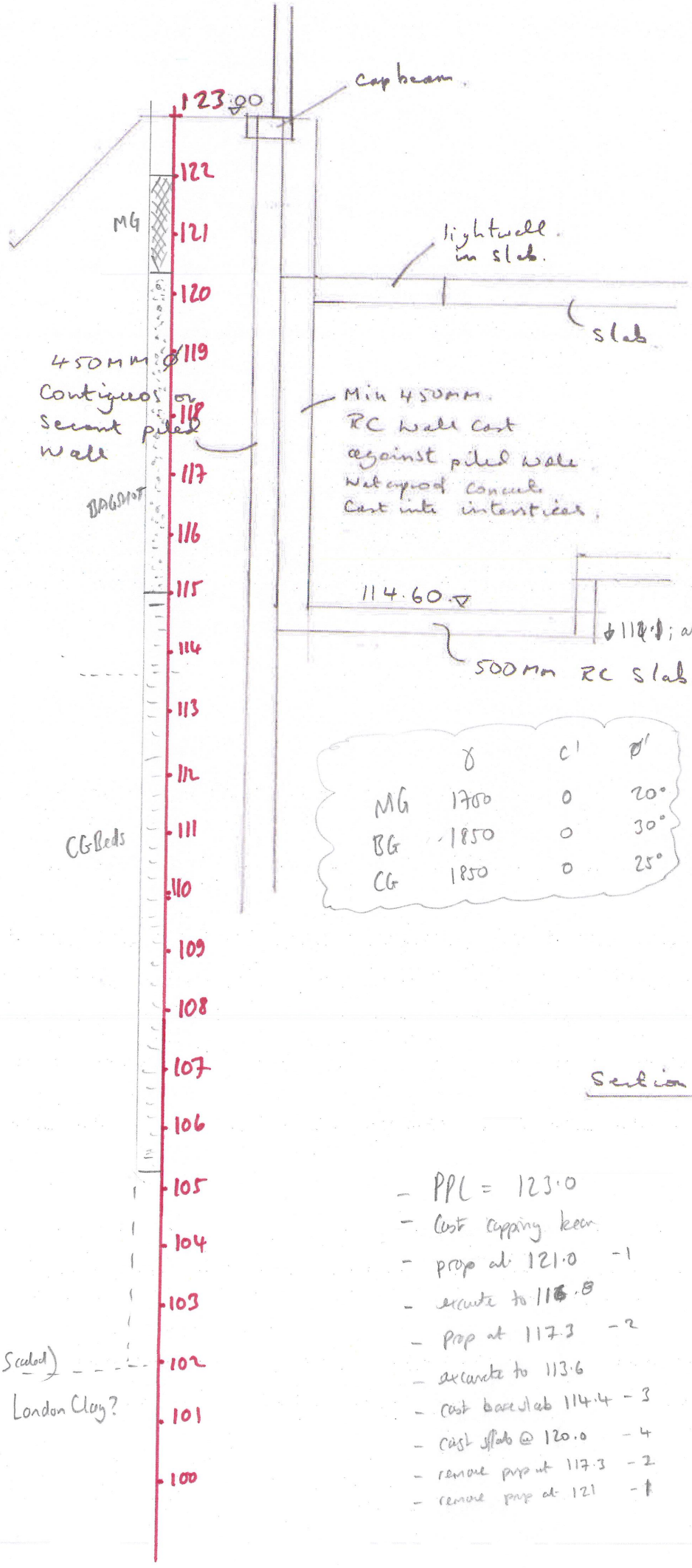
APPENDIX 3

Summary Sheets from Retaining Wall Design Calculations

(Area A-A)

(Area B-B)

(Area C-C)



	γ	c'	φ'
MG	1700	0	20°
BG	1850	0	30°
CG	1850	0	25°

- PPL = 123.0
- Cast capping beam
- prop at 121.0 -1
- excavate to 116.8
- Prop at 117.3 -2
- excavate to 113.6
- cast base slab 114.4 -3
- cast sl slab @ 120.0 -4
- remove prop at 117.3 -2
- remove prop at 121 -1

Prop 1 121.0 st top
Prop 2 117.3 st top
Prop 3 114.4 C pen
Prop 4 120.0 C pen

Piles 13m 600ϕ @ 700 c/c

Section A-A.

SECTION A-A
BH1 Relevant (7m only)

GWL NONE

14/1/14.

99K Fwgnal

GEOTECHNICAL & ENVIRONMENTAL ASSOCIATES | Sheet No.
Program: WALLAP Version 6.05 Revision A45.B58.R48 | Job No. J13053
Licensed from GEOSOLVE | Made by : MC
Data filename/Run ID: Frognal West Wall_SLS 600 wall |
99A Frognal | Date:21-01-2014
Section A-A West wall | Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	123.00	1 Made Ground	1 Made Ground
2	120.30	2 Bagshot Beds	2 Bagshot Beds
3	115.00	3 Claygate Beds	3 Claygate Beds
4	102.00	4 London Clay	4 London Clay

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	17.00	10000	0.500	OC (0.200)	0.333 (0.000)	3.000 (0.000)	
2	Bagshot Beds	18.50	32000	0.500	OC (0.200)	0.333 (0.000)	1.000 (0.000)	
3	Claygate Beds	18.50	50000	1.000	OC (0.490)	1.000 (2.000)	1.000 (1.000)	100.0u
4	London Clay	20.00	70000	1.000	OC (0.490)	1.000 (1.000)	1.000 (1.000)	150.0u
5	Made Ground Drained	17.00	10000	0.500	OC (0.200)	0.333 (0.000)	3.000 (0.000)	
6	Bagshot Beds Drained	18.50	32000	0.500	OC (0.200)	0.333 (0.000)	1.000 (0.000)	
7	Claygate Beds Draind	18.50	30000	1.000	OC (0.490)	1.000 (2.000)	1.000 (1.000)	100.0d
8	London Clay Drained	20.00	45000	1.000	OC (0.490)	1.000 (1.000)	1.000 (1.000)	150.0d

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	30.00	0.000	0.00	30.00	0.000	0.00
2	Bagshot Beds	30.00	0.000	0.00	0.00	0.000	0.00
3	Claygate Beds	0.00	0.000	0.00	0.00	-0.674	0.00
4	London Clay	0.00	-0.674	0.00	0.00	-0.674	0.00
5	Made Ground Drained	30.00	0.000	0.00	30.00	0.000	0.00
6	Bagshot Beds Drained	30.00	0.000	0.00	0.00	0.000	0.00
7	Claygate Beds Draind	0.00	0.000	0.00	0.00	-0.674	0.00
8	London Clay Drained	0.00	-0.674	0.00	0.00	-0.674	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	115.00	115.00

Automatic water pressure balancing at toe of wall : No

Water press.	Active side	Passive side

profile no.	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	115.00	115.00	0.0	1	115.00	115.00	0.0 WC
2	1	115.00	115.00	0.0	1	113.60	113.60	0.0 MC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 110.00
Maximum finite element length = 0.80 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 9.0890E-03 m4/m run
E.I = 254492 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	121.00	3.00	0.010000	2.000E+08	4.00	0.00	0	No
2	117.30	3.00	0.010000	2.000E+08	4.00	0.00	0	No
3	114.40	1.00	0.500000	3.000E+07	1.00	0.00	0	No
4	120.00	1.00	0.250000	3.000E+07	1.00	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	123.00	0.00(A)	20.00	3.00	10.00	=	N/A	1.00 -
2	113.60	-0.00(P)	20.00	20.00	160.00	=	N/A	1.00 -

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 123.00
	No analysis at this stage
2	Excavate to elevation 120.50 on PASSIVE side
3	Install strut or anchor no.1 at elevation 121.00
4	Excavate to elevation 116.80 on PASSIVE side
5	Install strut or anchor no.2 at elevation 117.30
6	Excavate to elevation 113.60 on PASSIVE side
7	Apply water pressure profile no.2 (Mod. Conserv.)
8	Install strut or anchor no.3 at elevation 114.40
9	Install strut or anchor no.4 at elevation 120.00
10	Remove strut or anchor no.2 at elevation 117.30
11	Remove strut or anchor no.1 at elevation 121.00
12	Apply surcharge no.2 at elevation 113.60
	No analysis at this stage
13	Change properties of soil type 1 to soil type 5
	Ko pressures will be reset
14	Change properties of soil type 2 to soil type 6
	Ko pressures will be reset
15	Change properties of soil type 3 to soil type 7
	Ko pressures will be reset
16	Change properties of soil type 4 to soil type 8
	Ko pressures will be reset

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FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: Serviceability Limit State
All loads and soil strengths are unfactored

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) = 0 m

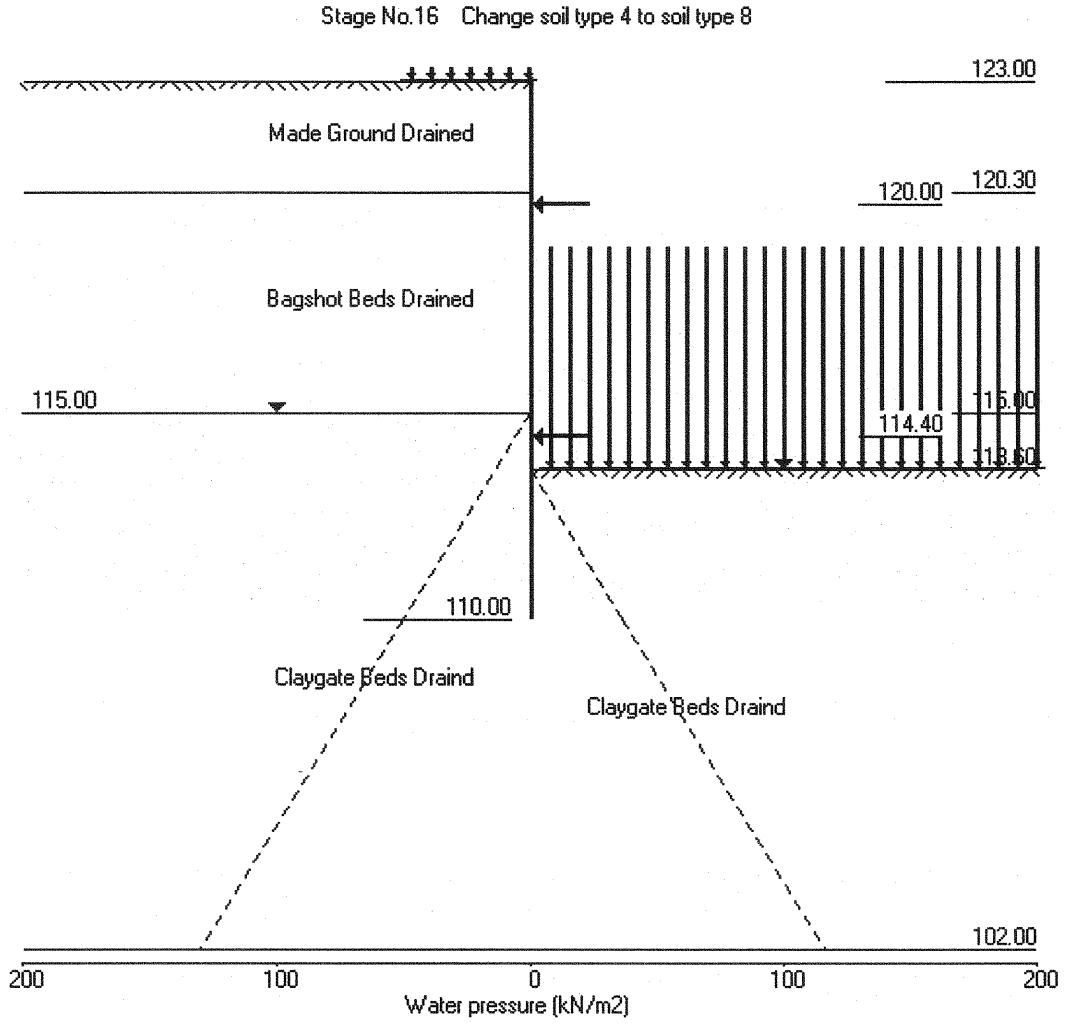
Boundary conditions:
Length of wall (normal to plane of analysis) = 1000.00 m

