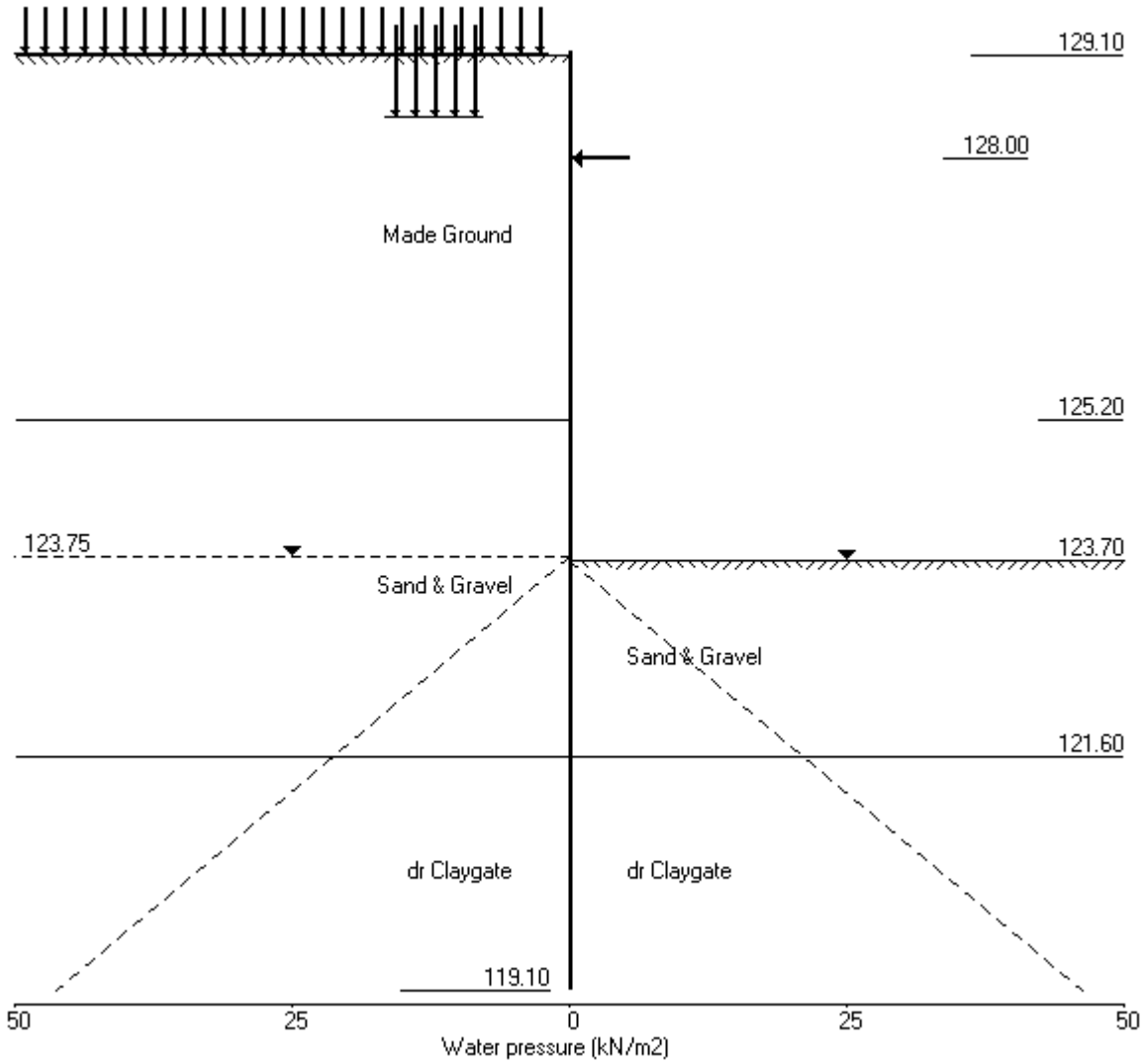
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 128.43	No	No	No
2	Change EI of wall to 83750kN.m2/m run	No	No	No
3	Apply surcharge no.2 at elev. 129.10	No	No	No
4	Excav. to elev. 127.50 on PASSIVE side	No	No	No
5	Install strut no.1 at elev. 128.00	No	No	No
6	Apply water pressure profile no.1	No	No	No
7	Excav. to elev. 123.70 on PASSIVE side	Yes	No	No
8	Install strut no.2 at elev. 124.00	No	No	No
9	Apply surcharge no.3 at elev. 123.70	No	No	No
10	Install strut no.3 at elev. 127.50	No	No	No
11	Remove strut no.1 at elev. 128.00	No	No	No
12	Apply water pressure profile no.2	Yes	No	No

Units: kN,m

Stage No.7 Excav. to elev. 123.70 on PASSIVE side



Units: kN,m

Stage No. 7 Excavate to elevation 123.70 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Burland-Potts method

Factor of safety on nett available passive

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 119.10 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.800 Toe elev.	Wall Penetr -ation
7	129.10	123.70	128.00	2.776	n/a	120.75	2.95

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

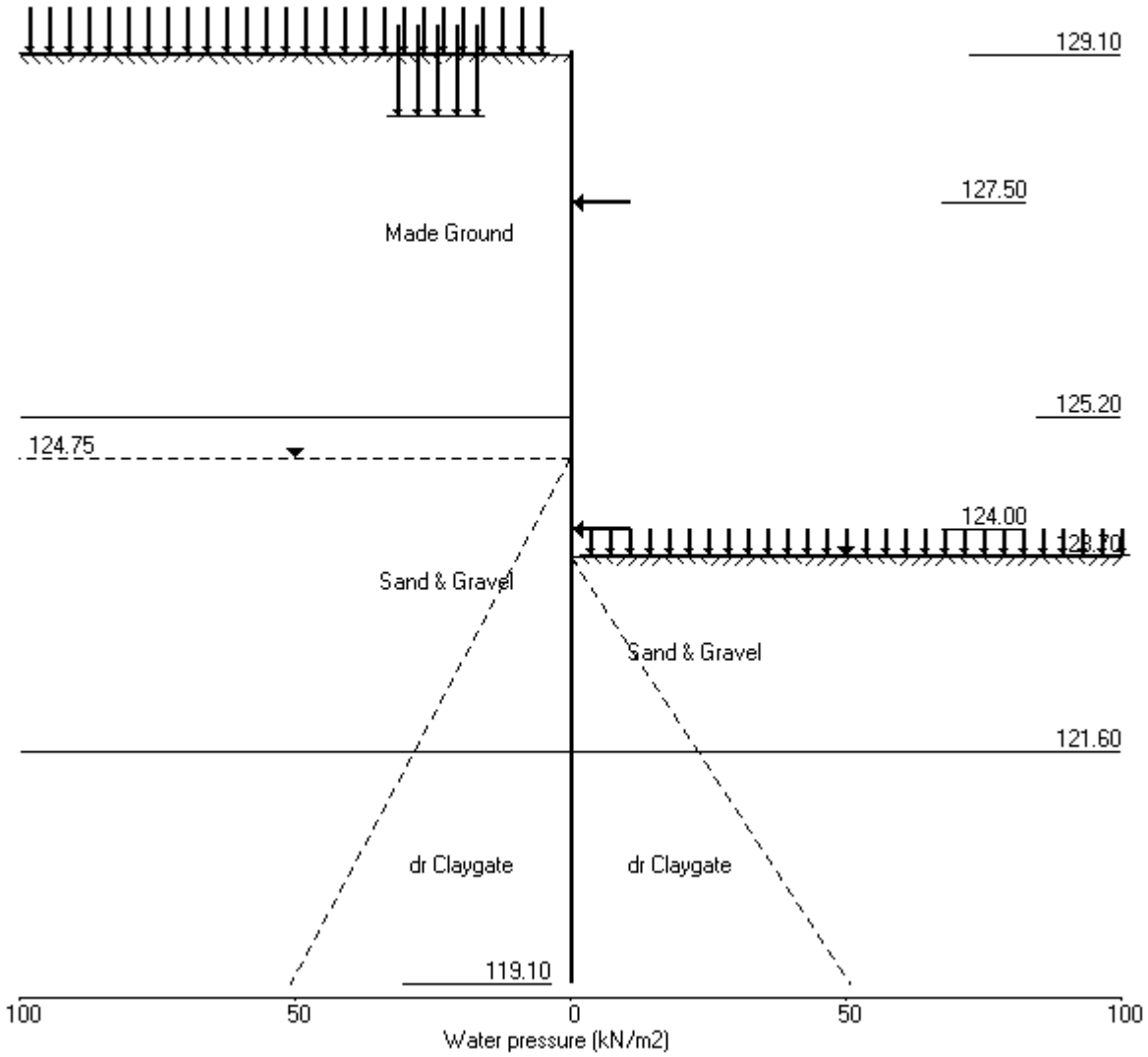
*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	129.10	0.00	0.002	-1.70E-03	0.0	-0.0	
2	128.77	8.97	0.003	-1.70E-03	1.5	0.1	
3	128.43	5.52	0.003	-1.71E-03	3.9	1.1	
4	128.22	7.15	0.004	-1.71E-03	5.3	2.1	
5	128.00	8.77	0.004	-1.72E-03	7.0	3.4	58.0
		8.77	0.004	-1.72E-03	-51.0	3.4	
6	127.75	10.72	0.004	-1.71E-03	-48.6	-9.0	
7	127.50	12.68	0.005	-1.67E-03	-45.7	-20.8	
8	127.15	15.32	0.005	-1.55E-03	-40.8	-35.8	
9	126.80	17.77	0.006	-1.38E-03	-35.0	-48.9	
10	126.40	20.38	0.006	-1.12E-03	-27.4	-61.4	
11	126.00	22.85	0.007	-8.09E-04	-18.7	-70.7	
12	125.60	25.24	0.007	-4.62E-04	-9.1	-76.3	
13	125.20	27.57	0.007	-9.72E-05	1.5	-77.9	
		21.46	0.007	-9.72E-05	1.5	-77.9	
14	124.97	22.48	0.007	1.09E-04	6.4	-77.0	
15	124.75	23.48	0.007	3.12E-04	11.6	-75.0	
16	124.38	25.16	0.007	6.32E-04	20.7	-69.0	
17	124.00	26.83	0.007	9.19E-04	30.4	-59.5	
18	123.75	27.94	0.006	1.08E-03	37.3	-51.0	
19	123.70	28.55	0.006	1.11E-03	38.7	-49.1	
20	123.45	14.98	0.006	1.24E-03	44.1	-38.7	
21	123.20	1.40	0.006	1.34E-03	46.2	-27.3	
22	122.80	-20.33	0.005	1.43E-03	42.4	-9.3	
23	122.40	-42.09	0.005	1.44E-03	29.9	5.5	
24	122.00	-50.46	0.004	1.39E-03	11.4	15.0	
25	121.60	-45.11	0.004	1.32E-03	-7.7	16.2	
		8.69	0.004	1.32E-03	-7.7	16.2	
26	121.20	-1.09	0.003	1.24E-03	-6.2	13.5	
27	120.80	-4.52	0.003	1.19E-03	-7.3	11.3	
28	120.40	-0.93	0.002	1.14E-03	-8.4	8.0	
29	120.00	3.22	0.002	1.11E-03	-7.9	4.6	
30	119.60	7.99	0.001	1.10E-03	-5.7	1.6	
31	119.35	11.31	0.001	1.09E-03	-3.3	0.5	
32	119.10	14.91	0.001	1.09E-03	0.0	0.0	

At elev. 128.00 Strut force = 348.2 kN/strut = 58.0 kN/m run

Units: kN,m

Stage No.12 Apply water pressure profile no.2



Units: kN,m

Stage No. 12 Apply water pressure profile no.2

STABILITY ANALYSIS of Fully Embedded Wall according to Burland-Potts method

Factor of safety on nett available passive

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 119.10 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.800 Toe elev.	Wall Penetr -ation
12	129.10	123.70		More than one strut			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	129.10	0.00	0.003	-1.23E-03	0.0	-0.0	
2	128.77	6.40	0.003	-1.23E-03	1.1	0.1	
3	128.43	5.94	0.004	-1.23E-03	3.1	0.8	
4	128.22	7.50	0.004	-1.23E-03	4.6	1.7	
5	128.00	9.04	0.004	-1.24E-03	6.4	2.8	
6	127.75	10.86	0.005	-1.25E-03	8.8	4.7	
7	127.50	12.68	0.005	-1.27E-03	11.8	7.3	66.8
		12.68	0.005	-1.27E-03	-55.0	7.3	
8	127.15	15.38	0.005	-1.27E-03	-50.1	-10.9	
9	126.80	18.15	0.006	-1.19E-03	-44.3	-27.3	
10	126.40	21.05	0.006	-1.02E-03	-36.4	-43.5	
11	126.00	23.72	0.007	-7.92E-04	-27.5	-56.4	
12	125.60	26.20	0.007	-5.05E-04	-17.5	-65.4	
13	125.20	28.52	0.007	-1.84E-04	-6.5	-70.3	
		22.38	0.007	-1.84E-04	-6.5	-70.3	
14	124.97	23.36	0.007	3.93E-06	-1.4	-71.2	
15	124.75	24.29	0.007	1.93E-04	4.0	-70.9	
16	124.38	28.41	0.007	5.01E-04	13.8	-67.6	
17	124.00	32.46	0.007	7.87E-04	25.3	-60.4	2.4
		32.46	0.007	7.87E-04	22.9	-60.4	
18	123.75	35.14	0.007	9.56E-04	31.3	-53.6	
19	123.70	35.67	0.006	9.88E-04	33.1	-52.0	
		32.21	0.006	9.88E-04	33.1	-52.0	
20	123.45	21.08	0.006	1.13E-03	39.7	-42.9	
21	123.20	6.80	0.006	1.24E-03	43.2	-32.5	
22	122.80	-16.04	0.005	1.35E-03	41.4	-15.2	
23	122.40	-38.86	0.005	1.39E-03	30.4	-0.5	
24	122.00	-48.22	0.004	1.37E-03	13.0	9.4	
25	121.60	-44.81	0.004	1.32E-03	-5.6	11.5	
		9.98	0.004	1.32E-03	-5.6	11.5	
26	121.20	-0.53	0.003	1.27E-03	-3.7	9.7	

(continued)

Stage No.12 Apply water pressure profile no.2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
27	120.80	-4.63	0.003	1.23E-03	-4.8	8.5	
28	120.40	-1.70	0.002	1.19E-03	-6.0	6.2	
29	120.00	1.78	0.002	1.17E-03	-6.0	3.6	
30	119.60	5.93	0.001	1.16E-03	-4.5	1.3	
31	119.35	8.88	0.001	1.16E-03	-2.6	0.4	
32	119.10	12.11	0.001	1.16E-03	0.0	0.0	

At elev. 127.50 Strut force = 66.8 kN/strut = 66.8 kN/m run
At elev. 124.00 Strut force = 2.4 kN/strut = 2.4 kN/m run

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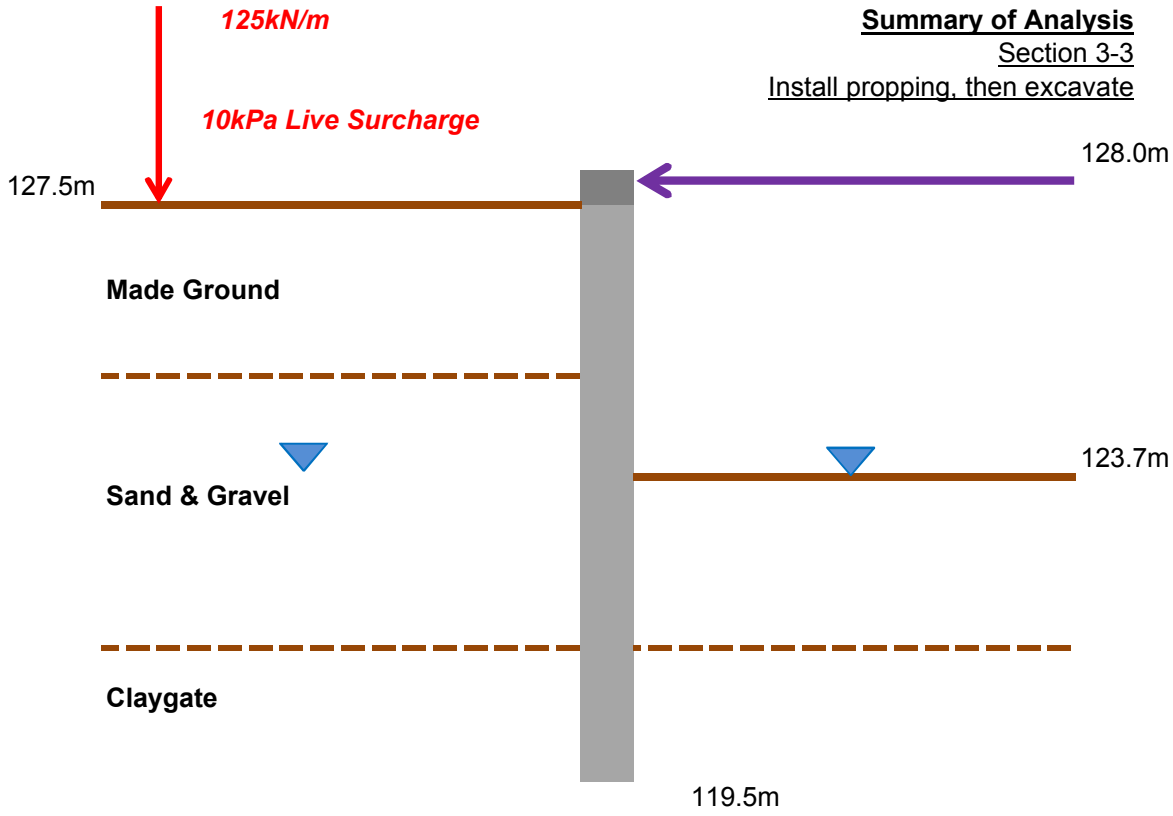
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Bored Pile Retaining Walls
mrf	07/07/15	njb	07/07/15	RE1366 des 001	37 of 61	

Reference

Summary of Analysis
Section 3-3
Install propping, then excavate

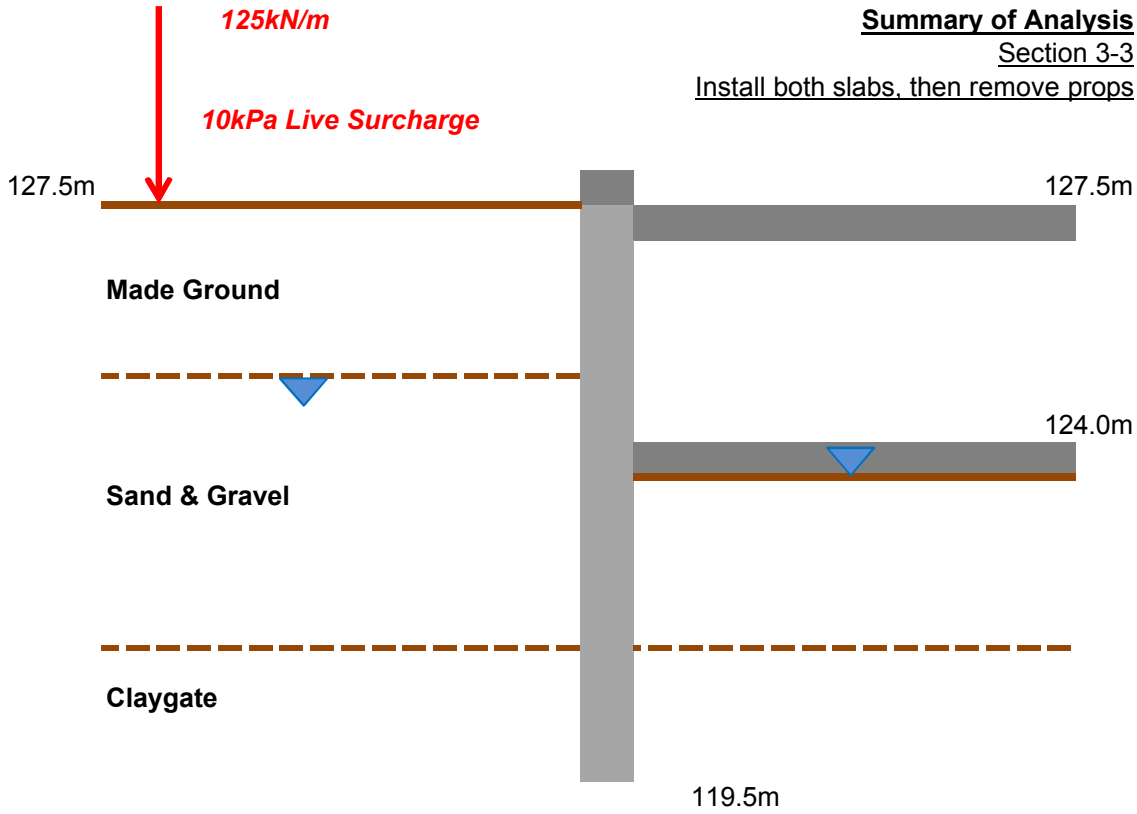


Excavation Level	123.7m	OD planned
	123.32m	OD with accidental overdig
Retained Level	127.5m	OD
Top of Pile Level	127.5m	OD
Toe Level	119.5m	OD
Wall Depth	8.0	m
Factor of safety	1.14	> 1.0 for factored strengths with overdig (ULS)
	3.59	Burland & Potts (SLS)
Maximum Moment	129	kNm (ULS)
	44	kNm (SLS)
Waling Load	49	kN/m (ULS)
	21	kN/m (SLS)
Deflection	3	mm