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. 123.00	No	No	No
2	Excav. to elev. 120.50 on PASSIVE side	Yes	Yes	Yes
3	Install strut no.1 at elev. 121.00	No	No	No
4	Excav. to elev. 116.80 on PASSIVE side	No	No	No
5	Install strut no.2 at elev. 117.30	No	No	No
6	Excav. to elev. 113.60 on PASSIVE side	No	No	No
7	Apply water pressure profile no.2	No	No	No
8	Install strut no.3 at elev. 114.40	No	No	No
9	Install strut no.4 at elev. 120.00	No	No	No
10	Remove strut no.2 at elev. 117.30	No	No	No
11	Remove strut no.1 at elev. 121.00	No	No	No
12	Apply surcharge no.2 at elev. 113.60	No	No	No
13	Change soil type 1 to soil type 5	No	No	No
14	Change soil type 2 to soil type 6	No	No	No
15	Change soil type 3 to soil type 7	No	No	No
16	Change soil type 4 to soil type 8	No	No	No
*	Summary output	Yes	-	Yes

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================================================================================GEOTECHNICAL &
ENVIRONMENTAL ASSOCIATES                          | Sheet No.
Program: WALLAP  Version 6.05  Revision A45.B58.R48          | Job No.  J13053
                              Licensed from GEOSOLVE         | Made by :    MC
Data filename/Run ID: Frognal West Wall_SLS 600 wall         |
99A Frognal                                                  | Date:21-01-2014
Section A-A West wall                                        | Checked :
--------------------------------------------------------------------------------
                                                                    Units: kN,m
Stage No. 2   Excavate to elevation 120.50 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.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 110.00: Factor of Safety	FoS for toe elev. = 110.00: Moment equilib. at elev.	Toe elev. for FoS = 1.000	Wall Penetration
2	123.00	120.50	Cant.	1.892	111.60	113.68	6.82

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

Limit State: Serviceability Limit State

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

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	123.00	3.33	0.018	2.71E-03	0.0	0.0	
2	122.50	6.15	0.017	2.71E-03	2.4	0.6	
3	122.00	8.94	0.016	2.71E-03	6.1	2.7	
4	121.50	11.69	0.014	2.70E-03	11.3	7.0	
5	121.00	14.38	0.013	2.68E-03	17.8	14.2	
6	120.50	17.05	0.012	2.64E-03	25.7	25.0	
7	120.30	7.91	0.011	2.62E-03	28.2	30.4	
		14.73	0.011	2.62E-03	28.2	30.4	
8	120.00	10.92	0.010	2.58E-03	32.0	39.5	
9	119.20	0.76	0.008	2.41E-03	36.7	67.4	
10	118.40	-9.39	0.007	2.15E-03	33.2	95.9	
11	117.85	-16.36	0.005	1.93E-03	26.2	112.3	
12	117.30	-23.32	0.004	1.67E-03	15.2	123.9	
13	116.80	-29.65	0.004	1.42E-03	2.0	128.3	
14	116.00	-20.12	0.003	1.03E-03	-17.9	124.7	
15	115.50	-14.69	0.002	7.96E-04	-26.6	113.2	
16	115.00	-10.61	0.002	5.88E-04	-32.9	98.1	
		-5.19	0.002	5.88E-04	-32.9	98.1	
17	114.40	2.23	0.002	3.82E-04	-33.8	77.3	
18	113.60	7.65	0.001	1.80E-04	-29.9	50.9	
19	112.80	9.55	0.001	5.42E-05	-23.0	29.4	
20	112.00	9.38	0.001	-1.41E-05	-15.4	14.0	
21	111.20	8.18	0.001	-4.34E-05	-8.4	4.7	
22	110.60	7.01	0.001	-5.02E-05	-3.8	1.1	
23	110.00	5.78	0.001	-5.14E-05	-0.0	-0.0	

(continued)

Stage No.2 Excavate to elevation 120.50 on PASSIVE side

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	123.00	0.00	10.00	3.33	30.00	3.33	3.33a	1668
2	122.50	0.00	18.48	6.15	55.44	6.15	6.15a	1668
3	122.00	0.00	26.86	8.94	80.58	8.94	8.94a	1668
4	121.50	0.00	35.09	11.69	105.27	11.69	11.69a	1668
5	121.00	0.00	43.18	14.38	129.55	14.38	14.38a	1668
6	120.50	0.00	51.19	17.05	153.57	17.05	17.05a	1668
7	120.30	0.00	54.38	18.11	163.13	18.11	18.11a	1668
		0.00	54.38	18.13	54.38	18.13	18.13a	5339

8	120.00	0.00	59.60	19.87	59.60	19.87	19.87a	5339
9	119.20	0.00	73.54	24.51	73.54	24.51	24.51a	5339
10	118.40	0.00	87.54	29.18	87.54	29.18	29.18a	5339
11	117.85	0.00	97.22	32.41	97.22	32.41	32.41a	5339
12	117.30	0.00	106.95	35.65	106.95	35.65	35.65a	5339
13	116.80	0.00	115.82	38.61	115.82	38.61	38.61a	5339
14	116.00	0.00	130.09	43.36	130.09	49.75	49.75	5339
15	115.50	0.00	139.04	46.35	139.04	56.74	56.74	5339
16	115.00	0.00	148.02	49.34	148.02	63.14	63.14	5339
		Total>	148.02	40.00m	248.02	125.63	125.63	12052
17	114.40	Total>	158.82	43.00m	258.82	139.93	139.93	12052
18	113.60	Total>	173.26	47.00m	273.26	157.03	157.03	12052
19	112.80	Total>	187.75	51.00m	287.75	172.61	172.61	12052
20	112.00	Total>	202.28	55.00m	302.28	187.31	187.31	12052
21	111.20	Total>	216.83	59.00m	316.83	201.57	201.57	12052
22	110.60	Total>	227.77	62.00m	327.77	212.17	212.17	12052
23	110.00	Total>	238.72	65.00m	338.72	222.76	222.76	12052

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	123.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	122.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	122.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	121.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	121.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	120.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	2114
7	120.30	0.00	3.40	1.13	10.20	10.20	10.20p	2114
		0.00	3.40	1.13	3.40	3.40	3.40p	6766
8	120.00	0.00	8.95	2.98	8.95	8.95	8.95p	6766
9	119.20	0.00	23.75	7.92	23.75	23.75	23.75p	6766
10	118.40	0.00	38.57	12.86	38.57	38.57	38.57p	6766
11	117.85	0.00	48.77	16.26	48.77	48.77	48.77p	6766
12	117.30	0.00	58.97	19.66	58.97	58.97	58.97p	6766
13	116.80	0.00	68.26	22.75	68.26	68.26	68.26p	6766
14	116.00	0.00	83.14	27.71	83.14	69.87	69.87	6766
15	115.50	0.00	92.46	30.82	92.46	71.43	71.43	6766
16	115.00	0.00	101.79	33.93	101.79	73.75	73.75	6766
		Total>	101.79	27.50m	201.79	130.82	130.82	15035
17	114.40	Total>	113.01	30.50m	213.01	137.70	137.70	15035
18	113.60	Total>	128.00	34.50m	228.00	149.38	149.38	15035
19	112.80	Total>	143.02	38.50m	243.02	163.06	163.06	15035
20	112.00	Total>	158.08	42.50m	258.08	177.92	177.92	15035

(continued)

Stage No.2 Excavate to elevation 120.50 on PASSIVE side

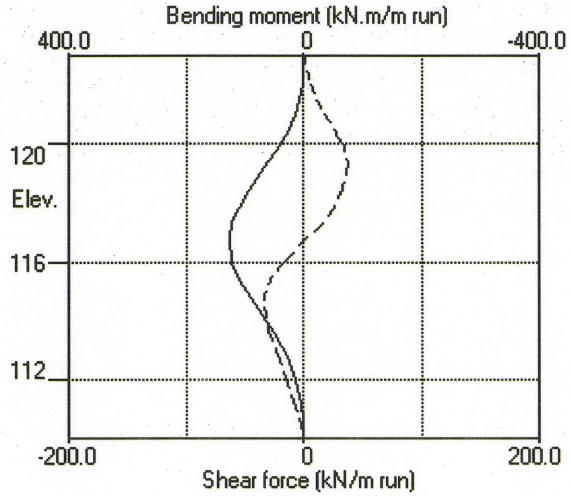
Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
21	111.20	Total>	173.18	46.50m	273.18	193.39	193.39	15035
22	110.60	Total>	184.53	49.50m	284.53	205.16	205.16	15035

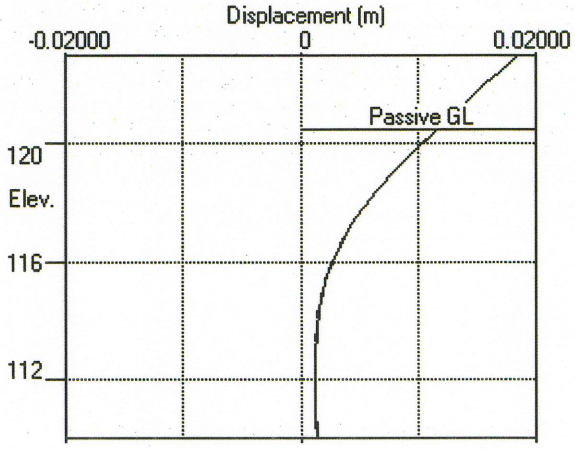
23	110.00	Total> 195.89	52.50m	295.89	216.98	216.98	15035

Note: 38.61a Soil pressure at active limit
68.26p Soil pressure at passive limit

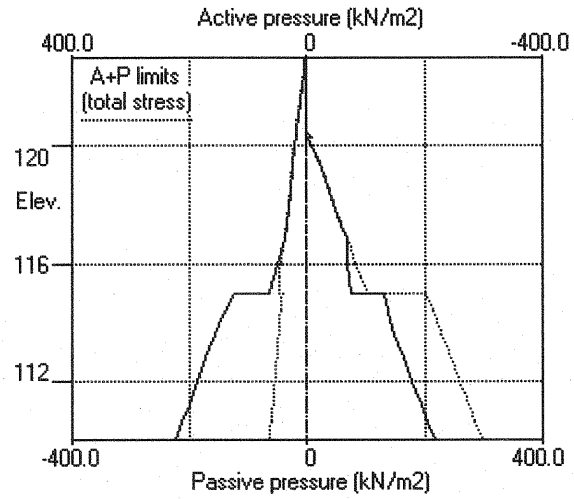
Units: kN,m

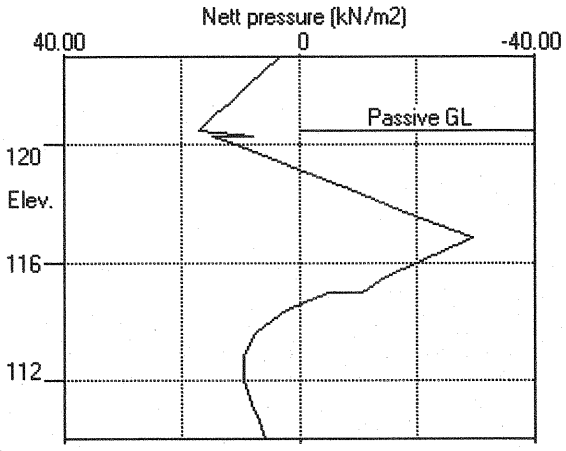
Stage No.2 Excav. to elev. 120.50 on PASSIVE side





Stage No.2 Excav. to elev. 120.50 on PASSIVE side





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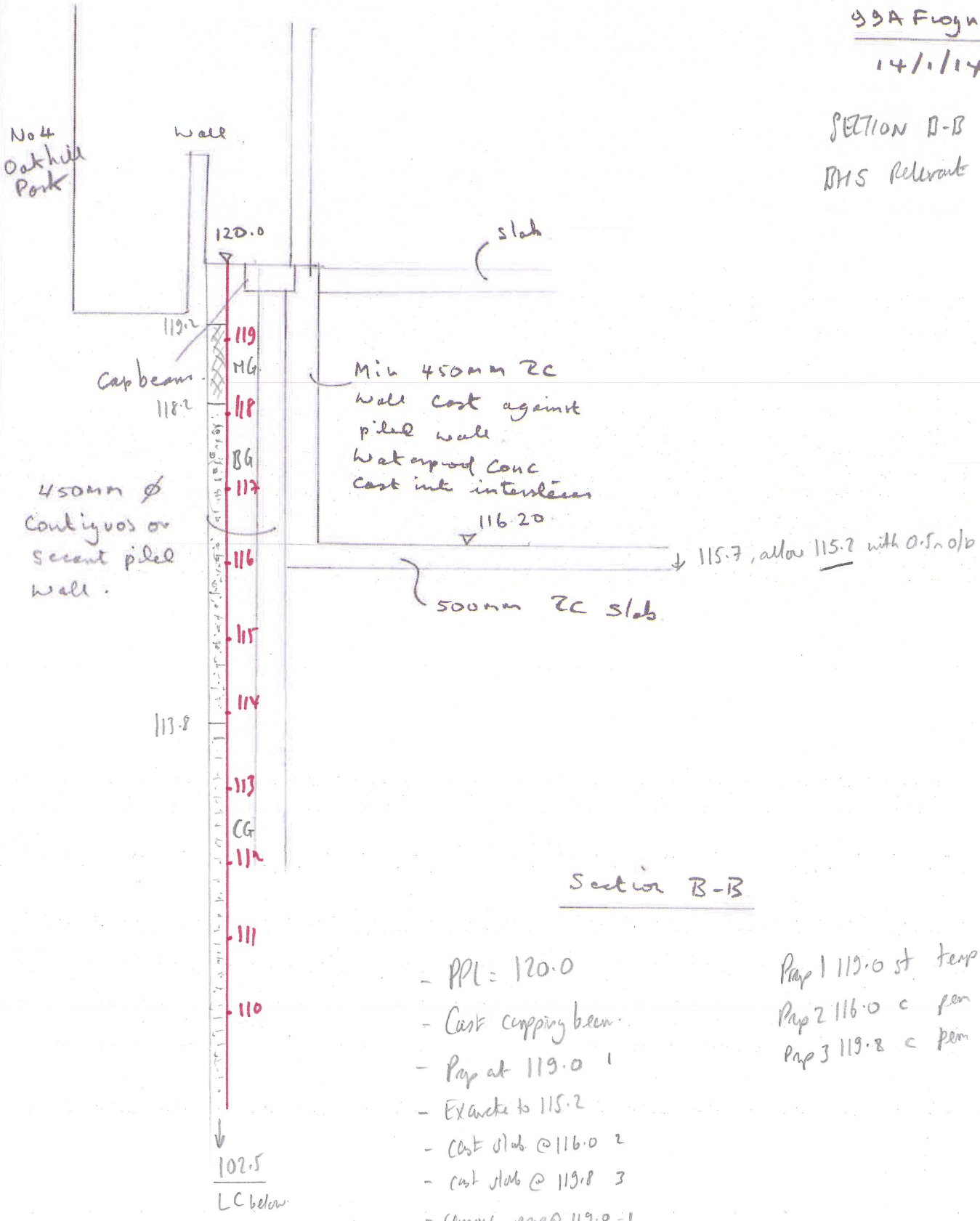
99A Frognal

14/1/14

SECTION B-B

DHS Relevant



Section B-B

- PPL = 120.0
- Cast capping beam
- Prop at 119.0 1
- Excavate to 115.2
- cast slab @ 116.0 2
- cast slab @ 119.8 3
- remove prop @ 119.0 -1

Prop 1 119.0 st temp
Prop 2 116.0 c perm
Prop 3 119.8 c perm

3.8m = 5/m

Piles 10m 450ø @ 600 c/c

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Soil types Passive side
1	120.00	1 Made Ground	1 Made Ground
2	118.20	2 Bagshot Beds	2 Bagshot Beds
3	113.80	3 Claygate Beds	3 Claygate Beds
4	102.50	4 London Clay	4 London Clay

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	17.00	10000	0.500	OC (0.200)	0.333 (0.000)	3.000 (0.000)	
2	Bagshot Beds	18.50	32000	0.500	OC (0.200)	0.333 (0.000)	1.000 (0.000)	
3	Claygate Beds	18.50	50000	1.000	OC (0.490)	1.000 (2.000)	1.000 (1.000)	100.0u
4	London Clay	20.00	70000	1.000	OC (0.490)	1.000 (1.000)	1.000 (1.000)	150.0u
5	Made Ground Drained	17.00	10000	0.500	OC (0.200)	0.333 (0.000)	3.000 (0.000)	
6	Bagshot Beds Drained	18.50	32000	0.500	OC (0.200)	0.333 (0.000)	1.000 (0.000)	
7	Claygate Beds Draind	18.50	30000	1.000	OC (0.490)	1.000 (2.000)	1.000 (1.000)	100.0d
8	London Clay Drained	20.00	45000	1.000	OC (0.490)	1.000 (1.000)	1.000 (1.000)	150.0d

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	30.00	0.000	0.00	30.00	0.000	0.00
2	Bagshot Beds	30.00	0.000	0.00	0.00	0.000	0.00
3	Claygate Beds	0.00	0.000	0.00	0.00	-0.674	0.00
4	London Clay	0.00	-0.674	0.00	0.00	-0.674	0.00
5	Made Ground Drained	30.00	0.000	0.00	30.00	0.000	0.00
6	Bagshot Beds Drained	30.00	0.000	0.00	0.00	0.000	0.00
7	Claygate Beds Draind	0.00	0.000	0.00	0.00	-0.674	0.00
8	London Clay Drained	0.00	-0.674	0.00	0.00	-0.674	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	110.20	108.80

Automatic water pressure balancing at toe of wall : No

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	108.80	108.80	0.0	1	108.80	108.80	0.0	WC
2	1	115.20	115.20	0.0	1	115.20	115.20	0.0	MC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 110.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 3.3550E-03 m4/m run
E.I = 93940 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	119.00	3.00	0.010000	2.000E+08	4.00	0.00	0	No
2	Not defined							
3	116.00	1.00	0.500000	3.000E+07	1.00	0.00	0	No
4	119.80	1.00	0.250000	3.000E+07	1.00	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	120.00	0.00(A)	20.00	3.00	10.00	=	N/A	1.00 -
2	115.20	-0.00(P)	20.00	20.00	90.00	=	N/A	1.00 -
3	118.00	5.00(A)	15.00	0.50	100.00	=	N/A	1.00 -

Note: A = Active side, P = Passive side
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 120.00 No analysis at this stage
2	Apply surcharge no.3 at elevation 118.00
3	Excavate to elevation 118.50 on PASSIVE side
4	Install strut or anchor no.1 at elevation 119.00
5	Excavate to elevation 115.20 on PASSIVE side
6	Install strut or anchor no.3 at elevation 116.00
7	Apply water pressure profile no.2 (Mod. Conserv.)
8	Install strut or anchor no.4 at elevation 119.80
9	Remove strut or anchor no.1 at elevation 119.00
10	Apply surcharge no.2 at elevation 115.20 No analysis at this stage
11	Change properties of soil type 1 to soil type 5 Ko pressures will be reset
12	Change properties of soil type 2 to soil type 6 Ko pressures will be reset
13	Change properties of soil type 3 to soil type 7 Ko pressures will be reset
14	Change properties of soil type 4 to soil type 8 Ko pressures will be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: Serviceability Limit State
All loads and soil strengths are unfactored

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) = 0 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

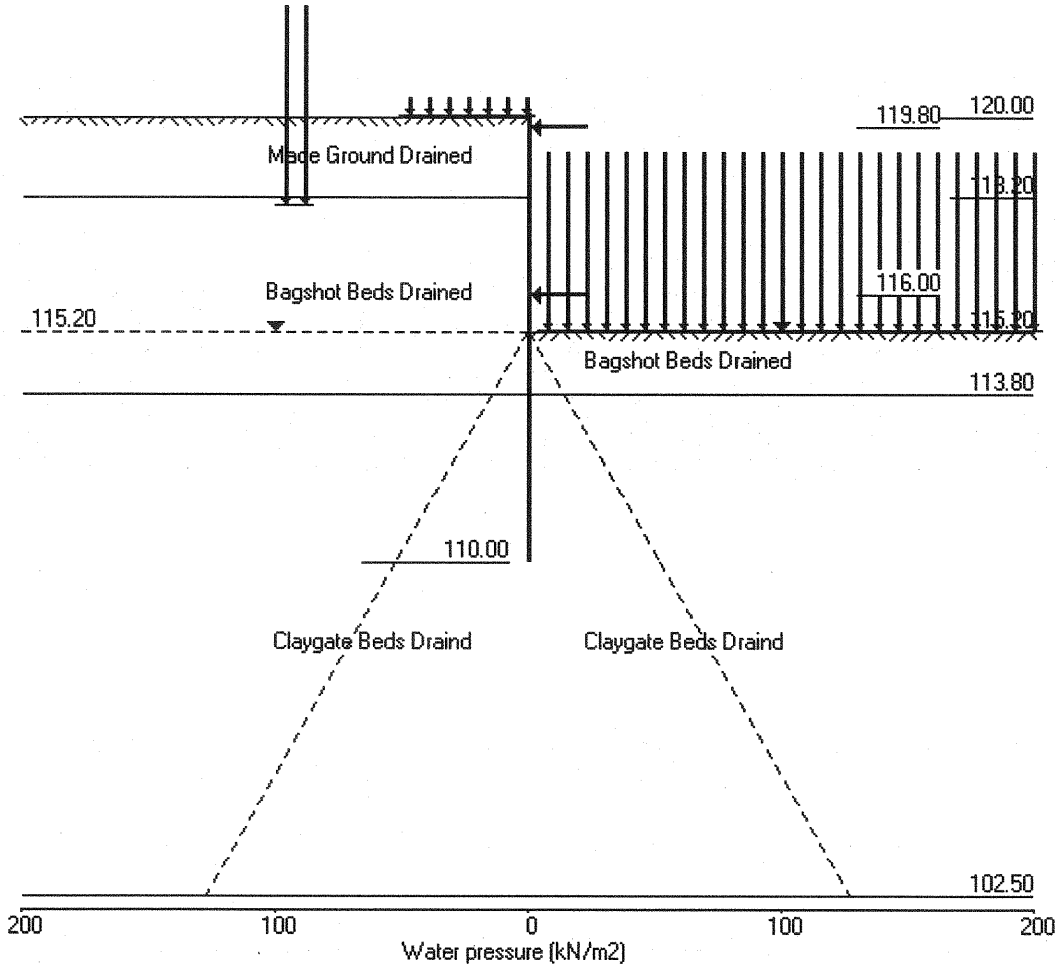
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