R&E Geotechnical Consultants Ltd						Grove Lodge, London NW3
Orig. by	Date	Verif. By	Date	Ref. No.	Sheet No.	Bored Pile Retaining Walls
mrf	07/07/15	njb	07/07/15	RE1366 des 001	38 of 61	

Reference

Summary of Analysis
Section 3-3
Install both slabs, then remove props



Retained Level	127.5m	OD
Top of Pile Level	127.5m	OD
Toe Level	119.5m	OD
Wall Depth	8.0	m
Factor of safety	n/a for multi-propped walls	
Maximum Moment	127	kNm (ULS)
	41	kNm (SLS)
Base Slab Load	30	kN/m (ULS)
	6	kN/m (SLS)
Ground Slab Load	65	kN/m (ULS)
	25	kN/m (SLS)
Deflection	3	mm

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	127.50	1 Made Ground	1 Made Ground
2	125.20	2 Sand & Gravel	2 Sand & Gravel
3	121.60	3 dr Claygate	3 dr Claygate

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made Ground	19.00a	5000	0.550	OC	0.382	3.062	0.0d
	(127.50)	20.00b	(4000)		(0.200)	(1.453)	(4.848)	
2	Sand & Gr..	19.00a	20000	0.500	OC	0.305	4.211	
	(125.20)	20.00b	(5000)		(0.200)	(0.000)	(0.000)	
3	dr Claygate	20.00	20000	1.000	OC	0.396	2.915	4.000d
	(121.60)		(4000)		(0.200)	(1.482)	(4.700)	

Note: (a) and (b) are Bulk Densities above and below the water table

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	23.04	0.660	0.00	23.04	0.660	0.00
2	Sand & Gravel	28.35	0.660	0.00	28.35	0.660	0.00
3	dr Claygate	22.17	0.660	0.00	22.17	0.660	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	124.75	124.75

Automatic water pressure balancing at toe of wall : Yes

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	124.75	124.75	0.0	1	123.32	123.32	0.0
2	1	127.50	127.50	0.0	1	123.70	123.70	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 119.50
Maximum finite element length = 0.50 m
Youngs modulus of wall E = 2.5000E+07 kN/m2
Moment of inertia of wall I = 3.3500E-03 m4/m run
E.I = 83750 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	128.00	6.00	0.015000	2.000E+08	10.00	0.00	0	No
2	124.00	1.00	0.300000	2.000E+07	10.00	0.00	0	No
3	127.50	1.00	0.300000	2.000E+07	10.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	127.50	6.00(A)	20.00	1.00	125.00	=	N/A	N/A
2	127.50	0.30(A)	20.00	20.00	13.00	=	N/A	N/A
3	123.70	-0.00(P)	20.00	20.00	6.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 127.50
2	Change EI of wall to 83750 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
3	Apply surcharge no.2 at elevation 127.50 No analysis at this stage
4	Install strut or anchor no.1 at elevation 128.00
5	Apply water pressure profile no.1 No analysis at this stage
6	Excavate to elevation 123.32 on PASSIVE side
7	Fill to elevation 123.70 on PASSIVE side with soil type 1
8	Install strut or anchor no.2 at elevation 124.00
9	Apply surcharge no.3 at elevation 123.70 No analysis at this stage
10	Install strut or anchor no.3 at elevation 127.50
11	Remove strut or anchor no.1 at elevation 128.00
12	Apply water pressure profile no.2

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Strength Factor method
Factor on soil strength for calculating wall depth = 1.00

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 8.000 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

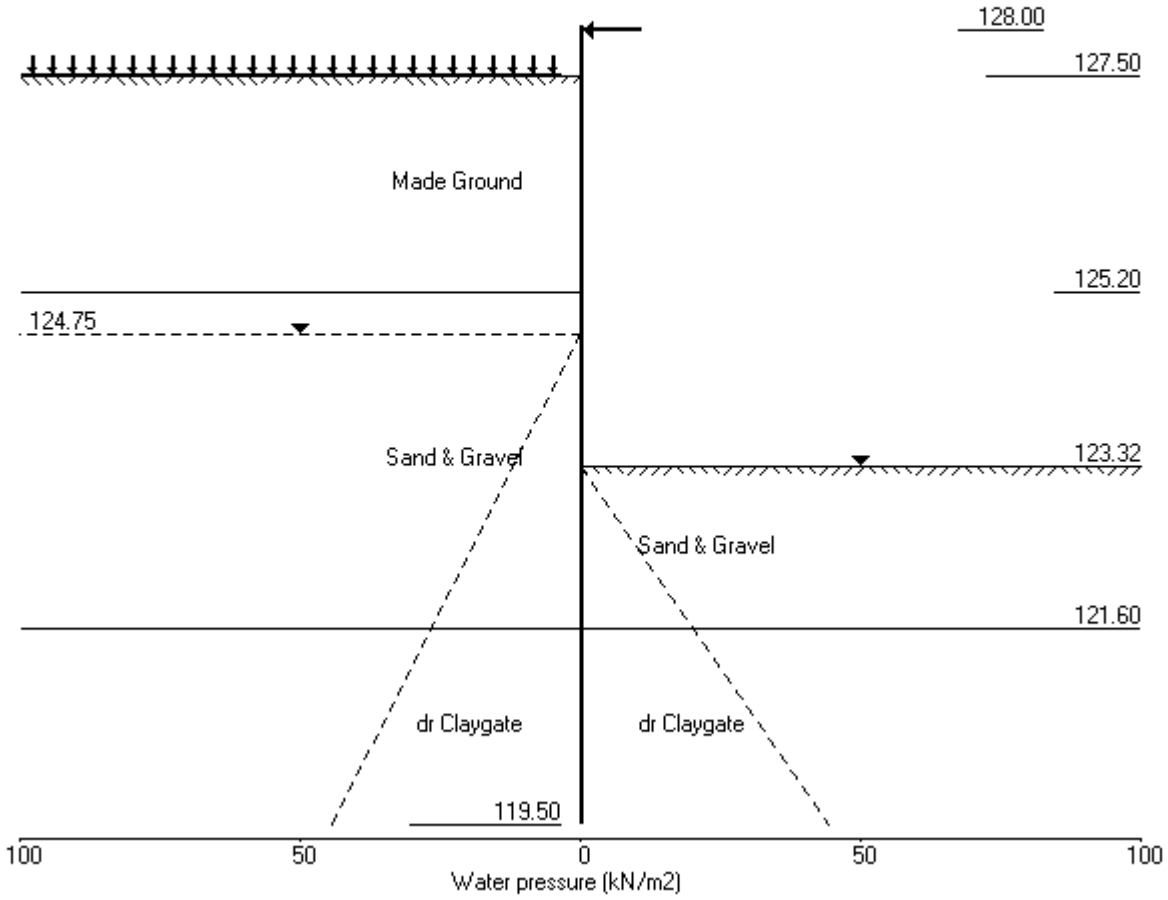
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 127.50	No	No	No
2	Change EI of wall to 83750kN.m2/m run	No	No	No
3	Apply surcharge no.2 at elev. 127.50	No	No	No
4	Install strut no.1 at elev. 128.00	No	No	No
5	Apply water pressure profile no.1	No	No	No
6	Excav. to elev. 123.32 on PASSIVE side	Yes	No	No
7	Fill to elev. 123.70 on PASSIVE side	No	No	No
8	Install strut no.2 at elev. 124.00	No	No	No
9	Apply surcharge no.3 at elev. 123.70	No	No	No
10	Install strut no.3 at elev. 127.50	No	No	No
11	Remove strut no.1 at elev. 128.00	No	No	No
12	Apply water pressure profile no.2	Yes	No	No

Units: kN,m

Stage No.6 Excav. to elev. 123.32 on PASSIVE side



Units: kN,m

Stage No. 6 Excavate to elevation 123.32 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 119.50 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
6	127.50	123.32	128.00	1.136	n/a	120.35	2.97

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

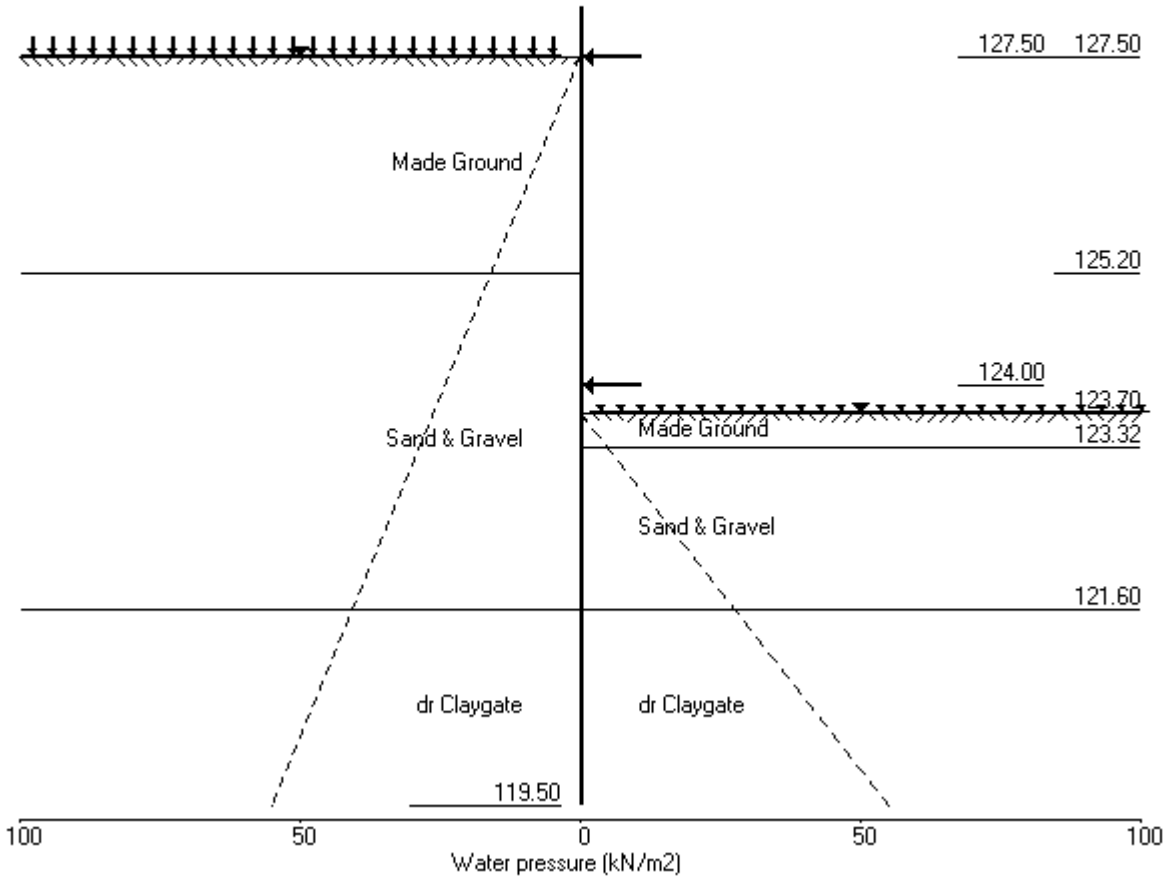
*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	128.00	0.00	0.001	-4.27E-03	-48.9	0.0	48.9
2	127.50	0.00	0.004	-4.19E-03	-48.9	-24.4	
3	127.00	5.50	0.006	-3.98E-03	-47.5	-48.6	
4	126.50	10.46	0.008	-3.62E-03	-43.5	-71.4	
5	126.00	14.72	0.009	-3.13E-03	-37.2	-91.7	
6	125.60	17.96	0.010	-2.66E-03	-30.7	-105.3	
7	125.20	21.14	0.011	-2.13E-03	-22.9	-116.1	
		16.87	0.011	-2.13E-03	-22.9	-116.1	
8	124.75	19.71	0.012	-1.48E-03	-14.6	-124.6	
9	124.38	24.37	0.013	-9.22E-04	-6.4	-128.6	
10	124.00	29.03	0.013	-3.45E-04	3.6	-129.1	
11	123.70	32.76	0.013	1.13E-04	12.9	-126.7	
12	123.32	37.46	0.013	6.71E-04	26.2	-119.3	
13	122.91	23.23	0.012	1.22E-03	38.7	-105.8	
14	122.50	8.98	0.012	1.69E-03	45.3	-88.3	
15	122.05	-6.70	0.011	2.11E-03	45.8	-67.6	
16	121.60	-22.43	0.010	2.42E-03	39.3	-48.1	
		-6.58	0.010	2.42E-03	39.3	-48.1	
17	121.30	-10.98	0.009	2.58E-03	36.6	-36.7	
18	121.00	-14.85	0.008	2.69E-03	32.7	-26.3	
19	120.50	-20.19	0.007	2.80E-03	24.0	-12.2	
20	120.00	-24.28	0.006	2.85E-03	12.9	-3.0	
21	119.50	-27.21	0.004	2.86E-03	0.0	-0.0	