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. 120.00	No	No	No
2	Apply surcharge no.3 at elev. 118.00	No	No	No
3	Excav. to elev. 118.50 on PASSIVE side	Yes	Yes	Yes
4	Install strut no.1 at elev. 119.00	No	No	No
5	Excav. to elev. 115.20 on PASSIVE side	No	No	No
6	Install strut no.3 at elev. 116.00	No	No	No
7	Apply water pressure profile no.2	No	No	No
8	Install strut no.4 at elev. 119.80	No	No	No
9	Remove strut no.1 at elev. 119.00	No	No	No
10	Apply surcharge no.2 at elev. 115.20	No	No	No
11	Change soil type 1 to soil type 5	No	No	No
12	Change soil type 2 to soil type 6	No	No	No
13	Change soil type 3 to soil type 7	No	No	No
14	Change soil type 4 to soil type 8	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.14 Change soil type 4 to soil type 8



Units: kN,m

Stage No. 3 Excavate to elevation 118.50 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.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 110.00 Factor of Safety	FoS for toe elev. = 110.00 Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Toe elev. for FoS = 1.000 Wall Penetration
3	120.00	118.50	Cant.	2.328	111.28	113.79	4.71

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

Limit State: Serviceability Limit State

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

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	120.00	3.33	0.007	1.41E-03	0.0	-0.0	
2	119.80	4.46	0.006	1.41E-03	0.8	0.1	
3	119.40	6.72	0.006	1.41E-03	3.0	0.8	
4	119.00	8.94	0.005	1.40E-03	6.1	2.6	
5	118.50	11.69	0.004	1.38E-03	11.3	6.9	
6	118.20	-1.99	0.004	1.35E-03	12.8	10.6	
		8.22	0.004	1.35E-03	12.8	10.6	
7	118.00	5.69	0.004	1.32E-03	14.1	13.3	
8	117.50	-0.64	0.003	1.23E-03	15.4	20.8	
9	117.00	-6.96	0.003	1.10E-03	13.5	28.2	
10	116.50	-13.26	0.002	9.42E-04	8.5	33.8	
11	116.00	-15.49	0.002	7.53E-04	1.3	37.1	
12	115.60	-11.33	0.001	5.96E-04	-4.1	36.4	
13	115.20	-8.11	0.001	4.47E-04	-8.0	33.9	
14	114.60	-4.86	0.001	2.50E-04	-11.9	27.6	
15	114.20	-3.61	0.001	1.44E-04	-13.6	22.5	
16	113.80	-2.95	0.001	6.07E-05	-14.9	16.8	
		6.78	0.001	6.07E-05	-14.9	16.8	
17	113.30	7.21	0.001	-1.08E-05	-11.4	10.2	
18	112.80	6.66	0.001	-5.22E-05	-7.9	5.4	
19	112.20	5.27	0.001	-7.51E-05	-4.3	1.8	
20	111.60	3.53	0.001	-8.13E-05	-1.7	0.1	
21	111.00	1.69	0.001	-8.10E-05	-0.1	-0.3	
22	110.60	0.44	0.001	-8.01E-05	0.3	-0.2	
23	110.20	-0.81	0.001	-7.96E-05	0.2	-0.0	
24	110.00	-1.44	0.001	-7.96E-05	0.0	-0.0	

(continued)

Stage No.3 Excavate to elevation 118.50 on PASSIVE side

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	120.00	0.00	10.00	3.33	30.00	3.33	3.33a	2167
2	119.80	0.00	13.40	4.46	40.19	4.46	4.46a	2167
3	119.40	0.00	20.17	6.72	60.50	6.72	6.72a	2167
4	119.00	0.00	26.86	8.94	80.58	8.94	8.94a	2167
5	118.50	0.00	35.09	11.69	105.27	11.69	11.69a	2167
6	118.20	0.00	39.96	13.31	119.88	13.31	13.31a	2167
		0.00	39.96	13.32	39.96	13.32	13.32a	6933
7	118.00	0.00	43.48	14.49	43.48	14.49	14.49a	6933
8	117.50	0.00	52.25	17.42	52.25	17.42	17.42a	6933
9	117.00	0.00	61.03	20.34	61.03	20.34	20.34a	6933
10	116.50	0.00	69.89	23.30	69.89	23.30	23.30a	6933
11	116.00	0.00	78.87	26.29	78.87	26.77	26.77	6933
12	115.60	0.00	86.13	28.71	86.13	32.32	32.32	6933
13	115.20	0.00	93.46	31.15	93.46	37.46	37.46	6933
14	114.60	0.00	104.51	34.84	104.51	44.46	44.46	6933
15	114.20	0.00	111.90	37.30	111.90	48.72	48.72	6933
16	113.80	0.00	119.28	39.76	119.28	52.72	52.72	6933
		Total> 119.28	31.00m	219.28	107.65	107.65		15386
17	113.30	Total> 128.50	33.50m	228.50	117.08	117.08		15386
18	112.80	Total> 137.69	36.00m	237.69	126.06	126.06		15386
19	112.20	Total> 148.67	39.00m	248.67	136.49	136.49		15386
20	111.60	Total> 159.61	42.00m	259.61	146.75	146.75		15386
21	111.00	Total> 170.51	45.00m	270.51	156.95	156.95		15386
22	110.60	Total> 177.76	47.00m	277.76	163.74	163.74		15386
23	110.20	Total> 185.00	49.00m	285.00	170.52	170.52		15386
24	110.00	Total> 188.62	50.00m	288.62	173.91	173.91		15386

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	120.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	119.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	119.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	119.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	118.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	2669
6	118.20	0.00	5.10	1.70	15.30	15.30	15.30p	2669
		0.00	5.10	1.70	5.10	5.10	5.10p	8540
7	118.00	0.00	8.80	2.93	8.80	8.80	8.80p	8540
8	117.50	0.00	18.05	6.02	18.05	18.05	18.05p	8540
9	117.00	0.00	27.30	9.10	27.30	27.30	27.30p	8540
10	116.50	0.00	36.56	12.19	36.56	36.56	36.56p	8540
11	116.00	0.00	45.82	15.27	45.82	42.26	42.26	8540
12	115.60	0.00	53.23	17.74	53.23	43.66	43.66	8540
13	115.20	0.00	60.65	20.22	60.65	45.57	45.57	8540
14	114.60	0.00	71.78	23.93	71.78	49.32	49.32	8540
15	114.20	0.00	79.20	26.40	79.20	52.33	52.33	8540
16	113.80	0.00	86.63	28.88	86.63	55.67	55.67	8540
		Total> 86.63	23.50m	186.63	100.87	100.87		18757
17	113.30	Total> 95.93	26.00m	195.93	109.87	109.87		18757
18	112.80	Total> 105.23	28.50m	205.23	119.40	119.40		18757
19	112.20	Total> 116.40	31.50m	216.40	131.22	131.22		18757

(continued)

Stage No.3 Excavate to elevation 118.50 on PASSIVE side

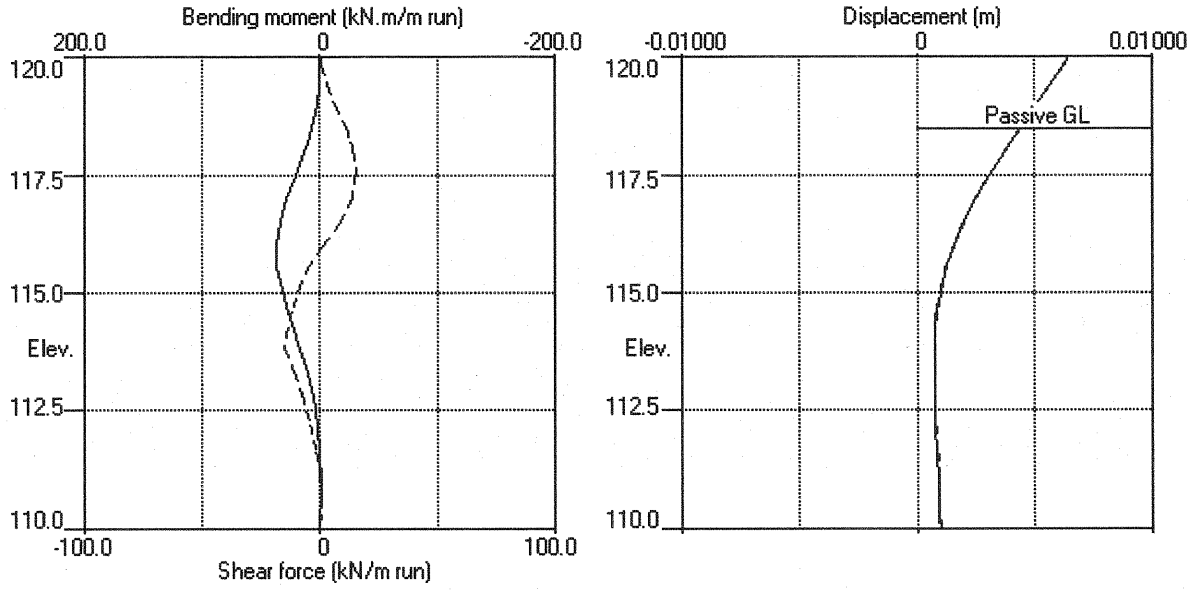
Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
20	111.60	Total>	127.59	34.50m	227.59	143.22	143.22	18757
21	111.00	Total>	138.79	37.50m	238.79	155.26	155.26	18757
22	110.60	Total>	146.26	39.50m	246.26	163.30	163.30	18757
23	110.20	Total>	153.74	41.50m	253.74	171.33	171.33	18757
24	110.00	Total>	157.48	42.50m	257.48	175.35	175.35	18757

Note: 23.30a Soil pressure at active limit
36.56p Soil pressure at passive limit

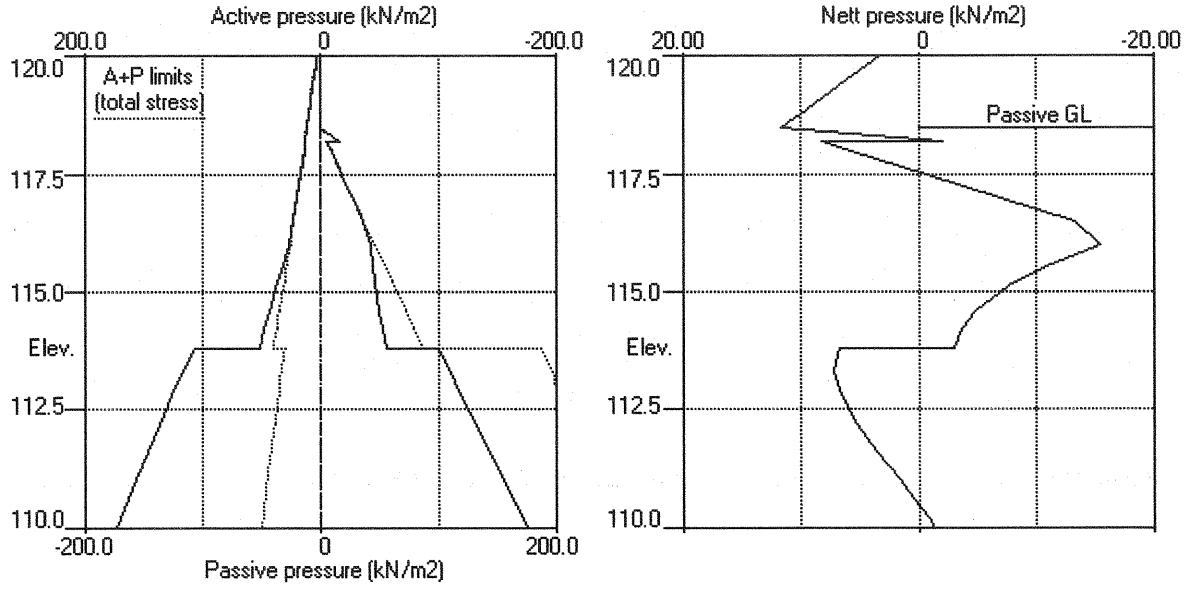
GEOTECHNICAL & ENVIRONMENTAL ASSOCIATES | Sheet No.
Program: WALLAP Version 6.05 Revision A45.B58.R48 | Job No. J13053
Licensed from GEOSOLVE | Made by : MC
Data filename/Run ID: Frognal South Wall_SLS 450 wall |
99A Frognal | Date:21-01-2014
Section B-B South Wall | Checked :

Units: kN,m

Stage No.3 Excav. to elev. 118.50 on PASSIVE side



Stage No.3 Excav. to elev. 118.50 on PASSIVE side



Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: Serviceability Limit State
All loads and soil strengths are unfactored

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. = 110.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	120.00	120.00	Cant.	9.832	111.61	119.79	0.21
2	120.00	120.00	Cant.	9.703	111.40	119.79	0.21
3	120.00	118.50	Cant.	2.328	111.28	113.79	4.71
4	120.00	118.50		No analysis at this stage			
5	120.00	115.20	119.00	2.555	n/a	113.24	1.96
6	120.00	115.20		No analysis at this stage			

All remaining stages have more than one strut - FoS calculation n/a

Units: kN,m

Summary of results

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

Limit State: Serviceability Limit State

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment Calculated		Bending moment Factored		Shear force Calculated		Shear force Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	120.00	0.007	0.000	0	-0	0	-0	0	0	0	0
2	119.80	0.006	0.000	1	0	1	0	4	-61	6	-82
3	119.40	0.006	0.000	4	-22	5	-30	10	-55	14	-74
4	119.00	0.006	0.000	9	-43	12	-58	15	-51	20	-69
5	118.50	0.007	0.000	7	-66	9	-89	11	-46	15	-62
6	118.20	0.007	0.000	11	-78	14	-105	13	-42	17	-57
7	118.00	0.007	0.000	13	-85	18	-114	14	-39	19	-53
8	117.50	0.008	0.000	21	-98	28	-133	15	-31	21	-42
9	117.00	0.008	0.000	28	-106	38	-143	14	-22	18	-30
10	116.50	0.008	0.000	34	-106	46	-143	8	-11	11	-15
11	116.00	0.008	0.000	37	-97	50	-130	26	-8	35	-11
12	115.60	0.008	0.000	36	-84	49	-114	42	-4	56	-6
13	115.20	0.008	0.000	34	-68	46	-92	59	-8	80	-11
14	114.60	0.008	0.000	28	-51	37	-69	59	-12	80	-16
15	114.20	0.007	0.000	22	-34	30	-45	60	-14	81	-18
16	113.80	0.007	0.000	20	-12	26	-16	65	-15	88	-20
17	113.30	0.006	0.000	40	-0	54	-0	32	-11	43	-15
18	112.80	0.005	0.000	46	-1	62	-1	12	-8	17	-11
19	112.20	0.005	0.000	40	-1	54	-1	0	-16	0	-21
20	111.60	0.004	-0.000	27	-0	37	-1	0	-23	0	-31
21	111.00	0.004	-0.001	13	-0	17	-0	0	-21	1	-28
22	110.60	0.003	-0.001	5	-0	7	-0	0	-15	0	-20
23	110.20	0.003	-0.002	1	-0	1	-0	0	-6	0	-8
24	110.00	0.003	-0.002	0	-0	0	-0	0	0	0	0

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Maximum and minimum bending moment and shear force at each stage

Stage	Bending moment						Shear force					
no.	Calculated				Factored		Calculated				Factored	
	max.	elev.	min.	elev.	max.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	kN/m
1	3	117.00	-0	112.20	4	-0	2	118.20	-1	113.80	3	-2
2	3	117.00	-1	112.20	5	-1	2	118.20	-2	113.80	3	-2
3	37	116.00	-0	111.00	50	-0	15	117.50	-15	113.80	21	-20
4	No calculation at this stage											
5	22	112.20	-78	116.00	29	-105	56	113.80	-51	119.00	75	-69
6	No calculation at this stage											
7	22	112.20	-75	116.00	29	-101	59	113.80	-50	119.00	79	-68
8	No calculation at this stage											
9	21	112.20	-70	117.00	28	-94	55	113.80	-43	119.80	74	-59
10	No calculation at this stage											
11	43	112.80	-96	116.50	58	-130	65	113.80	-56	119.80	88	-76
12	46	112.80	-106	116.50	62	-143	61	113.80	-61	119.80	82	-82
13	35	112.80	-105	116.50	48	-142	57	115.20	-60	119.80	76	-81
14	35	112.80	-105	116.50	48	-142	57	115.20	-60	119.80	76	-81

Maximum and minimum displacement at each stage

Stage	Displacement				Stage description
no.	maximum	elev.	minimum	elev.	
	m		m		
1	0.001	120.00	0.000	120.00	Apply surcharge no.1 at elev. 120.00
2	0.001	120.00	0.000	120.00	Apply surcharge no.3 at elev. 118.00
3	0.007	120.00	0.000	120.00	Excav. to elev. 118.50 on PASSIVE side
4	No calculation at this stage				Install strut no.1 at elev. 119.00
5	0.008	116.00	0.000	120.00	Excav. to elev. 115.20 on PASSIVE side
6	No calculation at this stage				Install strut no.3 at elev. 116.00
7	0.008	116.00	0.000	120.00	Apply water pressure profile no.2
8	No calculation at this stage				Install strut no.4 at elev. 119.80
9	0.008	116.00	0.000	120.00	Remove strut no.1 at elev. 119.00
10	No calculation at this stage				Apply surcharge no.2 at elev. 115.20
11	0.008	117.00	-0.002	110.00	Change soil type 1 to soil type 5
12	0.008	117.00	-0.002	110.00	Change soil type 2 to soil type 6
13	0.008	117.00	-0.002	110.00	Change soil type 3 to soil type 7
14	0.008	117.00	-0.002	110.00	Change soil type 4 to soil type 8

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Strut forces at each stage (horizontal components)

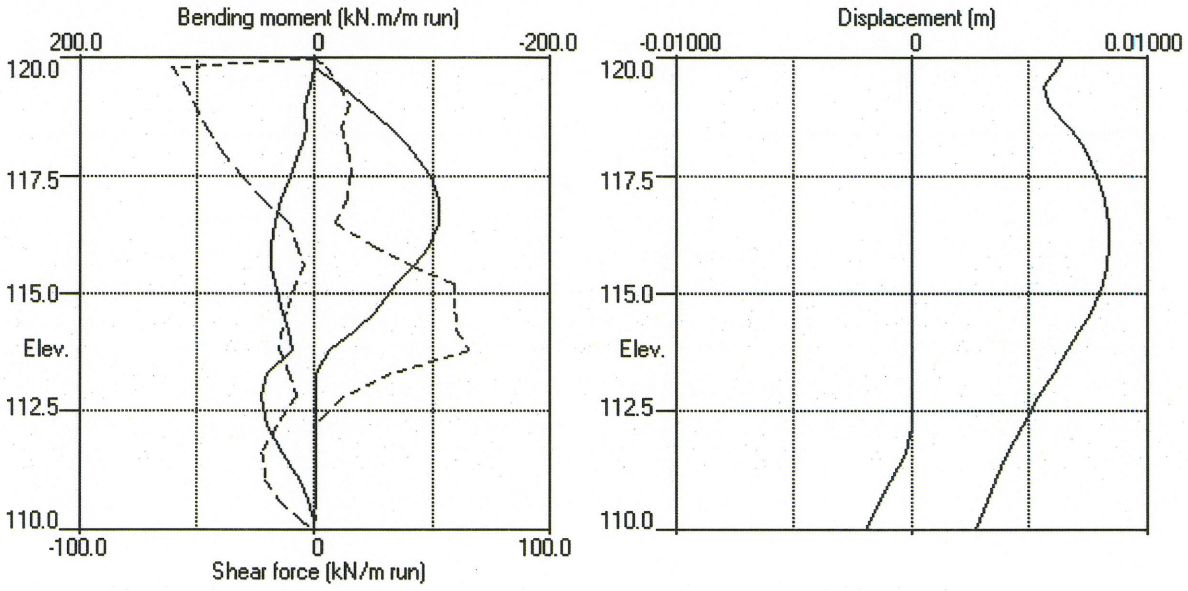
Stage no.	Strut no. 1 at elev. 119.00			Strut no. 3 at elev. 116.00			Strut no. 4 at elev. 119.80		
	--Calculated-- kN per m run	kN per strut	Factored kN per strut	--Calculated-- kN per m run	kN per strut	Factored kN per strut	--Calculated-- kN per m run	kN per strut	Factored kN per strut
5	66	197	266	---	---	---	---	---	---
7	65	195	263	5	5	7	---	---	---
9	---	---	---	27	27	37	48	48	65
11	---	---	---	slack	slack	slack	60	60	81
12	---	---	---	slack	slack	slack	65	65	88
13	---	---	---	slack	slack	slack	65	65	87
14	---	---	---	slack	slack	slack	65	65	87

* Indicates that the total force shown is the sum of the force in the strut plus a force applied at the same elevation which may represent temperature load or other forces which are part of the strut load. Force components are listed in the detailed results for individual stages.