At elev. 128.00 Strut force = 293.3 kN/strut = 48.9 kN/m run

Units: kN,m

Stage No.12 Apply water pressure profile no.2



Units: kN,m

Stage No. 12 Apply water pressure profile no.2

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 119.50 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
12	127.50	123.70		More than one strut			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	128.00	0.00	0.002	-3.96E-03	0.0	0.0	
2	127.50	0.00	0.004	-3.96E-03	0.0	-0.0	65.2
		0.00	0.004	-3.96E-03	-65.2	0.0	
3	127.00	8.24	0.006	-3.87E-03	-63.1	-32.2	
4	126.50	16.06	0.008	-3.58E-03	-57.0	-62.4	
5	126.00	23.14	0.009	-3.13E-03	-47.2	-88.6	
6	125.60	28.62	0.010	-2.67E-03	-36.9	-105.5	
7	125.20	34.02	0.011	-2.13E-03	-24.4	-117.8	
		29.92	0.011	-2.13E-03	-24.4	-117.8	
8	124.75	35.26	0.012	-1.48E-03	-9.7	-125.6	
9	124.38	39.53	0.013	-9.20E-04	4.3	-126.6	
10	124.00	43.77	0.013	-3.63E-04	19.9	-122.1	29.8
		43.77	0.013	-3.63E-04	-9.9	-122.1	
11	123.70	47.11	0.013	7.63E-05	3.8	-123.1	
		43.02	0.013	7.63E-05	3.8	-123.1	
12	123.32	40.47	0.013	6.25E-04	19.6	-118.6	
		40.82	0.013	6.25E-04	19.6	-118.6	
13	122.91	29.84	0.012	1.17E-03	34.1	-107.5	
14	122.50	14.14	0.012	1.66E-03	43.1	-91.4	
15	122.05	-3.06	0.011	2.10E-03	45.6	-71.1	
16	121.60	-20.16	0.010	2.43E-03	40.4	-51.5	
		-4.37	0.010	2.43E-03	40.4	-51.5	
17	121.30	-9.53	0.009	2.59E-03	38.3	-39.6	
18	121.00	-14.13	0.008	2.71E-03	34.8	-28.7	
19	120.50	-20.76	0.007	2.84E-03	26.0	-13.4	
20	120.00	-26.32	0.006	2.89E-03	14.3	-3.4	
21	119.50	-30.73	0.004	2.90E-03	0.0	-0.0	

At elev. 127.50 Strut force = 65.2 kN/strut = 65.2 kN/m run
At elev. 124.00 Strut force = 29.8 kN/strut = 29.8 kN/m run

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	127.50	1 Made Ground	1 Made Ground
2	125.20	2 Sand & Gravel	2 Sand & Gravel
3	121.60	3 dr Claygate	3 dr Claygate

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made Ground	19.00a	5000	0.550	OC	0.313	3.868	0.0d
	(127.50)	20.00b	(4000)		(0.200)	(1.293)	(5.395)	
2	Sand & Gr..	19.00a	20000	0.500	OC	0.243	5.675	
	(125.20)	20.00b	(5000)		(0.200)	(0.000)	(0.000)	
3	dr Claygate	20.00	20000	1.000	OC	0.326	3.647	5.000d
	(121.60)		(4000)		(0.200)	(1.322)	(5.195)	

Note: (a) and (b) are Bulk Densities above and below the water table

Additional soil parameters associated with Ka and Kp

Soil type No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	28.00	0.600	0.00	28.00	0.500	0.00
2	Sand & Gravel	34.00	0.540	0.00	34.00	0.500	0.00
3	dr Claygate	27.00	0.600	0.00	27.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	123.75	123.75

Automatic water pressure balancing at toe of wall : Yes

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	123.75	123.75	0.0	1	123.70	123.70	0.0
2	1	124.75	124.75	0.0	1	123.70	123.70	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 119.50
Maximum finite element length = 0.50 m
Youngs modulus of wall E = 2.5000E+07 kN/m2
Moment of inertia of wall I = 3.3500E-03 m4/m run
E.I = 83750 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	128.00	6.00	0.015000	2.000E+08	10.00	0.00	0	No
2	124.00	1.00	0.300000	2.000E+07	10.00	0.00	0	No
3	127.50	1.00	0.300000	2.000E+07	10.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	127.50	6.00(A)	20.00	1.00	125.00	=	N/A	N/A
2	127.50	0.30(A)	20.00	20.00	10.00	=	N/A	N/A
3	123.70	-0.00(P)	20.00	20.00	6.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 127.50
2	Change EI of wall to 83750 kN.m2/m run Yield moment not defined Reset wall displacements to zero at this stage
3	Apply surcharge no.2 at elevation 127.50 No analysis at this stage
4	Install strut or anchor no.1 at elevation 128.00
5	Apply water pressure profile no.1 No analysis at this stage
6	Excavate to elevation 123.70 on PASSIVE side
7	Install strut or anchor no.2 at elevation 124.00
8	Apply surcharge no.3 at elevation 123.70 No analysis at this stage
9	Install strut or anchor no.3 at elevation 127.50
10	Remove strut or anchor no.1 at elevation 128.00
11	Apply water pressure profile no.2

FACTORS OF SAFETY and ANALYSIS OPTIONS

Stability analysis:
Method of analysis - Burland-Potts
Factor on passive for calculating wall depth = 1.80

Parameters for undrained strata:
Minimum equivalent fluid density = 5.00 kN/m3
Maximum depth of water filled tension crack = 0.00 m

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 8.000 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

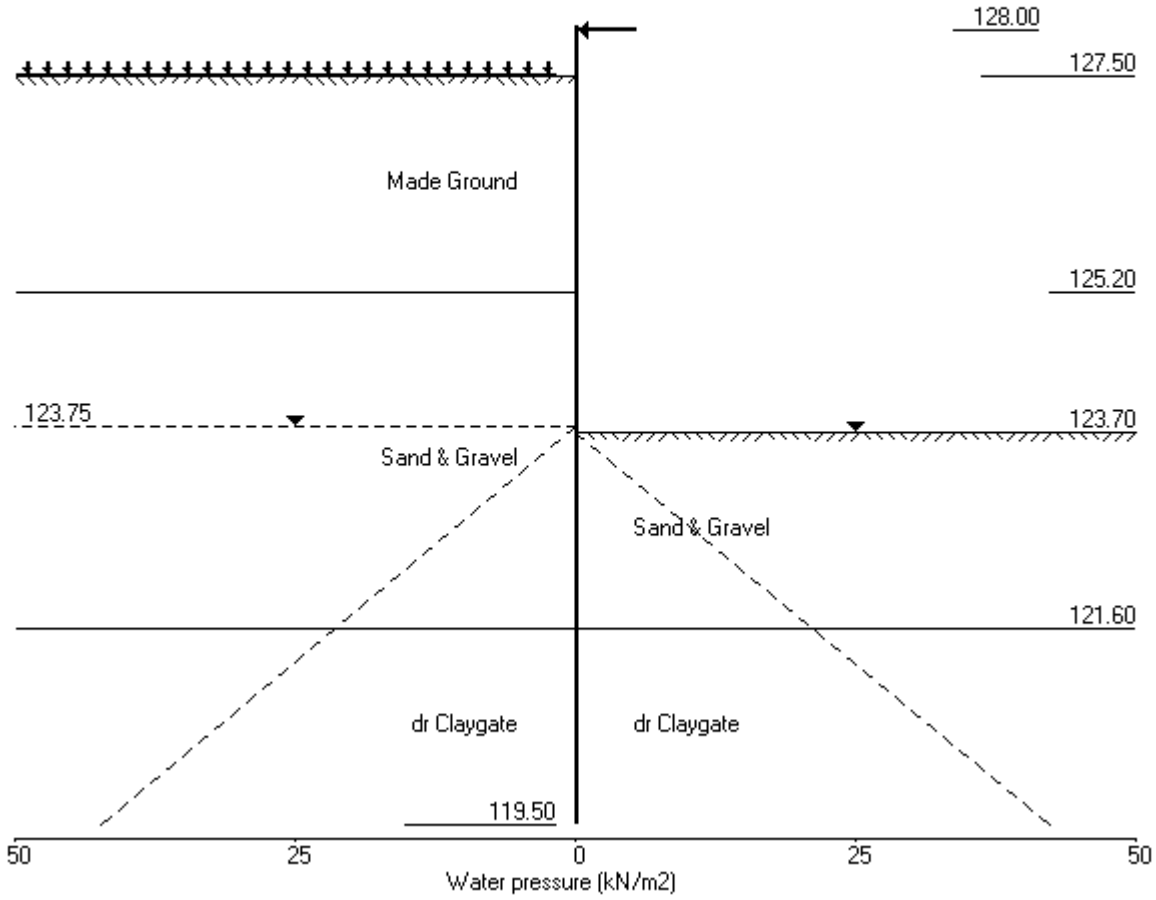
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 127.50	No	No	No
2	Change EI of wall to 83750kN.m2/m run	No	No	No
3	Apply surcharge no.2 at elev. 127.50	No	No	No
4	Install strut no.1 at elev. 128.00	No	No	No
5	Apply water pressure profile no.1	No	No	No
6	Excav. to elev. 123.70 on PASSIVE side	Yes	No	No
7	Install strut no.2 at elev. 124.00	No	No	No
8	Apply surcharge no.3 at elev. 123.70	No	No	No
9	Install strut no.3 at elev. 127.50	No	No	No
10	Remove strut no.1 at elev. 128.00	No	No	No
11	Apply water pressure profile no.2	Yes	No	No

Units: kN,m

Stage No.6 Excav. to elev. 123.70 on PASSIVE side



Units: kN,m

Stage No. 6 Excavate to elevation 123.70 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Burland-Potts method

Factor of safety on nett available passive

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 119.50 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.800 Toe elev.	Wall Penetr -ation
6	127.50	123.70	128.00	3.591	n/a	121.65	2.05

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

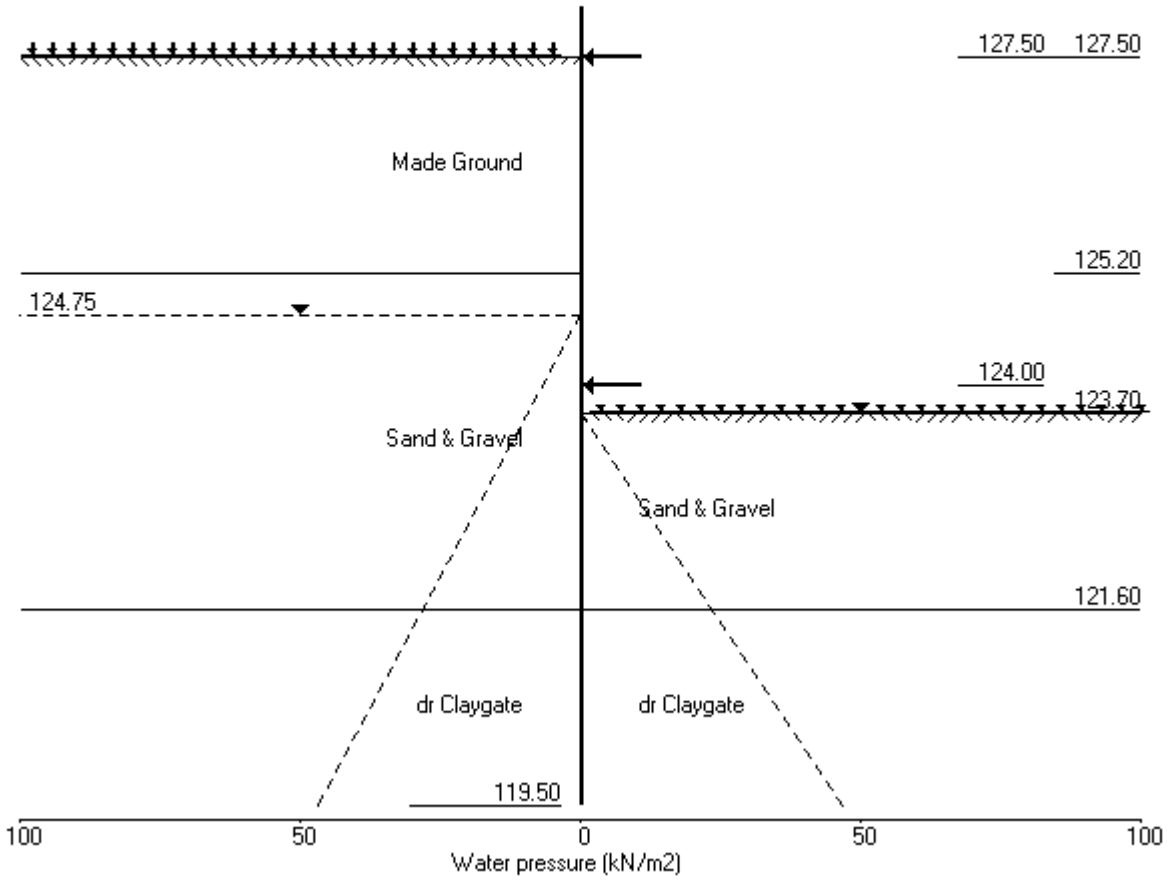
*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	128.00	0.00	0.001	-1.20E-03	-21.4	0.0	21.4
2	127.50	0.00	0.001	-1.17E-03	-21.4	-10.7	
3	127.00	4.14	0.002	-1.07E-03	-20.4	-21.2	
4	126.50	7.96	0.002	-9.20E-04	-17.4	-30.7	
5	126.00	11.34	0.003	-7.15E-04	-12.5	-38.2	
6	125.60	13.94	0.003	-5.22E-04	-7.5	-42.3	
7	125.20	16.52	0.003	-3.16E-04	-1.4	-44.1	
		12.86	0.003	-3.16E-04	-1.4	-44.1	
8	124.75	15.10	0.003	-8.11E-05	4.9	-43.3	
9	124.38	16.97	0.003	1.06E-04	10.9	-40.4	
10	124.00	18.84	0.003	2.75E-04	17.6	-35.0	
11	123.75	20.09	0.003	3.73E-04	22.5	-30.0	
12	123.70	20.72	0.003	3.90E-04	23.5	-28.9	
13	123.35	2.15	0.003	4.92E-04	27.5	-19.4	
14	123.00	-15.76	0.003	5.53E-04	25.1	-10.0	
15	122.50	-23.17	0.003	5.80E-04	15.4	1.3	
16	122.05	-21.58	0.002	5.61E-04	5.3	5.9	
17	121.60	-19.67	0.002	5.29E-04	-3.9	6.1	
		-0.08	0.002	5.29E-04	-3.9	6.1	
18	121.30	0.25	0.002	5.09E-04	-3.9	4.9	
19	121.00	0.69	0.002	4.94E-04	-3.8	3.8	
20	120.50	1.70	0.002	4.76E-04	-3.2	2.0	
21	120.00	3.07	0.001	4.68E-04	-2.0	0.6	
22	119.50	4.85	0.001	4.66E-04	0.0	-0.0	

At elev. 128.00 Strut force = 128.5 kN/strut = 21.4 kN/m run

Units: kN,m

Stage No.11 Apply water pressure profile no.2



Units: kN,m

Stage No. 11 Apply water pressure profile no.2

STABILITY ANALYSIS of Fully Embedded Wall according to Burland-Potts method

Factor of safety on nett available passive

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 119.50 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.800 Toe elev.	Wall Penetr -ation
11	127.50	123.70		More than one strut			

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Active side 20.00 from wall
Passive side 20.00 from wall

*** Wall displacements reset to zero at stage 2

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	128.00	0.00	0.001	-1.01E-03	0.0	0.0	
2	127.50	0.00	0.001	-1.01E-03	0.0	-0.0	24.6
		0.00	0.001	-1.01E-03	-24.6	0.0	
3	127.00	4.20	0.002	-9.80E-04	-23.6	-12.1	
4	126.50	8.12	0.002	-8.74E-04	-20.5	-23.2	
5	126.00	11.58	0.003	-7.08E-04	-15.6	-32.3	
6	125.60	14.22	0.003	-5.41E-04	-10.4	-37.5	
7	125.20	16.80	0.003	-3.55E-04	-4.2	-40.5	
		13.26	0.003	-3.55E-04	-4.2	-40.5	
8	124.75	15.45	0.003	-1.35E-04	2.2	-41.0	
9	124.38	19.81	0.003	4.33E-05	8.8	-39.0	
10	124.00	24.14	0.003	2.07E-04	17.1	-34.1	6.1
		24.14	0.003	2.07E-04	11.0	-34.1	
11	123.75	27.06	0.003	3.04E-04	17.4	-30.6	
12	123.70	27.65	0.003	3.22E-04	18.8	-29.7	
		24.99	0.003	3.22E-04	18.8	-29.7	
13	123.35	6.98	0.003	4.30E-04	24.4	-21.6	
14	123.00	-11.91	0.003	5.03E-04	23.5	-13.0	
15	122.50	-20.64	0.003	5.48E-04	15.4	-2.1	
16	122.05	-20.14	0.002	5.47E-04	6.2	2.7	
17	121.60	-19.20	0.002	5.31E-04	-2.7	3.4	
		1.15	0.002	5.31E-04	-2.7	3.4	
18	121.30	0.93	0.002	5.20E-04	-2.3	2.7	
19	121.00	0.87	0.002	5.12E-04	-2.1	2.0	
20	120.50	0.99	0.002	5.02E-04	-1.6	1.1	
21	120.00	1.50	0.001	4.98E-04	-1.0	0.3	
22	119.50	2.44	0.001	4.97E-04	0.0	-0.0	

At elev. 127.50 Strut force = 24.6 kN/strut = 24.6 kN/m run
At elev. 124.00 Strut force = 6.1 kN/strut = 6.1 kN/m run

Reference

Pile Reinforcement

Sections 2 Wost Case
450mm diameter at 600mm centres

SLS moment	78mkN/m	x 1.5 =	*70.2*	*kNm/pile*
ULS moment	213kNm/m	x 1.0 =	***127.8***	***kNm/pile***

Reinforcement Cage	Ultimate Capacity kNm/pile	Concrete	see sheet No
8B20	142	*30/37*	54

Pile diameter	450	mm	rvs =	146	mm	e= 56
Neutral Axis	140	mm	c =	84	mm	
d =	315	mm	z =	231	mm	
Bw =	351	mm	Bwt =	230	mm	
As 8B20 =	2513	mm²				
100As/ b x d =	3.47	%				

V_{Rdc}/bwd = 0.47 N/mm²

VRdc= .47 x 1.8 x 315 x 230 = 61 kN < 77kN

Maximum Shear "d" from support

SLS shear	46kN/m	x 1.5 =	*41.4*	*kN/pile*
ULS shear	127kN/m	x 1.0 =	***76.2***	***kN/pile***

Shear *77* *kN*

$V_{Ed} = V_{ed} / (b_w z)$ = **1.450 MPa** λ_2 = 1.023

V_{Rd} = 3.64 MPa λ_1 = 0.85

Consider B8 *A sw =* *100.5* *mm²* *pitch =* *200* *mm*

$V_{Rd,s} = \lambda_1\lambda_2 A_{sw} \times z \times f_{ywd} \cot\theta / S$ = 0 kN > 77kN