GEOTECHNICAL & ENVIRONMENTAL ASSOCIATES | Sheet No.
Program: WALLAP Version 6.05 Revision A45.B58.R48 | Job No. J13053
Licensed from GEOSOLVE | Made by : MC
Data filename/Run ID: Frognal South Wall_SLS 450 wall |
99A Frognal | Date:21-01-2014
Section B-B South Wall | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes

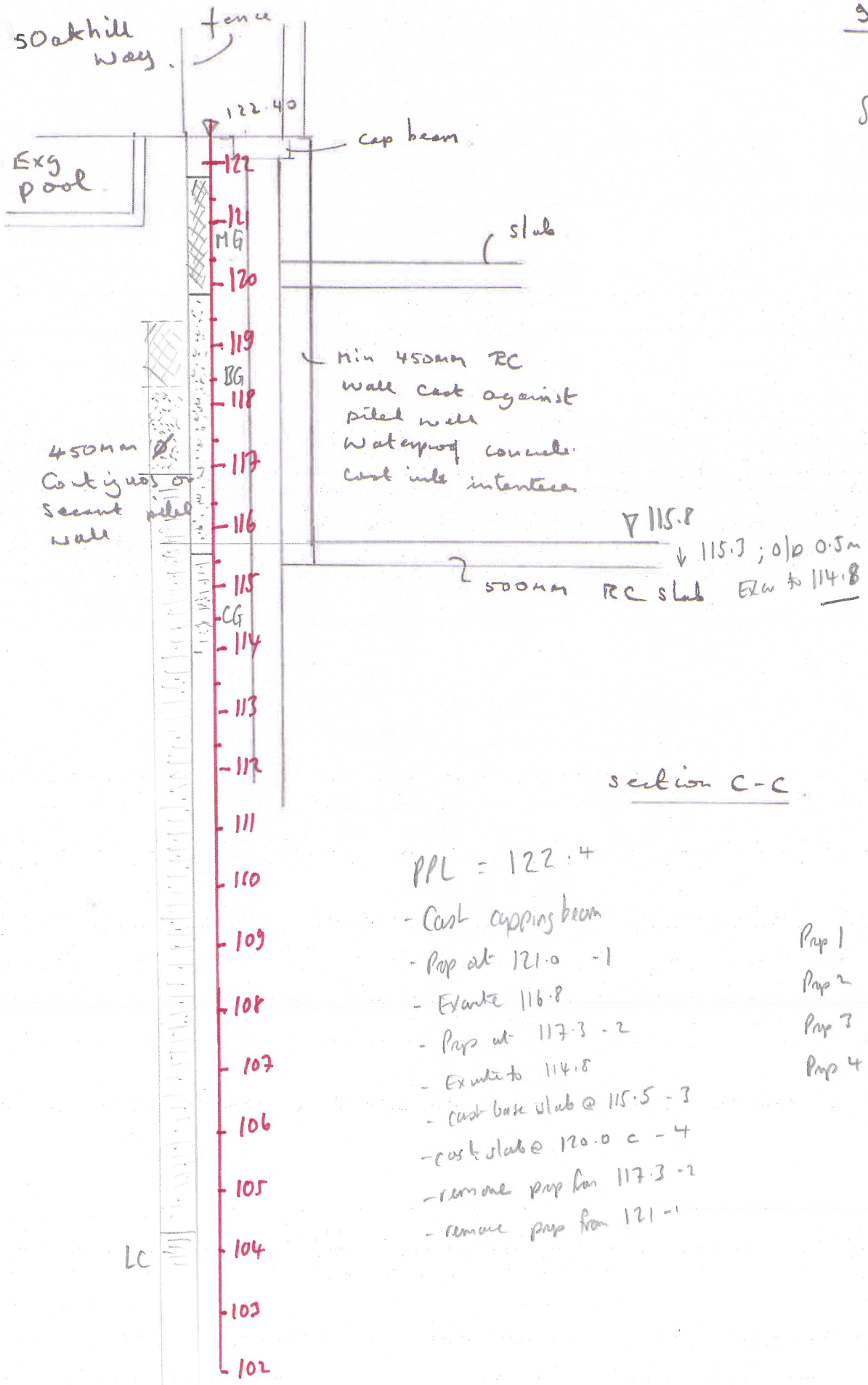


95A Frognal

14/1/14

SECTION C-C

DH 3 & 7



section C-C

PPL = 122.4

- Cast capping beam
- Prop at 121.0 -1
- Excavate 116.8
- Prop at 117.3 -2
- Excavate to 114.8
- cast base slab @ 115.5 - 3
- cast slab @ 120.0 c - 4
- remove prop from 117.3 -2
- remove prop from 121 -1

Prop 1 121.0st temp
Prop 2 117.3 st temp
Prop 3 115.5 C perm
Prop 4 120.0 c perm

Pds 12.4m 450Ø 600c/c

GEOTECHNICAL & ENVIRONMENTAL ASSOCIATES | Sheet No.
Program: WALLAP Version 6.05 Revision A45.B58.R48 | Job No. J13053
Licensed from GEOSOLVE | Made by : MC
Data filename/Run ID: Frognal North Wall_SLS 450 wall |
99A Frognal | Date:21-01-2014
Section C-C North Wall | Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	122.40	1 Made Ground	1 Made Ground
2	119.80	2 Bagshot Beds	2 Bagshot Beds
3	117.00	3 Claygate Beds	3 Claygate Beds
4	104.20	4 London Clay	4 London Clay

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	17.00	10000	0.500	OC (0.200)	0.333 (0.000)	3.000 (0.000)	
2	Bagshot Beds	18.50	32000	0.500	OC (0.200)	0.333 (0.000)	1.000 (0.000)	
3	Claygate Beds	18.50	50000	1.000	OC (0.490)	1.000 (2.000)	1.000 (1.000)	100.0u
4	London Clay	20.00	70000	1.000	OC (0.490)	1.000 (1.000)	1.000 (1.000)	150.0u
5	Made Ground Drained	17.00	10000	0.500	OC (0.200)	0.333 (0.000)	3.000 (0.000)	
6	Bagshot Beds Drained	18.50	32000	0.500	OC (0.200)	0.333 (0.000)	1.000 (0.000)	
7	Claygate Beds Draind	18.50	30000	1.000	OC (0.490)	1.000 (2.000)	1.000 (1.000)	100.0d
8	London Clay Drained	20.00	45000	1.000	OC (0.490)	1.000 (1.000)	1.000 (1.000)	150.0d

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	30.00	0.000	0.00	30.00	0.000	0.00
2	Bagshot Beds	30.00	0.000	0.00	0.00	0.000	0.00
3	Claygate Beds	0.00	0.000	0.00	0.00	-0.674	0.00
4	London Clay	0.00	-0.674	0.00	0.00	-0.674	0.00
5	Made Ground Drained	30.00	0.000	0.00	30.00	0.000	0.00
6	Bagshot Beds Drained	30.00	0.000	0.00	0.00	0.000	0.00
7	Claygate Beds Draind	0.00	0.000	0.00	0.00	-0.674	0.00
8	London Clay Drained	0.00	-0.674	0.00	0.00	-0.674	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	110.20	110.20

Automatic water pressure balancing at toe of wall : No

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	110.20	110.20	0.0	1	110.20	110.20	0.0	WC
2	1	113.60	113.60	0.0	1	113.60	113.60	0.0	MC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 110.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.8000E+07 kN/m2
Moment of inertia of wall I = 3.3550E-03 m4/m run
E.I = 93940 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	121.00	3.00	0.010000	2.000E+08	4.00	0.00	0	No
2	117.30	3.00	0.010000	2.000E+08	4.00	0.00	0	No
3	115.50	1.00	0.500000	3.000E+07	1.00	0.00	0	No
4	120.00	1.00	0.250000	3.000E+07	1.00	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	122.40	0.00(A)	20.00	3.00	10.00	=	N/A	1.00 -
2	114.80	-0.00(P)	20.00	20.00	160.00	145.00	N/A	1.00 -

Note: A = Active side, P = Passive side
A trapezoidal surcharge is defined by two values:
N = at edge near to wall, F = at edge far from wall
Limit State Categories P/U = Permanent Unfavourable
P/F = Permanent Favourable
Var = Variable (unfavourable)

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 122.40 No analysis at this stage
2	Excavate to elevation 120.50 on PASSIVE side
3	Install strut or anchor no.1 at elevation 121.00
4	Excavate to elevation 116.80 on PASSIVE side
5	Install strut or anchor no.2 at elevation 117.30
6	Excavate to elevation 114.80 on PASSIVE side
7	Apply water pressure profile no.2 (Mod. Conserv.)
8	Install strut or anchor no.3 at elevation 115.50
9	Install strut or anchor no.4 at elevation 120.00
10	Remove strut or anchor no.2 at elevation 117.30
11	Remove strut or anchor no.1 at elevation 121.00
12	Apply surcharge no.2 at elevation 114.80 No analysis at this stage
13	Change properties of soil type 1 to soil type 5 Ko pressures will be reset
14	Change properties of soil type 2 to soil type 6 Ko pressures will be reset
15	Change properties of soil type 3 to soil type 7 Ko pressures will be reset
16	Change properties of soil type 4 to soil type 8 Ko pressures will be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: Serviceability Limit State
All loads and soil strengths are unfactored

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) = 0 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