Asw/s =1.45 x 230/ (435 x 2.5) = 0.307 mm
B8 / 200 mm = 0.50 > 0.307

B8 links at 200mm centres

min Asw fywk / bw S = 0.08 √ fck 0 MPa

Asv > 0.438 x bw x S / fyv x 0.87 — 450mm dia

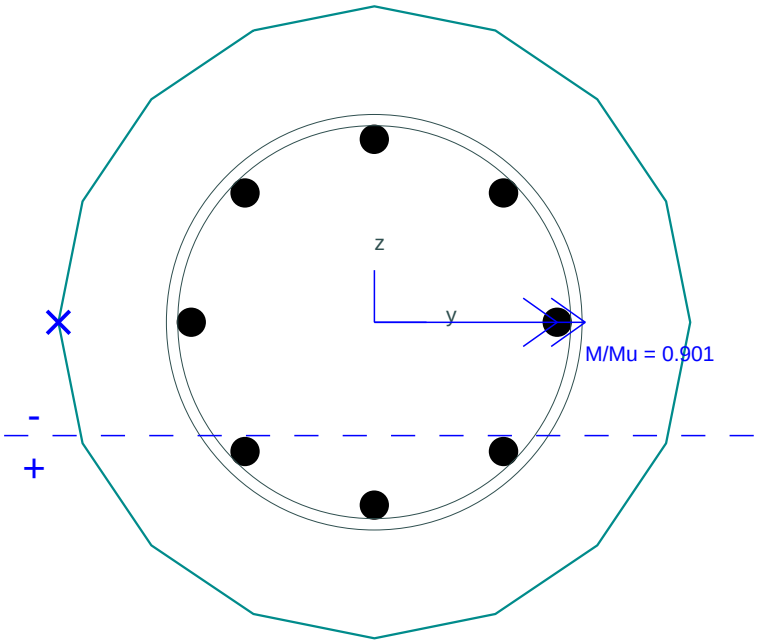
S < 236 mm

say S = 200 mm

Avs > 46 mm²

Allow B8 links at 200mm centres B8 = 100.5 mm²

Grove Lodge
450 diameter
8B20



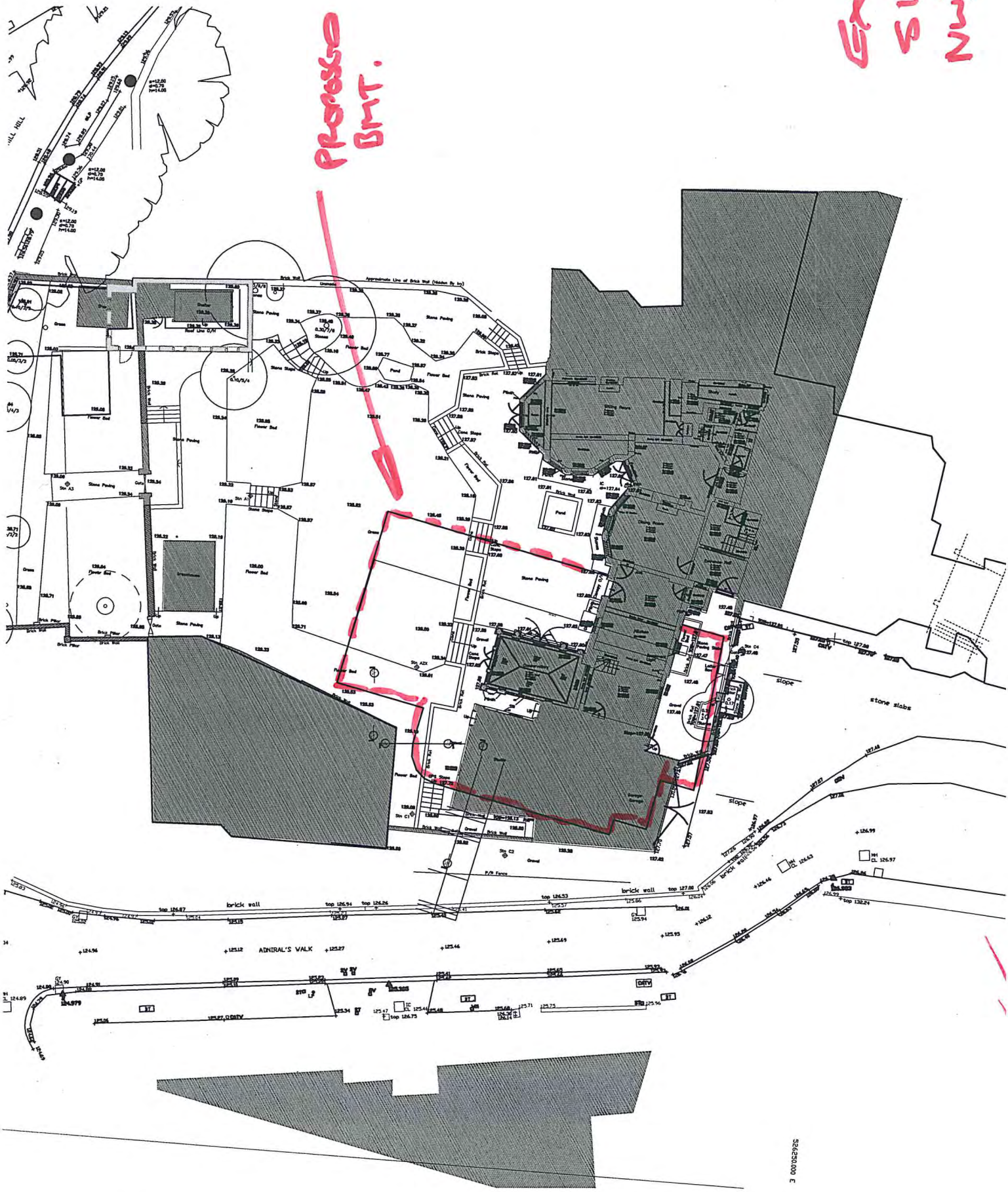
Reinforcement Details

Bar Arrangement	1 ring(s)/8 bars per ring
Diameter of main bars	20mm
Area of reinforcement	2513.27mm²
Diameter of links	8mm
Max. spacing of links	390mm
Nominal Cover (outer)	75mm

Design Results

Analysis Case Name	Analysis Case 1
Axial Design Force	0kN
Axial Capacity	3666.32kN
Design Moment 'M'	128kNm
Ultimate Moment 'Mu'	142.134kNm
Neutral Axis	— — —
Comp./Tens. Side	+/-
Governing Node/Bar	✕

Section 1
Analysis Case 1


PROPOSED LIMIT.
SITE.
NW3 6RS
brick wall
top 126.87
top 126.94
top 126.26
top 126.53
top 127.08
top 132.24
ADMIRAL'S WALK
slope
stone slabs
526250.000 E

F:\Projects\5900 - 5999\5954 - Grove Lodge, Admirals, Hamstead, NW3\11 Drawings\11.3 MBP\Grove Lodge Drawings latest.dwg USER: Julian Birch
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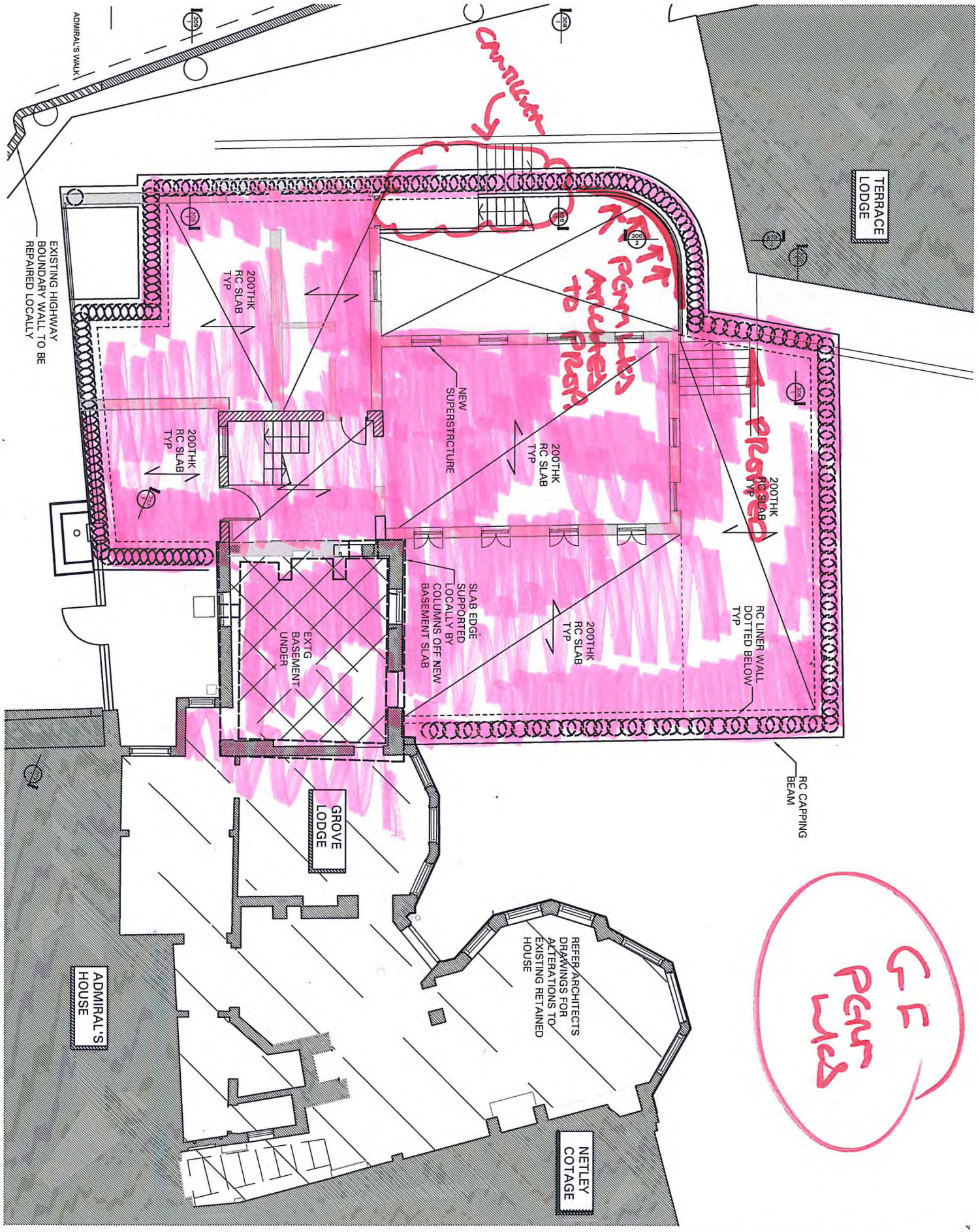