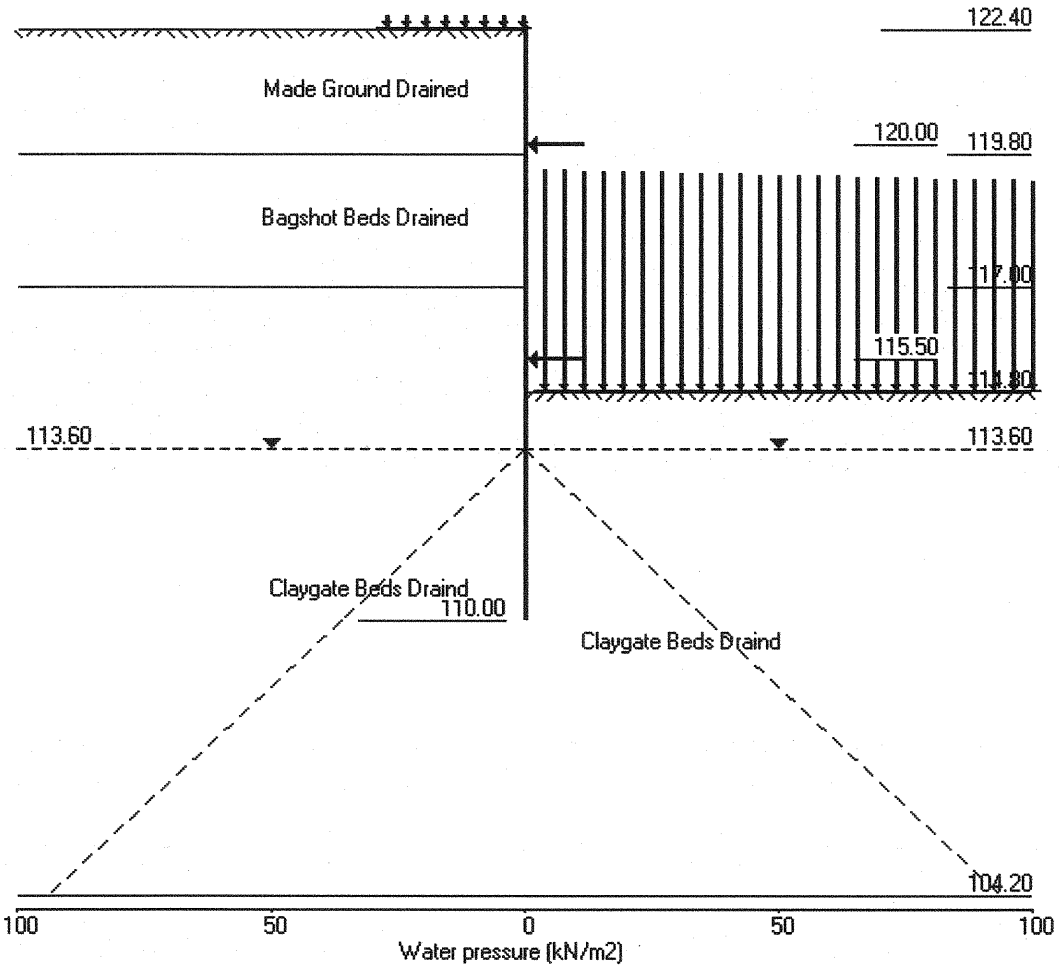
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 20.00 m

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. 122.40	No	No	No
2	Excav. to elev. 120.50 on PASSIVE side	Yes	Yes	Yes
3	Install strut no.1 at elev. 121.00	No	No	No
4	Excav. to elev. 116.80 on PASSIVE side	No	No	No
5	Install strut no.2 at elev. 117.30	No	No	No
6	Excav. to elev. 114.80 on PASSIVE side	No	No	No
7	Apply water pressure profile no.2	No	No	No
8	Install strut no.3 at elev. 115.50	No	No	No
9	Install strut no.4 at elev. 120.00	No	No	No
10	Remove strut no.2 at elev. 117.30	No	No	No
11	Remove strut no.1 at elev. 121.00	No	No	No
12	Apply surcharge no.2 at elev. 114.80	No	No	No
13	Change soil type 1 to soil type 5	No	No	No
14	Change soil type 2 to soil type 6	No	No	No
15	Change soil type 3 to soil type 7	No	No	No
16	Change soil type 4 to soil type 8	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.16 Change soil type 4 to soil type 8



Units: kN,m

Stage No. 2 Excavate to elevation 120.50 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.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 110.00 Factor of Safety	FoS for toe elev. = 110.00 Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Toe elev. for FoS = 1.000 Wall Penetr-ation
2	122.40	120.50	Cant.	3.253	111.62	115.80	4.70

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

Limit State: Serviceability Limit State

Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

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	122.40	3.33	0.011	2.20E-03	0.0	0.0	
2	121.80	6.72	0.010	2.20E-03	3.0	0.9	
3	121.40	8.94	0.009	2.19E-03	6.1	2.7	
4	121.00	11.14	0.008	2.17E-03	10.2	5.9	
5	120.50	13.84	0.007	2.12E-03	16.4	12.5	
6	120.00	-8.99	0.006	2.03E-03	17.6	21.5	
7	119.80	-10.54	0.006	1.98E-03	15.7	24.9	
		5.69	0.006	1.98E-03	15.7	24.9	
8	119.30	-0.66	0.005	1.83E-03	16.9	33.2	
9	118.80	-7.01	0.004	1.63E-03	15.0	41.3	
10	118.20	-14.63	0.003	1.34E-03	8.5	48.5	
11	117.75	-20.34	0.002	1.11E-03	0.7	50.7	
12	117.30	-16.76	0.002	8.70E-04	-7.7	49.8	
13	117.00	-13.33	0.002	7.16E-04	-12.2	46.8	
		-13.99	0.002	7.16E-04	-12.2	46.8	
14	116.80	-9.82	0.001	6.19E-04	-14.6	44.0	
15	116.48	-4.30	0.001	4.76E-04	-16.9	38.8	
16	116.15	-0.18	0.001	3.52E-04	-17.6	33.1	
17	115.83	2.73	0.001	2.47E-04	-17.2	27.3	
18	115.50	4.64	0.001	1.62E-04	-16.0	21.9	
19	115.15	5.82	0.001	9.12E-05	-14.2	16.6	
20	114.80	6.29	0.001	3.80E-05	-12.0	12.0	
21	114.20	6.00	0.001	-1.87E-05	-8.4	5.8	
22	113.60	4.96	0.001	-4.34E-05	-5.1	1.9	
23	113.20	4.09	0.001	-4.80E-05	-3.3	0.3	
24	112.80	3.21	0.001	-4.69E-05	-1.8	-0.7	
25	112.20	1.97	0.001	-4.06E-05	-0.2	-1.3	
26	111.60	0.87	0.001	-3.32E-05	0.6	-1.1	
27	111.00	-0.10	0.001	-2.80E-05	0.8	-0.6	
28	110.60	-0.70	0.001	-2.63E-05	0.7	-0.2	

(continued)

Stage No.2 Excavate to elevation 120.50 on PASSIVE side

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
29	110.20	-1.28	0.001	-2.57E-05	0.3	-0.0	
30	110.00	-1.57	0.001	-2.57E-05	0.0	-0.0	

ACTIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	122.40	0.00	10.00	3.33	30.00	3.33	3.33a	2029
2	121.80	0.00	20.17	6.72	60.50	6.72	6.72a	2029
3	121.40	0.00	26.86	8.94	80.58	8.94	8.94a	2029
4	121.00	0.00	33.46	11.14	100.37	11.14	11.14a	2029
5	120.50	0.00	41.57	13.84	124.72	13.84	13.84a	2029
6	120.00	0.00	49.59	16.51	148.78	16.51	16.51a	2029
7	119.80	0.00	52.78	17.58	158.35	17.58	17.58a	2029
		0.00	52.78	17.59	52.78	17.59	17.59a	6492
8	119.30	0.00	61.49	20.50	61.49	20.50	20.50a	6492
9	118.80	0.00	70.20	23.40	70.20	23.40	23.40a	6492
10	118.20	0.00	80.68	26.89	80.68	26.89	26.89a	6492
11	117.75	0.00	88.57	29.52	88.57	29.52	29.52a	6492
12	117.30	0.00	96.49	32.16	96.49	35.02	35.02	6492
13	117.00	0.00	101.79	33.93	101.79	39.28	39.28	6492
		Total>	101.79	27.00m	201.79	78.91	78.91	14462
14	116.80	Total>	105.33	28.00m	205.33	84.39	84.39	14462
15	116.48	Total>	111.09	29.62m	211.09	92.73	92.73	14462
16	116.15	Total>	116.86	31.25m	216.86	100.46	100.46	14462
17	115.83	Total>	122.65	32.87m	222.65	107.66	107.66	14462
18	115.50	Total>	128.45	34.50m	228.45	114.43	114.43	14462
19	115.15	Total>	134.71	36.25m	234.71	121.33	121.33	14462
20	114.80	Total>	140.98	38.00m	240.98	127.94	127.94	14462
21	114.20	Total>	151.76	41.00m	251.76	138.79	138.79	14462
22	113.60	Total>	162.58	44.00m	262.58	149.32	149.32	14462
23	113.20	Total>	169.80	46.00m	269.80	156.29	156.29	14462
24	112.80	Total>	177.03	48.00m	277.03	163.25	163.25	14462
25	112.20	Total>	187.90	51.00m	287.90	173.75	173.75	14462
26	111.60	Total>	198.79	54.00m	298.79	184.33	184.33	14462
27	111.00	Total>	209.70	57.00m	309.70	194.99	194.99	14462
28	110.60	Total>	216.98	59.00m	316.98	202.12	202.12	14462
29	110.20	Total>	224.27	61.00m	324.27	209.26	209.26	14462
30	110.00	Total>	227.92	62.00m	327.92	212.84	212.84	14462

PASSIVE side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	122.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	121.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	121.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	121.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	120.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	0.00	0.00	0.00	2581
6	120.00	0.00	8.50	2.83	25.50	25.50	25.50p	2581
7	119.80	0.00	11.90	3.96	35.70	28.11	28.11	2581
		0.00	11.90	3.97	11.90	11.90	11.90p	8260
8	119.30	0.00	21.15	7.05	21.15	21.15	21.15p	8260

(continued)

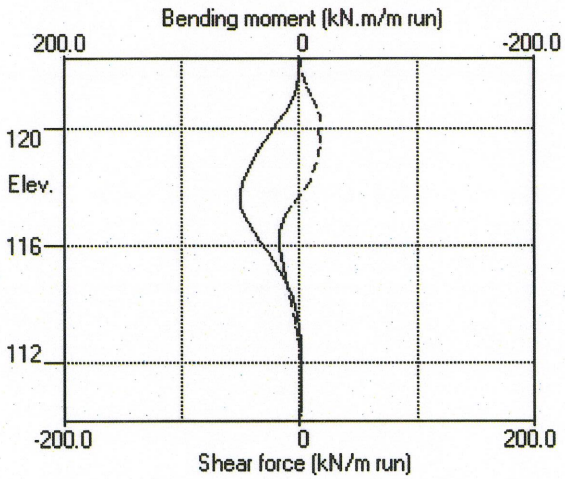
Stage No.2 Excavate to elevation 120.50 on PASSIVE side

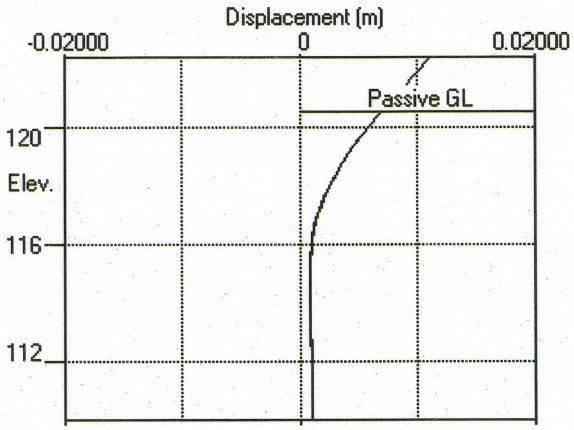
Node no.	Y coord	PASSIVE side						
		Effective stresses					Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
9	118.80	0.00	30.41	10.14	30.41	30.41	30.41p	8260
10	118.20	0.00	41.52	13.84	41.52	41.52	41.52p	8260
11	117.75	0.00	49.86	16.62	49.86	49.86	49.86p	8260
12	117.30	0.00	58.20	19.40	58.20	51.78	51.78	8260
13	117.00	0.00	63.77	21.26	63.77	52.60	52.60	8260
		Total>	63.77	17.50m	163.77	92.90	92.90	18168
14	116.80	Total>	67.48	18.50m	167.48	94.20	94.20	18168
15	116.48	Total>	73.52	20.12m	173.52	97.03	97.03	18168
16	116.15	Total>	79.56	21.75m	179.56	100.64	100.64	18168
17	115.83	Total>	85.60	23.37m	185.60	104.94	104.94	18168
18	115.50	Total>	91.65	25.00m	191.65	109.79	109.79	18168
19	115.15	Total>	98.17	26.75m	198.17	115.52	115.52	18168
20	114.80	Total>	104.69	28.50m	204.69	121.64	121.64	18168
21	114.20	Total>	115.88	31.50m	215.88	132.78	132.78	18168
22	113.60	Total>	127.09	34.50m	227.09	144.37	144.37	18168
23	113.20	Total>	134.57	36.50m	234.57	152.19	152.19	18168
24	112.80	Total>	142.06	38.50m	242.06	160.04	160.04	18168
25	112.20	Total>	153.31	41.50m	253.31	171.78	171.78	18168
26	111.60	Total>	164.57	44.50m	264.57	183.46	183.46	18168
27	111.00	Total>	175.85	47.50m	275.85	195.08	195.08	18168
28	110.60	Total>	183.38	49.50m	283.38	202.82	202.82	18168
29	110.20	Total>	190.91	51.50m	290.91	210.55	210.55	18168
30	110.00	Total>	194.68	52.50m	294.68	214.41	214.41	18168