56 of 61

Rev	Date	Description	By
P1	19/06/15	PLANNING ISSUE	JB

Job
GROVE LODGE
LONDON
NW3 6RS

Scale	Date	By	Checked
1:100@A3	FEB 15	JB	-

Status
PLANNING

Title
PROPOSED GROUND FLOOR PLAN

Drawing Number	Revision
5954 / 302	P1

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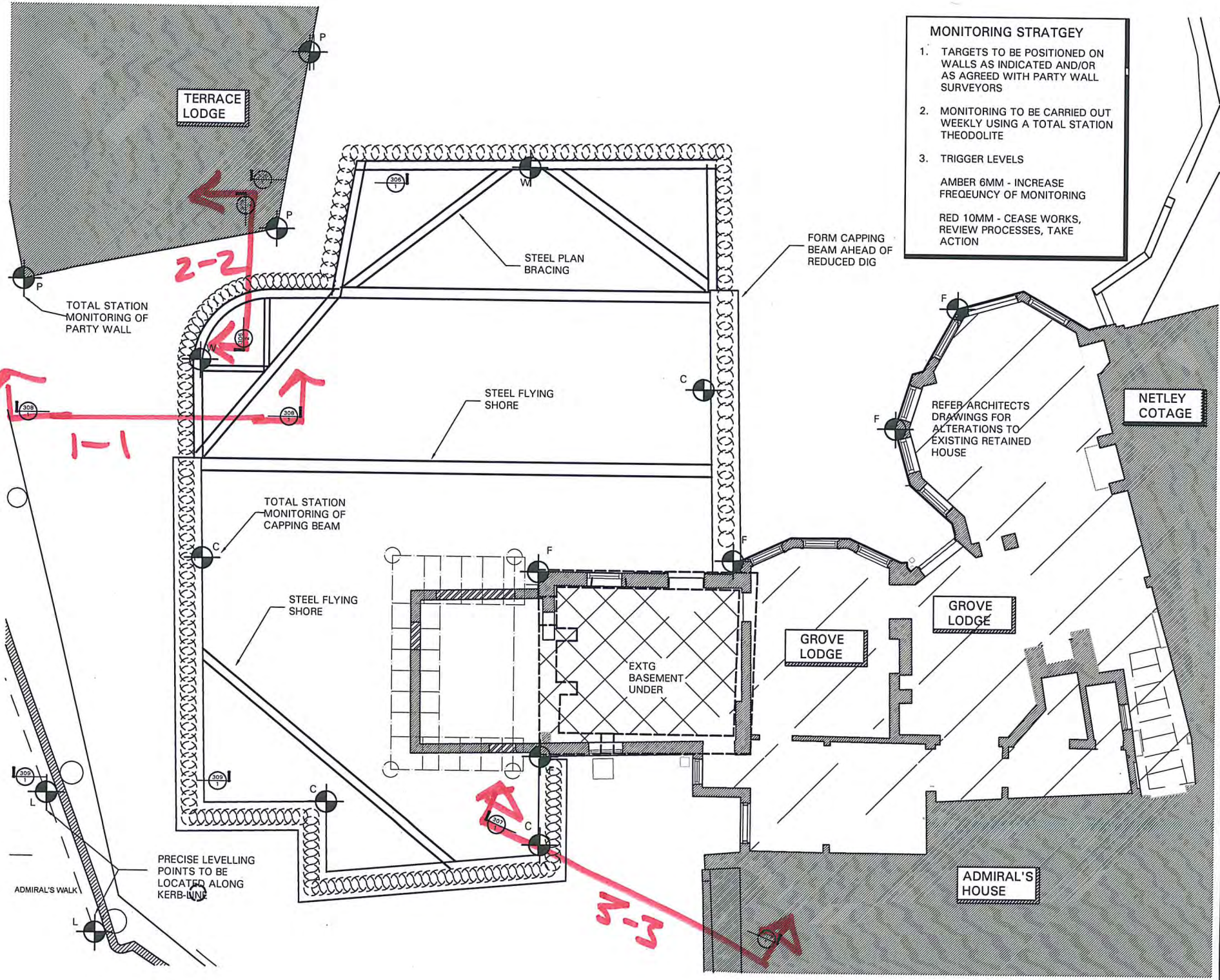
MONITORING STRATGEY
1. TARGETS TO BE POSITIONED ON WALLS AS INDICATED AND/OR AS AGREED WITH PARTY WALL SURVEYORS
2. MONITORING TO BE CARRIED OUT WEEKLY USING A TOTAL STATION THEODOLITE
3. TRIGGER LEVELS
AMBER 6MM - INCREASE FREQEUNCY OF MONITORING
RED 10MM - CEASE WORKS, REVIEW PROCESSES, TAKE ACTION
TERRACE LODGE
TOTAL STATION MONITORING OF PARTY WALL
STEEL PLAN BRACING
FORM CAPPING BEAM AHEAD OF REDUCED DIG
STEEL FLYING SHORE
TOTAL STATION MONITORING OF CAPPING BEAM
STEEL FLYING SHORE
EXTG BASEMENT UNDER
REFER ARCHITECTS DRAWINGS FOR ALTERATIONS TO EXISTING RETAINED HOUSE
NETLEY COTAGE
GROVE LODGE
GROVE LODGE
ADMIRAL'S HOUSE
ADMIRAL'S WALK
PRECISE LEVELLING POINTS TO BE LOCATED ALONG KERB-LINE
1-1
2-2
3-3
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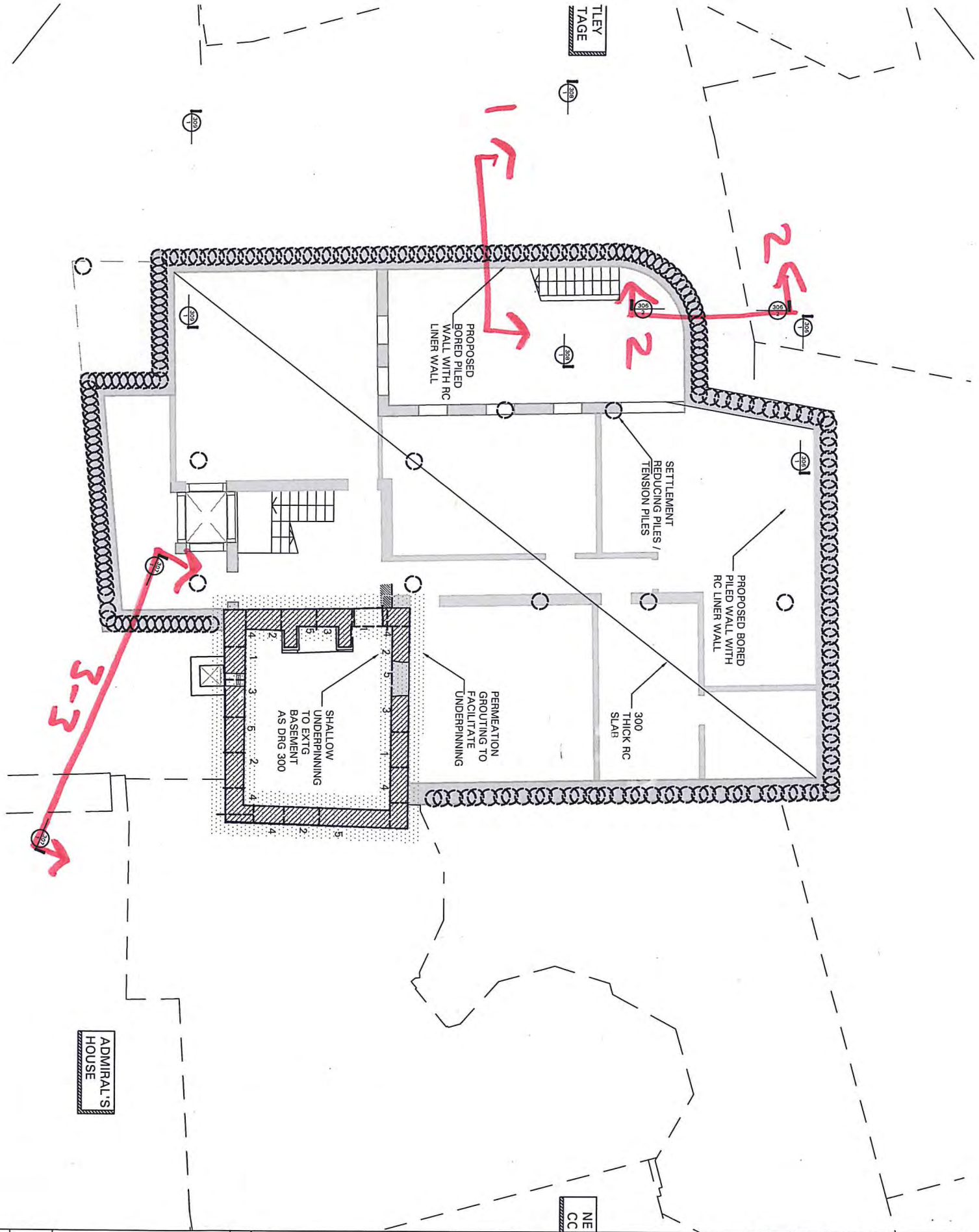
Title
PROPOSED GROUND FLOOR PLAN
TEMPORARY WORKS AND MONITORING
Revision P1
Drawing Number 5954 / 305
Job GROVE LODGE LONDON NW3 6RS
Scale 1:100@A3
Date FEB 15
By JB
Checked -
Status PLANNING
P1 19/06/15 PLANNING ISSUE JB
Rev Date Description By
57 of 61



Rev	Date	Description	By
P1	19/06/15	PLANNING ISSUE	JB

Job: GROVE LODGE
LONDON
NW3 6RS

Title: PROPOSED BASEMENT PLAN

Scale	Date	By	Checked
1:100@A3	FEB 15	JB	-

Drawing Number: 5954 / 303

Revision: P1

Status: PLANNING

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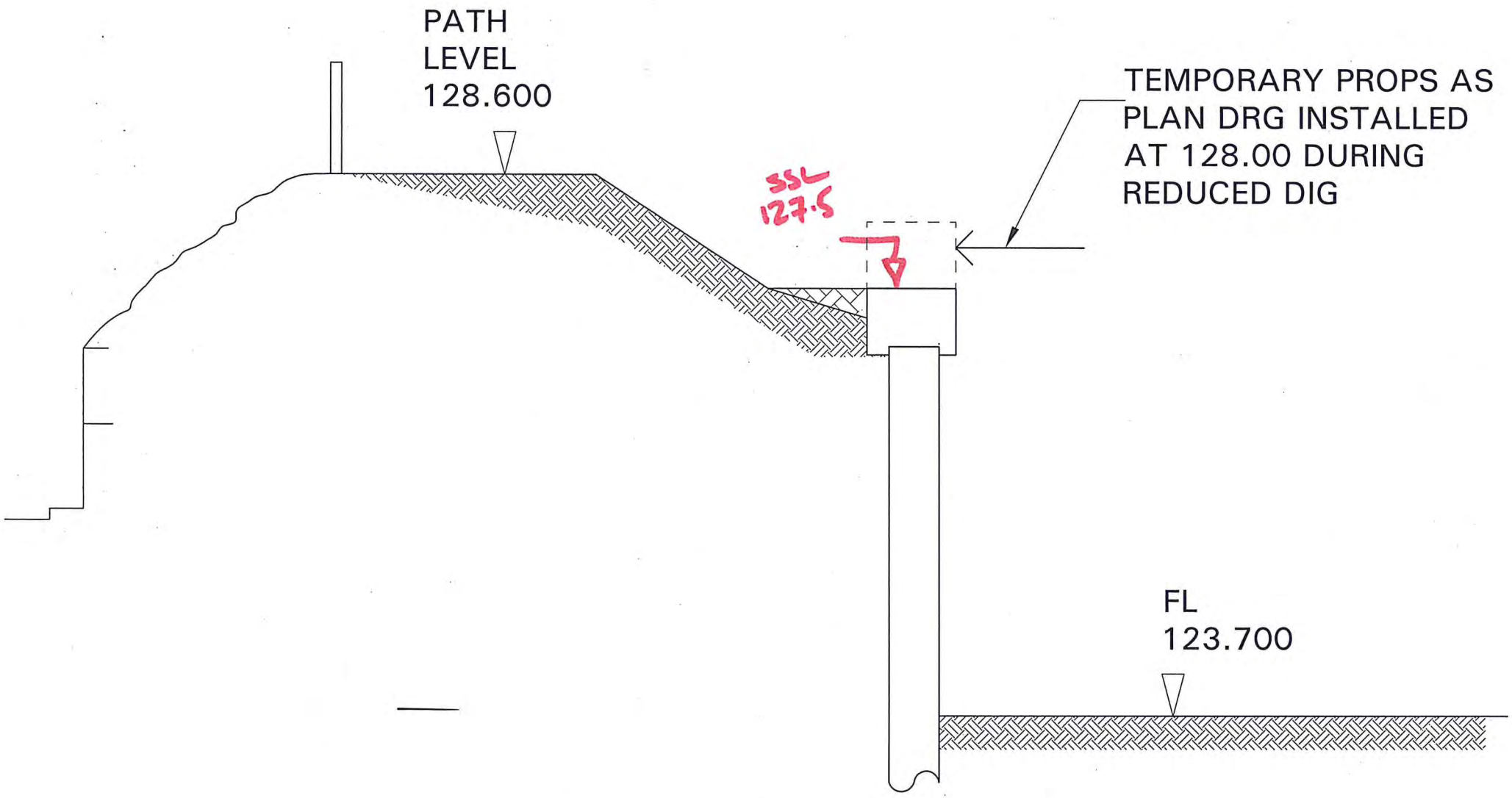
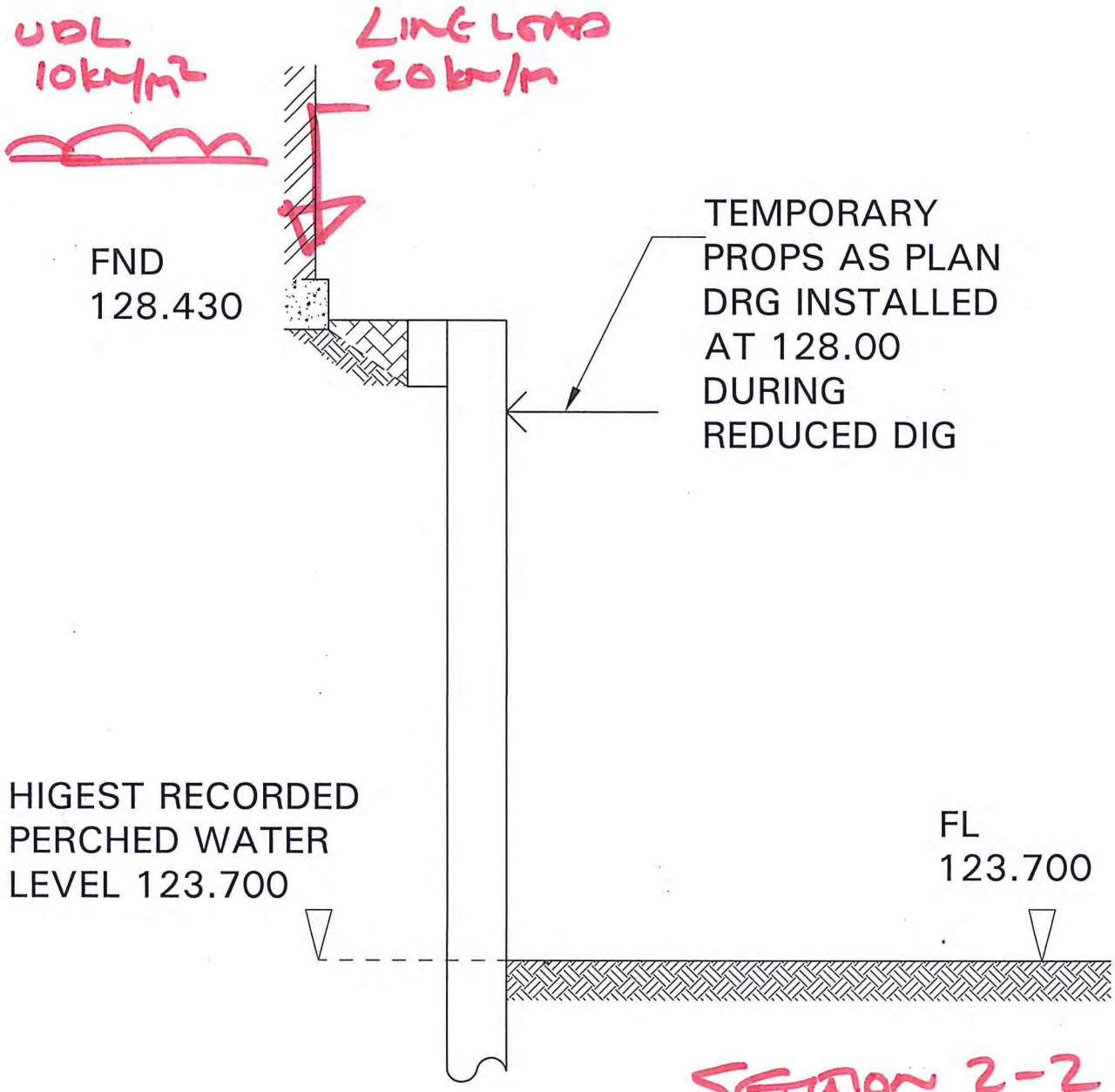
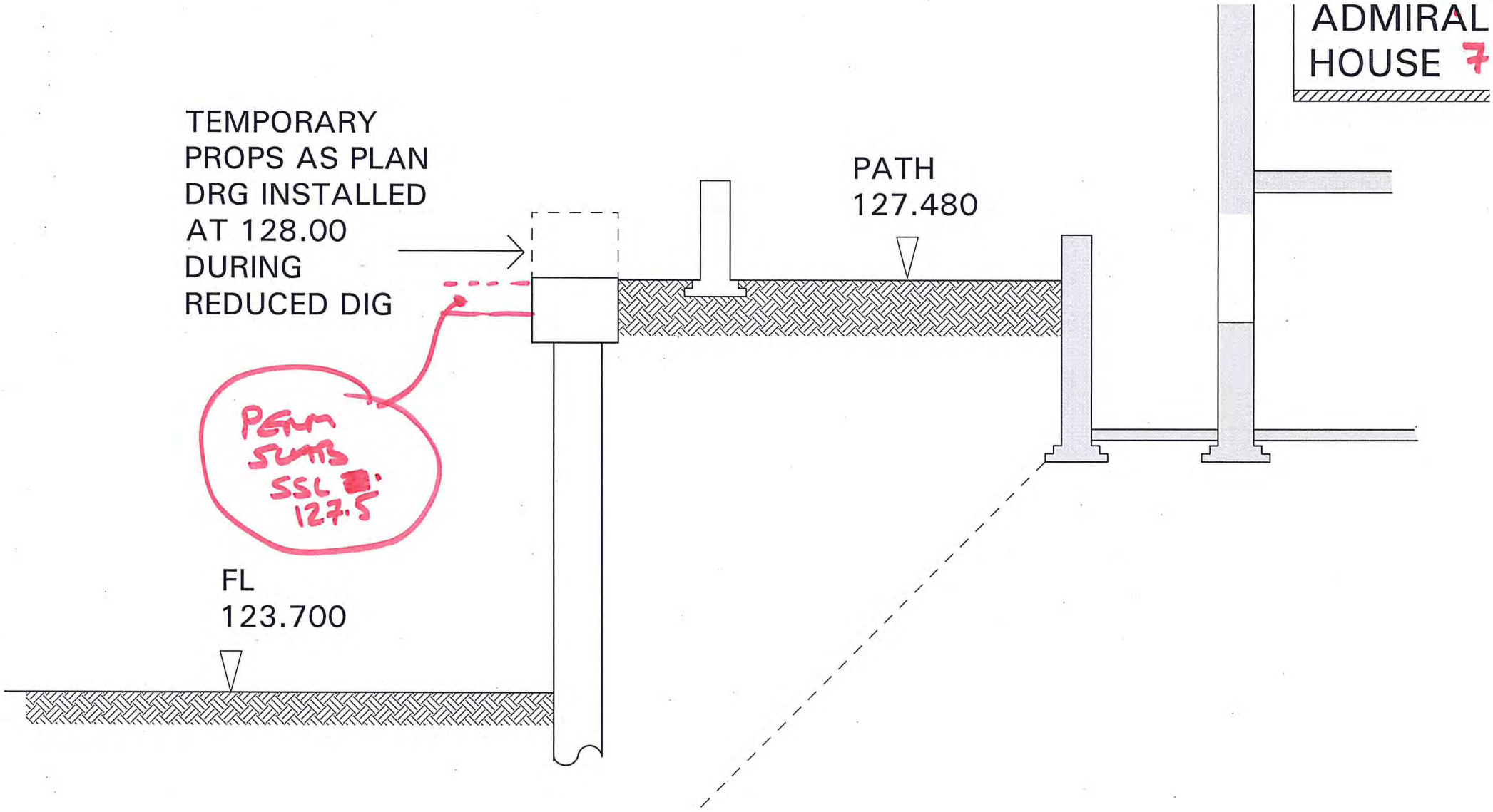


SECTION 1-1

1:50


UDL
10kN/m²
LINE LOAD
20kN/m
FND
128.430
TEMPORARY
PROPS AS PLAN
DRG INSTALLED
AT 128.00
DURING
REDUCED DIG
HIGEST RECORDED
PERCHED WATER
LEVEL 123.700
FL
123.700
SECTION 2-2



ADMIRALS HOUSE INTERFACE SECTION 3 - STAGE 3