Note: 29.52a Soil pressure at active limit
49.86p Soil pressure at passive limit

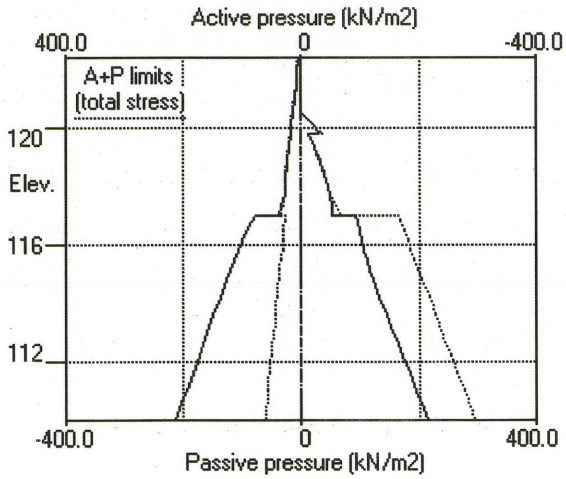
Units: kN,m

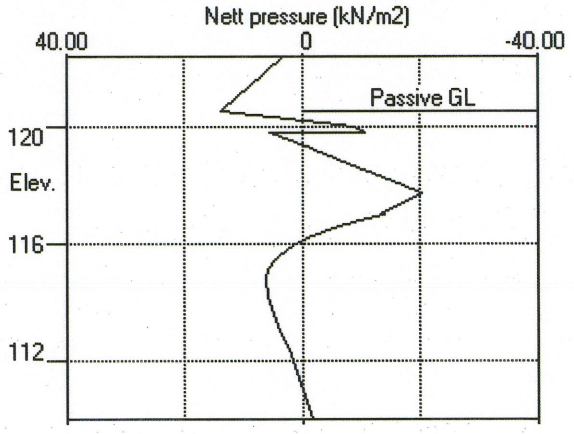
Stage No.2 Excav. to elev. 120.50 on PASSIVE side





Stage No.2 Excav. to elev. 120.50 on PASSIVE side





Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: Serviceability Limit State
All loads and soil strengths are unfactored

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. = 110.00 Factor of Safety	Moment equilib. at elev.	Toe FoS = 1.000 Toe elev.	Wall Penetr -ation
1	122.40	122.40	Cant.	Conditions not suitable for FoS calc.			
2	122.40	120.50	Cant.	3.253	111.62	115.80	4.70
3	122.40	120.50		No analysis at this stage			
4	122.40	116.80	121.00	2.706	n/a	116.15	0.65
5	122.40	116.80		No analysis at this stage			

All remaining stages have more than one strut - FoS calculation n/a

Units: kN,m

Summary of results

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

Limit State: Serviceability Limit State

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment Calculated		Bending moment Factored		Shear force Calculated		Shear force Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	122.40	0.011	0.000	0	0	0	0	0	0	0	0
2	121.80	0.010	0.000	5	0	7	0	15	0	20	0
3	121.40	0.009	0.000	13	0	17	0	22	0	30	0
4	121.00	0.008	0.000	23	0	31	0	30	-47	40	-63
5	120.50	0.009	0.000	41	-4	55	-6	40	-41	55	-55
6	120.00	0.009	0.000	64	-23	86	-30	52	-116	71	-157
7	119.80	0.009	0.000	41	-29	56	-39	16	-111	21	-150
8	119.30	0.010	0.000	33	-41	45	-56	17	-98	23	-132
9	118.80	0.011	0.000	41	-56	56	-76	15	-83	20	-112
10	118.20	0.011	0.000	49	-100	65	-135	23	-64	31	-86
11	117.75	0.012	0.000	51	-125	68	-169	36	-48	48	-65
12	117.30	0.012	0.000	50	-142	67	-192	50	-68	67	-92
13	117.00	0.012	0.000	47	-150	63	-202	42	-58	57	-79
14	116.80	0.012	0.000	44	-152	59	-205	50	-53	67	-71
15	116.48	0.011	0.000	39	-147	52	-198	36	-43	49	-58
16	116.15	0.011	0.000	33	-131	45	-176	66	-31	90	-41
17	115.83	0.010	0.000	27	-103	37	-140	103	-17	138	-23
18	115.50	0.009	0.000	22	-69	30	-94	141	-24	190	-32
19	115.15	0.009	0.000	25	-47	33	-63	90	-14	122	-19
20	114.80	0.009	0.000	25	-28	34	-38	122	-12	164	-16
21	114.20	0.009	0.000	46	-9	62	-12	65	-8	88	-11
22	113.60	0.008	0.000	66	-0	89	-0	25	-7	33	-10
23	113.20	0.008	0.000	68	-0	91	-0	8	-8	10	-10
24	112.80	0.008	0.000	65	-1	88	-1	3	-17	4	-23
25	112.20	0.007	0.000	52	-1	70	-2	0	-28	0	-37
26	111.60	0.007	-0.000	33	-1	45	-1	1	-30	1	-41
27	111.00	0.007	-0.001	15	-1	20	-1	1	-26	1	-35
28	110.60	0.007	-0.001	6	-0	8	-0	1	-18	1	-24
29	110.20	0.007	-0.002	1	-0	1	-0	0	-7	0	-9
30	110.00	0.007	-0.002	0	-0	0	-0	0	0	0	0

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Maximum and minimum bending moment and shear force at each stage

Stage	Bending moment						Shear force					
no.	Calculated				Factored		Calculated				Factored	
	max.	elev.	min.	elev.	max.	min.	max.	elev.	min.	elev.	max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	kN/m
1	4	118.80	-0	113.60	5	-0	2	119.80	-2	117.00	2	-2
2	51	117.75	-1	112.20	68	-2	18	120.00	-18	116.15	24	-24
3	No calculation at this stage											
4	25	114.80	-50	118.20	34	-67	50	116.80	-47	121.00	67	-63
5	No calculation at this stage											
6	27	117.30	-41	115.50	37	-55	50	117.30	-68	117.30	67	-92
7	27	117.30	-41	115.50	37	-55	50	117.30	-68	117.30	67	-92
8	No calculation at this stage											
9	No calculation at this stage											
10	31	120.00	-53	117.30	42	-72	68	115.50	-61	120.00	91	-83
11	45	120.00	-51	117.30	60	-69	65	115.50	-66	120.00	88	-89
12	No calculation at this stage											
13	63	113.20	-100	116.80	86	-135	118	114.80	-86	120.00	159	-116
14	68	113.20	-112	117.00	91	-151	122	114.80	-104	120.00	164	-141
15	67	113.20	-152	116.80	91	-205	141	115.50	-116	120.00	190	-157
16	67	113.20	-152	116.80	91	-205	141	115.50	-116	120.00	190	-157

Maximum and minimum displacement at each stage

Stage	Displacement				Stage description
no.	maximum	elev.	minimum	elev.	
	m		m		
1	0.001	122.40	0.000	122.40	Apply surcharge no.1 at elev. 122.40
2	0.011	122.40	0.000	122.40	Excav. to elev. 120.50 on PASSIVE side
3	No calculation at this stage				Install strut no.1 at elev. 121.00
4	0.009	119.30	0.000	122.40	Excav. to elev. 116.80 on PASSIVE side
5	No calculation at this stage				Install strut no.2 at elev. 117.30
6	0.009	115.83	0.000	122.40	Excav. to elev. 114.80 on PASSIVE side
7	0.009	115.83	0.000	122.40	Apply water pressure profile no.2
8	No calculation at this stage				Install strut no.3 at elev. 115.50
9	No calculation at this stage				Install strut no.4 at elev. 120.00
10	0.010	117.30	0.000	122.40	Remove strut no.2 at elev. 117.30
11	0.010	117.30	0.000	122.40	Remove strut no.1 at elev. 121.00
12	No calculation at this stage				Apply surcharge no.2 at elev. 114.80
13	0.010	117.75	-0.001	110.00	Change soil type 1 to soil type 5
14	0.011	117.75	-0.001	110.00	Change soil type 2 to soil type 6
15	0.012	117.30	-0.002	110.00	Change soil type 3 to soil type 7
16	0.012	117.30	-0.002	110.00	Change soil type 4 to soil type 8

Summary of results (continued)

Calculated Bending Moments and Strut Forces have been multiplied by a factor of 1.35 to obtain values for structural design.

Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 121.00			Strut no. 2 at elev. 117.30			Strut no. 3 at elev. 115.50		
	--Calculated-- kN per m run	kN per strut	Factored kN per strut	--Calculated-- kN per m run	kN per strut	Factored kN per strut	--Calculated-- kN per m run	kN per strut	Factored kN per strut
4	68	205	277	---	---	---	---	---	---
6	53	160	216	118	353	477	---	---	---
7	53	160	216	118	353	477	---	---	---
10	17	50	67	---	---	---	92	92	124
11	---	---	---	---	---	---	88	88	119
13	---	---	---	---	---	---	slack	slack	slack
14	---	---	---	---	---	---	slack	slack	slack
15	---	---	---	---	---	---	112	112	151
16	---	---	---	---	---	---	112	112	151

Stage no.	Strut no. 4 at elev. 120.00		
	--Calculated-- kN per m run	kN per strut	Factored kN per strut
10	82	82	111
11	101	101	136
13	130	130	176
14	151	151	204
15	168	168	227
16	168	168	227

* Indicates that the total force shown is the sum of the force in the strut plus a force applied at the same elevation which may represent temperature load or other forces which are part of the strut load. Force components are listed in the detailed results for individual stages.

GEOTECHNICAL & ENVIRONMENTAL ASSOCIATES | Sheet No.
Program: WALLAP Version 6.05 Revision A45.B58.R48 | Job No. J13053
Licensed from GEOSOLVE | Made by : MC
Data filename/Run ID: Frognal North Wall_SLS 450 wall |
99A Frognal | Date:21-01-2014
Section C-C North Wall | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes