

COMBI-GYRO WALL SYSTEM

- High Modulus Steel Combined Wall -

Design Case Study (Tube / Z Wall)

APPENDICES

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APPENDIX A

APPENDIX A-1. Design Summary of Combi-Giro Wall System (Pattern A) (Rev.3)

Characteristic and Design Soil Properties

Strata	Elevation (top of strata mAOD)	Thickness (m)	Unit weight (kN/m ³)	Angle of Shearing resistance ϕ' peak (Deg.)	Effective cohesion (kN/m ²)	Undrained shear strength (kN/m ²)	Drained Stiffness E' (MN/m ²)	Undrained Stiffness E' (MN/m ²)	Drained Poisson's ratio, ν	Undrained Poisson's ratio ν_u	K_0	Coefficient of permeability, K (m/s)	Dilatancy angle for drained analysis, ψ (Deg.)	Wall friction factor, k	Wall adhesion factor, α
Made Ground	10.0	5.0	18	30	0	-	15	-	0.30	-	0.50	10^{-5}	0	0.67	-
River Terrace Deposits	5.0	5.0	19	35	0	-	50	-	0.30	-	0.43	10^{-5}	5	0.67	-
London Clay	0.0	40.0	20	20	10	100 + 7z	80 + 5.6z	100 + 7z	0.20	0.49	1.50	10^{-10}	12.5	0.50	ignor ed

Partial Factors (BS EN 1997-1:2004)

Design Approach 1				Combination 1			Combination 2		
				Set			Set		
				A1	M1	R1	A2	M2	R1
Actions	Permanent	Unfavourable	γ_G	1.35			1		
		Favourable	$\gamma_{G,fav}$	1			1		
	Variable	Unfavourable	γ_Q	1.5			1.3		
		Favourable	$\gamma_{Q,fav}$	0			0		
Material Properties	Angle of shearing resistance	$\gamma_{\phi'}$			1			1.25	
	Effective cohesion	γ_c			1			1.25	
	Undrained shear strength	γ_{cu}			1			1.4	
	Unconfined strength	γ_{qu}			1			1.4	
	Weight density	γ_v			1			1	

Ground Levels and Groundwater Levels

Design case	Active side (mAOD)	Passive side (mAOD)
Design Ground Level (ULS)	10.0	4.0
Design Ground Level (SLS)	10.0	4.5
Design Groundwater Level (ULS)	5.0	3.0
Design Groundwater Level (SLS)	4.0	3.0

Surcharge loading

UDL (kN/m ²)	Extent
10.0	0.5m to 20m behind the wall

Wall Type / Section

Section	Grade	Young's modulus, E (GPa)	Length (m)	Head level (mAOD)	Toe level (mAOD)	Support	Spacing (m)	Elastic section modulus (cm ³ /m)	Moment of inertia (m ⁴ /m)	Wall stiffness, EI (kNm ² /m)
CHS (1000mm dia./ 16mm thick)	S390 GP	210	15.0	10.0	-5.0	Cantilever	2.8	4277	$2.139 \cdot 10^{-3}$	449098
AZ 28-700N	S390 GP	210	11.0	10.0	-1.0	Cantilever	-	2765	$0.637 \cdot 10^{-3}$	133770
Tubular / SSP system								7042	$2.776 \cdot 10^{-3}$	582868

Design Basis

Analysis	Approach	Factor set	Soil strength	Soil stiffness	Overdig	Surcharge	Resulting BM & SF
Serviceability	SLS	Unfactored	Unfactored	Unfactored	-	Unfactored	Unfactored
STR: ULS	DA1 - C1	A1, M1, R1	Unfactored	Unfactored	0.5m	Set A1 $\gamma_G/\gamma_Q = 1.11$	Set A1 $\gamma_G = 1.35$
GEO: ULS	DA1 - C2	A2, M2, R1	Set M2	$\frac{1}{2} E'$ or $\frac{1}{2} E_u$	0.5m	Set A2 $\gamma_Q = 1.3$	Set A2 $\gamma_G = 1.0$

Results

Serviceability [SLS] Wall Deflection: 26mm @ 10.00m AOD
Structural Forces [STR: ULS Design Approach 1 - Combination 1] Maximum bending moment (BM) - Calculated BM_c: 326 kNm/m @ 1.60m AOD - Design $BM_d = BM_c \cdot \gamma_G = 326 \cdot 1.35 = 440$ kNm/m - Minimum required section modulus = $BM_d \cdot 10^3 / f_y = 440 \cdot 10^3 / 390 = 1128$ cm³/m - Degree of utilisation = $1128 / 4277 = 26.4\%$ [$< 100\%$, OK] Maximum shear force - Calculated SF_c: 94 kN/m @ 4.00m AOD - Design $SF_d = BM_c \cdot \gamma_G = 94 \cdot 1.35 = 127$ kN/m
Wall Stability [GEO: ULS Design Approach 1 - Combination 2] Factor of safety: 1.09 [> 1 , OK]

Durability

- Durability check not undertaken for temporary works design

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Active side	Passive side
1	10.00	1 Made Ground	1 Made Ground
2	5.00	2 Terrace Gravel	2 Terrace Gravel
3	0.00	3 London Clay (Und)	3 London Clay (Und)

SOIL PROPERTIES

No.	Description	Bulk density kN/m3	Young's Modulus Eh,kN/m2	At rest coeff. Ko	Consol. state NC/OC	Active limit Ka	Passive limit Kp	Cohesion kN/m2
1	Made Ground	17.00a	10000	0.500	OC	0.283	4.696	
		18.00b		(0.300)	(0.000)	(0.000)		
2	Terrace Gravel	18.00a	50000	0.430	OC	0.227	6.670	
		19.00b		(0.300)	(0.000)	(0.000)		
3	London Cl..	20.00	100000	1.500	OC	1.000	1.000	100.0u
	(0.00)	(7000)		(0.490)	(2.000)	(2.000)	(7.000)	
4	London Cl..	20.00	80000	1.500	OC	0.444	2.488	10.00d
	(0.00)	(5600)		(0.200)	(1.529)	(4.088)		

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

Additional soil parameters associated with Ka and Kp

No.	Description	--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction angle	Wall adhesion coeff.	Backfill angle	Soil friction angle	Wall adhesion coeff.	Backfill angle
1	Made Ground	30.00	0.667	0.00	30.00	0.667	0.00
2	Terrace Gravel	35.00	0.667	0.00	35.00	0.667	0.00
3	London Clay (Und)	0.00	0.000	0.00	0.00	0.000	0.00
4	London Clay (Dra)	20.00	0.500	0.00	20.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 9.807 kN/m3

	Active side	Passive side
Initial water table elevation	3.00	3.00

Automatic water pressure balancing at toe of wall : No

Active side					Passive side				
Water profile	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Water profile	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
	1	4.00	4.00	0.0		1	3.00	3.00	0.0 MC
	2	5.00	5.00	0.0		1	3.00	3.00	0.0 WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = -5.00
 Maximum finite element length = 0.80 m
 Youngs modulus of wall E = 2.1000E+08 kN/m2
 Moment of inertia of wall I = 2.1386E-03 m4/m run
 E.I = 449098 kN.m2/m run
 Yield Moment of wall = Not defined

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

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. Partial soil factor/ type Category
1	10.00	0.50 (A)	1000.00	20.00	10.00	=	N/A 1.00 Var

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	Change EI of wall to 582868 kN.m2/m run From elevation 10.00 to -1.00 Yield moment not defined Reset wall displacements to zero at this stage
2	Apply surcharge no.1 at elevation 10.00
3	Excavate to elevation 4.50 on PASSIVE side
4	Apply water pressure profile no.1 (Mod. Conserv.)
5	Change properties of soil type 3 to soil type 4 Ko pressures will not 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

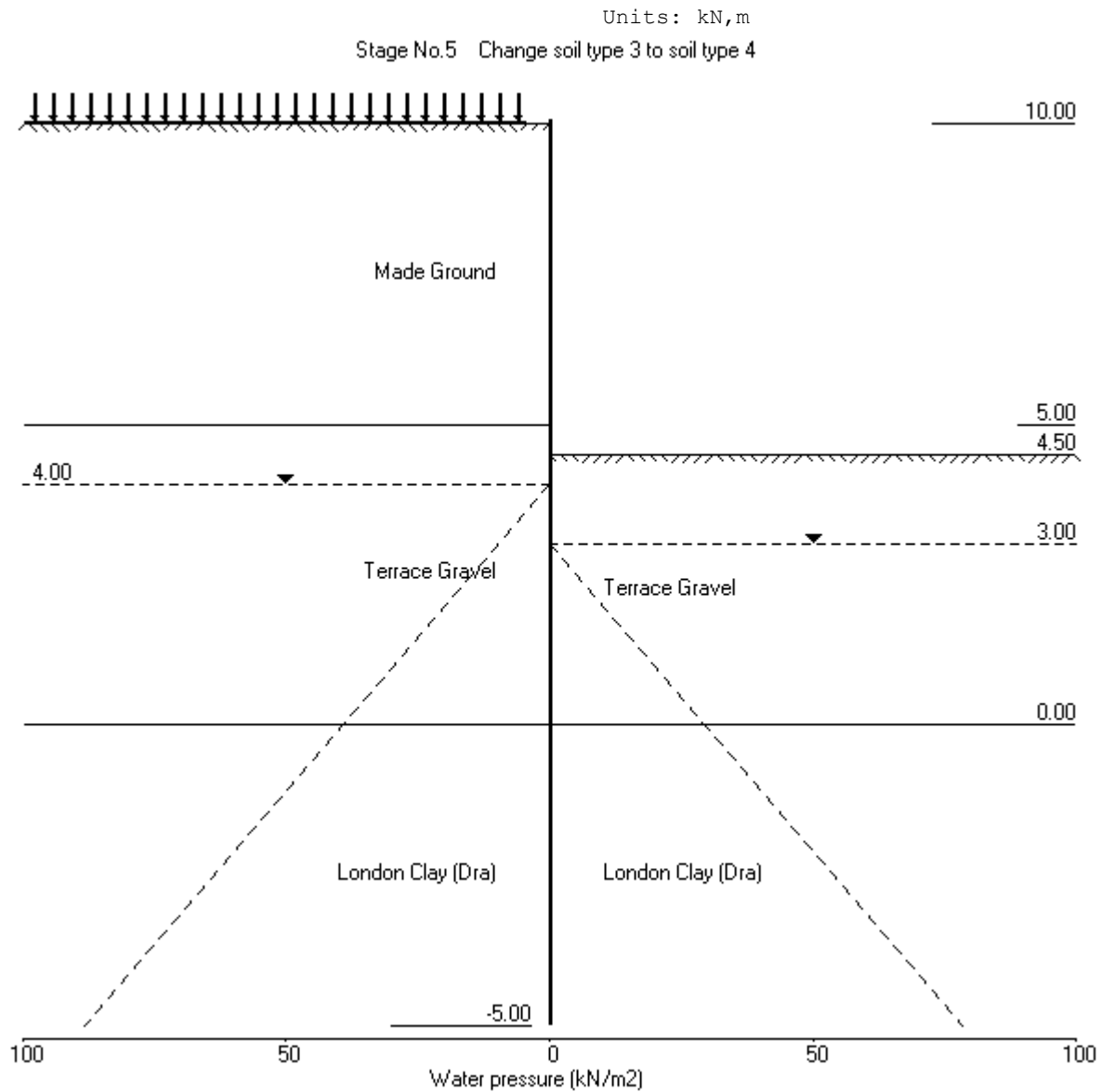
OUTPUT OPTIONS

Stage no.	Stage description	Output options -----		
		Displacement	Active, Graph.	
		Bending mom.	Passive output	
		Shear force	pressures	
1	Change EI of wall to 582868kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 10.00	No	No	No
3	Excav. to elev. 4.50 on PASSIVE side	Yes	Yes	Yes
4	Apply water pressure profile no.1	Yes	Yes	Yes
5	Change soil type 3 to soil type 4	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :



APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 4.50 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

			FoS for toe	Toe elev. for
			elev. = -5.00	FoS = 1.000

Stage	--- G.L. ---	Strut	Factor	Moment
No.	Act. Pass.	Elev.	of	equilib.
			Safety	at elev.
3	10.00 4.50	Cant.	1.874	-3.66
				Toe Wall
				elev. Penetr
				-ation
				1.17 3.33

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.

*** Wall displacements reset to zero at stage 1

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	EI of wall kN.m2/m
1	10.00	0.00	0.024	2.80E-03	0.0	0.0		582868
2	9.40	3.59	0.022	2.80E-03	1.1	0.4		582868
3	8.80	7.26	0.021	2.79E-03	4.3	1.9		582868
4	8.00	11.61	0.019	2.79E-03	11.9	8.1		582868
5	7.20	15.70	0.016	2.77E-03	22.8	21.7		582868
6	6.40	19.68	0.014	2.72E-03	37.0	45.4		582868
7	5.70	23.13	0.012	2.65E-03	51.9	76.4		582868
8	5.00	29.84	0.010	2.53E-03	70.5	120.2		582868
		21.26	0.010	2.53E-03	70.5	120.2		
9	4.50	23.32	0.009	2.41E-03	81.6	158.2		582868
10	4.00	-34.65	0.008	2.26E-03	78.8	199.4		582868
11	3.50	-62.12	0.007	2.07E-03	54.6	236.6		582868
12	3.00	-52.15	0.006	1.86E-03	26.0	256.1		582868
13	2.30	-39.14	0.005	1.55E-03	-5.9	261.4		582868
14	1.60	-28.76	0.004	1.24E-03	-29.7	247.5		582868
15	0.80	-11.96	0.003	9.28E-04	-46.0	217.4		582868
16	0.00	0.44	0.002	6.57E-04	-50.6	176.8		582868
		-16.53	0.002	6.57E-04	-50.6	176.8		
17	-0.50	-4.90	0.002	5.17E-04	-55.9	149.4		582868
18	-1.00	4.17	0.002	4.01E-04	-56.1	120.8		449098
19	-1.70	12.43	0.002	2.43E-04	-50.3	82.5		449098
20	-2.40	16.17	0.001	1.39E-04	-40.3	50.3		449098
21	-3.20	16.82	0.001	7.40E-05	-27.1	23.2		449098
22	-4.00	15.46	0.001	4.72E-05	-14.2	6.8		449098
23	-4.50	14.22	0.001	4.25E-05	-6.8	1.6		449098
24	-5.00	12.93	0.001	4.16E-05	0.0	-0.0		---

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.3 Excavate to elevation 4.50 on PASSIVE side

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1587
2	9.40	0.00	12.65	3.59	59.38	3.59	3.59a	1587
3	8.80	0.00	25.63	7.26	120.33	7.26	7.26a	1587
4	8.00	0.00	40.94	11.61	192.24	11.61	11.61a	1587
5	7.20	0.00	55.36	15.70	259.97	15.70	15.70a	1587
6	6.40	0.00	69.43	19.68	326.03	19.68	19.68a	1587
7	5.70	0.00	81.60	23.13	383.15	23.13	23.13a	1587
8	5.00	0.00	93.68	26.56	439.89	29.84	29.84	1587
		0.00	93.68	21.26	624.83	21.26	21.26a	7936
9	4.50	0.00	102.77	23.32	685.50	23.32	23.32a	7936
10	4.00	0.00	111.85	25.38	746.02	25.38	25.38a	7936
11	3.50	0.00	120.90	27.44	806.43	27.44	27.44a	7936
12	3.00	0.00	129.95	29.49	866.73	29.49	29.49a	7936
13	2.30	6.86	136.42	30.96	909.91	30.96	37.82a	7936
14	1.60	13.73	142.87	32.42	952.96	32.42	46.15a	7936
15	0.80	21.57	150.23	34.09	1002.01	42.07	63.65	7936
16	0.00	29.42	157.56	35.76	1050.95	50.20	79.62	7936
		Total>	186.98	50.00m	387.00	213.91	213.91	21243
17	-0.50	Total>	196.96	52.50m	403.98	231.19	231.19	21987
18	-1.00	Total>	206.94	55.00m	420.96	247.44	247.44	22730
19	-1.70	Total>	220.90	58.50m	444.72	268.44	268.44	23771
20	-2.40	Total>	234.84	62.00m	468.47	287.63	287.63	24812
21	-3.20	Total>	250.77	66.00m	495.60	308.14	308.14	26002
22	-4.00	Total>	266.70	70.00m	522.72	327.86	327.86	27191
23	-4.50	Total>	276.64	72.50m	539.67	340.05	340.05	27935
24	-5.00	Total>	286.59	75.00m	556.62	352.23	352.23	28679

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	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	12151
10	4.00	0.00	9.00	2.04	60.03	60.03	60.03p	12151
11	3.50	0.00	18.00	4.09	120.09	89.56	89.56	12151
12	3.00	0.00	27.02	6.13	180.20	81.64	81.64	12151
13	2.30	6.86	33.49	7.60	223.36	70.10	76.96	12151
14	1.60	13.73	39.99	9.07	266.73	61.18	74.91	12151
15	0.80	21.57	47.47	10.77	316.61	54.03	75.61	12151
16	0.00	29.42	55.01	12.48	366.91	49.76	79.18	12151
		Total>	84.43	22.50m	284.45	230.44	230.44	31764
17	-0.50	Total>	94.58	25.00m	301.60	236.09	236.09	32875
18	-1.00	Total>	104.76	27.50m	318.78	243.28	243.28	33987
19	-1.70	Total>	119.06	31.00m	342.89	256.01	256.01	35544
20	-2.40	Total>	133.43	34.50m	367.05	271.46	271.46	37100

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS | Sheet No.
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.3 Excavate to elevation 4.50 on PASSIVE side

Node no.	Y coord	Effective stresses					Total earth pressure	Soil stiffness
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		coeff. kN/m3
21	-3.20	Total>	149.93	38.50m	394.75	291.32	291.32	38879
22	-4.00	Total>	166.51	42.50m	422.53	312.41	312.41	40657
23	-4.50	Total>	176.91	45.00m	439.94	325.83	325.83	41769
24	-5.00	Total>	187.34	47.50m	457.37	339.30	339.30	42881

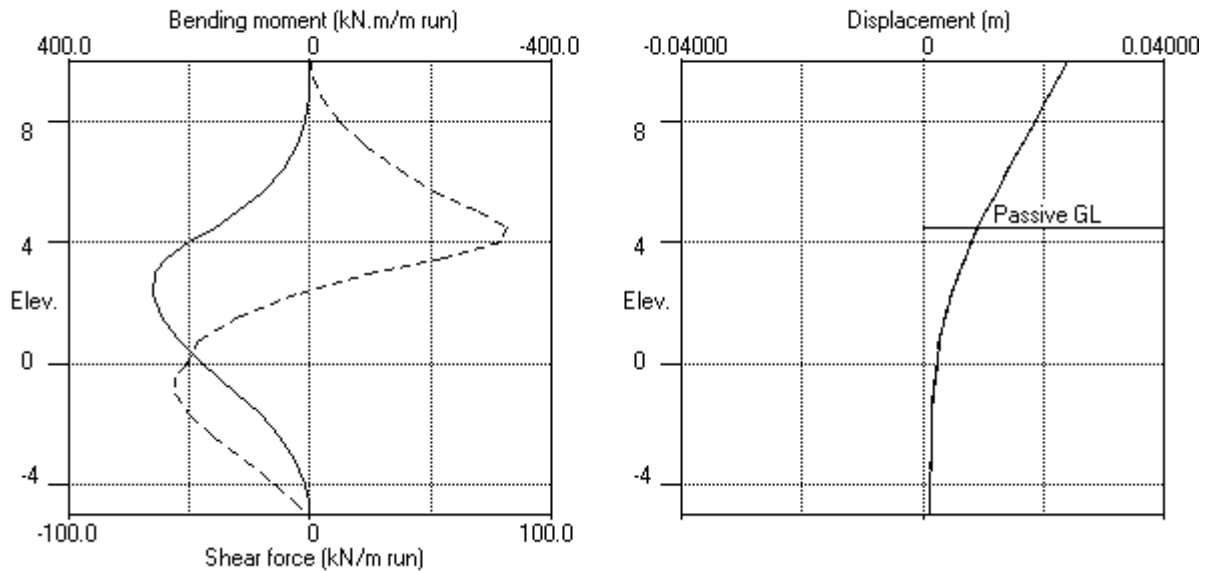
Note: 46.15a Soil pressure at active limit
 60.03p Soil pressure at passive limit

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

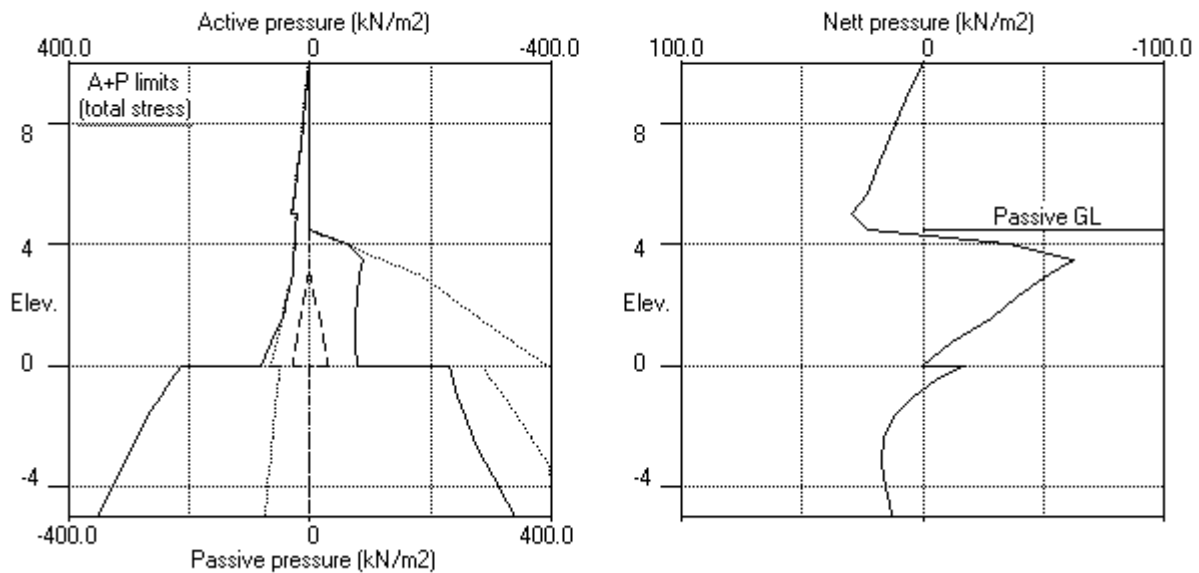
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No.3 Excav. to elev. 4.50 on PASSIVE side



Stage No.3 Excav. to elev. 4.50 on PASSIVE side



APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No. 4 Apply water pressure profile no.1 (Mod. Conserv.)

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

			FoS for toe	Toe elev. for
			elev. = -5.00	FoS = 1.000
			-----	-----
Stage	--- G.L. ---	Strut	Factor	Moment
No.	Act. Pass.	Elev.	of	equilib.
			Safety	at elev.
				Penetr
				-ation
4	10.00 4.50	Cant.	1.833	-3.65 1.11 3.39

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.

*** Wall displacements reset to zero at stage 1

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	EI of wall kN.m2/m
1	10.00	0.00	0.025	2.91E-03	0.0	0.0		582868
2	9.40	3.59	0.024	2.91E-03	1.1	0.4		582868
3	8.80	7.26	0.022	2.91E-03	4.3	1.9		582868
4	8.00	11.61	0.020	2.90E-03	11.9	8.1		582868
5	7.20	15.70	0.017	2.88E-03	22.8	21.7		582868
6	6.40	19.68	0.015	2.83E-03	37.0	45.4		582868
7	5.70	23.13	0.013	2.76E-03	51.9	76.4		582868
8	5.00	28.80	0.011	2.64E-03	70.1	120.2		582868
		21.26	0.011	2.64E-03	70.1	120.2		
9	4.50	23.32	0.010	2.52E-03	81.3	158.0		582868
10	4.00	-34.65	0.009	2.37E-03	78.4	199.1		582868
11	3.50	-64.14	0.008	2.18E-03	53.7	236.2		582868
12	3.00	-49.72	0.006	1.97E-03	25.3	255.2		582868
13	2.30	-35.95	0.005	1.66E-03	-4.7	260.5		582868
14	1.60	-24.81	0.004	1.36E-03	-26.0	248.3		582868
15	0.80	-10.98	0.003	1.03E-03	-40.3	222.3		582868
16	0.00	2.79	0.002	7.58E-04	-43.6	186.5		582868
		-25.04	0.002	7.58E-04	-43.6	186.5		
17	-0.50	-11.61	0.002	6.08E-04	-52.7	161.6		582868
18	-1.00	-0.83	0.002	4.82E-04	-55.8	133.7		449098
19	-1.70	9.54	0.002	3.04E-04	-52.8	94.4		449098
20	-2.40	14.94	0.001	1.84E-04	-44.2	59.8		449098
21	-3.20	17.05	0.001	1.05E-04	-31.4	29.1		449098
22	-4.00	16.83	0.001	7.09E-05	-17.9	9.3		449098
23	-4.50	17.54	0.001	6.43E-05	-9.3	2.5		449098
24	-5.00	19.65	0.001	6.29E-05	0.0	-0.0		---

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.4 Apply water pressure profile no.1 (Mod. Conserv.)

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1311
2	9.40	0.00	12.65	3.59	59.38	3.59	3.59a	1311
3	8.80	0.00	25.63	7.26	120.33	7.26	7.26a	1311
4	8.00	0.00	40.94	11.61	192.24	11.61	11.61a	1311
5	7.20	0.00	55.36	15.70	259.97	15.70	15.70a	1311
6	6.40	0.00	69.43	19.68	326.03	19.68	19.68a	1311
7	5.70	0.00	81.60	23.13	383.15	23.13	23.13a	1311
8	5.00	0.00	93.68	26.56	439.89	28.80	28.80	1311
		0.00	93.68	21.26	624.83	21.26	21.26a	6554
9	4.50	0.00	102.77	23.32	685.50	23.32	23.32a	6554
10	4.00	0.00	111.85	25.38	746.02	25.38	25.38a	6554
11	3.50	4.90	116.50	26.44	777.06	26.44	31.34a	6554
12	3.00	9.81	121.14	27.49	807.99	27.49	37.30a	6554
13	2.30	16.67	127.61	28.96	851.17	28.96	45.63a	6554
14	1.60	23.54	134.07	30.42	894.22	30.42	53.96a	6554
15	0.80	31.38	141.42	32.09	943.27	36.24	67.62	6554
16	0.00	39.23	148.76	33.76	992.21	44.92	84.15	6554
		Total>	187.98	50.00m	388.00	211.17	211.17	17847
17	-0.50	Total>	197.96	52.50m	404.98	229.19	229.19	18472
18	-1.00	Total>	207.94	55.00m	421.96	246.16	246.16	19096
19	-1.70	Total>	221.90	58.50m	445.72	268.03	268.03	19971
20	-2.40	Total>	235.84	62.00m	469.47	287.91	287.91	20845
21	-3.20	Total>	251.77	66.00m	496.60	309.02	309.02	21845
22	-4.00	Total>	267.70	70.00m	523.72	329.22	329.22	45514
23	-4.50	Total>	277.64	72.50m	540.67	342.24	342.24	73195
24	-5.00	Total>	287.59	75.00m	557.62	356.26	356.26	120256

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	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	9524
10	4.00	0.00	9.00	2.04	60.03	60.03	60.03p	9524
11	3.50	0.00	18.00	4.09	120.09	95.48	95.48	9524
12	3.00	0.00	27.02	6.13	180.20	87.01	87.01	9524
13	2.30	6.86	33.49	7.60	223.36	74.72	81.58	9524
14	1.60	13.73	39.99	9.07	266.73	65.03	78.76	9524
15	0.80	21.57	47.47	10.77	316.61	57.02	78.60	9524
16	0.00	29.42	55.01	12.48	366.91	51.94	81.36	9524
		Total>	84.43	22.50m	284.45	236.21	236.21	25195
17	-0.50	Total>	94.58	25.00m	301.60	240.80	240.80	26076
18	-1.00	Total>	104.76	27.50m	318.78	246.99	246.99	26958
19	-1.70	Total>	119.06	31.00m	342.89	258.49	258.49	28193
20	-2.40	Total>	133.43	34.50m	367.05	272.97	272.97	29427

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS | Sheet No.
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.4 Apply water pressure profile no.1 (Mod. Conserv.)

Node Y		----- PASSIVE side -----						
no.	coord	----- Effective stresses -----				Total	Soil	
		Water	Vertic	Active	Passive	Earth	earth	stiffness
		press.	-al	limit	limit	pressure	pressure	coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
21	-3.20	Total>	149.93	38.50m	394.75	291.97	291.97	30838
22	-4.00	Total>	166.51	42.50m	422.53	312.39	312.39	63750
23	-4.50	Total>	176.91	45.00m	439.94	324.70	324.70	97353
24	-5.00	Total>	187.34	47.50m	457.37	336.61	336.61	120256

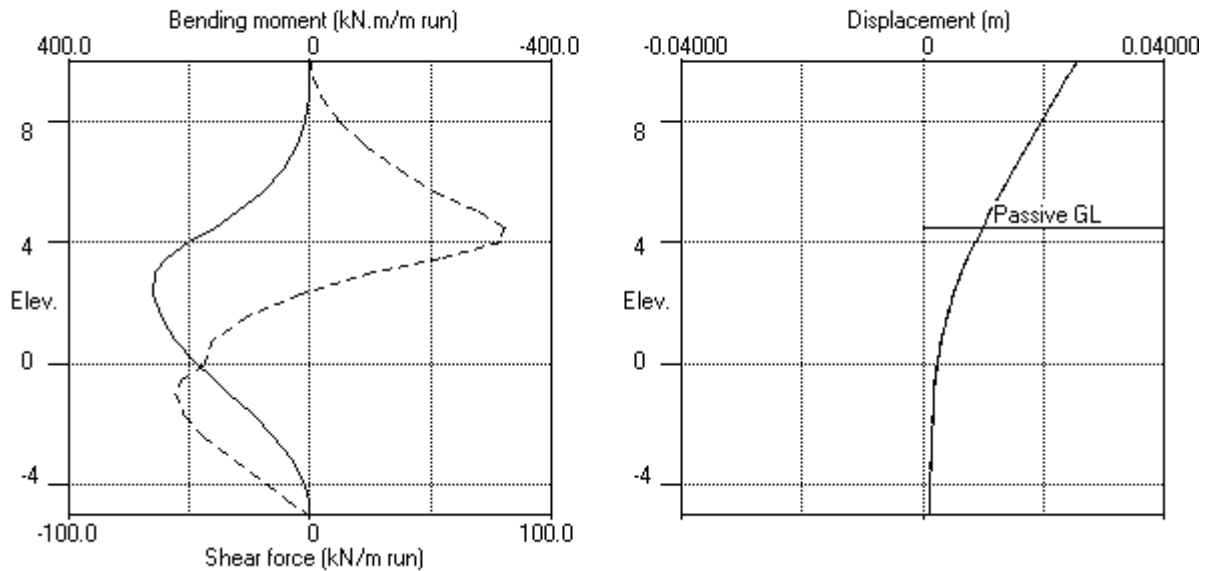
Note: 53.96a Soil pressure at active limit
 60.03p Soil pressure at passive limit

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

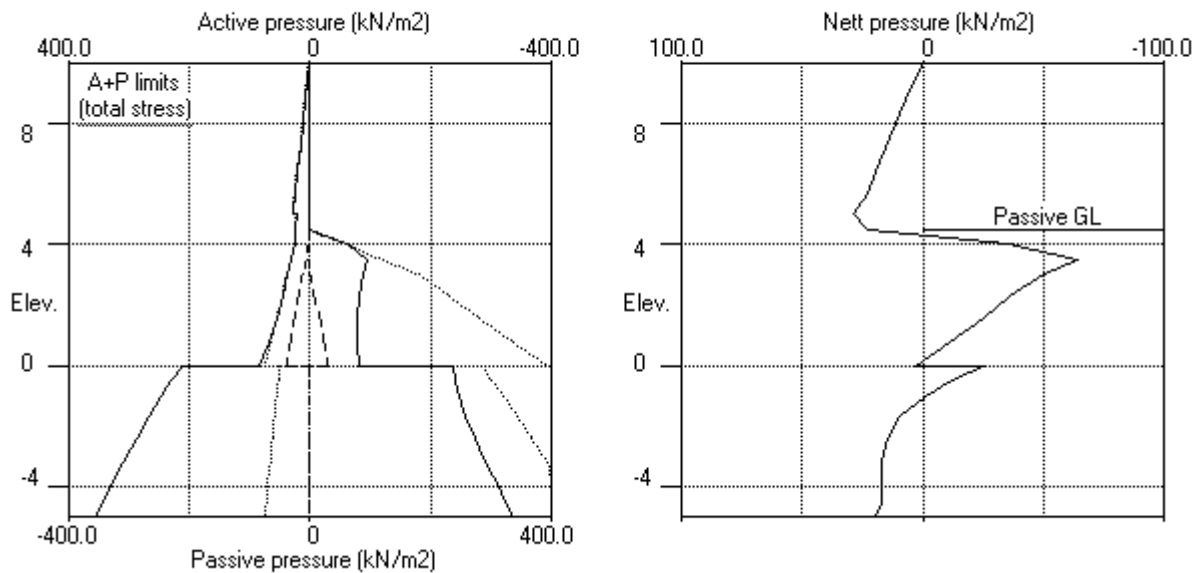
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No.4 Apply water pressure profile no.1 (Mod. Conserv.)



Stage No.4 Apply water pressure profile no.1 (Mod. Conserv.)



APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No. 5 Change properties of soil type 3 to soil type 4
 Ko pressures will not be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

			FoS for toe		Toe elev. for
			elev. = -5.00		FoS = 1.000
			-----		-----
Stage	--- G.L. ---	Strut	Factor	Moment	Toe Wall
No.	Act. Pass.	Elev.	of	equilib.	elev. Penetr
			Safety at elev.		-ation
5	10.00 4.50	Cant.	1.640	-4.12	1.11 3.39

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.

*** Wall displacements reset to zero at stage 1

Node no.	Y coord	Nett pressure kN/m ²	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m ² /m
1	10.00	0.00	0.026	2.90E-03	0.0	0.0		582868
2	9.40	3.59	0.024	2.90E-03	1.1	0.4		582868
3	8.80	7.26	0.022	2.90E-03	4.3	1.9		582868
4	8.00	11.61	0.020	2.89E-03	11.9	8.1		582868
5	7.20	15.70	0.018	2.87E-03	22.8	21.7		582868
6	6.40	19.68	0.015	2.83E-03	37.0	45.4		582868
7	5.70	23.13	0.013	2.75E-03	51.9	76.4		582868
8	5.00	28.56	0.011	2.63E-03	70.0	120.2		582868
		21.26	0.011	2.63E-03	70.0	120.2		
9	4.50	23.32	0.010	2.51E-03	81.2	157.9		582868
10	4.00	-34.65	0.009	2.36E-03	78.3	199.0		582868
11	3.50	-65.73	0.008	2.17E-03	53.2	236.1		582868
12	3.00	-51.33	0.007	1.96E-03	24.0	254.6		582868
13	2.30	-37.59	0.005	1.66E-03	-7.1	258.7		582868
14	1.60	-26.46	0.004	1.35E-03	-29.6	244.4		582868
15	0.80	-13.92	0.003	1.04E-03	-45.7	214.9		582868
16	0.00	-0.05	0.003	7.77E-04	-51.3	173.9		582868
		2.22	0.003	7.77E-04	-51.3	173.9		
17	-0.50	2.31	0.002	6.39E-04	-50.2	147.9		582868
18	-1.00	1.30	0.002	5.23E-04	-49.3	122.7		449098
19	-1.70	6.02	0.002	3.58E-04	-46.7	88.1		449098
20	-2.40	11.99	0.002	2.45E-04	-40.4	56.9		449098
21	-3.20	14.90	0.001	1.69E-04	-29.6	28.4		449098
22	-4.00	15.60	0.001	1.36E-04	-17.4	9.3		449098
23	-4.50	16.92	0.001	1.29E-04	-9.3	2.6		449098
24	-5.00	20.31	0.001	1.28E-04	0.0	-0.0		---

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.5 Change properties of soil type 3 to soil type 4
Ko pressures will not be reset

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		----- Effective stresses -----				Total earth pressure kN/m2		
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2		Earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	921
2	9.40	0.00	12.65	3.59	59.38	3.59	3.59a	921
3	8.80	0.00	25.63	7.26	120.33	7.26	7.26a	921
4	8.00	0.00	40.94	11.61	192.24	11.61	11.61a	921
5	7.20	0.00	55.36	15.70	259.97	15.70	15.70a	921
6	6.40	0.00	69.43	19.68	326.03	19.68	19.68a	921
7	5.70	0.00	81.60	23.13	383.15	23.13	23.13a	921
8	5.00	0.00	93.68	26.56	439.89	28.56	28.56	921
		0.00	93.68	21.26	624.83	21.26	21.26a	4603
9	4.50	0.00	102.77	23.32	685.50	23.32	23.32a	4603
10	4.00	0.00	111.85	25.38	746.02	25.38	25.38a	4603
11	3.50	4.90	116.50	26.44	777.06	26.44	31.34a	4603
12	3.00	9.81	121.14	27.49	807.99	27.49	37.30a	4603
13	2.30	16.67	127.61	28.96	851.17	28.96	45.63a	4603
14	1.60	23.54	134.07	30.42	894.22	30.42	53.96a	4603
15	0.80	31.38	141.42	32.09	943.27	34.95	66.33	4603
16	0.00	39.23	148.76	33.76	992.21	43.68	82.91	4603
		39.23	148.76	50.69	410.99	170.16	209.38	6593
17	-0.50	44.13	153.83	52.94	423.62	183.30	227.43	6824
18	-1.00	49.03	158.91	55.19	436.24	195.43	244.46	7054
19	-1.70	55.90	166.00	58.33	453.89	210.60	266.50	7377
20	-2.40	62.76	173.08	61.47	471.51	223.87	286.63	7700
21	-3.20	70.61	181.17	65.06	491.63	237.48	308.09	8070
22	-4.00	78.45	189.24	68.64	511.72	250.23	328.68	8439
23	-4.50	83.36	194.29	70.88	524.27	258.62	341.97	8669
24	-5.00	88.26	199.33	73.12	536.82	268.33	356.59	183587

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		----- Effective stresses -----				Total earth pressure kN/m2		
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2		Earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	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	5911
10	4.00	0.00	9.00	2.04	60.03	60.03	60.03p	5911
11	3.50	0.00	18.00	4.09	120.09	97.07	97.07	5911
12	3.00	0.00	27.02	6.13	180.20	88.63	88.63	5911
13	2.30	6.86	33.49	7.60	223.36	76.36	83.22	5911
14	1.60	13.73	39.99	9.07	266.73	66.69	80.42	5911
15	0.80	21.57	47.47	10.77	316.61	58.68	80.25	5911
16	0.00	29.42	55.01	12.48	366.91	53.54	82.96	5911
		29.42	55.01	9.11	177.74	177.74	207.16p	8587
17	-0.50	34.32	60.26	11.44	190.80	190.80	225.12p	8887
18	-1.00	39.23	65.53	13.78	203.93	203.93	243.16p	9188
19	-1.70	46.09	72.97	17.08	222.44	214.39	260.48	9608

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS | Sheet No.
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.5 Change properties of soil type 3 to soil type 4
 Ko pressures will not be reset

Node Y ----- PASSIVE side -----								
no.	coord	----- Effective stresses -----					Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
20	-2.40	52.96	80.48	20.40	241.11	221.68	274.64	10029
21	-3.20	60.80	89.13	24.24	262.63	232.39	293.19	10510
22	-4.00	68.65	97.86	28.11	284.36	244.44	313.08	10991
23	-4.50	73.55	103.36	30.55	298.05	251.50	325.05	11291
24	-5.00	78.45	108.89	33.01	311.81	257.83	336.28	183587

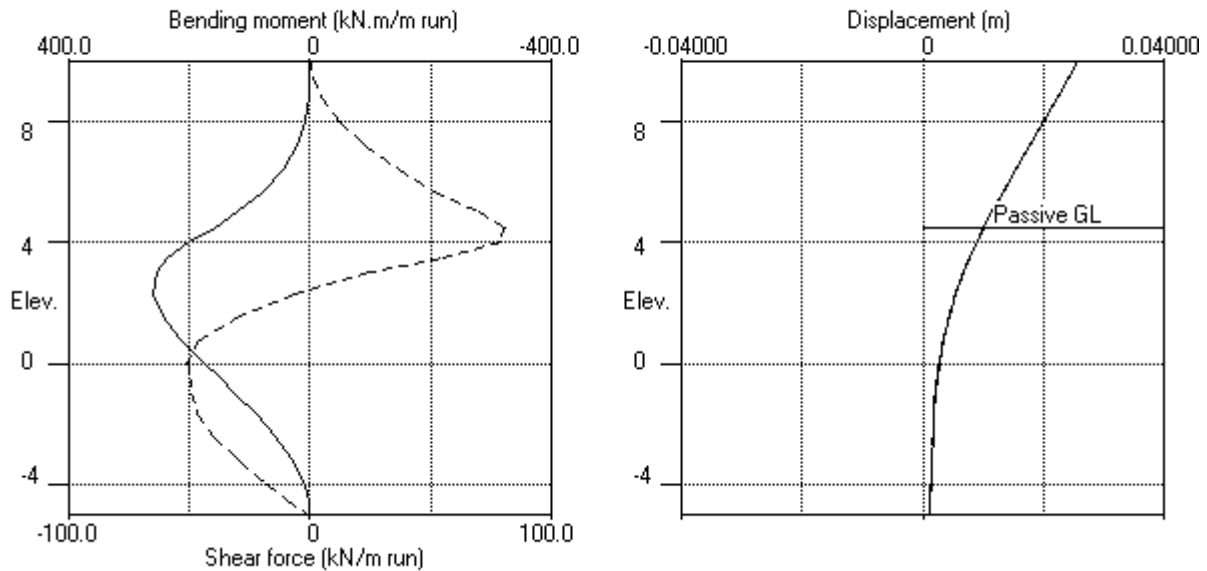
Note: 53.96a Soil pressure at active limit
 243.16p Soil pressure at passive limit

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

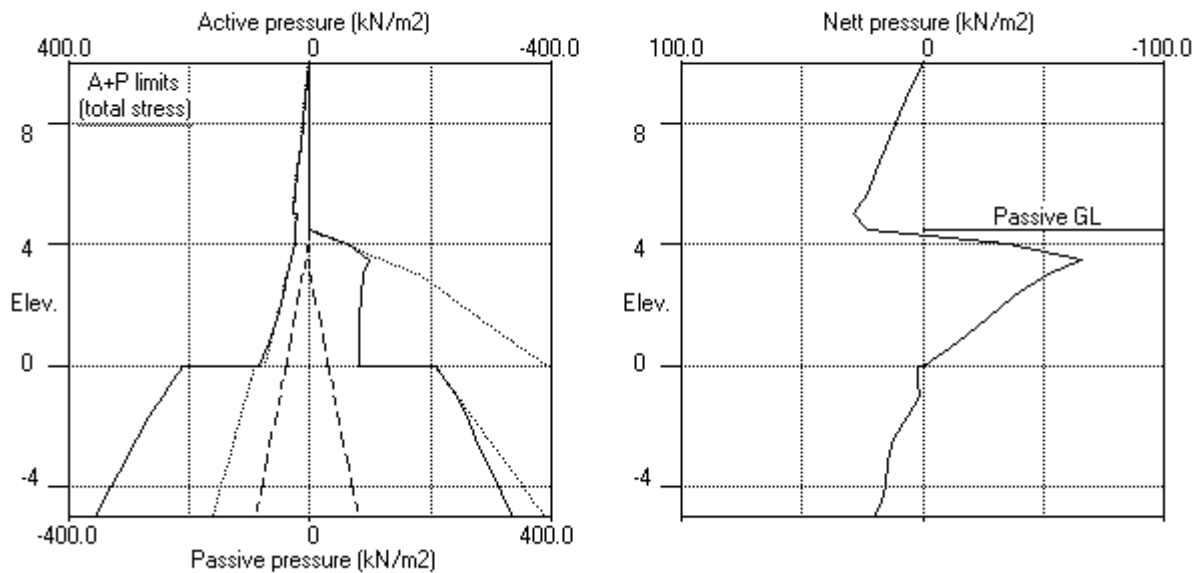
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No.5 Change soil type 3 to soil type 4



Stage No.5 Change soil type 3 to soil type 4



APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

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

			FoS for toe		Toe elev. for		
			elev. = -5.00		FoS = 1.000		
			-----		-----		
Stage	--- G.L. ---		Strut	Factor	Moment	Toe	Wall
No.	Act.	Pass.	Elev.	of	equilib.	elev.	Penetr
			Safety at elev.				
			-ation				
1	10.00	10.00	Cant.	Conditions not suitable for FoS calc.			
2	10.00	10.00	Cant.	Conditions not suitable for FoS calc.			
3	10.00	4.50	Cant.	1.874	-3.66	1.17	3.33
4	10.00	4.50	Cant.	1.833	-3.65	1.11	3.39
5	10.00	4.50	Cant.	1.640	-4.12	1.11	3.39

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

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				Shear force			
				Calculated		Factored		Calculated		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	10.00	0.026	0.000	0	-0	0	-0	0	0	0	0
2	9.40	0.024	0.000	0	0	0	0	1	-0	1	-1
3	8.80	0.022	0.000	2	-0	3	-0	4	-1	6	-1
4	8.00	0.020	0.000	8	-1	11	-1	12	-1	16	-1
5	7.20	0.018	0.000	22	-1	29	-1	23	0	31	0
6	6.40	0.015	0.000	45	-0	61	-0	37	0	50	0
7	5.70	0.013	0.000	76	-0	103	-0	52	0	70	0
8	5.00	0.011	0.000	120	-0	162	-0	70	0	95	0
9	4.50	0.010	0.000	158	-0	214	-0	82	0	110	0
10	4.00	0.009	0.000	199	-0	269	-0	79	0	106	0
11	3.50	0.008	0.000	237	-0	319	-0	55	0	74	0
12	3.00	0.007	0.000	256	-0	346	-0	26	-0	35	-0
13	2.30	0.005	0.000	261	-0	353	-0	0	-7	0	-10
14	1.60	0.004	0.000	248	-0	335	-0	0	-30	0	-40
15	0.80	0.003	0.000	222	-0	300	-0	0	-46	0	-62
16	0.00	0.003	0.000	186	-0	252	-0	0	-51	0	-69
17	-0.50	0.002	0.000	162	-0	218	-0	0	-56	0	-76
18	-1.00	0.002	0.000	134	0	181	0	0	-56	0	-76
19	-1.70	0.002	0.000	94	0	127	0	0	-53	0	-71
20	-2.40	0.002	0.000	60	0	81	0	0	-44	0	-60
21	-3.20	0.001	0.000	29	0	39	0	0	-31	0	-42
22	-4.00	0.001	0.000	9	0	13	0	0	-18	0	-24
23	-4.50	0.001	-0.000	3	0	3	0	0	-9	0	-13
24	-5.00	0.001	-0.000	0	-0	0	-0	0	0	0	0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment						Shear force					
	Calculated			Factored			Calculated			Factored		
	max.	elev.	min.	max.	min.		max.	elev.	min.	max.	min.	
	kN.m/m		kN.m/m	kN.m/m	kN/m		kN/m		kN/m	kN/m	kN/m	
1	0	-2.40	-0	1.60	0	-0	0	10.00	0	10.00	0	0
2	7	3.00	-1	7.20	10	-1	4	5.00	-1	0.80	6	-2
3	261	2.30	-0	-5.00	353	-0	82	4.50	-56	-1.00	110	-76
4	261	2.30	-0	-5.00	352	-0	81	4.50	-56	-1.00	110	-75
5	259	2.30	-0	-5.00	349	-0	81	4.50	-51	0.00	110	-69

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

Summary of results (continued)

Maximum and minimum displacement at each stage

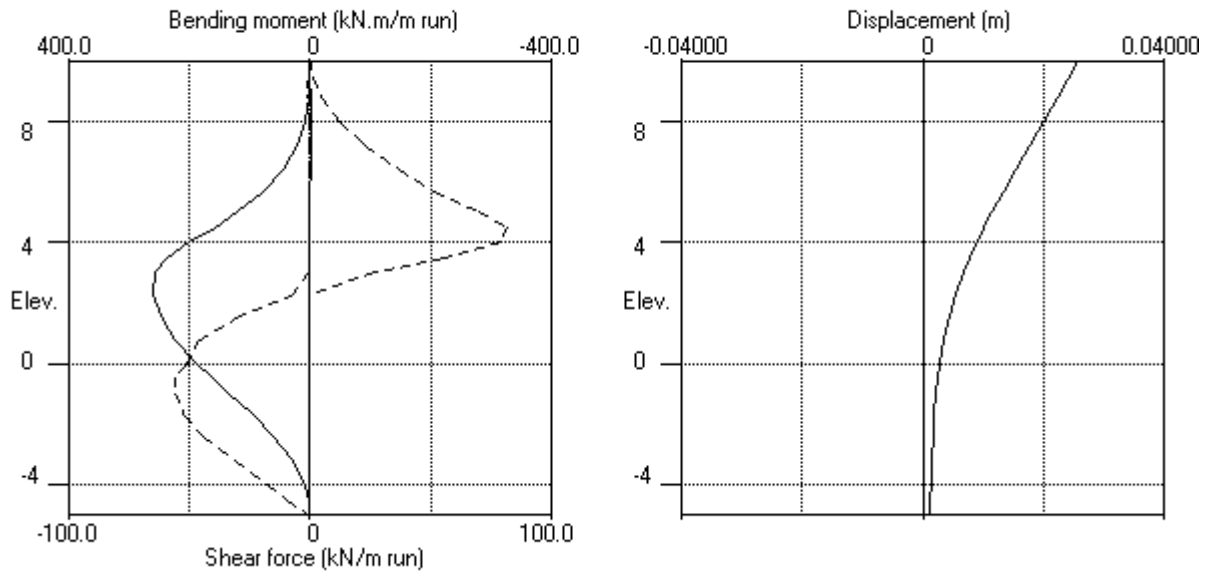
Stage	-----	Displacement	-----	Stage description	
no.	maximum	elev.	minimum	elev.	-----
	m		m		
1	0.000	2.30	-0.000	-5.00	Change EI of wall to 582868kN.m2/m run
2	0.001	10.00	0.000	10.00	Apply surcharge no.1 at elev. 10.00
3	0.024	10.00	0.000	10.00	Excav. to elev. 4.50 on PASSIVE side
4	0.025	10.00	0.000	10.00	Apply water pressure profile no.1
5	0.026	10.00	0.000	10.00	Change soil type 3 to soil type 4

APPENDIX A-2. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
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 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Active side	Soil types	Passive side
1	10.00	1 Made Ground	1 Made Ground	
2	5.00	2 Terrace Gravel	2 Terrace Gravel	
3	0.00	3 London Clay (Und)	3 London Clay (Und)	

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Description	Bulk density kN/m3	Young's Modulus Eh,kN/m2	At rest coeff. Ko	Consol state. NC/OC	Active limit Ka	Passive limit Kp	Cohesion kN/m2
1	Made Ground	17.00a	10000	0.500	OC	0.283	4.696	
		18.00b		(0.300)	(0.000)	(0.000)		
2	Terrace Gravel	18.00a	50000	0.430	OC	0.227	6.670	
		19.00b		(0.300)	(0.000)	(0.000)		
3	London Cl..	20.00	100000	1.500	OC	1.000	1.000	100.0u
	(0.00)	(7000)		(0.490)	(2.000)	(2.000)	(7.000)	
4	London Cl..	20.00	80000	1.500	OC	0.444	2.488	10.00d
	(0.00)	(5600)		(0.200)	(1.529)	(4.088)		

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

Additional soil parameters associated with Ka and Kp

No.	Description	--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction angle	Wall adhesion coeff.	Back-fill	Soil friction angle	Wall adhesion coeff.	Back-fill
1	Made Ground	30.00	0.667	0.00	30.00	0.667	0.00
2	Terrace Gravel	35.00	0.667	0.00	35.00	0.667	0.00
3	London Clay (Und)	0.00	0.000	0.00	0.00	0.000	0.00
4	London Clay (Dra)	20.00	0.500	0.00	20.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 9.807 kN/m3

	Active side	Passive side
Initial water table elevation	3.00	3.00

Automatic water pressure balancing at toe of wall : No

Active side					Passive side				
Water profile	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Water profile	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
	1	4.00	4.00	0.0		1	3.00	3.00	0.0 MC
	2	5.00	5.00	0.0		1	3.00	3.00	0.0 WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = -5.00
Maximum finite element length = 0.80 m
Youngs modulus of wall E = 2.1000E+08 kN/m2
Moment of inertia of wall I = 2.1386E-03 m4/m run
E.I = 449098 kN.m2/m run
Yield Moment of wall = Not defined

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

SURCHARGE LOADS

Surch	Distance	Length	Width	Surcharge	Equiv. Partial		
-arge	from	parallel	perpend.	----- kN/m2 -----	soil factor/		
no.	Elev.	wall	to wall	Near edge	Far edge	type	Category
1	10.00	0.50 (A)	1000.00	20.00	10.00	=	N/A 1.10 Var

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 description

stage no.	-----
1	Change EI of wall to 582868 kN.m2/m run From elevation 10.00 to -1.00 Yield moment not defined Reset wall displacements to zero at this stage
2	Apply surcharge no.1 at elevation 10.00
3	Excavate to elevation 4.50 on PASSIVE side
4	Excavate to elevation 4.00 on PASSIVE side
5	Apply water pressure profile no.1 (Mod. Conserv.)
6	Change properties of soil type 3 to soil type 4 Ko pressures will not be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 1

Water pressures : Moderately Conservative

Partial factor on C' = 1.000

Partial factor on Phi' = 1.000

Partial factor on Cu = 1.000

Partial factor on Soil Modulus = 1.000

Partial factor on Permanent Unfavourable loads = 1.000

Partial factor on Permanent Favourable loads = 1.000

Partial factor on Permanent Variable loads = 1.100

Design factor on calculated Bending Moments = 1.350

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

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

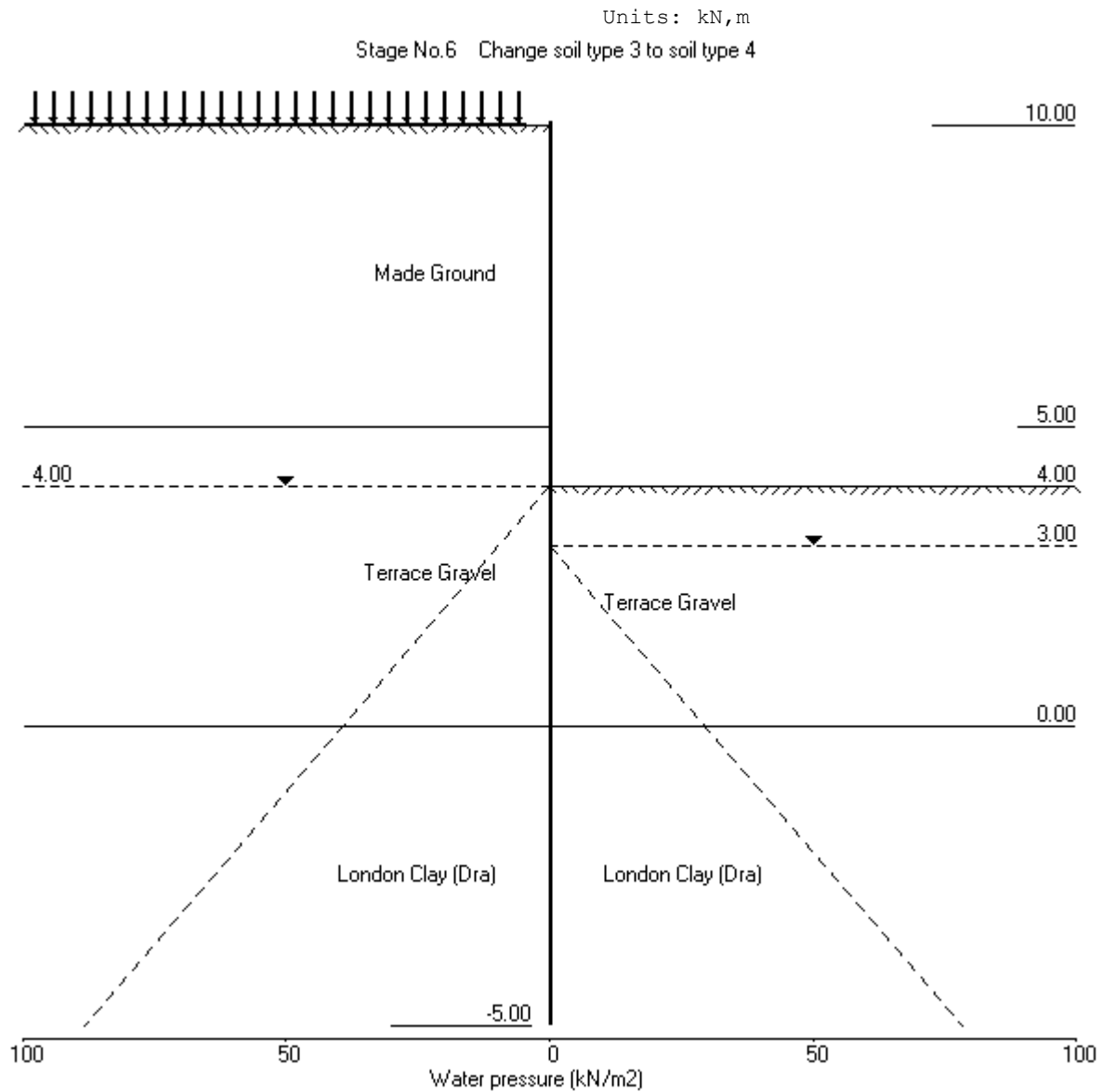
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 582868kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 10.00	No	No	No
3	Excav. to elev. 4.50 on PASSIVE side	No	No	No
4	Excav. to elev. 4.00 on PASSIVE side	Yes	Yes	No
5	Apply water pressure profile no.1	Yes	Yes	No
6	Change soil type 3 to soil type 4	Yes	Yes	No
*	Summary output	Yes	-	Yes

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APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :



APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No. 1 Change EI of wall to 582868 kN.m²/m run
 From elevation 10.00 to -1.00
 Yield moment not defined
 Reset wall displacements to zero at this stage

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: ULS DAL Combination 1

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.

*** Wall displacements reset to zero at stage 1

Node no.	Y coord	Nett pressure kN/m ²	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m	EI of wall kN.m ² /m
1	10.00	0.00	0.000	-1.60E-16	0.0	0.0		582868
2	9.40	0.00	0.000	-1.60E-16	0.0	0.0		582868
3	8.80	0.00	0.000	-1.60E-16	0.0	-0.0		582868
4	8.00	0.00	0.000	-1.60E-16	0.0	-0.0		582868
5	7.20	0.00	0.000	-1.58E-16	0.0	-0.0		582868
6	6.40	0.00	0.000	-1.55E-16	0.0	-0.0		582868
7	5.70	0.00	0.000	-1.49E-16	0.0	-0.0		582868
8	5.00	0.00	0.000	-1.40E-16	0.0	-0.0		582868
9	4.50	0.00	0.000	-1.31E-16	0.0	-0.0		582868
10	4.00	0.00	0.000	-1.18E-16	0.0	-0.0		582868
11	3.50	0.00	0.000	-9.81E-17	0.0	-0.0		582868
12	3.00	0.00	0.000	-6.92E-17	0.0	-0.0		582868
13	2.30	0.00	0.000	-1.16E-17	0.0	-0.0		582868
14	1.60	0.00	0.000	5.83E-17	0.0	-0.0		582868
15	0.80	0.00	0.000	1.40E-16	0.0	-0.0		582868
16	0.00	0.00	0.000	2.06E-16	0.0	-0.0		582868
17	-0.50	0.00	0.000	2.28E-16	0.0	-0.0		582868
18	-1.00	0.00	0.000	2.34E-16	0.0	0.0		449098
19	-1.70	0.00	0.000	2.24E-16	0.0	0.0		449098
20	-2.40	0.00	0.000	2.00E-16	0.0	0.0		449098
21	-3.20	0.00	0.000	1.71E-16	0.0	0.0		449098
22	-4.00	0.00	0.000	1.49E-16	0.0	0.0		449098
23	-4.50	0.00	-0.000	1.42E-16	0.0	0.0		449098
24	-5.00	0.00	-0.000	1.40E-16	0.0	0.0		---

Node no.	Y coord	----- ACTIVE side -----						
		----- Effective stresses -----					Total earth pressure	Soil stiffness
		Water press. kN/m ²	Vertic -al kN/m ²	Active limit kN/m ²	Passive limit kN/m ²	Earth pressure kN/m ²		coeff. kN/m ³
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1105
2	9.40	0.00	10.20	2.89	47.90	5.10	5.10	1105
3	8.80	0.00	20.40	5.78	95.79	10.20	10.20	1105
4	8.00	0.00	34.00	9.64	159.65	17.00	17.00	1105
5	7.20	0.00	47.60	13.49	223.52	23.80	23.80	1105
6	6.40	0.00	61.20	17.35	287.38	30.60	30.60	1105

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.1 Change EI of wall to 582868 kN.m2/m run
From elevation 10.00 to -1.00
Yield moment not defined
Reset wall displacements to zero at this stage

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
7	5.70	0.00	73.10	20.72	343.26	36.55	36.55	1105
8	5.00	0.00	85.00	24.10	399.14	42.50	42.50	1105
		0.00	85.00	19.29	566.96	36.55	36.55	5527
9	4.50	0.00	94.00	21.33	626.99	40.42	40.42	5527
10	4.00	0.00	103.00	23.37	687.02	44.29	44.29	5527
11	3.50	0.00	112.00	25.42	747.05	48.16	48.16	5527
12	3.00	0.00	121.00	27.46	807.08	52.03	52.03	5527
13	2.30	6.86	127.44	28.92	850.00	54.80	61.66	5527
14	1.60	13.73	133.87	30.38	892.93	57.56	71.29	5527
15	0.80	21.57	141.23	32.05	941.98	60.73	82.30	5527
16	0.00	29.42	148.58	33.72	991.04	63.89	93.31	5527
		Total>	178.00	50.00m	378.05	252.29	252.29	15397
17	-0.50	Total>	188.00	52.50m	395.05	264.84	264.84	15936
18	-1.00	Total>	198.00	55.00m	412.05	277.39	277.39	16475
19	-1.70	Total>	212.00	58.50m	435.86	294.95	294.95	17229
20	-2.40	Total>	226.00	62.00m	459.66	312.52	312.52	17984
21	-3.20	Total>	242.00	66.00m	486.86	332.60	332.60	18846
22	-4.00	Total>	258.00	70.00m	514.06	352.68	352.68	26498
23	-4.50	Total>	268.00	72.50m	531.07	365.23	365.23	167660
24	-5.00	Total>	278.00	75.00m	548.07	377.77	377.77	172122

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1105
2	9.40	0.00	10.20	2.89	47.90	5.10	5.10	1105
3	8.80	0.00	20.40	5.78	95.79	10.20	10.20	1105
4	8.00	0.00	34.00	9.64	159.65	17.00	17.00	1105
5	7.20	0.00	47.60	13.49	223.52	23.80	23.80	1105
6	6.40	0.00	61.20	17.35	287.38	30.60	30.60	1105
7	5.70	0.00	73.10	20.72	343.26	36.55	36.55	1105
8	5.00	0.00	85.00	24.10	399.14	42.50	42.50	1105
		0.00	85.00	19.29	566.96	36.55	36.55	5527
9	4.50	0.00	94.00	21.33	626.99	40.42	40.42	5527
10	4.00	0.00	103.00	23.37	687.02	44.29	44.29	5527
11	3.50	0.00	112.00	25.42	747.05	48.16	48.16	5527
12	3.00	0.00	121.00	27.46	807.08	52.03	52.03	5527
13	2.30	6.86	127.44	28.92	850.00	54.80	61.66	5527
14	1.60	13.73	133.87	30.38	892.93	57.56	71.29	5527
15	0.80	21.57	141.23	32.05	941.98	60.73	82.30	5527
16	0.00	29.42	148.58	33.72	991.04	63.89	93.31	5527
		Total>	178.00	50.00m	378.05	252.29	252.29	15397
17	-0.50	Total>	188.00	52.50m	395.05	264.84	264.84	15936
18	-1.00	Total>	198.00	55.00m	412.05	277.39	277.39	16475
19	-1.70	Total>	212.00	58.50m	435.86	294.95	294.95	17229
20	-2.40	Total>	226.00	62.00m	459.66	312.52	312.52	17984
21	-3.20	Total>	242.00	66.00m	486.86	332.60	332.60	18846
22	-4.00	Total>	258.00	70.00m	514.06	352.68	352.68	26498
23	-4.50	Total>	268.00	72.50m	531.07	365.23	365.23	167660

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.1 Change EI of wall to 582868 kN.m2/m run
From elevation 10.00 to -1.00
Yield moment not defined
Reset wall displacements to zero at this stage

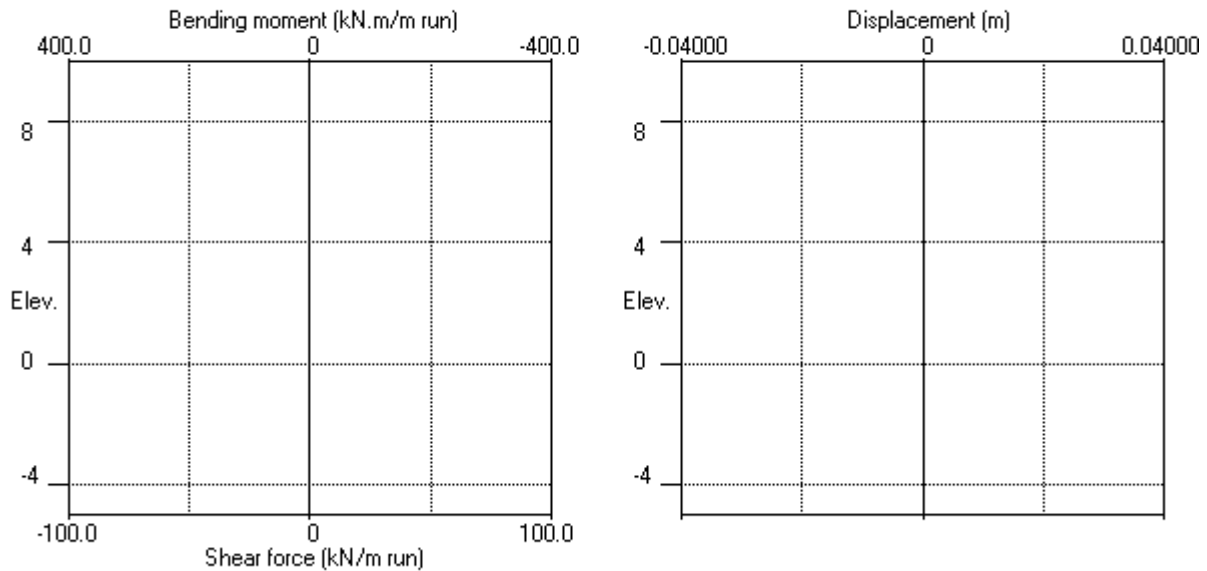
Node	Y	----- PASSIVE side -----						
no.	coord	----- Effective stresses -----				Total	Soil	
		Water	Vertic	Active	Passive	Earth	earth	stiffness
		press.	-al	limit	limit	pressure	pressure	coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
24	-5.00	Total>	278.00	75.00m	548.07	377.77	377.77	172122

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

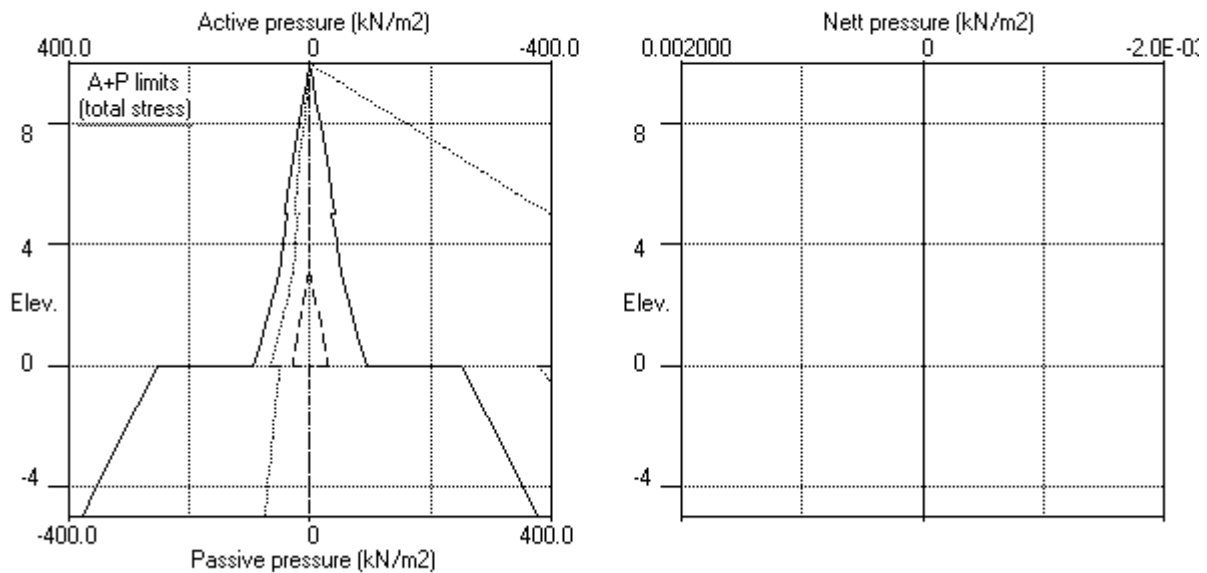
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No.1 Change EI of wall to 582868kN.m2/m run



Stage No.1 Change EI of wall to 582868kN.m2/m run



APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 4.50 on PASSIVE side

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: ULS DA1 Combination 1

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.

*** Wall displacements reset to zero at stage 1

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	EI of wall kN.m2/m
1	10.00	0.00	0.024	2.84E-03	0.0	0.0		582868
2	9.40	3.65	0.023	2.84E-03	1.1	0.4		582868
3	8.80	7.41	0.021	2.84E-03	4.4	1.9		582868
4	8.00	11.80	0.019	2.83E-03	12.1	8.3		582868
5	7.20	15.91	0.017	2.81E-03	23.2	22.1		582868
6	6.40	19.92	0.014	2.76E-03	37.5	46.2		582868
7	5.70	23.37	0.012	2.69E-03	52.7	77.6		582868
8	5.00	29.97	0.011	2.57E-03	71.3	122.0		582868
		21.45	0.011	2.57E-03	71.3	122.0		
9	4.50	23.52	0.009	2.45E-03	82.6	160.4		582868
10	4.00	-34.45	0.008	2.29E-03	79.9	202.2		582868
11	3.50	-63.08	0.007	2.10E-03	55.5	240.0		582868
12	3.00	-52.92	0.006	1.89E-03	26.5	259.7		582868
13	2.30	-39.68	0.005	1.57E-03	-5.9	265.2		582868
14	1.60	-29.10	0.004	1.26E-03	-30.0	251.1		582868
15	0.80	-12.23	0.003	9.42E-04	-46.5	220.7		582868
16	0.00	0.37	0.002	6.67E-04	-51.3	179.5		582868
		-16.88	0.002	6.67E-04	-51.3	179.5		
17	-0.50	-5.04	0.002	5.25E-04	-56.8	151.8		582868
18	-1.00	4.19	0.002	4.07E-04	-57.0	122.8		449098
19	-1.70	12.60	0.002	2.46E-04	-51.1	83.9		449098
20	-2.40	16.41	0.001	1.41E-04	-40.9	51.1		449098
21	-3.20	17.08	0.001	7.49E-05	-27.6	23.6		449098
22	-4.00	15.71	0.001	4.77E-05	-14.4	6.9		449098
23	-4.50	14.45	0.001	4.30E-05	-6.9	1.7		449098
24	-5.00	13.14	0.001	4.20E-05	0.0	-0.0		---

Node no.	Y coord	----- ACTIVE side -----					Total earth pressure	Soil stiffness
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	coeff. kN/m3
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1588
2	9.40	0.00	12.89	3.65	60.53	3.65	3.65a	1588
3	8.80	0.00	26.15	7.41	122.78	7.41	7.41a	1588
4	8.00	0.00	41.63	11.80	195.49	11.80	11.80a	1588
5	7.20	0.00	56.14	15.91	263.61	15.91	15.91a	1588
6	6.40	0.00	70.25	19.92	329.90	19.92	19.92a	1588
7	5.70	0.00	82.44	23.37	387.14	23.37	23.37a	1588

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.3 Excavate to elevation 4.50 on PASSIVE side

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff.
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	Total earth pressure	
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
8	5.00	0.00	94.55	26.80	443.96	29.97	29.97	1588
		0.00	94.55	21.45	630.62	21.45	21.45a	7941
9	4.50	0.00	103.65	23.52	691.36	23.52	23.52a	7941
10	4.00	0.00	112.73	25.58	751.93	25.58	25.58a	7941
11	3.50	0.00	121.79	27.64	812.38	27.64	27.64a	7941
12	3.00	0.00	130.84	29.69	872.71	29.69	29.69a	7941
13	2.30	6.86	137.32	31.16	915.92	31.16	38.03a	7941
14	1.60	13.73	143.77	32.63	958.97	32.63	46.35a	7941
15	0.80	21.57	151.13	34.29	1008.03	42.18	63.76	7941
16	0.00	29.42	158.46	35.96	1056.95	50.39	79.81	7941
		Total>	187.88	50.00m	387.93	214.24	214.24	21257
17	-0.50	Total>	197.86	52.50m	404.91	231.60	231.60	22001
18	-1.00	Total>	207.83	55.00m	421.89	247.92	247.92	22745
19	-1.70	Total>	221.79	58.50m	445.64	268.97	268.97	23786
20	-2.40	Total>	235.73	62.00m	469.39	288.19	288.19	24828
21	-3.20	Total>	251.65	66.00m	496.51	308.70	308.70	26018
22	-4.00	Total>	267.57	70.00m	523.63	328.41	328.41	27208
23	-4.50	Total>	277.51	72.50m	540.57	340.59	340.59	27952
24	-5.00	Total>	287.45	75.00m	557.52	352.76	352.76	28696

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff.
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	Total earth pressure	
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	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	12180
10	4.00	0.00	9.00	2.04	60.03	60.03	60.03p	12180
11	3.50	0.00	18.00	4.09	120.09	90.72	90.72	12180
12	3.00	0.00	27.02	6.13	180.20	82.61	82.61	12180
13	2.30	6.86	33.49	7.60	223.37	70.84	77.70	12180
14	1.60	13.73	39.99	9.07	266.73	61.73	75.46	12180
15	0.80	21.57	47.47	10.77	316.62	54.41	75.99	12180
16	0.00	29.42	55.01	12.48	366.91	50.01	79.43	12180
		Total>	84.43	22.50m	284.46	231.12	231.12	31837
17	-0.50	Total>	94.58	25.00m	301.61	236.64	236.64	32952
18	-1.00	Total>	104.76	27.50m	318.79	243.73	243.73	34066
19	-1.70	Total>	119.06	31.00m	342.90	256.36	256.36	35626
20	-2.40	Total>	133.43	34.50m	367.07	271.78	271.78	37186
21	-3.20	Total>	149.93	38.50m	394.77	291.61	291.61	38969
22	-4.00	Total>	166.51	42.50m	422.55	312.71	312.71	40752
23	-4.50	Total>	176.91	45.00m	439.96	326.14	326.14	41866
24	-5.00	Total>	187.34	47.50m	457.39	339.62	339.62	42980

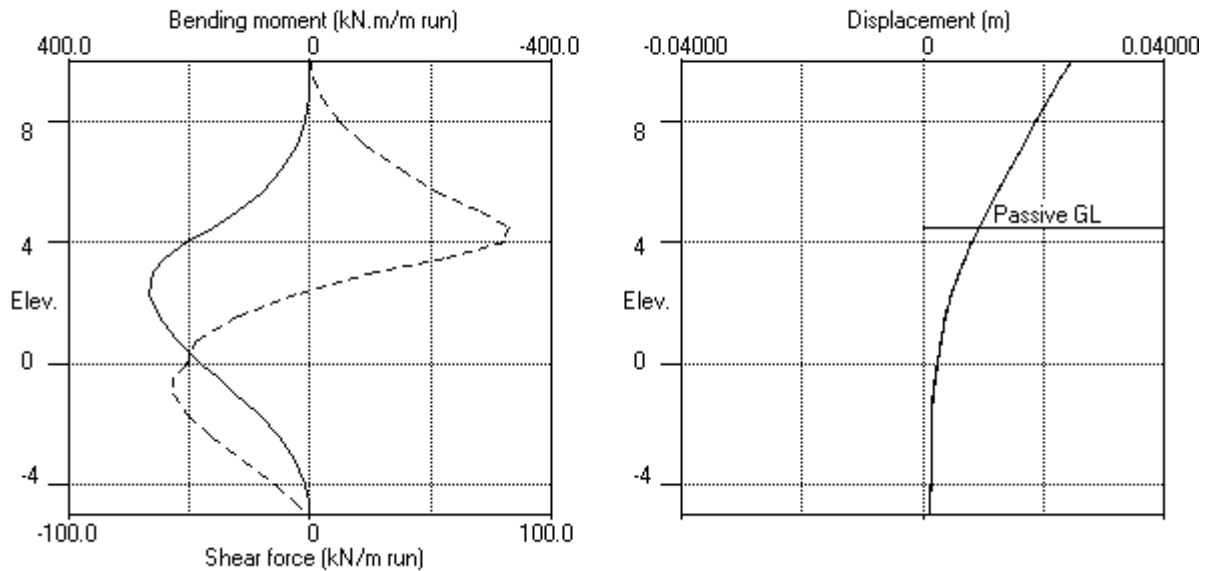
Note: 46.35a Soil pressure at active limit
60.03p Soil pressure at passive limit

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

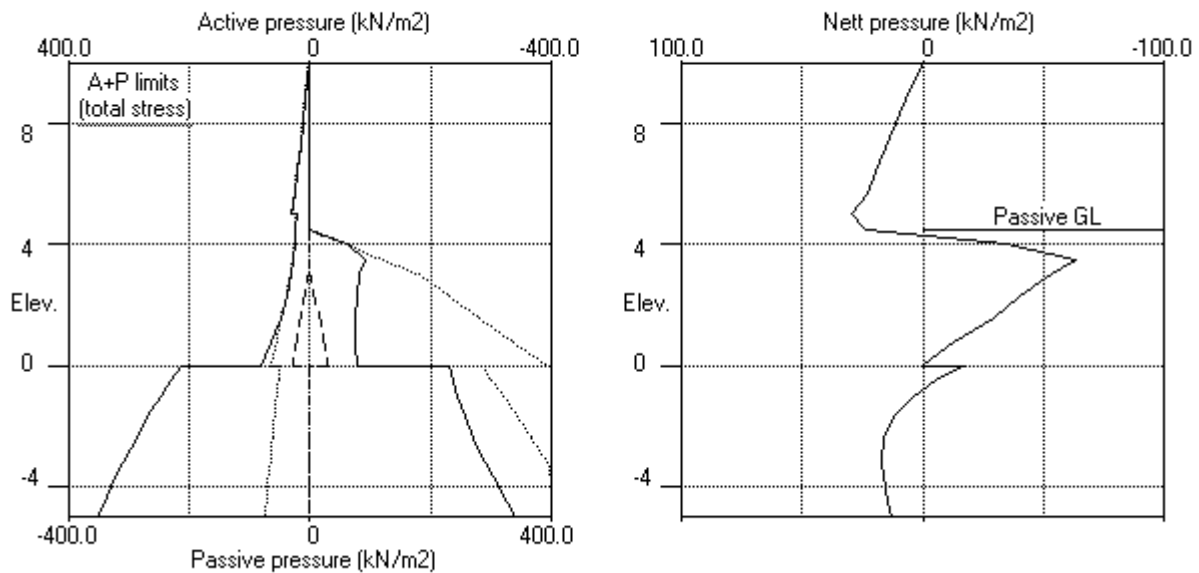
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No.3 Excav. to elev. 4.50 on PASSIVE side



Stage No.3 Excav. to elev. 4.50 on PASSIVE side



APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No. 4 Excavate to elevation 4.00 on PASSIVE side

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: ULS DA1 Combination 1

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.

*** Wall displacements reset to zero at stage 1

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	EI of wall kN.m2/m
1	10.00	0.00	0.032	3.55E-03	0.0	0.0		582868
2	9.40	3.65	0.029	3.55E-03	1.1	0.4		582868
3	8.80	7.41	0.027	3.55E-03	4.4	1.9		582868
4	8.00	11.80	0.025	3.54E-03	12.1	8.3		582868
5	7.20	15.91	0.022	3.52E-03	23.2	22.1		582868
6	6.40	19.92	0.019	3.47E-03	37.5	46.2		582868
7	5.70	23.37	0.016	3.40E-03	52.7	77.6		582868
8	5.00	26.80	0.014	3.28E-03	70.2	121.8		582868
		21.45	0.014	3.28E-03	70.2	121.8		
9	4.50	23.52	0.013	3.16E-03	81.5	159.6		582868
10	4.00	25.58	0.011	3.00E-03	93.8	203.4		582868
11	3.50	-32.40	0.010	2.80E-03	92.1	254.3		582868
12	3.00	-76.04	0.008	2.57E-03	64.9	295.1		582868
13	2.30	-57.07	0.006	2.20E-03	18.4	321.8		582868
14	1.60	-41.34	0.005	1.81E-03	-16.1	320.5		582868
15	0.80	-25.94	0.004	1.39E-03	-43.0	297.3		582868
16	0.00	-7.04	0.003	1.01E-03	-56.2	254.6		582868
		-38.03	0.003	1.01E-03	-56.2	254.6		
17	-0.50	-18.71	0.002	8.10E-04	-70.4	221.7		582868
18	-1.00	-3.09	0.002	6.36E-04	-75.8	184.2		449098
19	-1.70	12.14	0.002	3.91E-04	-72.7	130.3		449098
20	-2.40	20.33	0.001	2.25E-04	-61.3	82.4		449098
21	-3.20	23.86	0.001	1.16E-04	-43.6	39.8		449098
22	-4.00	24.00	0.001	6.98E-05	-24.5	12.5		449098
23	-4.50	24.02	0.001	6.11E-05	-12.5	3.2		449098
24	-5.00	25.82	0.001	5.93E-05	0.0	-0.0		---

Node no.	Y coord	----- ACTIVE side -----					Total earth pressure	Soil stiffness
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		coeff.
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1452
2	9.40	0.00	12.89	3.65	60.53	3.65	3.65a	1452
3	8.80	0.00	26.15	7.41	122.78	7.41	7.41a	1452
4	8.00	0.00	41.63	11.80	195.49	11.80	11.80a	1452
5	7.20	0.00	56.14	15.91	263.61	15.91	15.91a	1452
6	6.40	0.00	70.25	19.92	329.90	19.92	19.92a	1452
7	5.70	0.00	82.44	23.37	387.14	23.37	23.37a	1452

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.4 Excavate to elevation 4.00 on PASSIVE side

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	Total earth pressure	
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
8	5.00	0.00	94.55	26.80	443.96	26.80	26.80a	1452
		0.00	94.55	21.45	630.62	21.45	21.45a	7260
9	4.50	0.00	103.65	23.52	691.36	23.52	23.52a	7260
10	4.00	0.00	112.73	25.58	751.93	25.58	25.58a	7260
11	3.50	0.00	121.79	27.64	812.38	27.64	27.64a	7260
12	3.00	0.00	130.84	29.69	872.71	29.69	29.69a	7260
13	2.30	6.86	137.32	31.16	915.92	31.16	38.03a	7260
14	1.60	13.73	143.77	32.63	958.97	32.63	46.35a	7260
15	0.80	21.57	151.13	34.29	1008.03	35.70	57.28	7260
16	0.00	29.42	158.46	35.96	1056.95	46.22	75.64	7260
		Total>	187.88	50.00m	387.93	203.01	203.01	19576
17	-0.50	Total>	197.86	52.50m	404.91	223.17	223.17	20261
18	-1.00	Total>	207.83	55.00m	421.89	241.89	241.89	20946
19	-1.70	Total>	221.79	58.50m	445.64	265.49	265.49	21906
20	-2.40	Total>	235.73	62.00m	469.39	286.35	286.35	22865
21	-3.20	Total>	251.65	66.00m	496.51	307.93	307.93	23961
22	-4.00	Total>	267.57	70.00m	523.63	328.22	328.22	25057
23	-4.50	Total>	277.51	72.50m	540.57	340.98	340.98	171768
24	-5.00	Total>	287.45	75.00m	557.52	354.70	354.70	176340

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	Total earth pressure	
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	4.00	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	12451
11	3.50	0.00	9.00	2.04	60.04	60.04	60.04p	12451
12	3.00	0.00	18.01	4.09	120.10	105.73	105.73	12451
13	2.30	6.86	24.46	5.55	163.16	88.23	95.09	12451
14	1.60	13.73	30.95	7.02	206.41	73.97	87.70	12451
15	0.80	21.57	38.40	8.71	256.13	61.64	83.21	12451
16	0.00	29.42	45.91	10.42	306.25	53.26	82.68	12451
		Total>	75.33	20.00m	275.36	241.04	241.04	32515
17	-0.50	Total>	85.47	22.50m	292.50	241.88	241.88	33653
18	-1.00	Total>	95.64	25.00m	309.67	244.98	244.98	34791
19	-1.70	Total>	109.92	28.50m	333.76	253.35	253.35	36384
20	-2.40	Total>	124.27	32.00m	357.91	266.02	266.02	37978
21	-3.20	Total>	140.76	36.00m	385.60	284.07	284.07	39799
22	-4.00	Total>	157.34	40.00m	413.38	304.22	304.22	41619
23	-4.50	Total>	167.75	42.50m	430.79	316.95	316.95	171768
24	-5.00	Total>	178.19	45.00m	448.24	328.88	328.88	176340

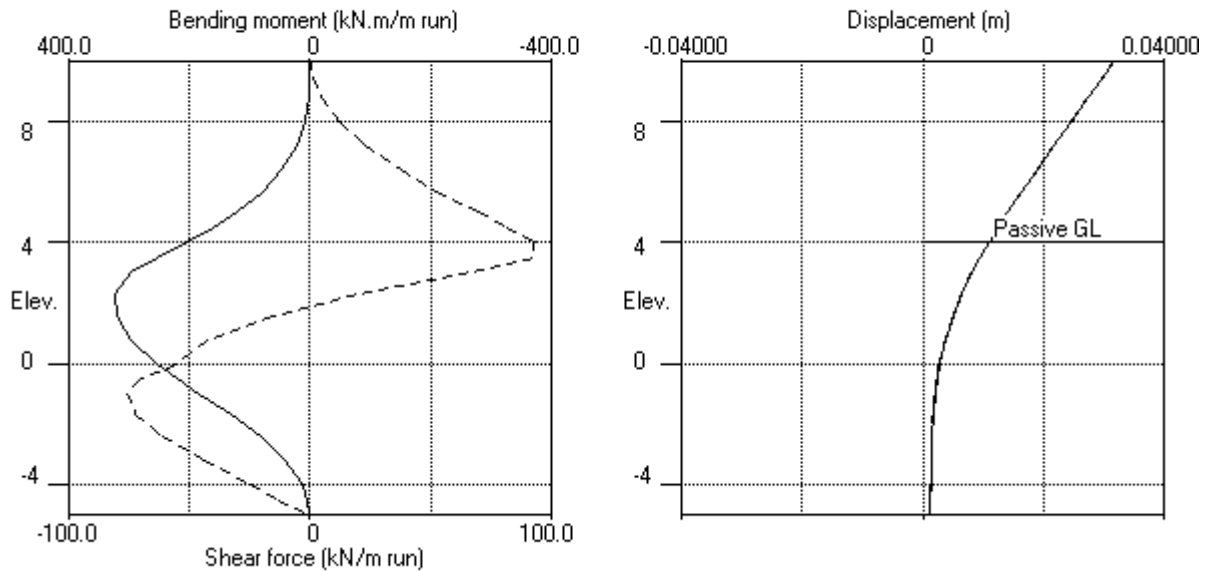
Note: 46.35a Soil pressure at active limit
60.04p Soil pressure at passive limit

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

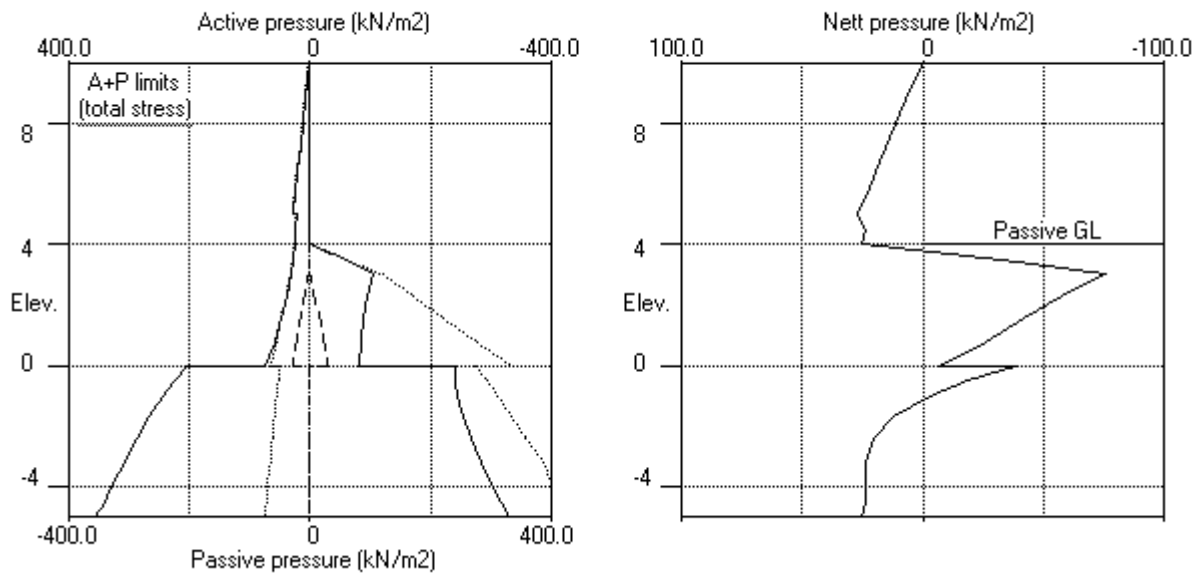
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No.4 Excav. to elev. 4.00 on PASSIVE side



Stage No.4 Excav. to elev. 4.00 on PASSIVE side



APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No. 6 Change properties of soil type 3 to soil type 4
Ko pressures will not be reset

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: ULS DA1 Combination 1

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.

*** Wall displacements reset to zero at stage 1

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	EI of wall kN.m2/m
1	10.00	0.00	0.035	3.72E-03	0.0	0.0		582868
2	9.40	3.65	0.033	3.72E-03	1.1	0.4		582868
3	8.80	7.41	0.030	3.72E-03	4.4	1.9		582868
4	8.00	11.80	0.027	3.71E-03	12.1	8.3		582868
5	7.20	15.91	0.024	3.69E-03	23.2	22.1		582868
6	6.40	19.92	0.021	3.65E-03	37.5	46.2		582868
7	5.70	23.37	0.019	3.57E-03	52.7	77.6		582868
8	5.00	26.80	0.016	3.45E-03	70.2	121.8		582868
		21.45	0.016	3.45E-03	70.2	121.8		
9	4.50	23.52	0.015	3.33E-03	81.5	159.6		582868
10	4.00	25.58	0.013	3.18E-03	93.8	203.4		582868
11	3.50	-28.49	0.012	2.98E-03	93.0	254.5		582868
12	3.00	-82.60	0.010	2.74E-03	65.3	296.1		582868
13	2.30	-63.39	0.008	2.37E-03	14.2	322.0		582868
14	1.60	-46.44	0.007	1.99E-03	-24.3	316.2		582868
15	0.80	-31.03	0.005	1.58E-03	-55.3	284.7		582868
16	0.00	-18.29	0.004	1.22E-03	-75.0	230.5		582868
		7.14	0.004	1.22E-03	-75.0	230.5		
17	-0.50	10.44	0.004	1.04E-03	-70.6	193.1		582868
18	-1.00	12.30	0.003	8.95E-04	-64.9	158.4		449098
19	-1.70	12.32	0.003	6.82E-04	-56.3	114.4		449098
20	-2.40	9.51	0.002	5.33E-04	-48.7	76.8		449098
21	-3.20	14.02	0.002	4.28E-04	-39.3	41.3		449098
22	-4.00	20.23	0.002	3.79E-04	-25.6	14.3		449098
23	-4.50	24.92	0.001	3.68E-04	-14.3	4.0		449098
24	-5.00	32.13	0.001	3.66E-04	0.0	-0.0		---

Node no.	Y coord	----- ACTIVE side -----						
		----- Effective stresses -----					Total earth pressure	Soil stiffness
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	925
2	9.40	0.00	12.89	3.65	60.53	3.65	3.65a	925
3	8.80	0.00	26.15	7.41	122.78	7.41	7.41a	925
4	8.00	0.00	41.63	11.80	195.49	11.80	11.80a	925
5	7.20	0.00	56.14	15.91	263.61	15.91	15.91a	925
6	6.40	0.00	70.25	19.92	329.90	19.92	19.92a	925

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.6 Change properties of soil type 3 to soil type 4
Ko pressures will not be reset

Node no.	Y coord	----- ACTIVE side -----						
		----- Effective stresses -----					Total	Soil
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	earth pressure kN/m2	stiffness coeff. kN/m3
7	5.70	0.00	82.44	23.37	387.14	23.37	23.37a	925
8	5.00	0.00	94.55	26.80	443.96	26.80	26.80a	925
		0.00	94.55	21.45	630.62	21.45	21.45a	4623
9	4.50	0.00	103.65	23.52	691.36	23.52	23.52a	4623
10	4.00	0.00	112.73	25.58	751.93	25.58	25.58a	4623
11	3.50	4.90	117.39	26.64	783.01	26.64	31.54a	4623
12	3.00	9.81	122.03	27.69	813.97	27.69	37.50a	4623
13	2.30	16.67	128.51	29.16	857.18	29.16	45.83a	4623
14	1.60	23.54	134.97	30.63	900.23	30.63	54.16a	4623
15	0.80	31.38	142.32	32.30	949.29	32.30	63.68a	4623
16	0.00	39.23	149.66	33.96	998.21	35.19	74.42	4623
		39.23	149.66	51.09	413.23	152.45	191.68	6624
17	-0.50	44.13	154.73	53.34	425.86	168.77	212.90	6856
18	-1.00	49.03	159.80	55.58	438.47	183.73	232.76	7088
19	-1.70	55.90	166.89	58.73	456.10	202.20	258.10	7413
20	-2.40	62.76	173.97	61.87	473.71	218.03	280.79	7737
21	-3.20	70.61	182.04	65.45	493.81	233.93	304.54	8108
22	-4.00	78.45	190.11	69.03	513.89	248.95	327.40	8479
23	-4.50	83.36	195.15	71.26	526.42	258.83	342.19	8711
24	-5.00	88.26	200.19	73.50	538.95	270.32	358.58	8943

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		----- Effective stresses -----				Total earth pressure kN/m2		
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2		Earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	4.00	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	6130
11	3.50	0.00	9.00	2.04	60.04	60.04	60.04p	6130
12	3.00	0.00	18.01	4.09	120.10	120.10	120.10p	6130
13	2.30	6.86	24.46	5.55	163.16	102.36	109.23	6130
14	1.60	13.73	30.95	7.02	206.41	86.87	100.60	6130
15	0.80	21.57	38.40	8.71	256.13	73.13	94.71	6130
16	0.00	29.42	45.91	10.42	306.25	63.29	92.71	6130
		29.42	45.91	5.07	155.12	155.12	184.54p	8917
17	-0.50	34.32	51.15	7.39	168.14	168.14	202.46p	9229
18	-1.00	39.23	56.41	9.73	181.23	181.23	220.46p	9541
19	-1.70	46.09	63.83	13.02	199.69	199.69	245.78p	9978
20	-2.40	52.96	71.32	16.34	218.32	218.32	271.28p	10415
21	-3.20	60.80	79.96	20.17	239.83	229.71	290.51	10914
22	-4.00	68.65	88.69	24.05	261.55	238.53	307.18	11413
23	-4.50	73.55	94.20	26.49	275.25	243.71	317.26	11726
24	-5.00	78.45	99.74	28.95	289.03	248.00	326.45	12038

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1	Sheet No.
Combi-Gyro Wall System (Pattern A)	Date:17-03-2015
D1000-16 / AZ28-700N	Checked :

(continued)

Stage No.6 Change properties of soil type 3 to soil type 4
 Ko pressures will not be reset

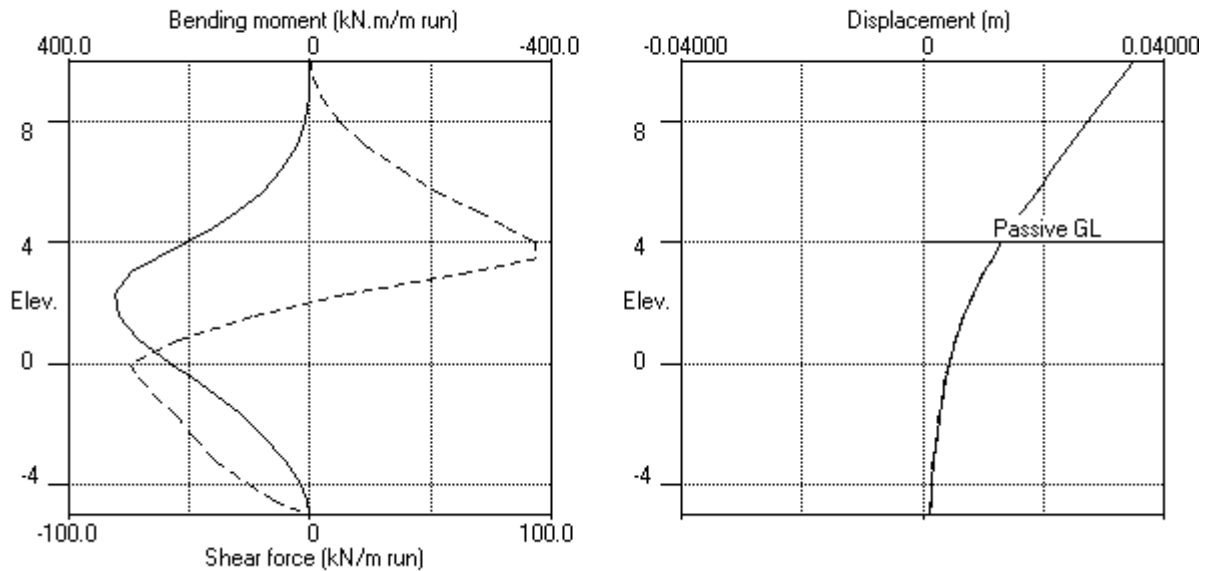
Note: 63.68a Soil pressure at active limit
 271.28p Soil pressure at passive limit

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

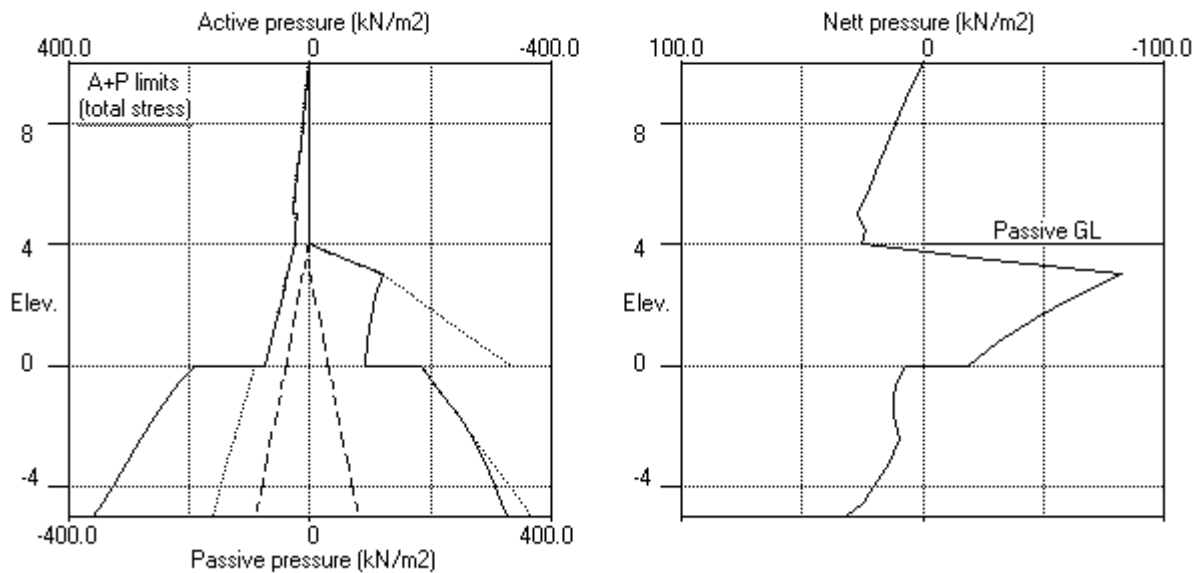
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No.6 Change soil type 3 to soil type 4



Stage No.6 Change soil type 3 to soil type 4



APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

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: ULS DA1 Combination 1

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				Shear force			
		max.	min.	Calculated		Factored		Calculated		Factored	
				max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m		kN/m	
1	10.00	0.035	0.000	0	-0	0	-0	0	0	0	0
2	9.40	0.033	0.000	0	0	1	0	1	-0	1	-1
3	8.80	0.030	0.000	2	-0	3	-1	4	-1	6	-1
4	8.00	0.027	0.000	8	-1	11	-1	12	-1	16	-1
5	7.20	0.024	0.000	22	-1	30	-2	23	0	31	0
6	6.40	0.021	0.000	46	-0	62	-1	38	0	51	0
7	5.70	0.019	0.000	78	-0	105	-0	53	0	71	0
8	5.00	0.016	0.000	122	-0	165	-0	71	0	96	0
9	4.50	0.015	0.000	160	-0	217	-0	83	0	111	0
10	4.00	0.013	0.000	203	-0	275	-0	94	0	127	0
11	3.50	0.012	0.000	254	-0	344	-0	93	0	126	0
12	3.00	0.010	0.000	296	-0	400	-0	67	-0	90	-0
13	2.30	0.008	0.000	325	-0	438	-0	21	-6	28	-8
14	1.60	0.007	0.000	326	-0	440	-0	0	-30	0	-41
15	0.80	0.005	0.000	306	-0	414	-0	0	-55	0	-75
16	0.00	0.004	0.000	269	-0	364	-0	0	-75	0	-101
17	-0.50	0.004	0.000	239	-0	323	-0	0	-71	0	-95
18	-1.00	0.003	0.000	202	0	273	0	0	-76	0	-103
19	-1.70	0.003	0.000	146	0	197	0	0	-77	0	-103
20	-2.40	0.002	0.000	95	0	128	0	0	-67	0	-90
21	-3.20	0.002	0.000	47	0	64	0	0	-49	0	-67
22	-4.00	0.002	0.000	15	0	21	0	0	-29	0	-39
23	-4.50	0.001	-0.000	4	0	6	0	0	-15	0	-21
24	-5.00	0.001	-0.000	0	-0	0	-0	0	0	0	0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment						Shear force					
	Calculated			Factored			Calculated			Factored		
	max.	elev.	min.	max.	min.	max.	max.	elev.	min.	max.	min.	max.
	kN.m/m		kN.m/m	kN.m/m	kN/m	kN/m	kN/m		kN/m	kN/m	kN/m	kN/m
1	0	-2.40	-0	1.60	0	-0	0	10.00	0	10.00	0	0
2	8	3.00	-1	7.20	11	-2	5	5.00	-1	0.80	7	-2
3	265	2.30	-0	-5.00	358	-0	83	4.50	-57	-1.00	111	-77
4	322	2.30	-0	-5.00	434	-0	94	4.00	-76	-1.00	127	-102
5	326	1.60	-0	-5.00	440	-0	94	4.00	-77	-1.70	127	-103
6	322	2.30	-0	-5.00	435	-0	94	4.00	-75	0.00	127	-101

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

Summary of results (continued)

Maximum and minimum displacement at each stage

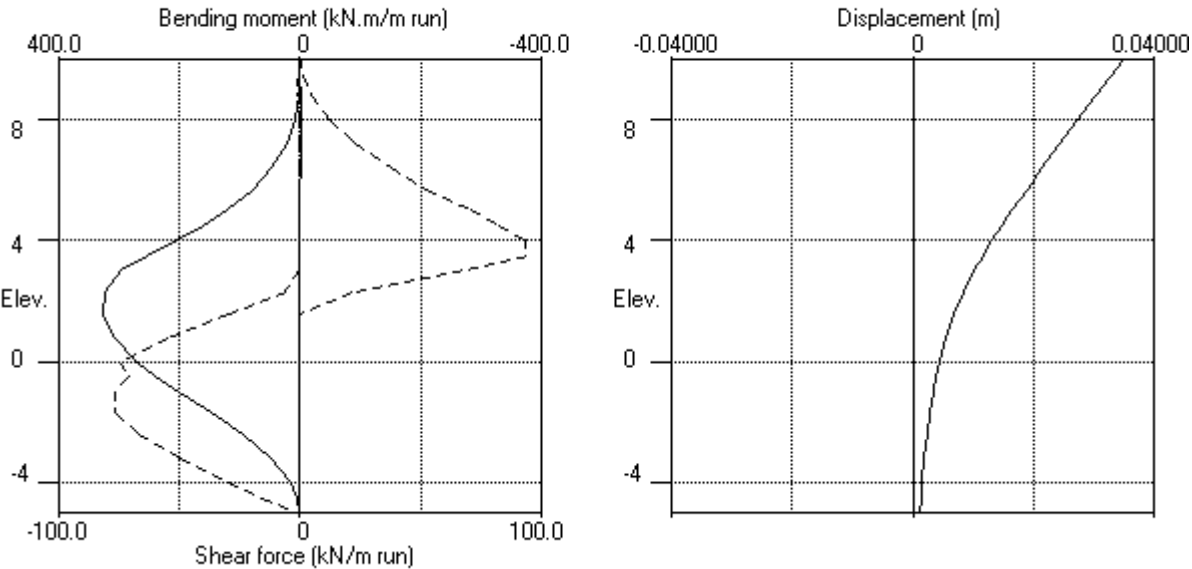
Stage	no.	maximum m	elev.	minimum m	elev.	Stage description
1	0.000	2.30	-0.000	-5.00	Change EI of wall to 582868kN.m2/m run	
2	0.001	10.00	0.000	10.00	Apply surcharge no.1 at elev. 10.00	
3	0.024	10.00	0.000	10.00	Excav. to elev. 4.50 on PASSIVE side	
4	0.032	10.00	0.000	10.00	Excav. to elev. 4.00 on PASSIVE side	
5	0.033	10.00	0.000	10.00	Apply water pressure profile no.1	
6	0.035	10.00	0.000	10.00	Change soil type 3 to soil type 4	

APPENDIX A-3. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Active side	Soil types	Passive side
1	10.00	1 Made Ground	1 Made Ground	
2	5.00	2 Terrace Gravel	2 Terrace Gravel	
3	0.00	3 London Clay (Und)	3 London Clay (Und)	

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Description	Bulk density kN/m3	Young's Modulus Eh,kN/m2	At rest coeff. Ko	Consol state. NC/OC	Active limit Ka	Passive limit Kp	Cohesion kN/m2
1	Made Ground	17.00a	10000	0.500	OC	0.283	4.696	
		18.00b		(0.300)	(0.000)	(0.000)		
2	Terrace Gravel	18.00a	50000	0.430	OC	0.227	6.670	
		19.00b		(0.300)	(0.000)	(0.000)		
3	London Cl..	20.00	100000	1.500	OC	1.000	1.000	100.0u
	(0.00)	(7000)		(0.490)	(2.000)	(2.000)	(7.000)	
4	London Cl..	20.00	80000	1.500	OC	0.444	2.488	10.00d
	(0.00)	(5600)		(0.200)	(1.529)	(4.088)		

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

Additional soil parameters associated with Ka and Kp

No.	Description	--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction angle	Wall adhesion coeff.	Backfill	Soil friction angle	Wall adhesion coeff.	Backfill
1	Made Ground	30.00	0.667	0.00	30.00	0.667	0.00
2	Terrace Gravel	35.00	0.667	0.00	35.00	0.667	0.00
3	London Clay (Und)	0.00	0.000	0.00	0.00	0.000	0.00
4	London Clay (Dra)	20.00	0.500	0.00	20.00	0.500	0.00

GROUND WATER CONDITIONS

Density of water = 9.807 kN/m3

	Active side	Passive side
Initial water table elevation	3.00	3.00

Automatic water pressure balancing at toe of wall : No

Active side					Passive side				
Water press.	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Water press.	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
	1	4.00	4.00	0.0		1	3.00	3.00	0.0 MC
	2	5.00	5.00	0.0		1	3.00	3.00	0.0 WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = -5.00
Maximum finite element length = 0.80 m
Youngs modulus of wall E = 2.1000E+08 kN/m2
Moment of inertia of wall I = 2.1386E-03 m4/m run
E.I = 449098 kN.m2/m run
Yield Moment of wall = Not defined

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

SURCHARGE LOADS

Surch	Distance	Length	Width	Surcharge	Equiv. Partial		
-arge	from	parallel	perpend.	----- kN/m2 -----	soil factor/		
no.	Elev.	wall	to wall	Near edge	Far edge	type	Category
1	10.00	0.50 (A)	1000.00	20.00	10.00	=	N/A 1.30 Var

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

stage no.	-----
1	Change EI of wall to 582868 kN.m2/m run From elevation 10.00 to -1.00 Yield moment not defined Reset wall displacements to zero at this stage
2	Apply surcharge no.1 at elevation 10.00
3	Excavate to elevation 4.50 on PASSIVE side
4	Excavate to elevation 4.00 on PASSIVE side
5	Apply water pressure profile no.2 (Worst Cred.)
6	Change properties of soil type 3 to soil type 4 Ko pressures will not be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 2

Water pressures : Worst Credible

Partial factor on C' = 1.250

Partial factor on Phi' = 1.250

Partial factor on Cu = 1.400

Partial factor on Soil Modulus = 1.000

Partial factor on Permanent Unfavourable loads = 1.000

Partial factor on Permanent Favourable loads = 1.000

Partial factor on Permanent Variable loads = 1.300

Stability analysis:

Method of analysis - Strength Factor method

Overall 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

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

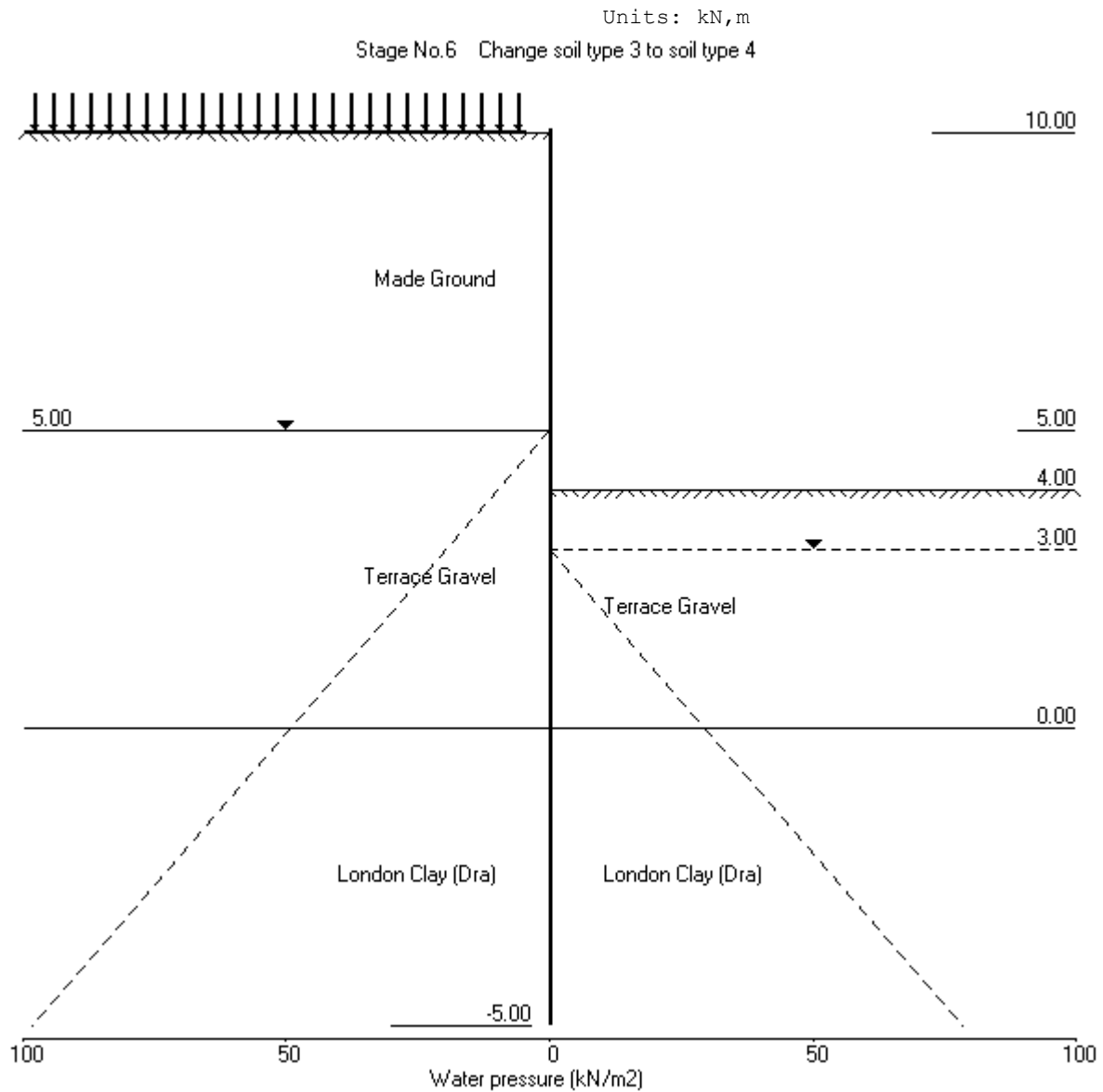
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive	Graph. output pressures
1	Change EI of wall to 582868kN.m2/m run	No	No	No
2	Apply surcharge no.1 at elev. 10.00	No	No	No
3	Excav. to elev. 4.50 on PASSIVE side	No	No	No
4	Excav. to elev. 4.00 on PASSIVE side	Yes	Yes	Yes
5	Apply water pressure profile no.2	Yes	Yes	Yes
6	Change soil type 3 to soil type 4	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :



APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No. 4 Excavate to elevation 4.00 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

				Overall			
				FoS for toe		Toe elev. for	
				elev. = -5.00		FoS = 1.000	
				-----		-----	
Stage	--- G.L. ---	Strut	Factor	Moment		Toe	Wall
No.	Act. Pass.	Elev.	of	equilib.		elev.	Penetr
			Safety	at elev.		-ation	
4	10.00 4.00	Cant.	1.270	-3.69		-2.39	6.39

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: ULS DA1 Combination 2

*** Wall displacements reset to zero at stage 1

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	EI of wall kN.m2/m
1	10.00	0.00	0.055	5.92E-03	0.0	-0.0		582868
2	9.40	4.74	0.052	5.92E-03	1.4	0.5		582868
3	8.80	9.64	0.048	5.91E-03	5.7	2.5		582868
4	8.00	15.25	0.043	5.90E-03	15.7	10.7		582868
5	7.20	20.45	0.039	5.88E-03	30.0	28.7		582868
6	6.40	25.49	0.034	5.82E-03	48.4	59.7		582868
7	5.70	29.83	0.030	5.72E-03	67.7	100.2		582868
8	5.00	34.14	0.026	5.57E-03	90.1	155.2		582868
		28.19	0.026	5.57E-03	90.1	155.2		
9	4.50	30.87	0.023	5.41E-03	104.9	203.9		582868
10	4.00	33.53	0.020	5.21E-03	121.0	260.3		582868
11	3.50	-4.07	0.018	4.96E-03	128.3	323.3		582868
12	3.00	-41.70	0.015	4.66E-03	116.9	385.4		582868
13	2.30	-68.68	0.012	4.15E-03	78.3	461.9		582868
14	1.60	-83.80	0.010	3.57E-03	24.9	500.4		582868
15	0.80	-54.19	0.007	2.89E-03	-30.3	493.4		582868
16	0.00	-31.02	0.005	2.24E-03	-64.4	451.7		582868
		-55.05	0.005	2.24E-03	-64.4	451.7		
17	-0.50	-39.84	0.004	1.87E-03	-88.1	412.5		582868
18	-1.00	-27.04	0.003	1.54E-03	-104.8	365.9		449098
19	-1.70	-13.94	0.002	1.03E-03	-119.2	284.5		449098
20	-2.40	13.01	0.002	6.59E-04	-119.5	199.2		449098
21	-3.20	32.76	0.001	3.86E-04	-101.2	107.7		449098
22	-4.00	52.60	0.001	2.57E-04	-67.1	37.2		449098
23	-4.50	67.09	0.001	2.30E-04	-37.1	10.2		449098
24	-5.00	81.43	0.001	2.25E-04	0.0	-0.0		---

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.4 Excavate to elevation 4.00 on PASSIVE side

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1396
2	9.40	0.00	13.38	4.74	45.42	4.74	4.74a	1396
3	8.80	0.00	27.19	9.64	92.31	9.64	9.64a	1396
4	8.00	0.00	43.02	15.25	146.04	15.25	15.25a	1396
5	7.20	0.00	57.69	20.45	195.84	20.45	20.45a	1396
6	6.40	0.00	71.90	25.49	244.08	25.49	25.49a	1396
7	5.70	0.00	84.14	29.83	285.64	29.83	29.83a	1396
8	5.00	0.00	96.28	34.14	326.84	34.14	34.14a	1396
		0.00	96.28	28.19	430.65	28.19	28.19a	6980
9	4.50	0.00	105.41	30.87	471.46	30.87	30.87a	6980
10	4.00	0.00	114.50	33.53	512.15	33.53	33.53a	6980
11	3.50	0.00	123.57	36.19	552.73	36.19	36.19a	6980
12	3.00	0.00	132.63	38.84	593.23	38.84	38.84a	6980
13	2.30	6.86	139.11	40.74	622.24	40.74	47.60a	6980
14	1.60	13.73	145.57	42.63	651.13	42.63	56.36a	6980
15	0.80	21.57	152.93	44.78	684.02	44.78	66.36a	6980
16	0.00	29.42	160.26	46.93	716.81	46.93	76.35a	6980
		Total>	189.68	50.00m	332.58	163.16	163.16	18887
17	-0.50	Total>	199.65	52.50m	347.56	193.51	193.51	19548
18	-1.00	Total>	209.62	56.74	362.53	221.47	221.47	20209
19	-1.70	Total>	223.56	63.69	383.47	255.87	255.87	21135
20	-2.40	Total>	237.50	70.62	404.41	284.73	284.73	22060
21	-3.20	Total>	253.41	78.53	428.32	312.68	312.68	23118
22	-4.00	Total>	269.30	86.43	452.22	342.09	342.09	85837
23	-4.50	Total>	279.24	91.36	467.15	361.95	361.95	88184
24	-5.00	Total>	289.16	96.28	482.08	381.77	381.77	90531

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	4.00	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	11333
11	3.50	0.00	9.00	2.64	40.26	40.26	40.26p	11333
12	3.00	0.00	18.01	5.27	80.54	80.54	80.54p	11333
13	2.30	6.86	24.46	7.16	109.41	109.41	116.28p	11333
14	1.60	13.73	30.95	9.06	138.41	126.43	140.16	11333
15	0.80	21.57	38.40	11.24	171.75	98.97	120.55	11333
16	0.00	29.42	45.91	13.44	205.37	77.95	107.37	11333
		Total>	75.33	20.00m	218.21	218.21	218.21p	29717
17	-0.50	Total>	85.47	22.50m	233.35	233.35	233.35p	30757
18	-1.00	Total>	95.64	25.00m	248.52	248.52	248.52p	31797
19	-1.70	Total>	109.92	28.50m	269.81	269.81	269.81p	33253
20	-2.40	Total>	124.27	32.00m	291.16	271.72	271.72	34709

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 | Sheet No.
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.4 Excavate to elevation 4.00 on PASSIVE side

Node Y		----- PASSIVE side -----					
no.	coord	----- Effective stresses -----				Total	Soil
		Water	Vertic	Active	Passive	Earth	earth
		press.	-al	limit	limit	pressure	pressure
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	coeff.
							kN/m3
21	-3.20	Total>	140.76	36.00m	315.65	279.92	279.92
22	-4.00	Total>	157.34	40.00m	340.23	289.49	289.49
23	-4.50	Total>	167.75	42.50m	355.64	294.86	294.86
24	-5.00	Total>	178.19	45.00m	371.09	300.33	300.33

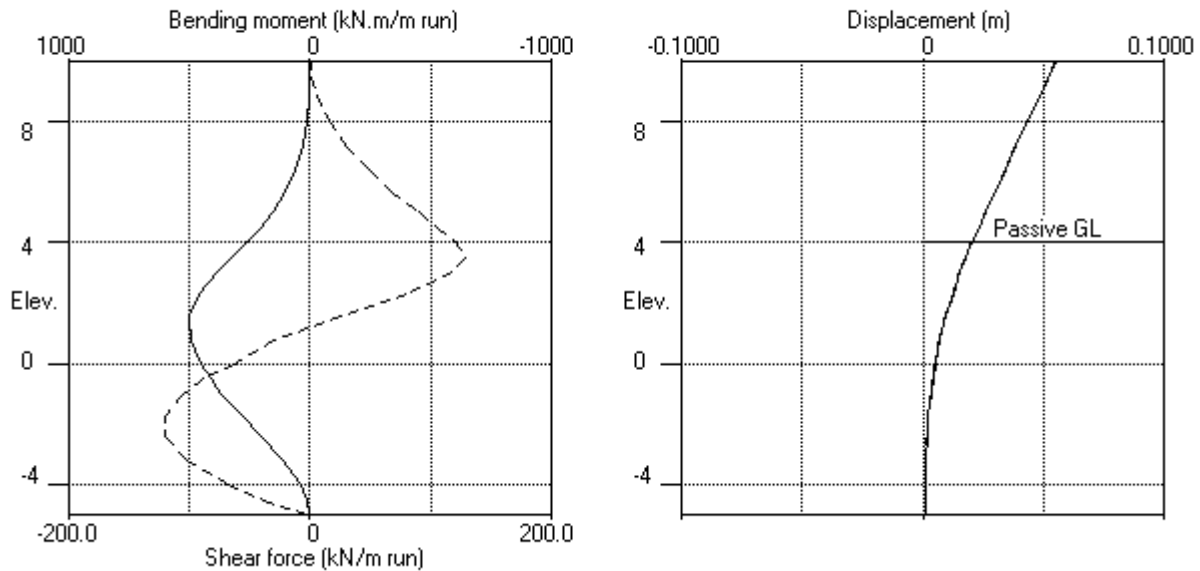
Note: 76.35a Soil pressure at active limit
 269.81p Soil pressure at passive limit

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

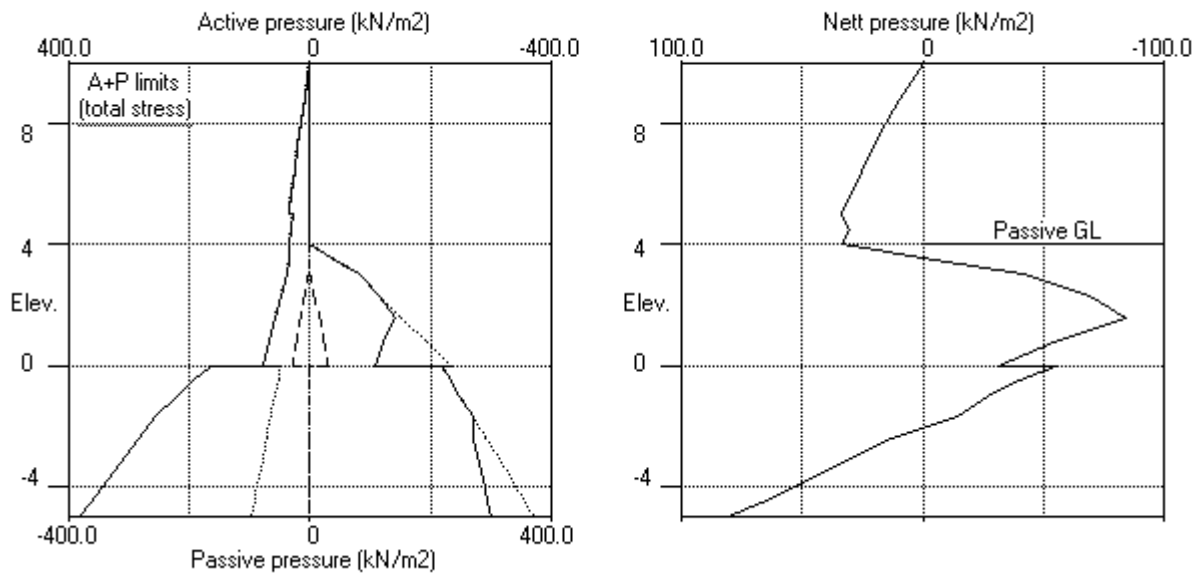
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
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Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No.4 Excav. to elev. 4.00 on PASSIVE side



Stage No.4 Excav. to elev. 4.00 on PASSIVE side



APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No. 5 Apply water pressure profile no.2 (Worst Cred.)

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

		Overall			
		FoS for toe		Toe elev. for	
		elev. = -5.00		FoS = 1.000	
		-----		-----	
Stage	--- G.L. ---	Strut	Factor	Moment	Toe Wall
No.	Act. Pass.	Elev.	of	equilib.	elev. Penetr
		Safety at elev.		-ation	
5	10.00 4.00	Cant.	1.202	-3.66	-2.94 6.94

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: ULS DA1 Combination 2

*** Wall displacements reset to zero at stage 1

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	EI of wall kN.m2/m
1	10.00	0.00	0.067	6.96E-03	0.0	-0.0		582868
2	9.40	4.74	0.063	6.96E-03	1.4	0.5		582868
3	8.80	9.64	0.059	6.96E-03	5.7	2.5		582868
4	8.00	15.25	0.053	6.95E-03	15.7	10.7		582868
5	7.20	20.45	0.048	6.93E-03	30.0	28.7		582868
6	6.40	25.49	0.042	6.87E-03	48.4	59.7		582868
7	5.70	29.83	0.037	6.77E-03	67.7	100.2		582868
8	5.00	34.14	0.033	6.62E-03	90.1	155.2		582868
		28.19	0.033	6.62E-03	90.1	155.2		
9	4.50	34.48	0.029	6.46E-03	105.8	204.0		582868
10	4.00	40.76	0.026	6.26E-03	124.6	261.5		582868
11	3.50	6.77	0.023	6.01E-03	136.5	327.4		582868
12	3.00	-27.24	0.020	5.70E-03	131.4	395.0		582868
13	2.30	-54.22	0.016	5.17E-03	102.8	485.2		582868
14	1.60	-81.33	0.013	4.55E-03	55.4	543.5		582868
15	0.80	-65.68	0.010	3.80E-03	-3.4	562.9		582868
16	0.00	-35.38	0.007	3.04E-03	-43.8	539.1		582868
		-85.33	0.007	3.04E-03	-43.8	539.1		
17	-0.50	-64.10	0.005	2.59E-03	-81.2	506.4		582868
18	-1.00	-45.57	0.004	2.18E-03	-108.6	460.2		449098
19	-1.70	-25.33	0.003	1.53E-03	-133.4	371.6		449098
20	-2.40	-4.92	0.002	1.02E-03	-144.0	273.6		449098
21	-3.20	27.83	0.001	6.46E-04	-134.8	156.7		449098
22	-4.00	63.81	0.001	4.55E-04	-98.2	57.7		449098
23	-4.50	98.26	0.001	4.14E-04	-57.7	16.6		449098
24	-5.00	132.40	0.001	4.05E-04	0.0	0.0		---

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.5 Apply water pressure profile no.2 (Worst Cred.)

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1348
2	9.40	0.00	13.38	4.74	45.42	4.74	4.74a	1348
3	8.80	0.00	27.19	9.64	92.31	9.64	9.64a	1348
4	8.00	0.00	43.02	15.25	146.04	15.25	15.25a	1348
5	7.20	0.00	57.69	20.45	195.84	20.45	20.45a	1348
6	6.40	0.00	71.90	25.49	244.08	25.49	25.49a	1348
7	5.70	0.00	84.14	29.83	285.64	29.83	29.83a	1348
8	5.00	0.00	96.28	34.14	326.84	34.14	34.14a	1348
		0.00	96.28	28.19	430.65	28.19	28.19a	6740
9	4.50	4.90	101.00	29.58	451.77	29.58	34.48a	6740
10	4.00	9.81	105.70	30.95	472.76	30.95	40.76a	6740
11	3.50	14.71	110.37	32.32	493.65	32.32	47.03a	6740
12	3.00	19.61	115.02	33.68	514.45	33.68	53.29a	6740
13	2.30	26.48	121.50	35.58	543.46	35.58	62.06a	6740
14	1.60	33.34	127.96	37.47	572.35	37.47	70.81a	6740
15	0.80	41.19	135.31	39.62	605.24	39.62	80.81a	6740
16	0.00	49.03	142.65	41.77	638.03	41.77	90.80a	6740
		Total>	191.68	50.00m	334.58	132.88	132.88	18301
17	-0.50	Total>	201.65	53.78	349.55	169.25	169.25	18942
18	-1.00	Total>	211.62	58.75	364.52	202.95	202.95	19582
19	-1.70	Total>	225.56	65.69	385.47	244.48	244.48	20479
20	-2.40	Total>	239.50	72.62	406.40	279.18	279.18	21376
21	-3.20	Total>	255.41	80.53	430.32	312.32	312.32	22401
22	-4.00	Total>	271.30	88.43	454.22	348.90	348.90	93096
23	-4.50	Total>	281.24	93.36	469.15	378.88	378.88	102415
24	-5.00	Total>	291.16	98.29	484.08	408.60	408.60	105141

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	4.00	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	10448
11	3.50	0.00	9.00	2.64	40.26	40.26	40.26p	10448
12	3.00	0.00	18.01	5.27	80.54	80.54	80.54p	10448
13	2.30	6.86	24.46	7.16	109.41	109.41	116.28p	10448
14	1.60	13.73	30.95	9.06	138.41	138.41	152.14p	10448
15	0.80	21.57	38.40	11.24	171.75	124.91	146.49	10448
16	0.00	29.42	45.91	13.44	205.37	96.77	126.19	10448
		Total>	75.33	20.00m	218.21	218.21	218.21p	27502
17	-0.50	Total>	85.47	22.50m	233.35	233.35	233.35p	28464
18	-1.00	Total>	95.64	25.00m	248.52	248.52	248.52p	29427
19	-1.70	Total>	109.92	28.50m	269.81	269.81	269.81p	30774
20	-2.40	Total>	124.27	32.00m	291.16	284.10	284.10	32122

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 | Sheet No.
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.5 Apply water pressure profile no.2 (Worst Cred.)

Node Y		----- PASSIVE side -----						
no.	coord	----- Effective stresses -----				Total	Soil	
		Water	Vertic	Active	Passive	Earth	earth	stiffness
		press.	-al	limit	limit	pressure	pressure	coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
21	-3.20	Total>	140.76	36.00m	315.65	284.50	284.50	33662
22	-4.00	Total>	157.34	40.00m	340.23	285.09	285.09	99689
23	-4.50	Total>	167.75	42.50m	355.64	280.63	280.63	102415
24	-5.00	Total>	178.19	45.00m	371.09	276.19	276.19	105141

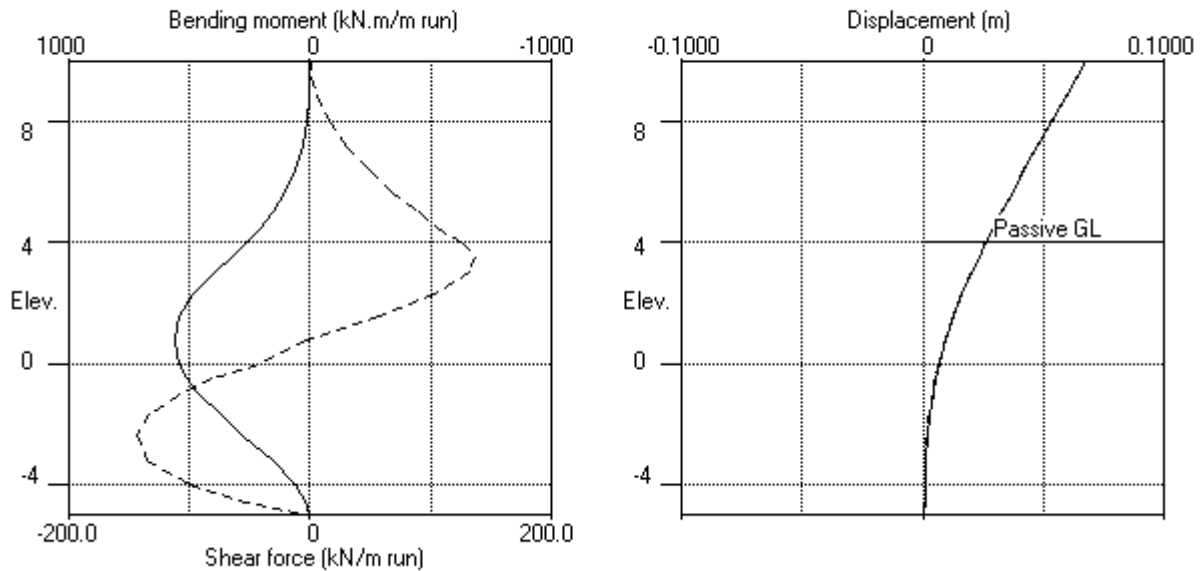
Note: 90.80a Soil pressure at active limit
 269.81p Soil pressure at passive limit

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

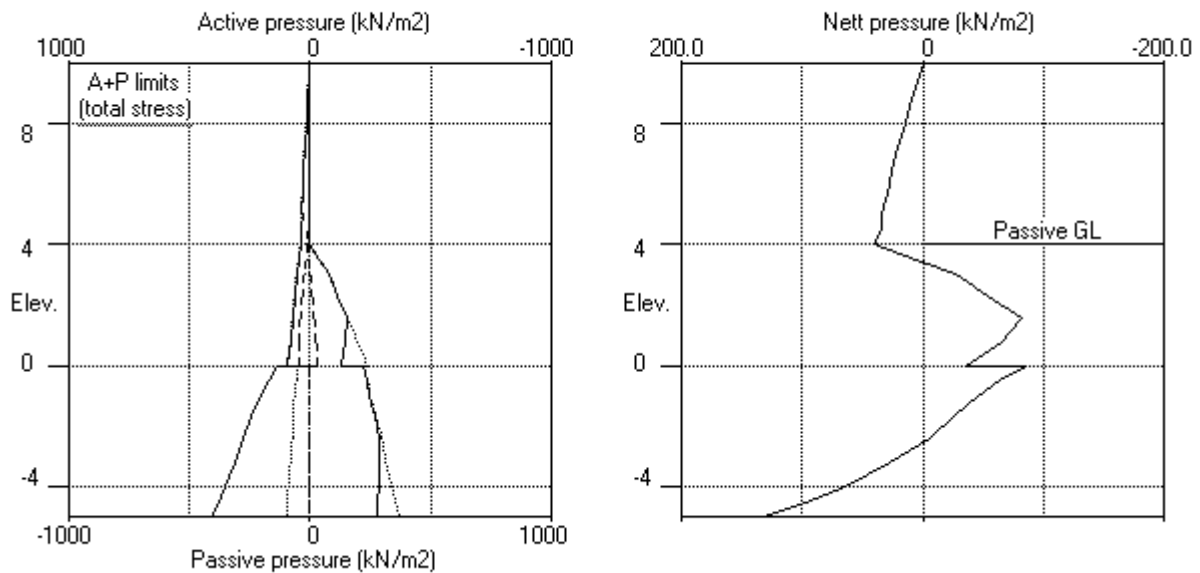
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No.5 Apply water pressure profile no.2 (Worst Cred.)



Stage No.5 Apply water pressure profile no.2 (Worst Cred.)



APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

Units: kN,m
Stage No. 6 Change properties of soil type 3 to soil type 4
Ko pressures will not be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Overall	
FoS for toe	Toe elev. for
elev. = -5.00	FoS = 1.000

Stage --- G.L. ---	Strut Factor Moment
No. Act. Pass.	Elev. of equilib. Toe Wall
	Safety at elev. Penetr
6 10.00 4.00	Cant. 1.085 -4.17 -3.25 7.25

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: ULS DA1 Combination 2

*** Wall displacements reset to zero at stage 1

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	EI of wall kN.m2/m
1	10.00	0.00	0.079	7.62E-03	0.0	-0.0		582868
2	9.40	4.74	0.075	7.62E-03	1.4	0.5		582868
3	8.80	9.64	0.070	7.62E-03	5.7	2.5		582868
4	8.00	15.25	0.064	7.61E-03	15.7	10.7		582868
5	7.20	20.45	0.058	7.58E-03	30.0	28.7		582868
6	6.40	25.49	0.052	7.52E-03	48.4	59.7		582868
7	5.70	29.83	0.046	7.43E-03	67.7	100.2		582868
8	5.00	34.14	0.041	7.27E-03	90.1	155.2		582868
		28.19	0.041	7.27E-03	90.1	155.2		
9	4.50	34.48	0.038	7.12E-03	105.8	204.0		582868
10	4.00	40.76	0.034	6.92E-03	124.6	261.5		582868
11	3.50	6.77	0.031	6.67E-03	136.5	327.4		582868
12	3.00	-27.24	0.028	6.36E-03	131.4	395.0		582868
13	2.30	-54.22	0.023	5.83E-03	102.8	485.2		582868
14	1.60	-81.33	0.019	5.21E-03	55.4	543.5		582868
15	0.80	-105.35	0.016	4.45E-03	-19.3	562.9		582868
16	0.00	-71.52	0.012	3.71E-03	-90.0	513.7		582868
		-43.78	0.012	3.71E-03	-90.0	513.7		
17	-0.50	-40.04	0.010	3.29E-03	-111.0	464.0		582868
18	-1.00	-20.50	0.009	2.92E-03	-126.1	405.9		449098
19	-1.70	1.83	0.007	2.36E-03	-132.6	311.2		449098
20	-2.40	18.17	0.006	1.95E-03	-125.6	219.7		449098
21	-3.20	31.37	0.004	1.64E-03	-105.8	122.2		449098
22	-4.00	48.95	0.003	1.50E-03	-73.7	44.8		449098
23	-4.50	67.45	0.002	1.46E-03	-44.6	13.2		449098
24	-5.00	110.98	0.001	1.46E-03	0.0	-0.0		---

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.6 Change properties of soil type 3 to soil type 4
Ko pressures will not be reset

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		----- Effective stresses -----				Total earth pressure kN/m2		
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2		Earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1059
2	9.40	0.00	13.38	4.74	45.42	4.74	4.74a	1059
3	8.80	0.00	27.19	9.64	92.31	9.64	9.64a	1059
4	8.00	0.00	43.02	15.25	146.04	15.25	15.25a	1059
5	7.20	0.00	57.69	20.45	195.84	20.45	20.45a	1059
6	6.40	0.00	71.90	25.49	244.08	25.49	25.49a	1059
7	5.70	0.00	84.14	29.83	285.64	29.83	29.83a	1059
8	5.00	0.00	96.28	34.14	326.84	34.14	34.14a	1059
		0.00	96.28	28.19	430.65	28.19	28.19a	5296
9	4.50	4.90	101.00	29.58	451.77	29.58	34.48a	5296
10	4.00	9.81	105.70	30.95	472.76	30.95	40.76a	5296
11	3.50	14.71	110.37	32.32	493.65	32.32	47.03a	5296
12	3.00	19.61	115.02	33.68	514.45	33.68	53.29a	5296
13	2.30	26.48	121.50	35.58	543.46	35.58	62.06a	5296
14	1.60	33.34	127.96	37.47	572.35	37.47	70.81a	5296
15	0.80	41.19	135.31	39.62	605.24	39.62	80.81a	5296
16	0.00	49.03	142.65	41.77	638.03	41.77	90.80a	5296
		49.03	142.65	60.43	323.25	60.43	109.46a	7656
17	-0.50	53.94	147.72	63.05	333.70	74.96	128.89	7924
18	-1.00	58.84	152.78	65.67	344.14	105.35	164.19	8192
19	-1.70	65.70	159.86	69.32	358.73	142.97	208.68	8567
20	-2.40	72.57	166.93	72.98	373.30	174.76	247.32	8942
21	-3.20	80.41	174.99	77.14	389.93	205.77	286.18	9371
22	-4.00	88.26	183.05	81.30	406.53	241.35	329.61	9800
23	-4.50	93.16	188.07	83.90	416.90	271.20	364.36	10068
24	-5.00	98.07	193.10	86.50	427.26	301.08	399.14	10336

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		----- Effective stresses -----				Total earth pressure kN/m2		
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2		Earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	4.00	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	6646
11	3.50	0.00	9.00	2.64	40.26	40.26	40.26p	6646
12	3.00	0.00	18.01	5.27	80.54	80.54	80.54p	6646
13	2.30	6.86	24.46	7.16	109.41	109.41	116.28p	6646
14	1.60	13.73	30.95	9.06	138.41	138.41	152.14p	6646
15	0.80	21.57	38.40	11.24	171.75	164.58	186.16	6646
16	0.00	29.42	45.91	13.44	205.37	132.91	162.33	6646
		29.42	45.91	10.45	123.82	123.82	153.24p	9692
17	-0.50	34.32	51.15	13.15	134.61	134.61	168.93p	10032
18	-1.00	39.23	56.41	15.87	145.46	145.46	184.69p	10371
19	-1.70	46.09	63.83	19.70	160.76	160.76	206.85p	10846

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

(continued)

Stage No.6 Change properties of soil type 3 to soil type 4
 Ko pressures will not be reset

Node Y ----- PASSIVE side -----								
no.	coord	----- Effective stresses -----					Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
20	-2.40	52.96	71.32	23.57	176.20	176.20	229.15p	11321
21	-3.20	60.80	79.96	28.04	194.01	194.01	254.81p	11863
22	-4.00	68.65	88.69	32.55	212.02	212.02	280.66p	12406
23	-4.50	73.55	94.20	35.40	223.36	223.36	296.91p	12746
24	-5.00	78.45	99.74	38.26	234.78	209.71	288.16	13085

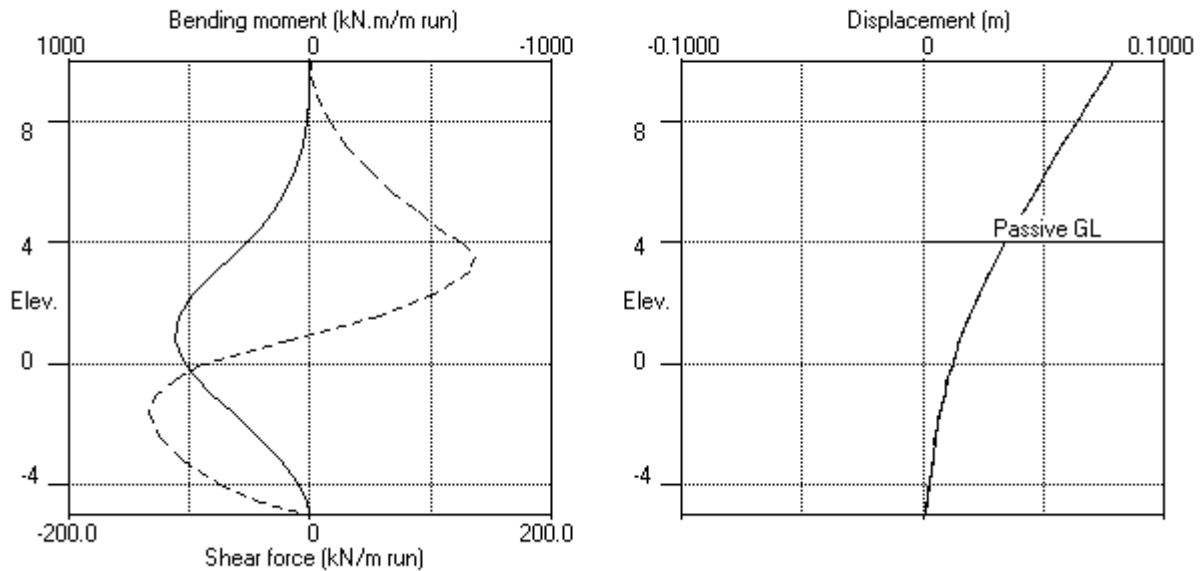
Note: 109.46a Soil pressure at active limit
 296.91p Soil pressure at passive limit

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

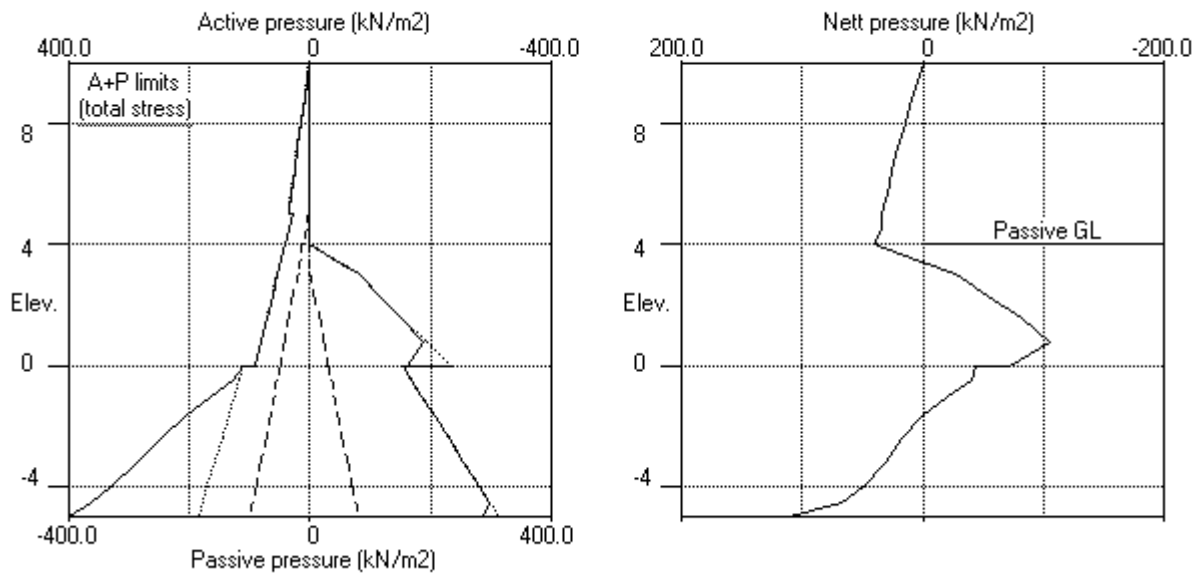
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
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 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Stage No.6 Change soil type 3 to soil type 4



Stage No.6 Change soil type 3 to soil type 4



APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: ULS DA1 Combination 2
 Water pressures : Worst Credible
 Partial factor on C' = 1.250
 Partial factor on Phi' = 1.250
 Partial factor on Cu = 1.400
 Partial factor on Soil Modulus = 1.000
 Partial factor on Permanent Unfavourable loads = 1.000
 Partial factor on Permanent Favourable loads = 1.000
 Partial factor on Permanent Variable loads = 1.300

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

		Overall					
		FoS for toe		Toe elev. for			
		elev. = -5.00		FoS = 1.000			
		-----		-----			
Stage	--- G.L. ---	Strut	Factor	Moment	Toe	Wall	
No.	Act. Pass.	Elev.	of	equilib.	elev.	Penetr	
		Safety at elev.		-ation			
1	10.00	10.00	Cant.	Conditions not	suitable	for	FoS calc.
2	10.00	10.00	Cant.	Conditions not	suitable	for	FoS calc.
3	10.00	4.50	Cant.	1.439	-3.74	-1.13	5.63
4	10.00	4.00	Cant.	1.270	-3.69	-2.39	6.39
5	10.00	4.00	Cant.	1.202	-3.66	-2.94	6.94
6	10.00	4.00	Cant.	1.085	-4.17	-3.25	7.25

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

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: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	10.00	0.079	0.000	0.0	-0.0	0.0	0.0
2	9.40	0.075	0.000	0.5	0.0	1.4	-0.5
3	8.80	0.070	0.000	2.5	-0.5	5.7	-1.1
4	8.00	0.064	0.000	10.7	-1.3	15.7	-0.7
5	7.20	0.058	0.000	28.7	-1.4	30.0	0.0
6	6.40	0.052	0.000	59.7	-0.5	48.4	0.0
7	5.70	0.046	0.000	100.2	-0.0	67.7	0.0
8	5.00	0.041	0.000	155.2	-0.0	90.1	0.0
9	4.50	0.038	0.000	204.0	-0.0	105.8	0.0
10	4.00	0.034	0.000	261.5	-0.0	124.6	0.0
11	3.50	0.031	0.000	327.4	-0.0	136.5	0.0
12	3.00	0.028	0.000	395.0	-0.0	131.4	-0.1
13	2.30	0.023	0.000	485.2	-0.0	102.8	-1.1
14	1.60	0.019	0.000	543.5	-0.0	55.4	-22.5
15	0.80	0.016	0.000	562.9	-0.0	0.0	-50.7
16	0.00	0.012	0.000	539.1	-0.0	0.0	-90.0
17	-0.50	0.010	0.000	506.4	-0.0	0.0	-111.0
18	-1.00	0.009	0.000	460.2	0.0	0.0	-126.1
19	-1.70	0.007	0.000	371.6	0.0	0.0	-133.4
20	-2.40	0.006	0.000	273.6	0.0	0.0	-144.0
21	-3.20	0.004	0.000	156.7	0.0	0.0	-134.8
22	-4.00	0.003	0.000	57.7	0.0	0.0	-98.2
23	-4.50	0.002	-0.000	16.6	0.0	0.0	-57.7
24	-5.00	0.001	-0.000	0.0	-0.0	0.0	0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment				Shear force			
	maximum	elev.	minimum	elev.	maximum	elev.	minimum	elev.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	0.0	-2.40	-0.0	1.60	0.0	10.00	0.0	10.00
2	9.6	3.00	-1.4	7.20	5.8	5.00	-1.6	0.80
3	388.6	2.30	-0.0	10.00	110.9	4.00	-86.8	-1.70
4	500.4	1.60	-0.0	10.00	128.3	3.50	-119.5	-2.40
5	562.9	0.80	-0.0	10.00	136.5	3.50	-144.0	-2.40
6	562.9	0.80	-0.0	10.00	136.5	3.50	-132.6	-1.70

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 | Sheet No.
Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
D1000-16 / AZ28-700N | Checked :

Summary of results (continued)

Maximum and minimum displacement at each stage

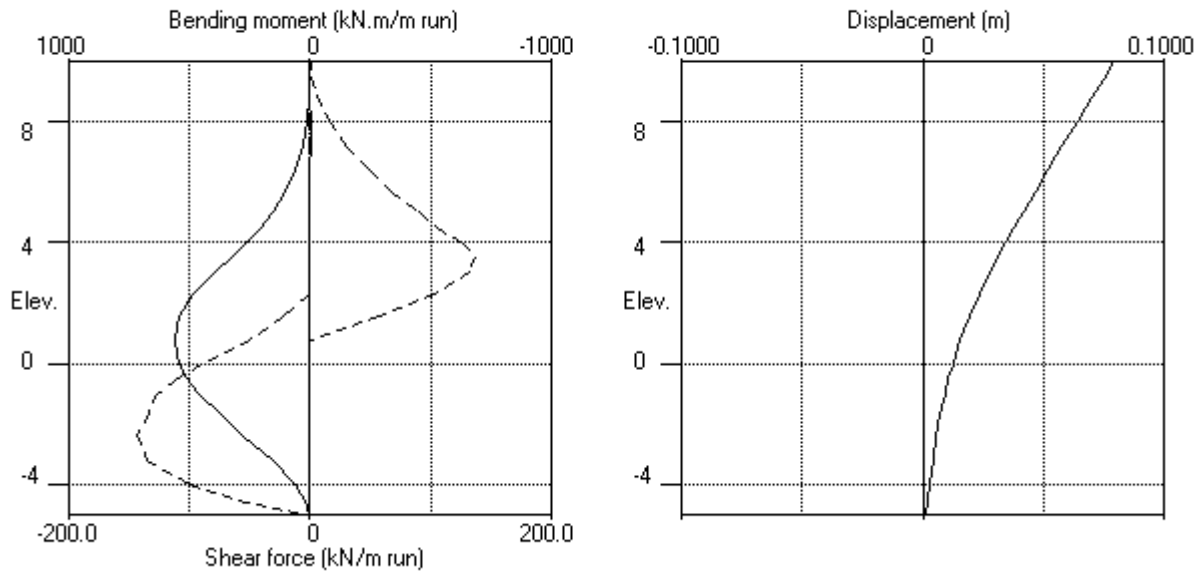
Stage	no.	maximum m	elev.	minimum m	elev.	Stage description
1	0.000	2.30	-0.000	-5.00	Change EI of wall to 582868kN.m2/m run	
2	0.001	10.00	0.000	10.00	Apply surcharge no.1 at elev. 10.00	
3	0.038	10.00	0.000	10.00	Excav. to elev. 4.50 on PASSIVE side	
4	0.055	10.00	0.000	10.00	Excav. to elev. 4.00 on PASSIVE side	
5	0.067	10.00	0.000	10.00	Apply water pressure profile no.2	
6	0.079	10.00	0.000	10.00	Change soil type 3 to soil type 4	

APPENDIX A-4. WALLAP run ID: Combi-Gyro Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Combi-Gyro Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Combi-Gyro Wall System (Pattern A) | Date:17-03-2015
 D1000-16 / AZ28-700N | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



APPENDIX B

APPENDIX B Plaxis 2D FE Analysis of Combi-Gyro Wall

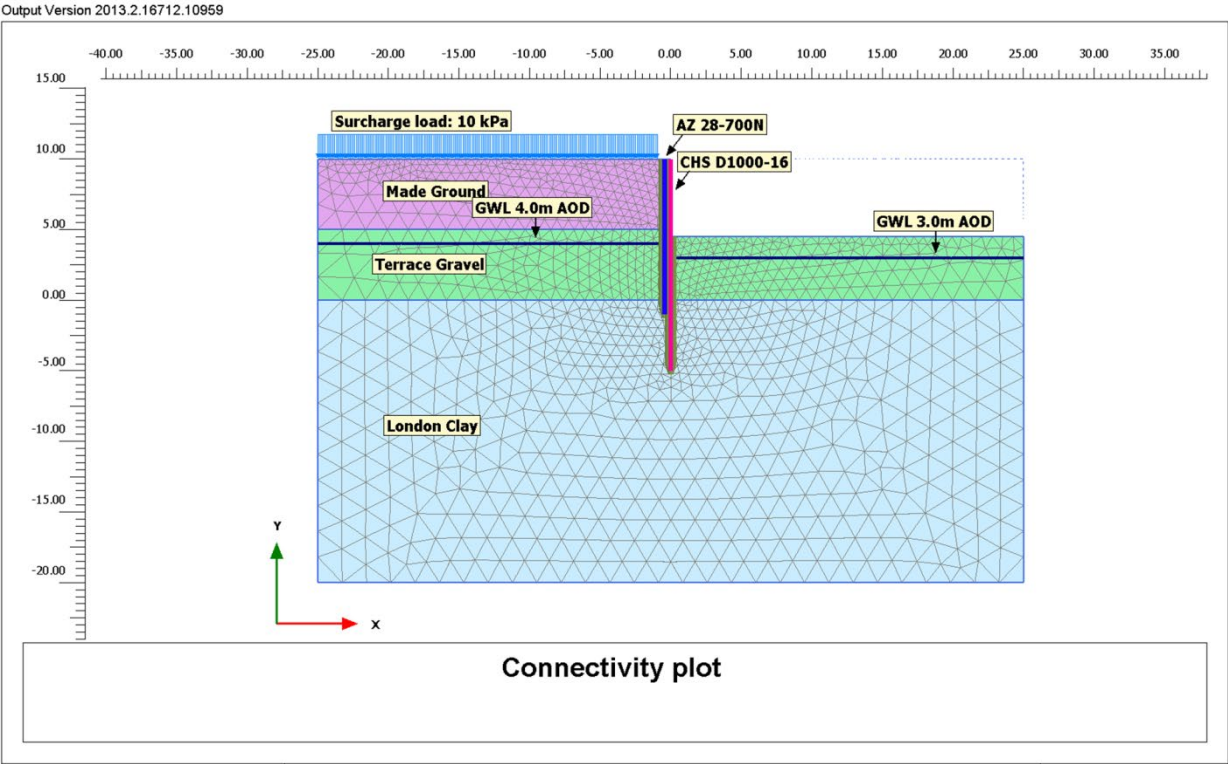


Figure B.1 Connectivity plot

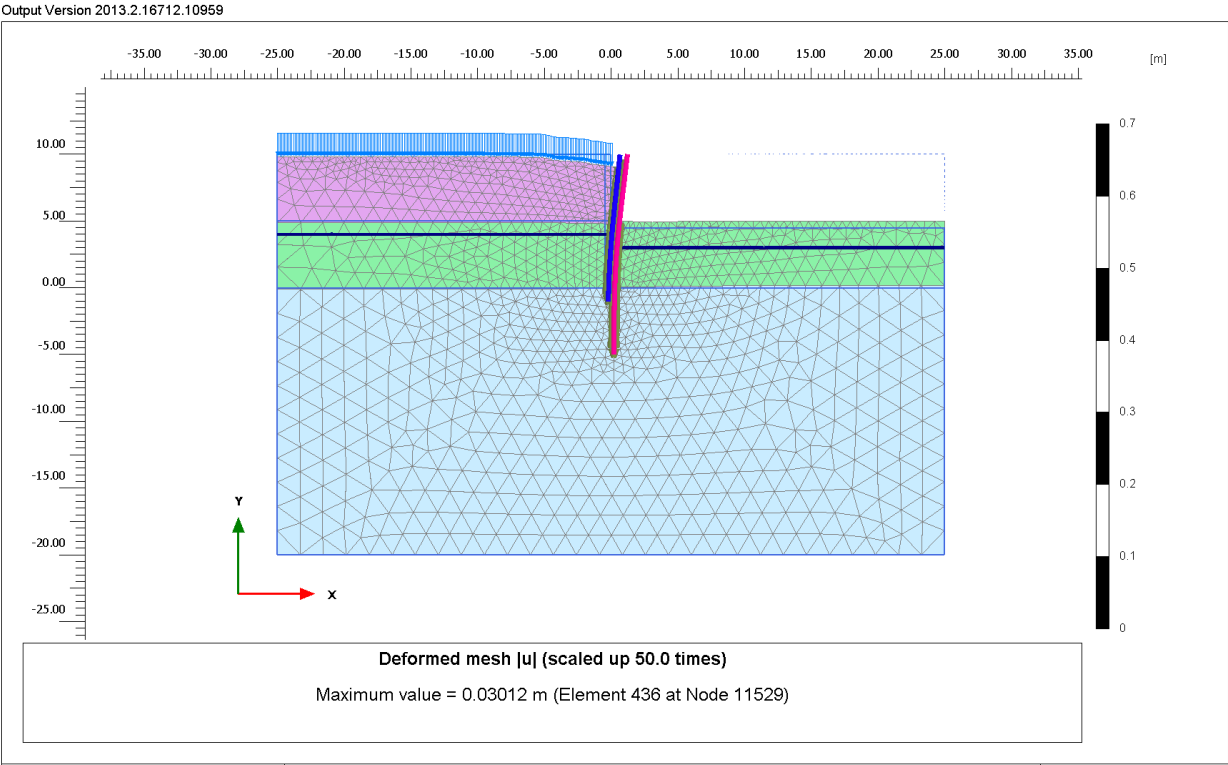


Figure B.2 Deformed mesh | u |

APPENDIX B Plaxis 2D FE Analysis of Combi-Gyro Wall

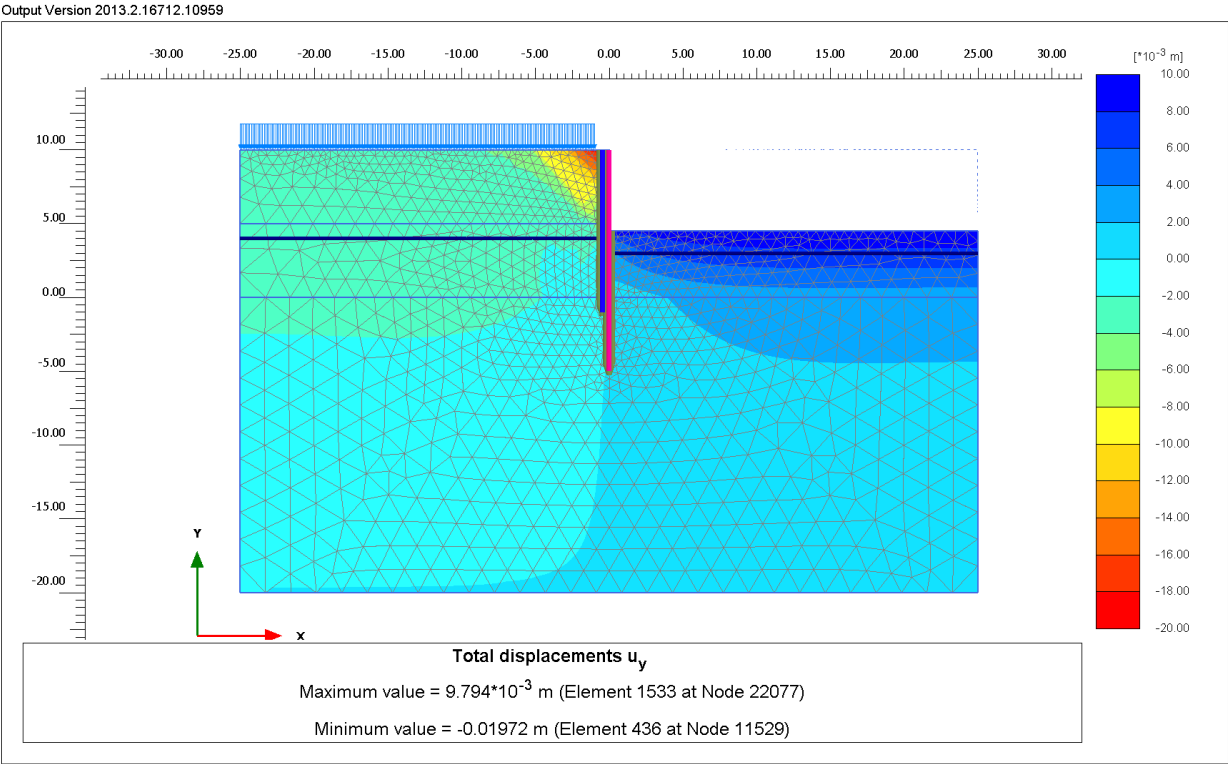


Figure B.3 Total vertical displacements

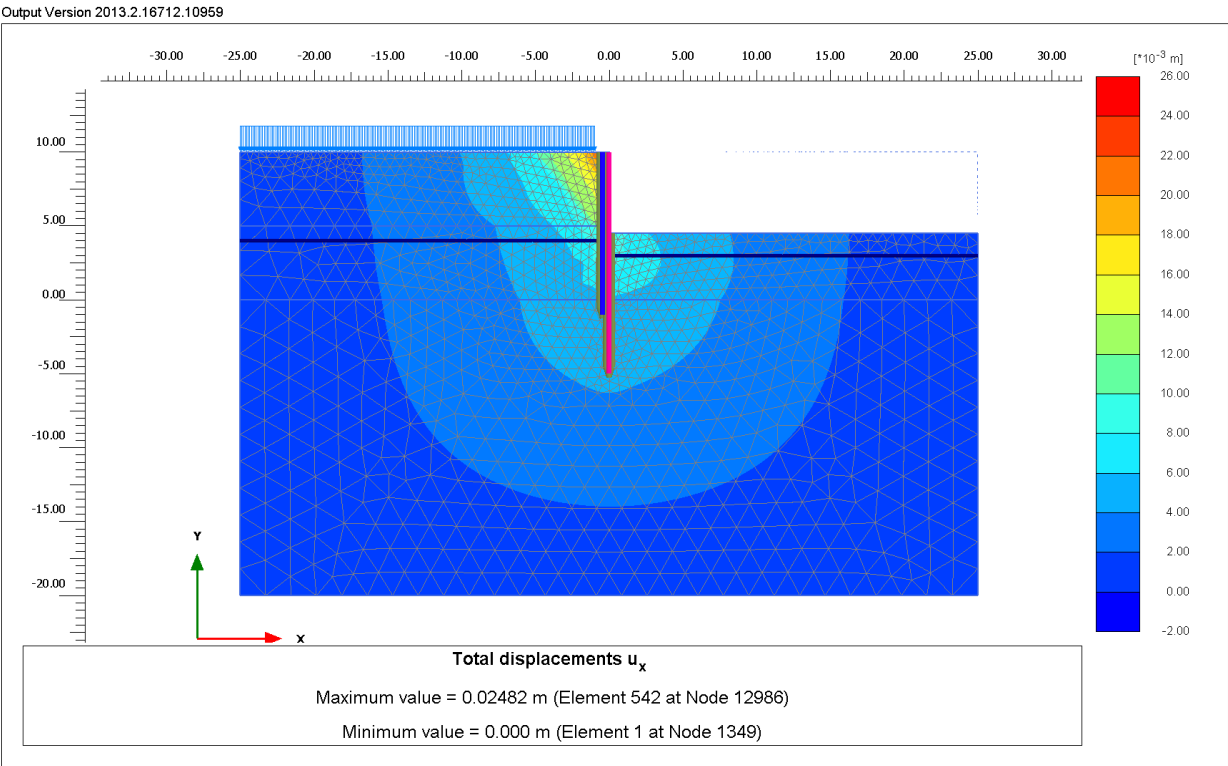


Figure B.4 Total horizontal displacements

APPENDIX B Plaxis 2D FE Analysis of Combi-Gyro Wall

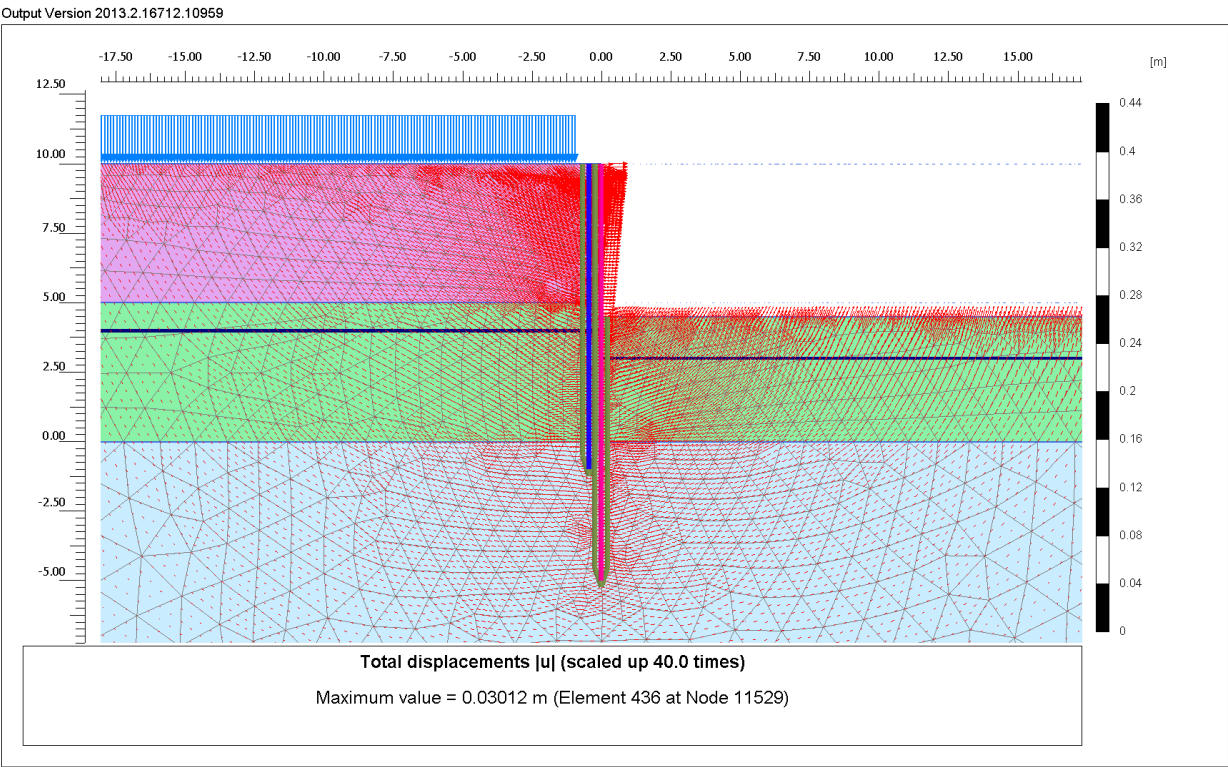


Figure B.5 Vector of total displacements

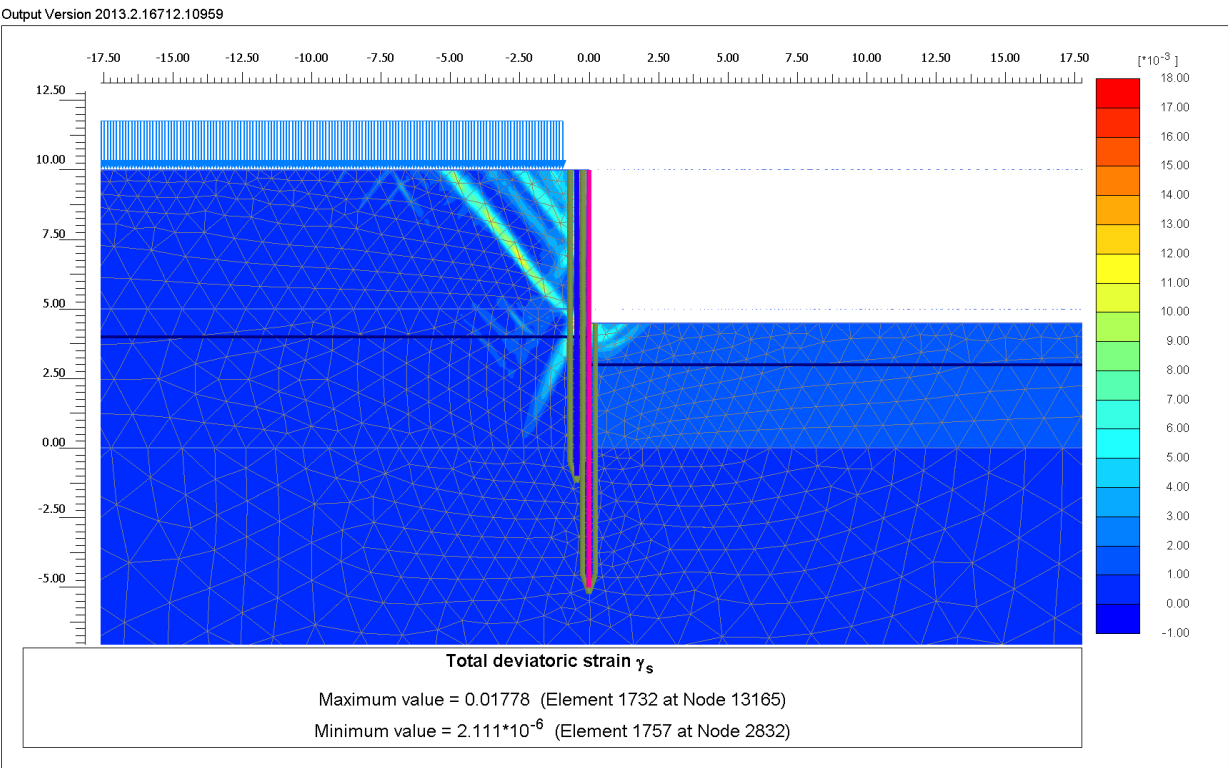


Figure B.6 Total shear strain, γ_s

APPENDIX B Plaxis 2D FE Analysis of Combi-Gyro Wall

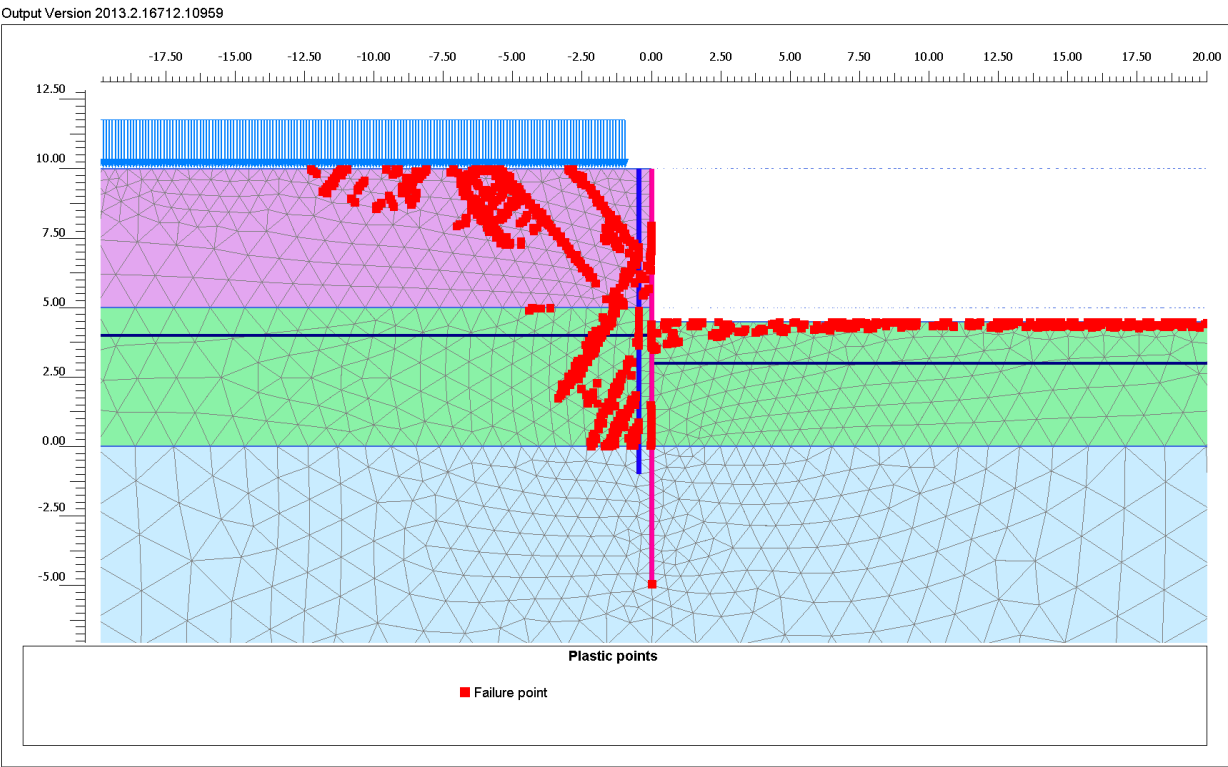


Figure B.7 Distribution of plastic points

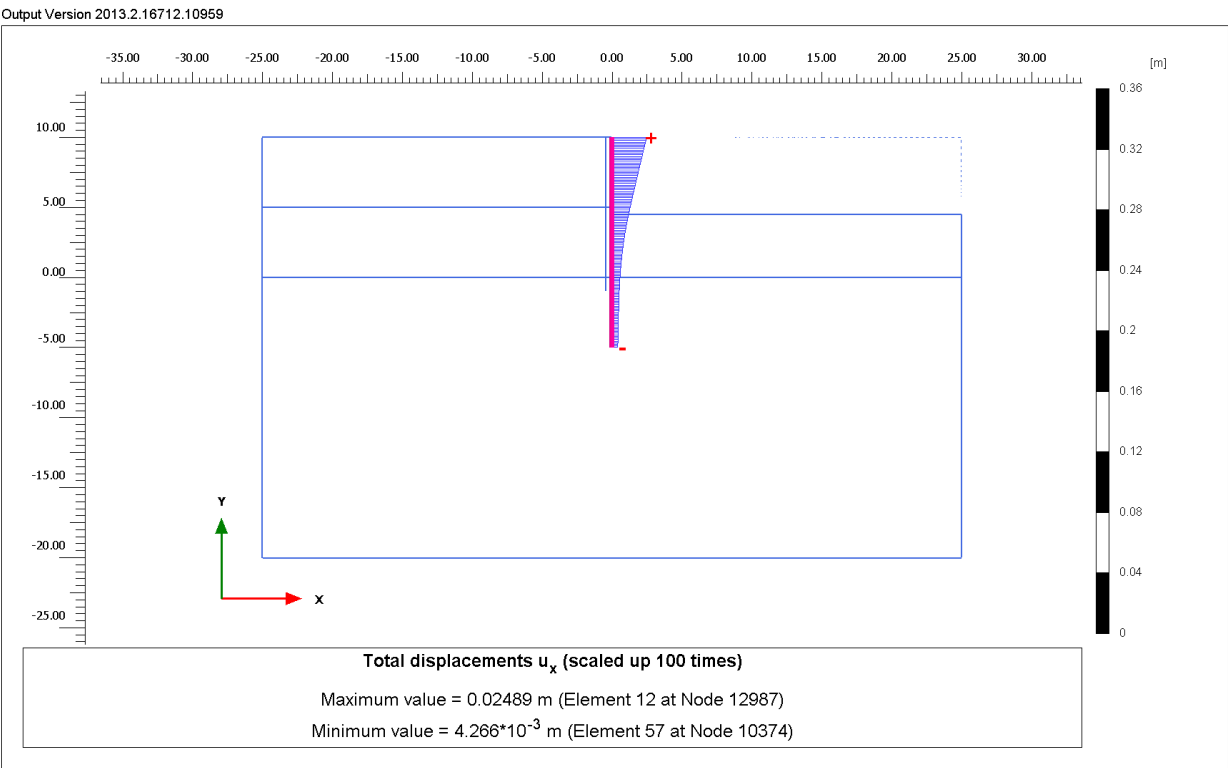


Figure B.8 Profile of horizontal wall displacements for CHS D1000-16

APPENDIX B Plaxis 2D FE Analysis of Combi-Gyro Wall

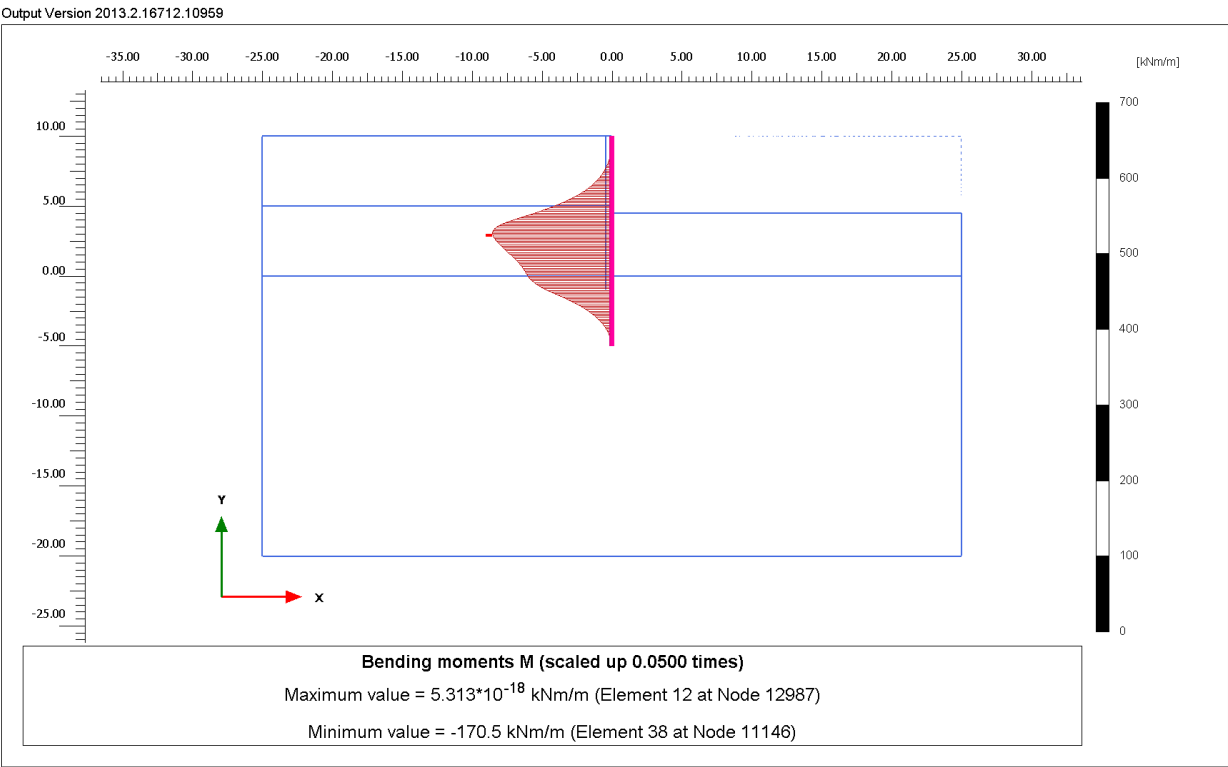


Figure B.9 Profile of wall bending moment for CHS D1000-16

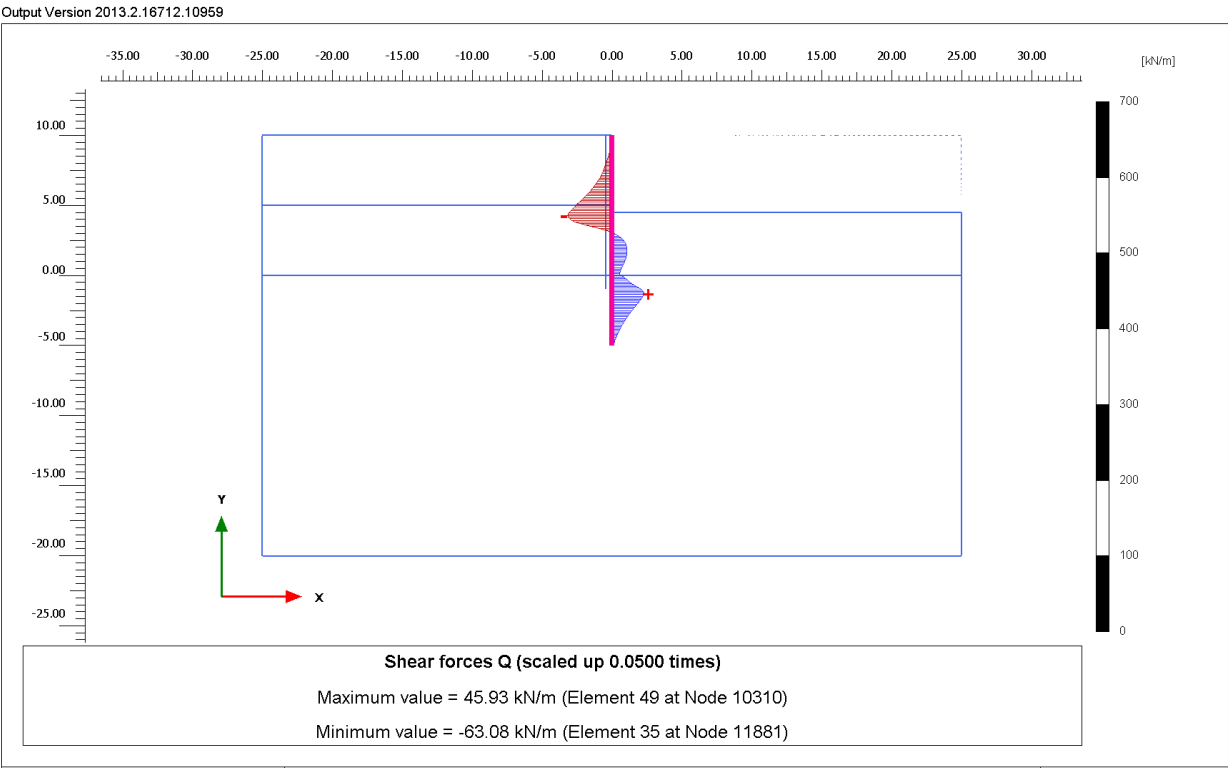


Figure B.10 Profile of wall shear force for CHS D1000-16

APPENDIX B Plaxis 2D FE Analysis of Combi-Gyro Wall

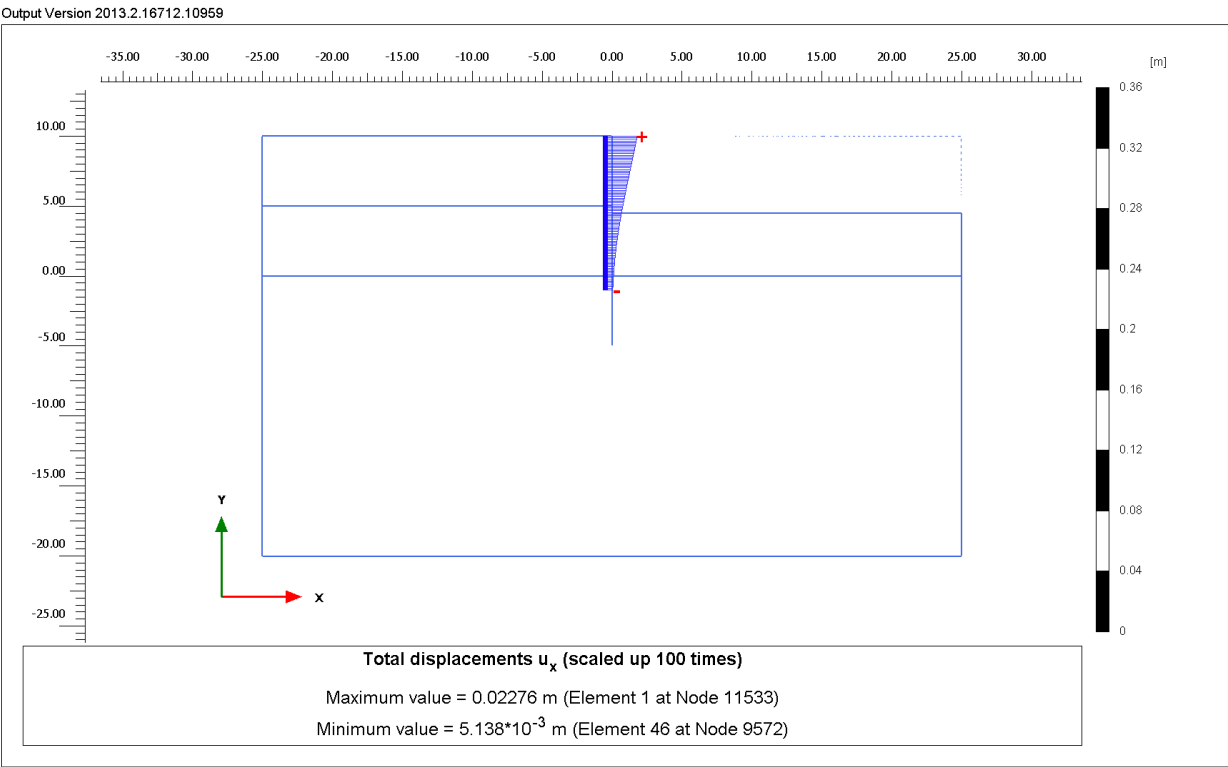


Figure B.11 Profile of horizontal wall displacements for AZ 28-700N

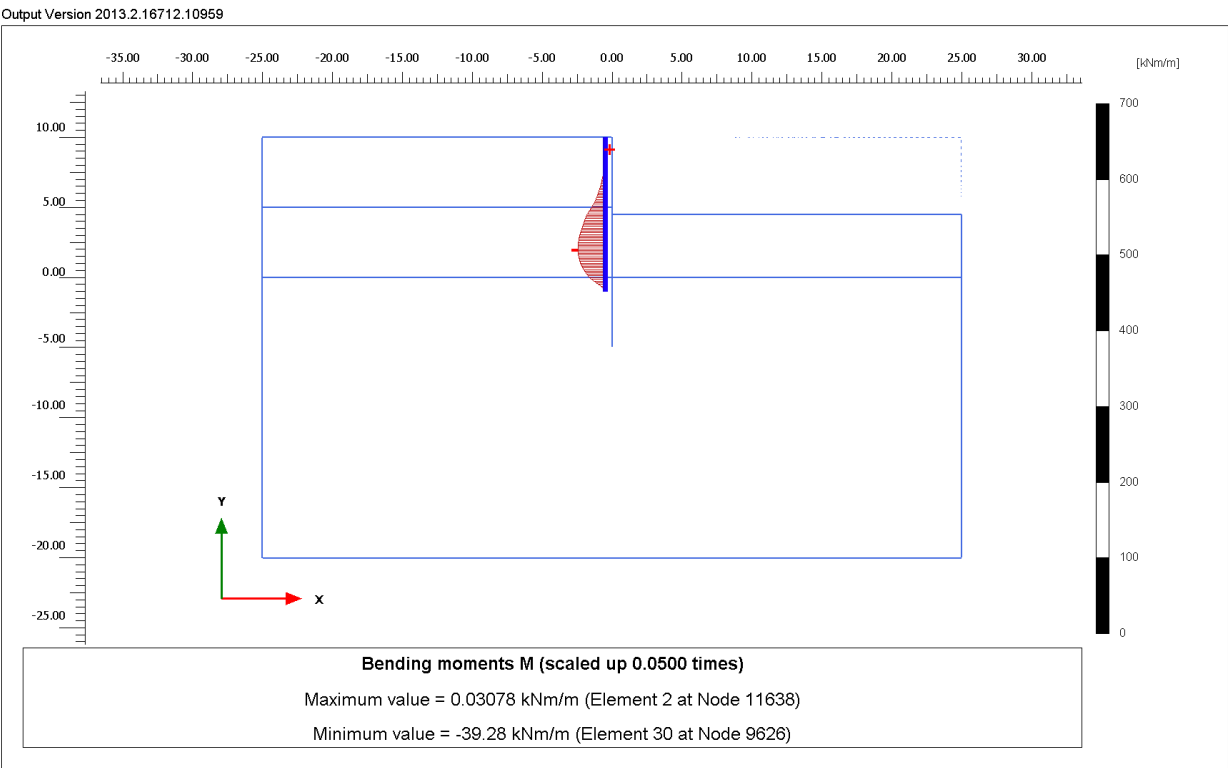


Figure B.12 Profile of wall bending moment for AZ 28-700N

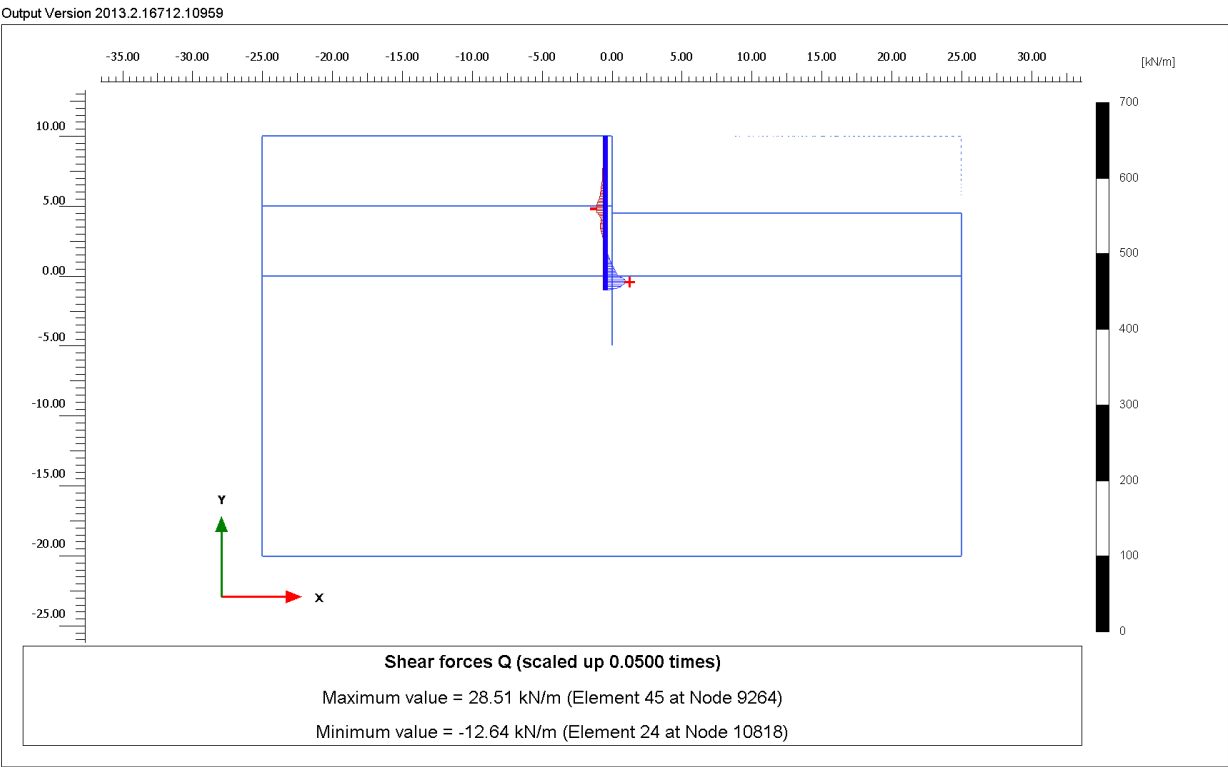


Figure B.13 Profile of wall shear force for AZ 28-700N

APPENDIX C

APPENDIX C-1. Design Summary of Secant Piled Wall (Rev.3)

Characteristic and Design Soil Properties

Strata	Elevation (top of strata mAOD)	Thickness (m)	Unit weight (kN/m ³)	Angle of Shearing resistance ϕ' peak (Deg.)	Effective cohesion (kN/m ²)	Undrained shear strength (kN/m ²)	Drained Stiffness E' (MN/m ²)	Undrained Stiffness E' (MN/m ²)	Drained Poisson's ratio, ν	Undrained Poisson's ratio ν_u	K_0	Coefficient of permeability. K (m/s)	Dilatancy angle for drained analysis, ψ (Deg.)	Wall friction factor, k	Wall adhesion factor, α
Made Ground	10.0	5.0	18	30	0	-	15	-	0.30	-	0.50	10^{-5}	0	1.0	-
River Terrace Deposits	5.0	5.0	19	35	0	-	50	-	0.30	-	0.43	10^{-5}	5	1.0	-
London Clay	0.0	40.0	20	20	10	100 + 7z	80 + 5.6z	100 + 7z	0.20	0.49	1.50	10^{-10}	12.5	1.0	ignored

Partial Factors (BS EN 1997-1:2004)

Design Approach 1				Combination 1			Combination 2		
				Set			Set		
				A1	M1	R1	A2	M2	R1
Actions	Permanent	Unfavourable	γ_G	1.35			1		
		Favourable	$\gamma_{G,fav}$	1			1		
	Variable	Unfavourable	γ_Q	1.5			1.3		
		Favourable	$\gamma_{Q,fav}$	0			0		
Material Properties	Angle of shearing resistance			$\gamma_{\phi'}$	1		1.25		
	Effective cohesion			$\gamma_{c'}$	1		1.25		
	Undrained shear strength			γ_{cu}	1		1.4		
	Unconfined strength			γ_{au}	1		1.4		
	Weight density			γ_y	1		1		

Ground Levels and Groundwater Levels

Design case	Active side (mAOD)	Passive side (mAOD)
Design Ground Level (ULS)	10.0	4.0
Design Ground Level (SLS)	10.0	4.5
Design Groundwater Level (ULS)	5.0	3.0
Design Groundwater Level (SLS)	4.0	3.0

Surcharge loading

UDL (kN/m ²)	Extent
10.0	0.5m to 20m behind the wall

Wall Type / Section

Section	Young's modulus, E (GPa)	Length (m)	Head (mAOD)	Toe (mAOD)	Support	Spacing (m)	Elastic section modulus (cm ³ /m)	Moment of inertia (m ⁴ /m)	Wall stiffness, $0.7 \cdot EI$ (kNm ² /m)
Hard (male pile) C30/37	28	15.0	10.0	-5.0	Cantilever	1.2	59641	$26.84 \cdot 10^{-3}$	526035

Design Basis

Analysis	Approach	Factor set	Soil strength	Soil stiffness	Overdig	Surcharge	Resulting BM & SF
Serviceability	SLS	Unfactored	Unfactored	Unfactored	-	Unfactored	Unfactored
STR: ULS	DA1 - C1	A1, M1, R1	Unfactored	Unfactored	0.5m	Set A1 $\gamma_G/\gamma_Q = 1.11$	Set A1 $\gamma_G = 1.35$
GEO: ULS	DA1 - C2	A2, M2, R1	Set M2	$\frac{1}{2} E'$ or $\frac{1}{2} E_u$	0.5m	Set A2 $\gamma_Q = 1.3$	Set A2 $\gamma_G = 1.0$

Results

Serviceability [SLS] Wall Deflection: 25mm @ 10.00m AOD
Structural Forces [STR: ULS Design Approach 1 - Combination 1] Maximum bending moment (BM) - Calculated BM_c: 309 kNm/m @ 1.60m AOD - Design $BM_d = BM_c \cdot \gamma_G = 309 \cdot 1.35 = 417$ kNm/m Maximum shear force - Calculated SF_c: 90 kN/m @ 4.00m AOD - Design $SF_d = BM_c \cdot \gamma_G = 90 \cdot 1.35 = 122$ kN/m
Wall Stability [GEO: ULS Design Approach 1 - Combination 2] Factor of safety: 1.14 [> 1 , OK]

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Active side	Soil types	Passive side
1	10.00	1 Made Ground	1 Made Ground	
2	5.00	2 Terrace Gravel	2 Terrace Gravel	
3	0.00	3 London Clay (Und)	3 London Clay (Und)	

SOIL PROPERTIES

No.	Description	Bulk density kN/m3	Young's Modulus Eh,kN/m2	At rest coeff. Ko	Consol. state. NC/OC	Active limit Ka	Passive limit Kp	Cohesion kN/m2
1	Made Ground	17.00a	10000	0.500	OC	0.273	5.026	
		18.00b		(0.300)	(0.000)	(0.000)		
2	Terrace Gravel	18.00a	50000	0.430	OC	0.218	7.250	
		19.00b		(0.300)	(0.000)	(0.000)		
3	London Cl..	20.00	100000	1.500	OC	1.000	1.000	100.0u
	(0.00)	(7000)		(0.490)	(2.000)	(2.000)	(7.000)	
4	London Cl..	20.00	80000	1.500	OC	0.422	2.699	10.00d
	(0.00)	(5600)		(0.200)	(1.589)	(4.668)		

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

Additional soil parameters associated with Ka and Kp

No.	Description	--- parameters for Ka ---			--- parameters for Kp ---		
		Soil friction angle	Wall adhesion coeff.	Back-fill	Soil friction angle	Wall adhesion coeff.	Back-fill
1	Made Ground	30.00	1.000	0.00	30.00	1.000	0.00
2	Terrace Gravel	35.00	1.000	0.00	35.00	1.000	0.00
3	London Clay (Und)	0.00	0.000	0.00	0.00	0.000	0.00
4	London Clay (Dra)	20.00	1.000	0.00	20.00	1.000	0.00

GROUND WATER CONDITIONS

Density of water = 9.807 kN/m3

	Active side	Passive side
Initial water table elevation	3.00	3.00

Automatic water pressure balancing at toe of wall : No

Water press. profile		Active side			Passive side			
Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	4.00	4.00	0.0	1	3.00	3.00	0.0 MC
2	1	5.00	5.00	0.0	1	3.00	3.00	0.0 WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
 Elevation of toe of wall = -5.00
 Maximum finite element length = 0.80 m
 Youngs modulus of wall E = 1.9600E+07 kN/m2
 Moment of inertia of wall I = 0.026839 m4/m run
 E.I = 526035 kN.m2/m run
 Yield Moment of wall = Not defined

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

SURCHARGE LOADS

Surch -arge no.	Distance from Elev.	Length parallel to wall	Width perpend. to wall	Surcharge Near edge	Surcharge Far edge	Equiv. soil type	Partial factor/ Category
1	10.00	0.50 (A)	1000.00	20.00	10.00	=	N/A 1.00 Var

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 10.00
2	Excavate to elevation 4.50 on PASSIVE side
3	Apply water pressure profile no.1 (Mod. Conserv.)
4	Change properties of soil type 3 to soil type 4 Ko pressures will not 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

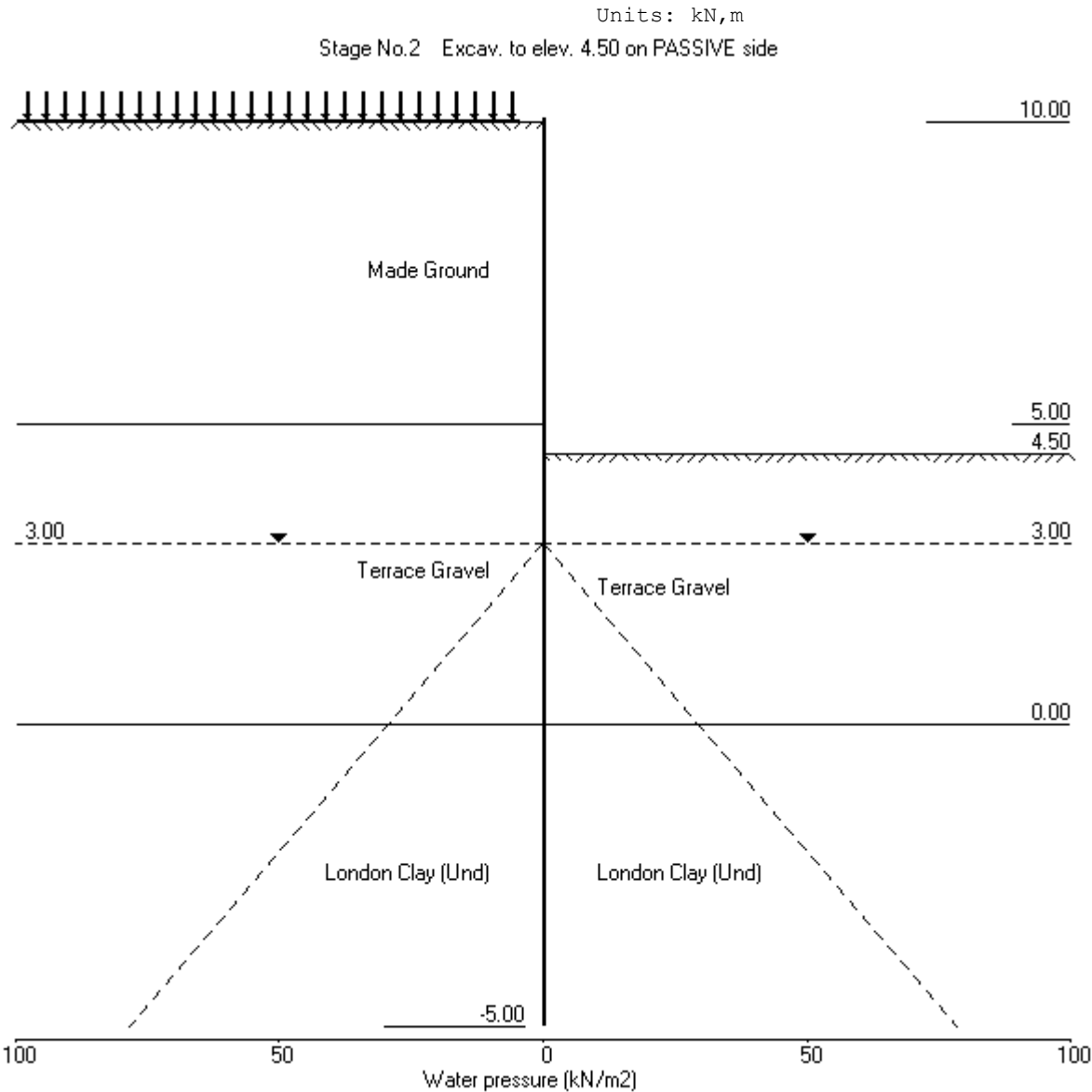
OUTPUT OPTIONS

Stage no.	Stage description	Displacement	Active, Graph.	Output options
		Bending mom.	Passive output	
		Shear force	pressures	
1	Apply surcharge no.1 at elev. 10.00	No	No	No
2	Excav. to elev. 4.50 on PASSIVE side	Yes	Yes	Yes
3	Apply water pressure profile no.1	Yes	Yes	Yes
4	Change soil type 3 to soil type 4	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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69 Rodenhurst Road, London SW4, UK. Tel: +44 20 8674 7251

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :



APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No. 2 Excavate to elevation 4.50 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

			FoS for toe		Toe elev. for	
			elev. = -5.00		FoS = 1.000	

Stage	--- G.L. ---		Strut	Factor	Moment	Toe Wall
No.	Act.	Pass.	Elev.	of	equilib.	elev. Penetr
			Safety at elev.		-ation	
2	10.00	4.50	Cant.	1.931	-3.69	1.37 3.13

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	Y	Nett	Wall	Wall	Shear	Bending	Strut
no.	coord	pressure	disp.	rotation	force	moment	forces
		kN/m ²	m	rad.	kN/m	kN.m/m	kN/m
1	10.00	0.00	0.024	2.81E-03	0.0	0.0	
2	9.40	3.45	0.022	2.81E-03	1.0	0.4	
3	8.80	7.00	0.020	2.81E-03	4.2	1.8	
4	8.00	11.18	0.018	2.80E-03	11.4	7.8	
5	7.20	15.12	0.016	2.78E-03	22.0	20.9	
6	6.40	18.96	0.014	2.73E-03	35.6	43.7	
7	5.70	22.29	0.012	2.65E-03	50.0	73.6	
8	5.00	30.26	0.010	2.53E-03	68.4	115.9	
		20.40	0.010	2.53E-03	68.4	115.9	
9	4.50	22.38	0.009	2.40E-03	79.1	152.8	
10	4.00	-40.90	0.008	2.24E-03	74.5	192.5	
11	3.50	-60.72	0.007	2.04E-03	49.1	226.9	
12	3.00	-50.76	0.006	1.81E-03	21.2	243.8	
13	2.30	-37.91	0.004	1.49E-03	-9.8	246.1	
14	1.60	-25.13	0.003	1.17E-03	-31.9	232.1	
15	0.80	-8.89	0.003	8.45E-04	-45.5	198.5	
16	0.00	2.41	0.002	5.73E-04	-48.1	159.3	
		-11.21	0.002	5.73E-04	-48.1	159.3	
17	-0.80	3.16	0.002	3.63E-04	-51.3	117.2	
18	-1.60	11.12	0.002	2.15E-04	-45.6	77.2	
19	-2.40	14.38	0.001	1.23E-04	-35.4	44.2	
20	-3.20	14.68	0.001	7.43E-05	-23.8	20.4	
21	-4.00	13.50	0.001	5.42E-05	-12.5	6.0	
22	-4.50	12.50	0.001	5.06E-05	-6.0	1.5	
23	-5.00	11.49	0.001	4.99E-05	0.0	-0.0	

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.2 Excavate to elevation 4.50 on PASSIVE side

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1608
2	9.40	0.00	12.65	3.45	63.56	3.45	3.45a	1608
3	8.80	0.00	25.63	7.00	128.80	7.00	7.00a	1608
4	8.00	0.00	40.94	11.18	205.76	11.18	11.18a	1608
5	7.20	0.00	55.36	15.12	278.26	15.12	15.12a	1608
6	6.40	0.00	69.43	18.96	348.97	18.96	18.96a	1608
7	5.70	0.00	81.60	22.29	410.11	22.29	22.29a	1608
8	5.00	0.00	93.68	25.59	470.84	30.26	30.26	1608
		0.00	93.68	20.40	679.14	20.40	20.40a	8040
9	4.50	0.00	102.77	22.38	745.08	22.38	22.38a	8040
10	4.00	0.00	111.85	24.35	810.87	24.35	24.35a	8040
11	3.50	0.00	120.90	26.33	876.52	26.33	26.33a	8040
12	3.00	0.00	129.95	28.29	942.07	28.29	28.29a	8040
13	2.30	6.86	136.42	29.70	989.00	29.70	36.57a	8040
14	1.60	13.73	142.87	31.11	1035.79	33.85	47.58	8040
15	0.80	21.57	150.23	32.71	1089.11	43.44	65.02	8040
16	0.00	29.42	157.56	34.31	1142.30	51.10	80.52	8040
		Total>	186.98	50.00m	387.00	216.36	216.36	21503
17	-0.80	Total>	202.95	54.00m	414.17	242.26	242.26	22707
18	-1.60	Total>	218.90	58.00m	441.32	265.63	265.63	23911
19	-2.40	Total>	234.84	62.00m	468.47	287.15	287.15	25115
20	-3.20	Total>	250.77	66.00m	495.60	307.51	307.51	26319
21	-4.00	Total>	266.70	70.00m	522.72	327.31	327.31	27524
22	-4.50	Total>	276.64	72.50m	539.67	339.60	339.60	28276
23	-5.00	Total>	286.59	75.00m	556.62	351.89	351.89	29029

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	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	12475
10	4.00	0.00	9.00	1.96	65.25	65.25	65.25p	12475
11	3.50	0.00	18.00	3.92	130.53	87.04	87.04	12475
12	3.00	0.00	27.02	5.88	195.86	79.06	79.06	12475
13	2.30	6.86	33.49	7.29	242.78	67.61	74.48	12475
14	1.60	13.73	39.99	8.71	289.91	58.98	72.71	12475
15	0.80	21.57	47.47	10.34	344.13	52.34	73.91	12475
16	0.00	29.42	55.01	11.98	398.80	48.69	78.11	12475
		Total>	84.43	22.50m	284.45	227.58	227.58	32577
17	-0.80	Total>	100.68	26.50m	311.91	239.11	239.11	34401
18	-1.60	Total>	117.02	30.50m	339.44	254.51	254.51	36225
19	-2.40	Total>	133.43	34.50m	367.05	272.77	272.77	38049
20	-3.20	Total>	149.93	38.50m	394.75	292.83	292.83	39874
21	-4.00	Total>	166.51	42.50m	422.53	313.81	313.81	41698

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.2 Excavate to elevation 4.50 on PASSIVE side

Node Y		----- PASSIVE side -----						
no.	coord	----- Effective stresses -----				Total	Soil	
		Water	Vertic	Active	Passive	Earth	earth	
		press.	-al	limit	limit	pressure	pressure	
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	coeff.	
							kN/m3	
22	-4.50	Total>	176.91	45.00m	439.94	327.10	327.10	42838
23	-5.00	Total>	187.34	47.50m	457.37	340.40	340.40	43978

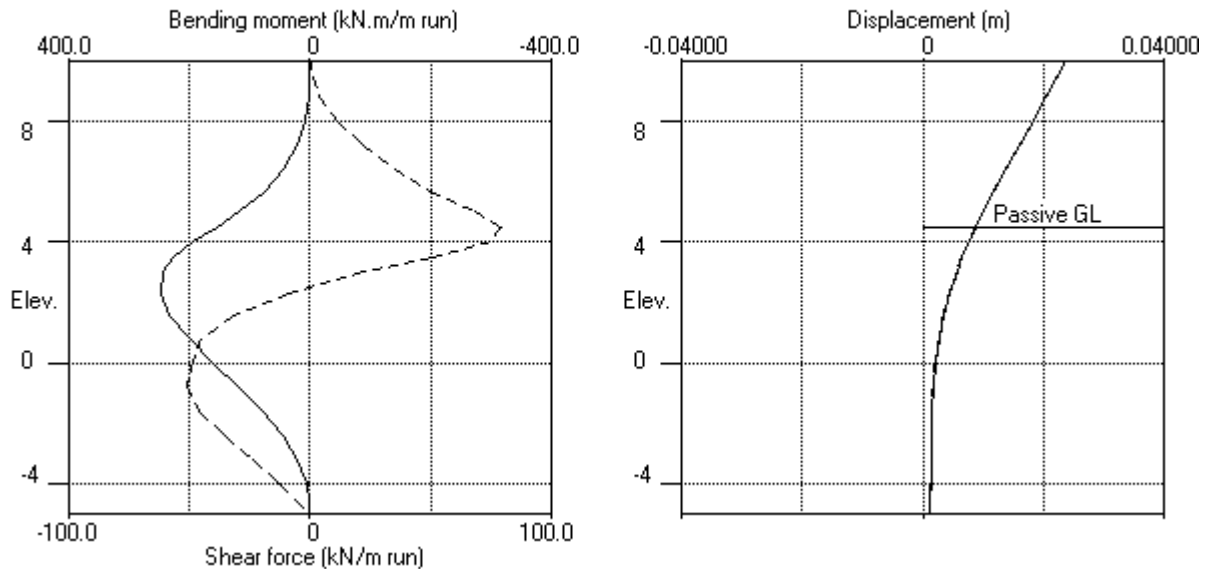
Note: 36.57a Soil pressure at active limit
 65.25p Soil pressure at passive limit

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

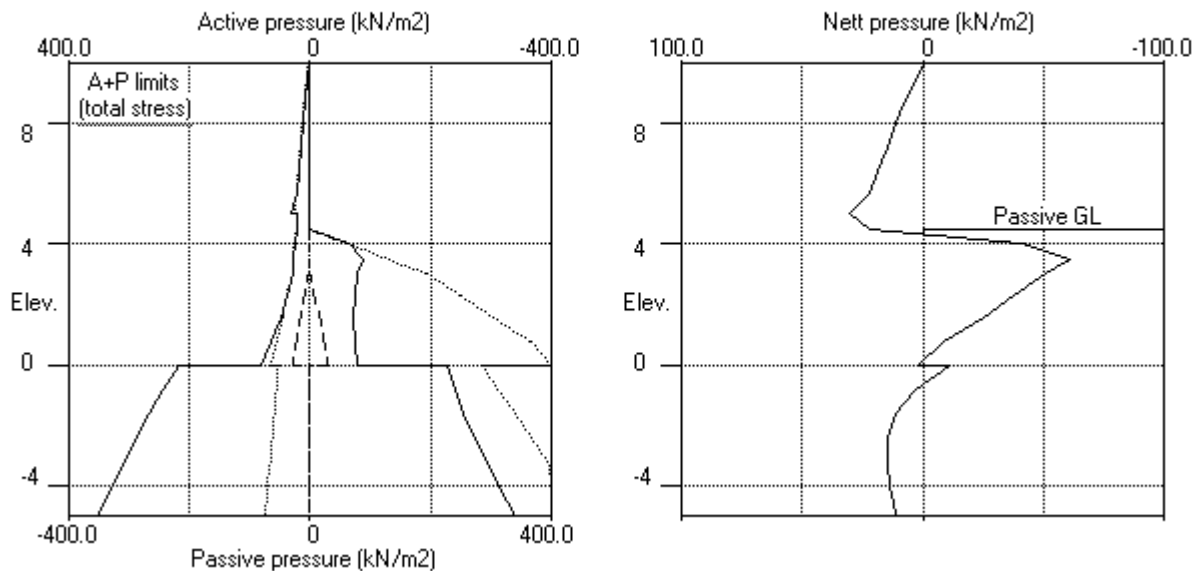
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No.2 Excav. to elev. 4.50 on PASSIVE side



Stage No.2 Excav. to elev. 4.50 on PASSIVE side

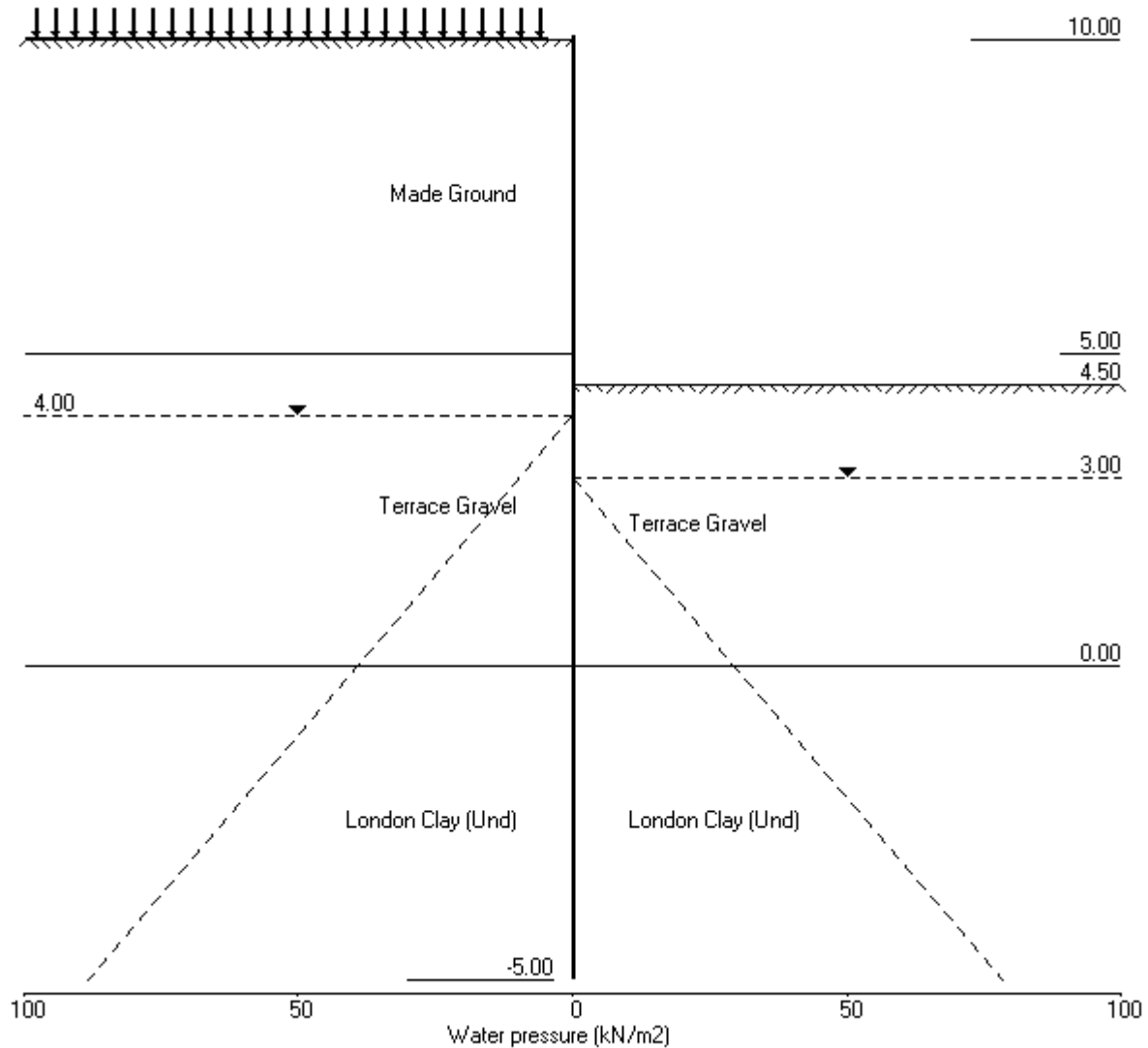


APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No.3 Apply water pressure profile no.1 (Mod. Conserv.)



APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No. 3 Apply water pressure profile no.1 (Mod. Conserv.)

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

			FoS for toe	Toe elev. for
			elev. = -5.00	FoS = 1.000

Stage	--- G.L. ---	Strut	Factor	Moment
No.	Act. Pass.	Elev.	of	equilib.
			Safety	at elev.
3	10.00 4.50	Cant.	1.890	-3.68
				Toe Wall
				elev. Penetr
				-ation
				1.30 3.20

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	10.00	0.00	0.025	2.92E-03	0.0	0.0	
2	9.40	3.45	0.023	2.92E-03	1.0	0.4	
3	8.80	7.00	0.022	2.92E-03	4.2	1.8	
4	8.00	11.18	0.019	2.91E-03	11.4	7.8	
5	7.20	15.12	0.017	2.89E-03	22.0	20.9	
6	6.40	18.96	0.015	2.84E-03	35.6	43.7	
7	5.70	22.29	0.013	2.76E-03	50.0	73.6	
8	5.00	29.29	0.011	2.63E-03	68.1	115.9	
		20.40	0.011	2.63E-03	68.1	115.9	
9	4.50	22.38	0.009	2.51E-03	78.8	152.6	
10	4.00	-40.90	0.008	2.34E-03	74.2	192.1	
11	3.50	-62.31	0.007	2.14E-03	48.4	226.6	
12	3.00	-47.90	0.006	1.92E-03	20.8	243.1	
13	2.30	-34.32	0.005	1.59E-03	-8.0	245.7	
14	1.60	-23.55	0.004	1.28E-03	-28.2	233.7	
15	0.80	-7.51	0.003	9.48E-04	-40.6	203.7	
16	0.00	5.06	0.002	6.64E-04	-41.6	168.7	
		-18.93	0.002	6.64E-04	-41.6	168.7	
17	-0.80	-2.01	0.002	4.38E-04	-50.0	129.4	
18	-1.60	8.14	0.002	2.72E-04	-47.6	88.7	
19	-2.40	13.15	0.001	1.64E-04	-39.0	53.2	
20	-3.20	14.82	0.001	1.04E-04	-27.9	26.1	
21	-4.00	14.76	0.001	7.80E-05	-16.0	8.5	
22	-4.50	15.55	0.001	7.29E-05	-8.4	2.3	
23	-5.00	18.23	0.001	7.18E-05	0.0	-0.0	

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.3 Apply water pressure profile no.1 (Mod. Conserv.)

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1318
2	9.40	0.00	12.65	3.45	63.56	3.45	3.45a	1318
3	8.80	0.00	25.63	7.00	128.80	7.00	7.00a	1318
4	8.00	0.00	40.94	11.18	205.76	11.18	11.18a	1318
5	7.20	0.00	55.36	15.12	278.26	15.12	15.12a	1318
6	6.40	0.00	69.43	18.96	348.97	18.96	18.96a	1318
7	5.70	0.00	81.60	22.29	410.11	22.29	22.29a	1318
8	5.00	0.00	93.68	25.59	470.84	29.29	29.29	1318
		0.00	93.68	20.40	679.14	20.40	20.40a	6588
9	4.50	0.00	102.77	22.38	745.08	22.38	22.38a	6588
10	4.00	0.00	111.85	24.35	810.87	24.35	24.35a	6588
11	3.50	4.90	116.50	25.37	844.60	25.37	30.27a	6588
12	3.00	9.81	121.14	26.38	878.23	26.38	36.18a	6588
13	2.30	16.67	127.61	27.79	925.16	27.79	44.46a	6588
14	1.60	23.54	134.07	29.19	971.94	29.19	52.73a	6588
15	0.80	31.38	141.42	30.79	1025.27	37.78	69.16	6588
16	0.00	39.23	148.76	32.39	1078.45	45.95	85.18	6588
		Total>	187.98	50.00m	388.00	213.96	213.96	17931
17	-0.80	Total>	203.95	54.00m	415.17	240.91	240.91	18935
18	-1.60	Total>	219.90	58.00m	442.32	265.19	265.19	19939
19	-2.40	Total>	235.84	62.00m	469.47	287.43	287.43	20943
20	-3.20	Total>	251.77	66.00m	496.60	308.36	308.36	21947
21	-4.00	Total>	267.70	70.00m	523.72	328.62	328.62	22951
22	-4.50	Total>	277.64	72.50m	540.67	341.67	341.67	73135
23	-5.00	Total>	287.59	75.00m	557.62	355.93	355.93	128286

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	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	9617
10	4.00	0.00	9.00	1.96	65.25	65.25	65.25p	9617
11	3.50	0.00	18.00	3.92	130.53	92.58	92.58	9617
12	3.00	0.00	27.02	5.88	195.86	84.08	84.08	9617
13	2.30	6.86	33.49	7.29	242.78	71.91	78.77	9617
14	1.60	13.73	39.99	8.71	289.91	62.54	76.27	9617
15	0.80	21.57	47.47	10.34	344.13	55.09	76.67	9617
16	0.00	29.42	55.01	11.98	398.80	50.70	80.12	9617
		Total>	84.43	22.50m	284.45	232.89	232.89	25425
17	-0.80	Total>	100.68	26.50m	311.91	242.93	242.93	26849
18	-1.60	Total>	117.02	30.50m	339.44	257.05	257.05	28273
19	-2.40	Total>	133.43	34.50m	367.05	274.28	274.28	29697
20	-3.20	Total>	149.93	38.50m	394.75	293.54	293.54	31121
21	-4.00	Total>	166.51	42.50m	422.53	313.86	313.86	32545

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

(continued)
Stage No.3 Apply water pressure profile no.1 (Mod. Conserv.)

Node no.	Y coord	----- PASSIVE side -----					Total earth pressure kN/m2	Soil stiffness kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
22	-4.50	Total>	176.91	45.00m	439.94	326.13	326.13	97090
23	-5.00	Total>	187.34	47.50m	457.37	337.70	337.70	128286

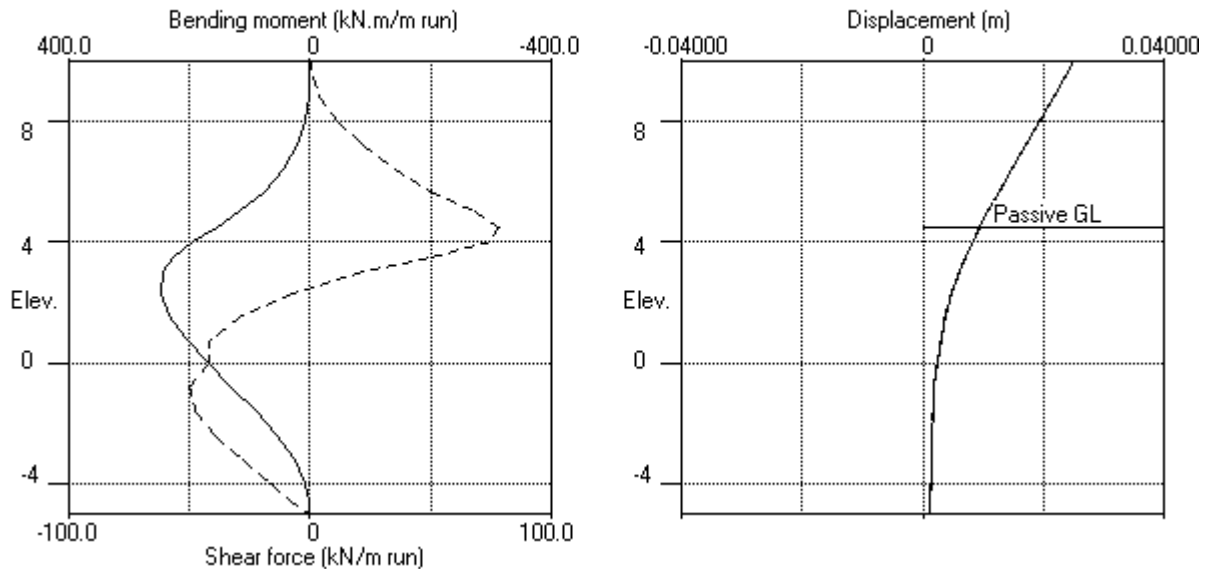
Note: 52.73a Soil pressure at active limit
 65.25p Soil pressure at passive limit

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

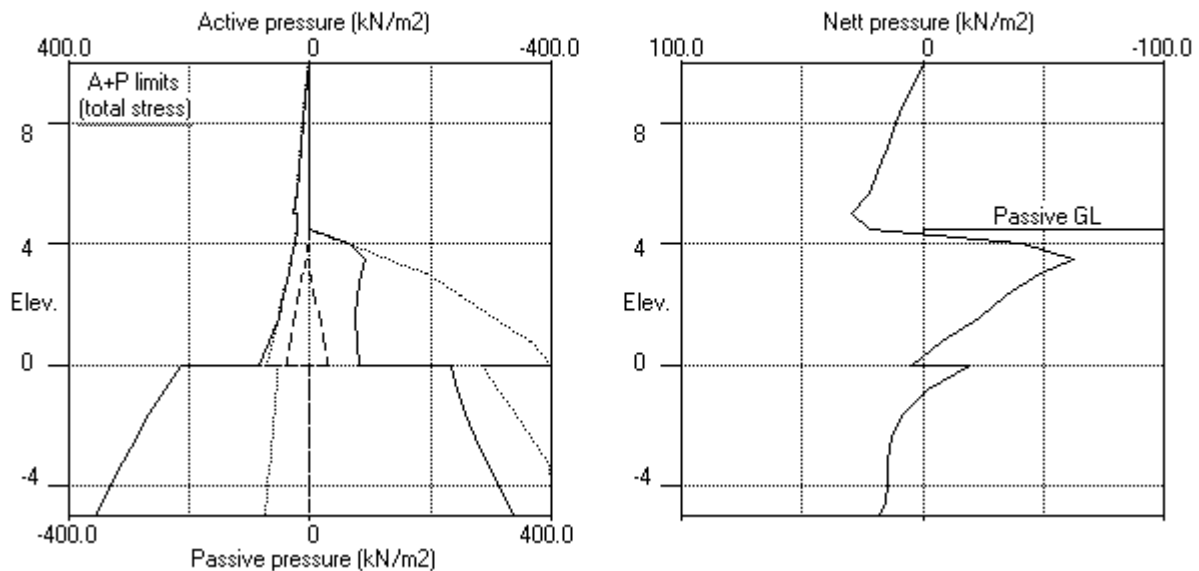
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No.3 Apply water pressure profile no.1 (Mod. Conserv.)

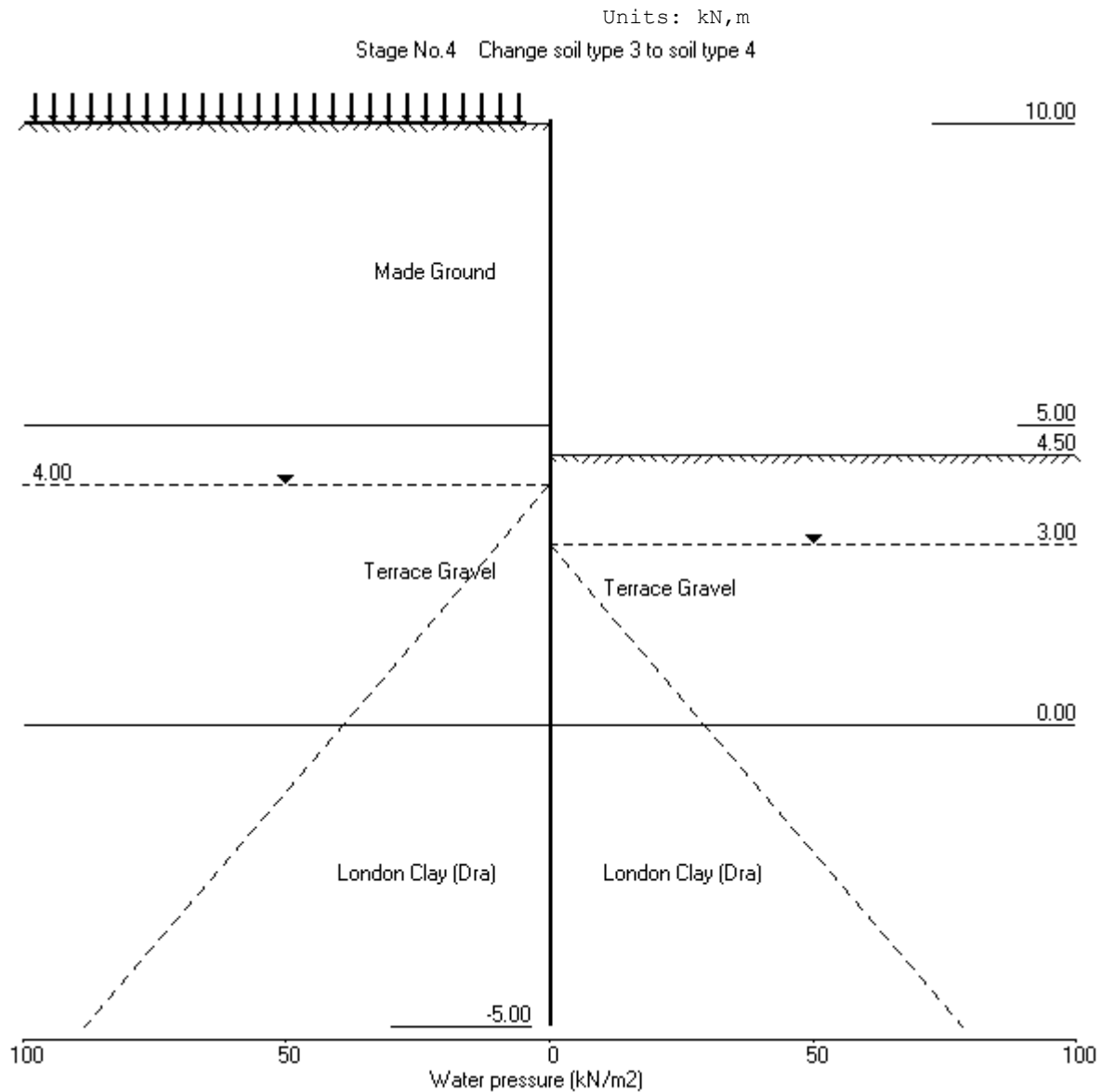


Stage No.3 Apply water pressure profile no.1 (Mod. Conserv.)



APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :



APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No. 4 Change properties of soil type 3 to soil type 4
 Ko pressures will not be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

			FoS for toe	Toe elev. for
			elev. = -5.00	FoS = 1.000
			-----	-----
Stage	--- G.L. ---	Strut	Factor	Moment
No.	Act. Pass.	Elev.	of	equilib.
			Safety	at elev.
4	10.00 4.50	Cant.	1.715	-4.10
				1.30 3.20

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	10.00	0.00	0.025	2.92E-03	0.0	0.0	
2	9.40	3.45	0.023	2.92E-03	1.0	0.4	
3	8.80	7.00	0.022	2.92E-03	4.2	1.8	
4	8.00	11.18	0.019	2.91E-03	11.4	7.8	
5	7.20	15.12	0.017	2.89E-03	22.0	20.9	
6	6.40	18.96	0.015	2.84E-03	35.6	43.7	
7	5.70	22.29	0.013	2.76E-03	50.0	73.6	
8	5.00	29.25	0.011	2.63E-03	68.1	115.9	
		20.40	0.011	2.63E-03	68.1	115.9	
9	4.50	22.38	0.009	2.51E-03	78.8	152.6	
10	4.00	-40.90	0.008	2.34E-03	74.1	192.1	
11	3.50	-62.61	0.007	2.14E-03	48.3	226.6	
12	3.00	-48.20	0.006	1.92E-03	20.6	242.9	
13	2.30	-34.62	0.005	1.59E-03	-8.4	245.4	
14	1.60	-23.85	0.004	1.28E-03	-28.9	233.0	
15	0.80	-8.04	0.003	9.50E-04	-41.7	202.3	
16	0.00	4.55	0.002	6.69E-04	-43.1	166.4	
		-10.94	0.002	6.69E-04	-43.1	166.4	
17	-0.80	-2.71	0.002	4.46E-04	-48.5	127.5	
18	-1.60	7.53	0.002	2.82E-04	-46.6	87.8	
19	-2.40	12.66	0.001	1.75E-04	-38.5	52.9	
20	-3.20	14.47	0.001	1.15E-04	-27.6	26.1	
21	-4.00	14.57	0.001	8.88E-05	-16.0	8.6	
22	-4.50	15.46	0.001	8.37E-05	-8.5	2.3	
23	-5.00	18.62	0.001	8.25E-05	0.0	-0.0	

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.4 Change properties of soil type 3 to soil type 4
 Ko pressures will not be reset

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		----- Effective stresses -----				Total earth pressure kN/m2		
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2		Earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	928
2	9.40	0.00	12.65	3.45	63.56	3.45	3.45a	928
3	8.80	0.00	25.63	7.00	128.80	7.00	7.00a	928
4	8.00	0.00	40.94	11.18	205.76	11.18	11.18a	928
5	7.20	0.00	55.36	15.12	278.26	15.12	15.12a	928
6	6.40	0.00	69.43	18.96	348.97	18.96	18.96a	928
7	5.70	0.00	81.60	22.29	410.11	22.29	22.29a	928
8	5.00	0.00	93.68	25.59	470.84	29.25	29.25	928
		0.00	93.68	20.40	679.14	20.40	20.40a	4641
9	4.50	0.00	102.77	22.38	745.08	22.38	22.38a	4641
10	4.00	0.00	111.85	24.35	810.87	24.35	24.35a	4641
11	3.50	4.90	116.50	25.37	844.60	25.37	30.27a	4641
12	3.00	9.81	121.14	26.38	878.23	26.38	36.18a	4641
13	2.30	16.67	127.61	27.79	925.16	27.79	44.46a	4641
14	1.60	23.54	134.07	29.19	971.94	29.19	52.73a	4641
15	0.80	31.38	141.42	30.79	1025.27	37.55	68.93	4641
16	0.00	39.23	148.76	32.39	1078.45	45.73	84.96	4641
		39.23	148.76	46.86	448.21	174.42	213.64	6651
17	-0.80	47.07	156.88	50.28	470.13	193.54	240.62	7024
18	-1.60	54.92	164.99	53.70	492.01	210.01	264.93	7396
19	-2.40	62.76	173.08	57.12	513.86	224.46	287.22	7769
20	-3.20	70.61	181.17	60.53	535.69	237.60	308.21	8141
21	-4.00	78.45	189.24	63.93	557.49	250.09	328.54	8514
22	-4.50	83.36	194.29	66.06	571.10	258.28	341.64	8747
23	-5.00	88.26	199.33	68.19	584.71	267.87	356.13	184444

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		----- Effective stresses -----				Total earth pressure kN/m2		
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2		Earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	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	6031
10	4.00	0.00	9.00	1.96	65.25	65.25	65.25p	6031
11	3.50	0.00	18.00	3.92	130.53	92.88	92.88	6031
12	3.00	0.00	27.02	5.88	195.86	84.38	84.38	6031
13	2.30	6.86	33.49	7.29	242.78	72.22	79.08	6031
14	1.60	13.73	39.99	8.71	289.91	62.85	76.58	6031
15	0.80	21.57	47.47	10.34	344.13	55.40	76.97	6031
16	0.00	29.42	55.01	11.98	398.80	50.98	80.40	6031
		29.42	55.01	7.32	195.16	195.16	224.58p	8767
17	-0.80	37.26	63.42	10.86	217.87	206.06	243.32	9258
18	-1.60	45.11	71.91	14.44	240.77	212.28	257.39	9749
19	-2.40	52.96	80.48	18.06	263.90	221.60	274.55	10240
20	-3.20	60.80	89.13	21.71	287.25	232.93	293.73	10731

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.4 Change properties of soil type 3 to soil type 4
 Ko pressures will not be reset

Node no.	Y coord	----- PASSIVE side -----					Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
21	-4.00	68.65	97.86	25.39	310.83	245.32	313.97	11222
22	-4.50	73.55	103.36	27.71	325.68	252.63	326.17	11529
23	-5.00	78.45	108.89	30.04	340.60	259.05	337.51	184444

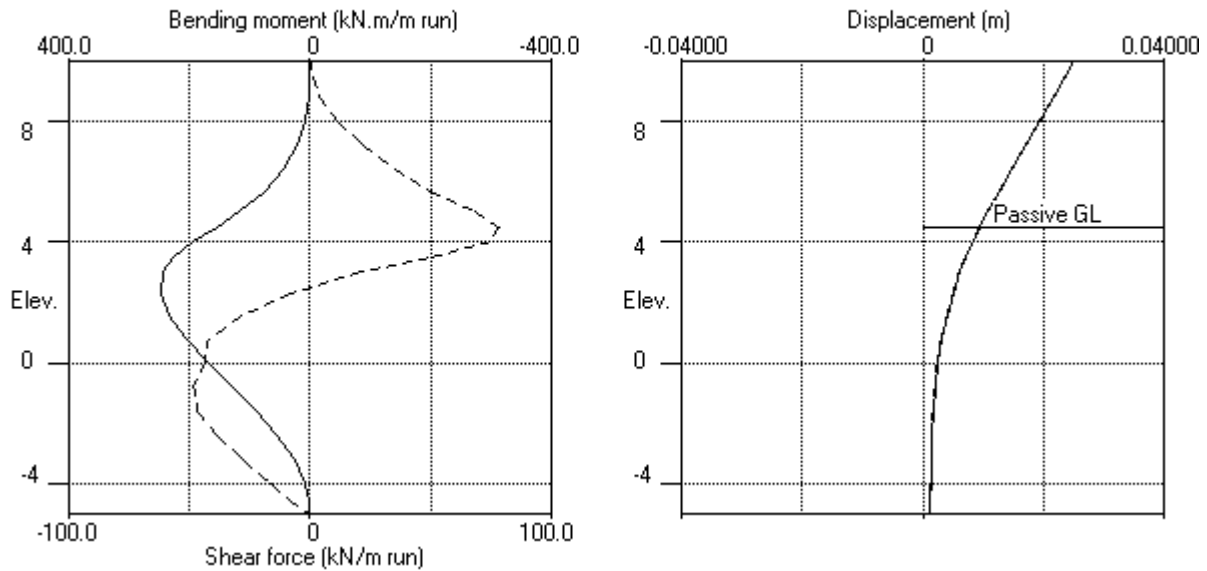
Note: 52.73a Soil pressure at active limit
 224.58p Soil pressure at passive limit

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

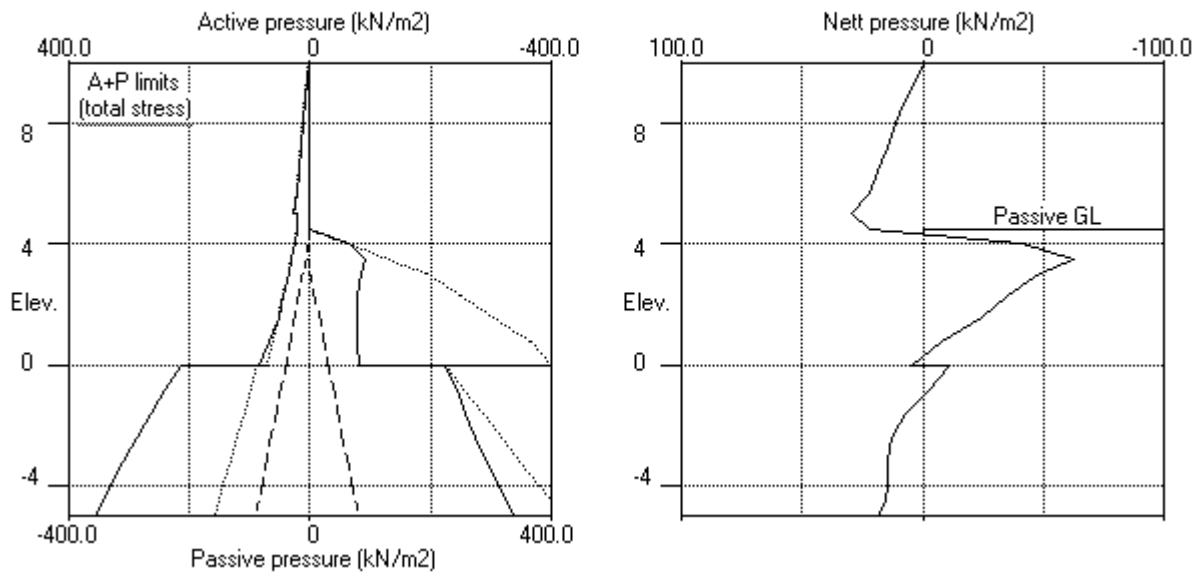
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No.4 Change soil type 3 to soil type 4



Stage No.4 Change soil type 3 to soil type 4



APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

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

			FoS for toe		Toe elev. for		
			elev. = -5.00		FoS = 1.000		
			-----		-----		
Stage	--- G.L. ---		Strut	Factor	Moment	Toe	Wall
No.	Act.	Pass.	Elev.	of	equilib.	elev.	Penetr
			Safety at elev.		-ation		
1	10.00	10.00	Cant.	Conditions not suitable for FoS calc.			
2	10.00	4.50	Cant.	1.931	-3.69	1.37	3.13
3	10.00	4.50	Cant.	1.890	-3.68	1.30	3.20
4	10.00	4.50	Cant.	1.715	-4.10	1.30	3.20

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

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				Shear force			
				Calculated		Factored		Calculated		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	10.00	0.025	0.000	0	-0	0	-0	0	0	0	0
2	9.40	0.023	0.000	0	0	0	0	1	-0	1	-1
3	8.80	0.022	0.000	2	-0	2	-1	4	-1	6	-1
4	8.00	0.019	0.000	8	-1	11	-1	11	-1	15	-1
5	7.20	0.017	0.000	21	-1	28	-2	22	0	30	0
6	6.40	0.015	0.000	44	-0	59	-1	36	0	48	0
7	5.70	0.013	0.000	74	0	99	0	50	0	68	0
8	5.00	0.011	0.000	116	0	157	0	68	0	92	0
9	4.50	0.009	0.000	153	0	206	0	79	0	107	0
10	4.00	0.008	0.000	192	0	260	0	74	0	101	0
11	3.50	0.007	0.000	227	0	306	0	49	0	66	0
12	3.00	0.006	0.000	244	0	329	0	21	-0	29	-0
13	2.30	0.005	0.000	246	0	332	0	0	-10	0	-13
14	1.60	0.004	0.000	234	0	316	0	0	-32	0	-43
15	0.80	0.003	0.000	204	0	275	0	0	-45	0	-61
16	0.00	0.002	0.000	169	0	228	0	0	-48	0	-65
17	-0.80	0.002	0.000	129	0	175	0	0	-51	0	-69
18	-1.60	0.002	0.000	89	0	120	0	0	-48	0	-64
19	-2.40	0.001	0.000	53	0	72	0	0	-39	0	-53
20	-3.20	0.001	0.000	26	0	35	0	0	-28	0	-38
21	-4.00	0.001	0.000	9	0	12	0	0	-16	0	-22
22	-4.50	0.001	0.000	2	0	3	0	0	-9	0	-12
23	-5.00	0.001	0.000	0	-0	0	-0	0	0	0	0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment						Shear force					
	Calculated			Factored			Calculated			Factored		
	max.	elev.	min.	max.	min.		max.	elev.	min.	max.	min.	
	kN.m/m		kN.m/m	kN.m/m	kN/m		kN/m		kN/m	kN/m	kN/m	
1	7	3.00	-1	7.20	10	-2	4	5.00	-1	0.80	6	-2
2	246	2.30	-0	-5.00	332	-0	79	4.50	-51	-0.80	107	-69
3	246	2.30	-0	-5.00	332	-0	79	4.50	-50	-0.80	106	-68
4	245	2.30	-0	-5.00	331	-0	79	4.50	-49	-0.80	106	-65

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

Summary of results (continued)

Maximum and minimum displacement at each stage

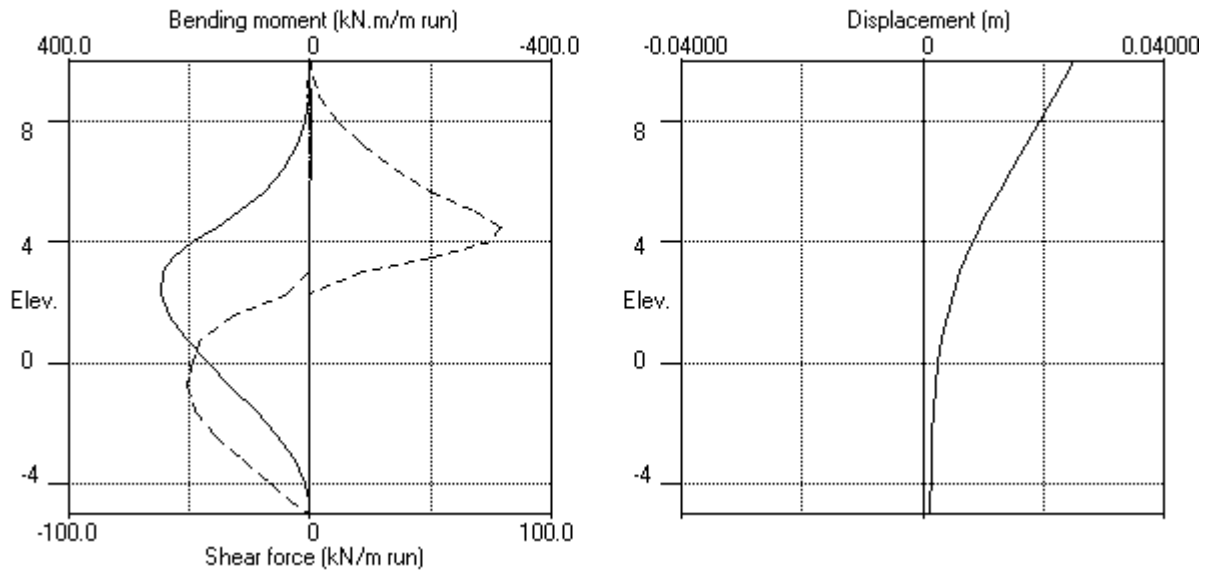
Stage	no.	maximum m	elev.	Displacement minimum m	elev.	Stage description
1	0.001	10.00	0.000	10.00	Apply surcharge no.1 at elev. 10.00	
2	0.024	10.00	0.000	10.00	Excav. to elev. 4.50 on PASSIVE side	
3	0.025	10.00	0.000	10.00	Apply water pressure profile no.1	
4	0.025	10.00	0.000	10.00	Change soil type 3 to soil type 4	

APPENDIX C-2. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT SLS (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
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 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
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Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Active side	Soil types	Passive side
1	10.00	1 Made Ground	1 Made Ground	
2	5.00	2 Terrace Gravel	2 Terrace Gravel	
3	0.00	3 London Clay (Und)	3 London Clay (Und)	

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil type	density	Bulk Modulus	Young's Modulus	At rest coeff.	Consol. state.	Active limit	Passive limit	Cohesion
No. Description	kN/m3	Eh, kN/m2	Ko	NC/OC	Ka	Kp		kN/m2
(Datum elev.)		(dEh/dy)	(dKo/dy)	(Nu)	(Kac)	(Kpc)		(dc/dy)
1 Made Ground	17.00a	10000	0.500	OC	0.273	5.026		
	18.00b			(0.300)	(0.000)	(0.000)		
2 Terrace Gravel	18.00a	50000	0.430	OC	0.218	7.250		
	19.00b			(0.300)	(0.000)	(0.000)		
3 London Cl..	20.00	100000	1.500	OC	1.000	1.000	100.0u	
(0.00)	(7000)			(0.490)	(2.000)	(2.000)	(7.000)	
4 London Cl..	20.00	80000	1.500	OC	0.422	2.699	10.00d	
(0.00)	(5600)			(0.200)	(1.589)	(4.668)		

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

Additional soil parameters associated with Ka and Kp

Soil type	parameters for Ka			parameters for Kp		
	Soil friction angle	Wall coeff.	Back-fill	Soil friction angle	Wall coeff.	Back-fill
1 Made Ground	30.00	1.000	0.00	30.00	1.000	0.00
2 Terrace Gravel	35.00	1.000	0.00	35.00	1.000	0.00
3 London Clay (Und)	0.00	0.000	0.00	0.00	0.000	0.00
4 London Clay (Dra)	20.00	1.000	0.00	20.00	1.000	0.00

GROUND WATER CONDITIONS

Density of water = 9.807 kN/m3

	Active side	Passive side
Initial water table elevation	3.00	3.00

Automatic water pressure balancing at toe of wall : No

Water press.	Active side				Passive side			
	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	4.00	4.00	0.0	1	3.00	3.00	0.0 MC
2	1	5.00	5.00	0.0	1	3.00	3.00	0.0 WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = -5.00
Maximum finite element length = 0.80 m
Youngs modulus of wall E = 1.9600E+07 kN/m2
Moment of inertia of wall I = 0.026839 m4/m run
E.I = 526035 kN.m2/m run
Yield Moment of wall = Not defined

APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

SURCHARGE LOADS

Surch	Distance	Length	Width	Surcharge	Equiv. Partial
-arge	from	parallel	perpend.	----- kN/m2 -----	soil factor/
no.	Elev.	wall	to wall	Near edge Far edge	type Category
1	10.00	0.50 (A)	1000.00	20.00 10.00	= N/A 1.10 Var

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 description
stage no.	-----
1	Apply surcharge no.1 at elevation 10.00
2	Excavate to elevation 4.50 on PASSIVE side
3	Excavate to elevation 4.00 on PASSIVE side
4	Apply water pressure profile no.1 (Mod. Conserv.)
5	Change properties of soil type 3 to soil type 4
	Ko pressures will not be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 1
Water pressures : Moderately Conservative
Partial factor on C' = 1.000
Partial factor on Phi' = 1.000
Partial factor on Cu = 1.000
Partial factor on Soil Modulus = 1.000
Partial factor on Permanent Unfavourable loads = 1.000
Partial factor on Permanent Favourable loads = 1.000
Partial factor on Permanent Variable loads = 1.100
Design factor on calculated Bending Moments = 1.350

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

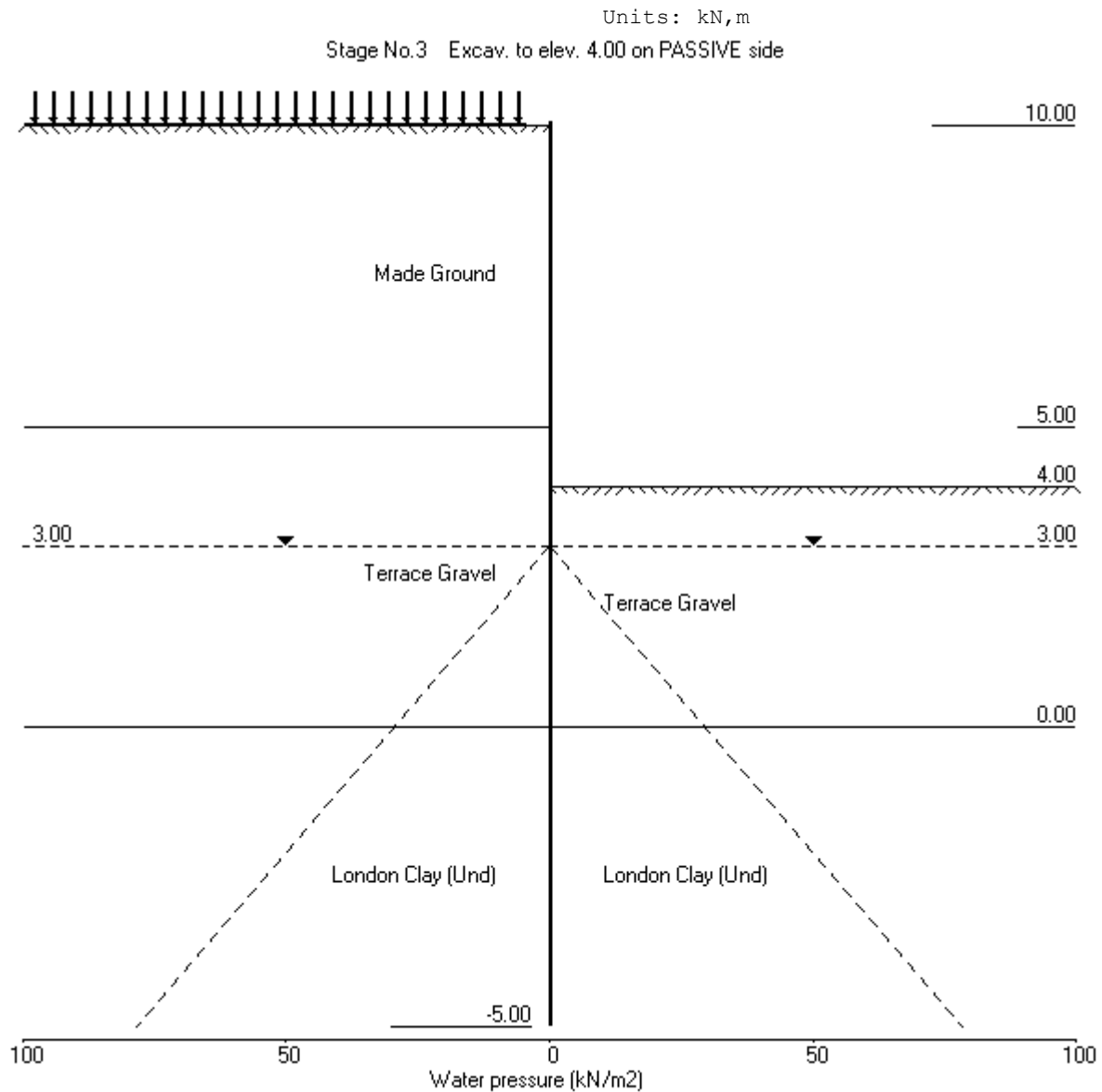
OUTPUT OPTIONS

Stage	-----	Stage description	-----	-----	Output options	-----
no.						
			Displacement	Active, Graph.		
			Bending mom.	Passive output		
			Shear force	pressures		
1	Apply surcharge no.1 at elev. 10.00	No	No	No	No	
2	Excav. to elev. 4.50 on PASSIVE side	No	No	No	No	
3	Excav. to elev. 4.00 on PASSIVE side	Yes	Yes	Yes	Yes	
4	Apply water pressure profile no.1	Yes	Yes	Yes	Yes	
5	Change soil type 3 to soil type 4	Yes	Yes	Yes	Yes	
*	Summary output	Yes	-	Yes		

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APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :



APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 4.00 on PASSIVE side

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: ULS DA1 Combination 1

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	10.00	0.00	0.031	3.56E-03	0.0	0.0	
2	9.40	3.52	0.029	3.56E-03	1.1	0.4	
3	8.80	7.14	0.027	3.56E-03	4.3	1.8	
4	8.00	11.37	0.024	3.55E-03	11.7	8.0	
5	7.20	15.33	0.021	3.53E-03	22.3	21.3	
6	6.40	19.19	0.018	3.48E-03	36.2	44.5	
7	5.70	22.52	0.016	3.40E-03	50.7	74.8	
8	5.00	25.82	0.014	3.27E-03	67.7	117.3	
		20.59	0.014	3.27E-03	67.7	117.3	
9	4.50	22.57	0.012	3.14E-03	78.5	153.8	
10	4.00	24.54	0.010	2.97E-03	90.2	195.9	
11	3.50	-38.73	0.009	2.76E-03	86.7	244.6	
12	3.00	-73.72	0.008	2.51E-03	58.6	282.3	
13	2.30	-54.87	0.006	2.12E-03	13.6	305.1	
14	1.60	-39.52	0.005	1.72E-03	-19.5	303.1	
15	0.80	-21.50	0.004	1.28E-03	-43.9	275.1	
16	0.00	-4.07	0.003	8.97E-04	-54.1	233.1	
		-30.05	0.003	8.97E-04	-54.1	233.1	
17	-0.80	-5.15	0.002	5.83E-04	-68.2	180.2	
18	-1.60	10.17	0.002	3.52E-04	-66.2	124.0	
19	-2.40	18.09	0.001	2.01E-04	-54.9	74.2	
20	-3.20	21.14	0.001	1.17E-04	-39.2	36.1	
21	-4.00	21.63	0.001	8.14E-05	-22.1	11.4	
22	-4.50	21.15	0.001	7.45E-05	-11.4	3.1	
23	-5.00	24.38	0.001	7.31E-05	0.0	0.0	

Node no.	Y coord	----- ACTIVE side -----					Total earth pressure	Soil stiffness
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		coeff. kN/m3
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1464
2	9.40	0.00	12.89	3.52	64.79	3.52	3.52a	1464
3	8.80	0.00	26.15	7.14	131.42	7.14	7.14a	1464
4	8.00	0.00	41.63	11.37	209.25	11.37	11.37a	1464
5	7.20	0.00	56.14	15.33	282.16	15.33	15.33a	1464
6	6.40	0.00	70.25	19.19	353.11	19.19	19.19a	1464
7	5.70	0.00	82.44	22.52	414.38	22.52	22.52a	1464
8	5.00	0.00	94.55	25.82	475.20	25.82	25.82a	1464
		0.00	94.55	20.59	685.43	20.59	20.59a	7318
9	4.50	0.00	103.65	22.57	751.44	22.57	22.57a	7318

APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.3 Excavate to elevation 4.00 on PASSIVE side

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
10	4.00	0.00	112.73	24.54	817.28	24.54	24.54a	7318
11	3.50	0.00	121.79	26.52	882.98	26.52	26.52a	7318
12	3.00	0.00	130.84	28.49	948.56	28.49	28.49a	7318
13	2.30	6.86	137.32	29.90	995.52	29.90	36.76a	7318
14	1.60	13.73	143.77	31.30	1042.32	31.30	45.03a	7318
15	0.80	21.57	151.13	32.90	1095.64	37.63	59.21	7318
16	0.00	29.42	158.46	34.50	1148.81	47.52	76.94	7318
		Total>	187.88	50.00m	387.93	206.55	206.55	19719
17	-0.80	Total>	203.84	54.00m	415.10	236.37	236.37	20823
18	-1.60	Total>	219.79	58.00m	442.25	262.47	262.47	21927
19	-2.40	Total>	235.73	62.00m	469.39	285.71	285.71	23032
20	-3.20	Total>	251.65	66.00m	496.51	307.09	307.09	24136
21	-4.00	Total>	267.57	70.00m	523.63	327.51	327.51	25240
22	-4.50	Total>	277.51	72.50m	540.57	339.96	339.96	162832
23	-5.00	Total>	287.45	75.00m	557.52	354.16	354.16	167166

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	4.00	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	12732
11	3.50	0.00	9.00	1.96	65.25	65.25	65.25p	12732
12	3.00	0.00	18.01	3.92	130.54	102.21	102.21	12732
13	2.30	6.86	24.46	5.33	177.34	84.77	91.64	12732
14	1.60	13.73	30.95	6.74	224.34	70.82	84.55	12732
15	0.80	21.57	38.40	8.36	278.39	59.13	80.70	12732
16	0.00	29.42	45.91	10.00	332.87	51.59	81.01	12732
		Total>	75.33	20.00m	275.36	236.60	236.60	33221
17	-0.80	Total>	91.56	24.00m	302.80	241.51	241.51	35081
18	-1.60	Total>	107.88	28.00m	330.31	252.30	252.30	36942
19	-2.40	Total>	124.27	32.00m	357.91	267.62	267.62	38802
20	-3.20	Total>	140.76	36.00m	385.60	285.95	285.95	40662
21	-4.00	Total>	157.34	40.00m	413.38	305.88	305.88	42523
22	-4.50	Total>	167.75	42.50m	430.79	318.81	318.81	200771
23	-5.00	Total>	178.19	45.00m	448.24	329.78	329.78	206114

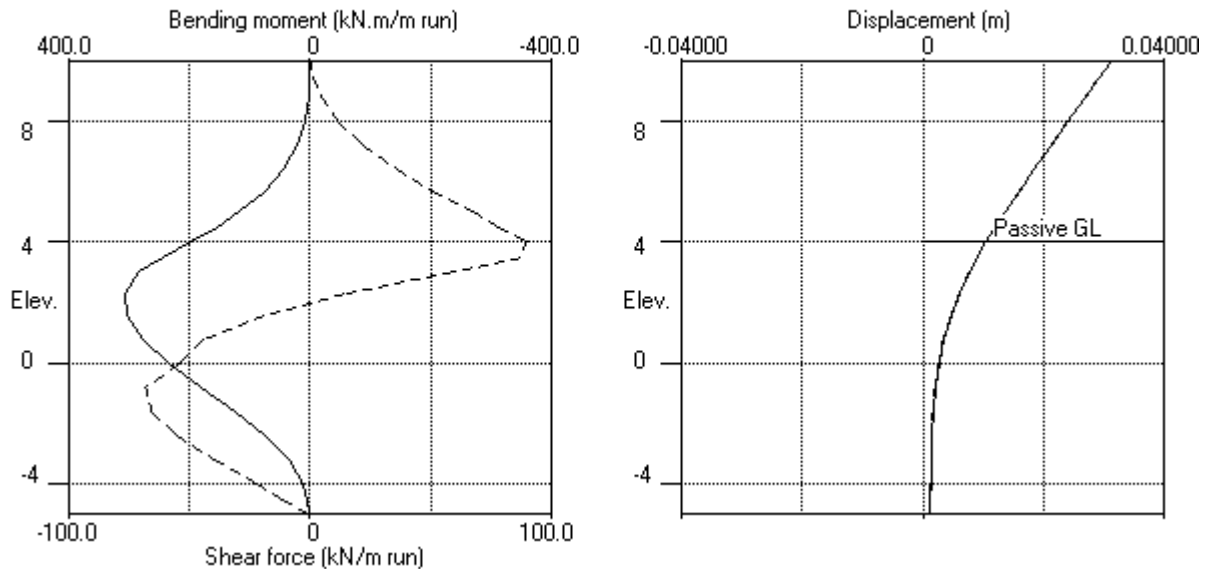
Note: 45.03a Soil pressure at active limit
 65.25p Soil pressure at passive limit

APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

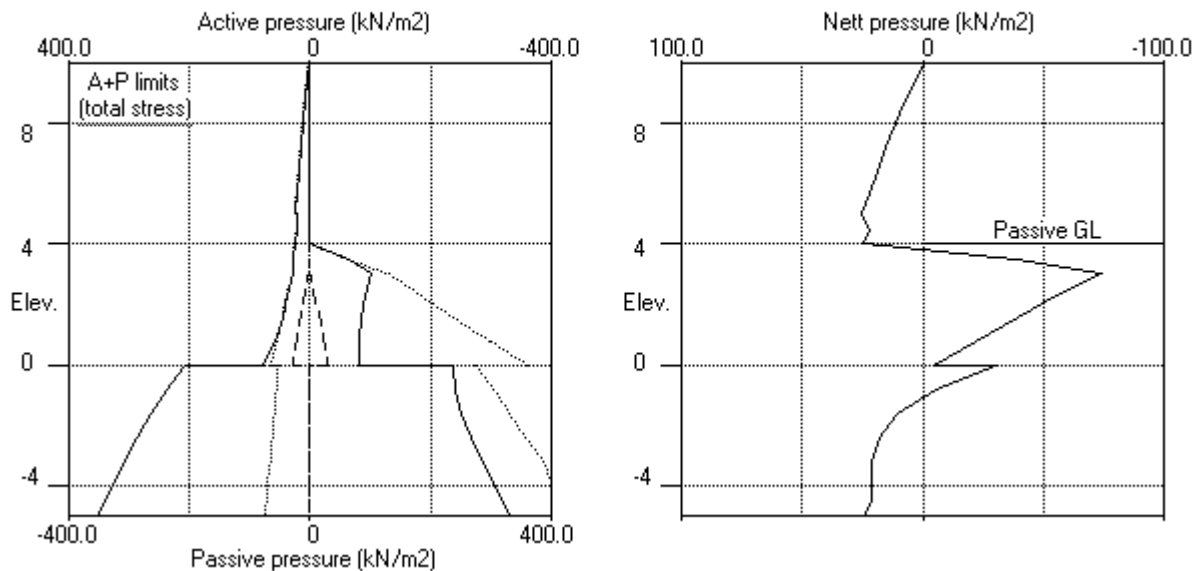
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No.3 Excav. to elev. 4.00 on PASSIVE side

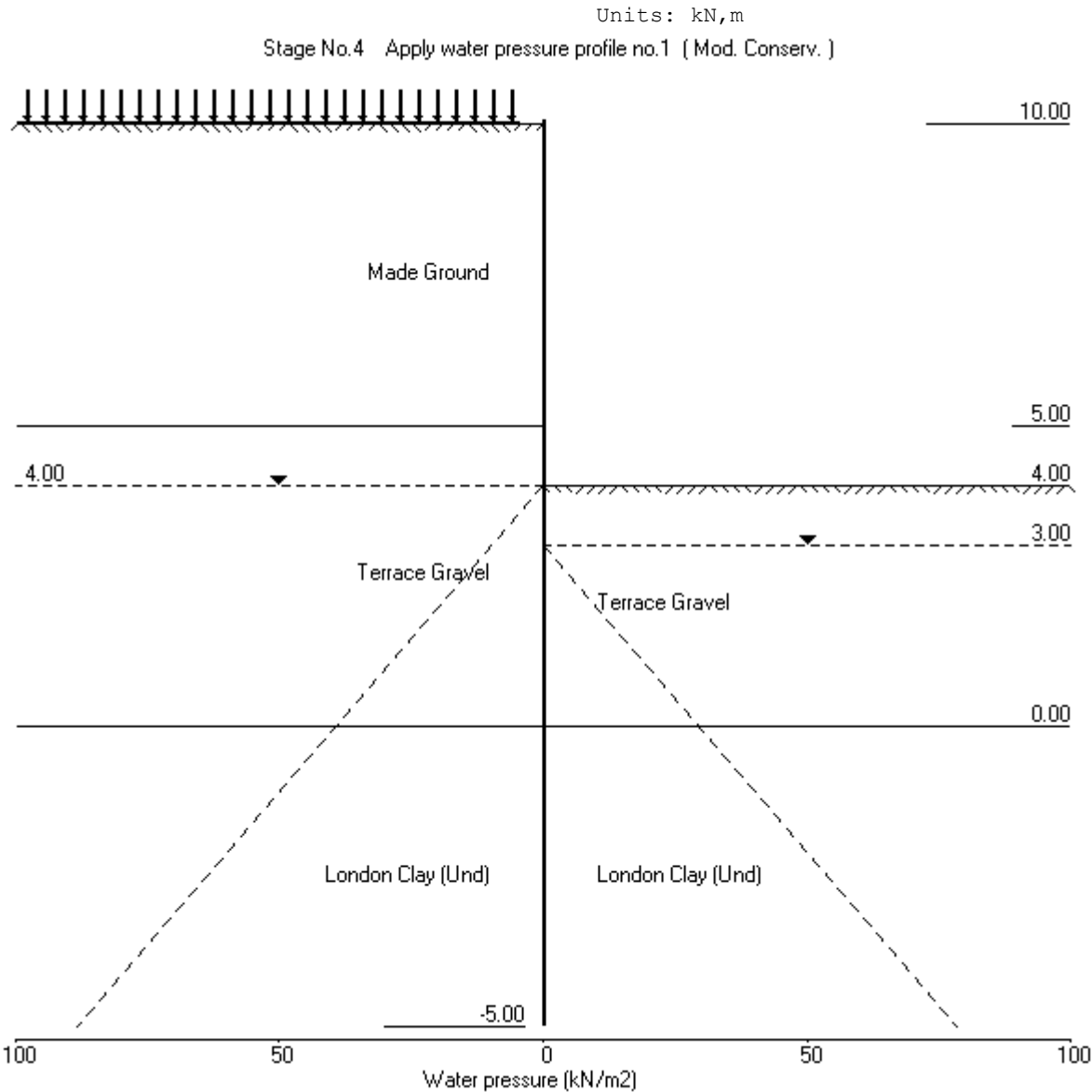


Stage No.3 Excav. to elev. 4.00 on PASSIVE side



APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :



APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No. 4 Apply water pressure profile no.1 (Mod. Conserv.)

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: ULS DA1 Combination 1

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	10.00	0.00	0.033	3.71E-03	0.0	0.0	
2	9.40	3.52	0.031	3.71E-03	1.1	0.4	
3	8.80	7.14	0.028	3.71E-03	4.3	1.8	
4	8.00	11.37	0.025	3.71E-03	11.7	8.0	
5	7.20	15.33	0.022	3.68E-03	22.3	21.3	
6	6.40	19.19	0.020	3.63E-03	36.2	44.5	
7	5.70	22.52	0.017	3.55E-03	50.7	74.8	
8	5.00	25.82	0.015	3.43E-03	67.7	117.3	
		20.59	0.015	3.43E-03	67.7	117.3	
9	4.50	22.57	0.013	3.30E-03	78.5	153.8	
10	4.00	24.54	0.011	3.13E-03	90.2	195.9	
11	3.50	-34.79	0.010	2.92E-03	87.7	244.8	
12	3.00	-73.00	0.008	2.67E-03	60.7	283.6	
13	2.30	-52.98	0.007	2.28E-03	16.6	308.1	
14	1.60	-36.49	0.005	1.87E-03	-14.7	308.7	
15	0.80	-21.41	0.004	1.41E-03	-37.8	285.3	
16	0.00	-2.21	0.003	1.01E-03	-47.3	248.2	
		-39.80	0.003	1.01E-03	-47.3	248.2	
17	-0.80	-11.41	0.002	6.75E-04	-67.8	197.6	
18	-1.60	6.78	0.002	4.18E-04	-69.6	139.7	
19	-2.40	16.88	0.002	2.46E-04	-60.2	86.1	
20	-3.20	21.52	0.001	1.48E-04	-44.8	43.3	
21	-4.00	23.85	0.001	1.04E-04	-26.7	14.3	
22	-4.50	25.73	0.001	9.58E-05	-14.3	3.9	
23	-5.00	31.33	0.001	9.40E-05	0.0	0.0	

Node no.	Y coord	----- ACTIVE side -----						Total earth pressure	Soil stiffness
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2			
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00		1361
2	9.40	0.00	12.89	3.52	64.79	3.52	3.52a		1361
3	8.80	0.00	26.15	7.14	131.42	7.14	7.14a		1361
4	8.00	0.00	41.63	11.37	209.25	11.37	11.37a		1361
5	7.20	0.00	56.14	15.33	282.16	15.33	15.33a		1361
6	6.40	0.00	70.25	19.19	353.11	19.19	19.19a		1361
7	5.70	0.00	82.44	22.52	414.38	22.52	22.52a		1361
8	5.00	0.00	94.55	25.82	475.20	25.82	25.82a		1361
		0.00	94.55	20.59	685.43	20.59	20.59a		6804
9	4.50	0.00	103.65	22.57	751.44	22.57	22.57a		6804

APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.4 Apply water pressure profile no.1 (Mod. Conserv.)

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
10	4.00	0.00	112.73	24.54	817.28	24.54	24.54a	6804
11	3.50	4.90	117.39	25.56	851.06	25.56	30.46a	6804
12	3.00	9.81	122.03	26.57	884.71	26.57	36.38a	6804
13	2.30	16.67	128.51	27.98	931.67	27.98	44.65a	6804
14	1.60	23.54	134.97	29.39	978.47	29.39	52.92a	6804
15	0.80	31.38	142.32	30.99	1031.79	31.55	62.93	6804
16	0.00	39.23	149.66	32.58	1084.97	42.13	81.36	6804
		Total>	188.88	50.00m	388.93	203.51	203.51	18458
17	-0.80	Total>	204.84	54.00m	416.10	234.71	234.71	19492
18	-1.60	Total>	220.79	58.00m	443.25	261.94	261.94	20526
19	-2.40	Total>	236.73	62.00m	470.39	286.05	286.05	21559
20	-3.20	Total>	252.65	66.00m	497.51	308.05	308.05	22593
21	-4.00	Total>	268.57	70.00m	524.63	329.29	329.29	103168
22	-4.50	Total>	278.51	72.50m	541.57	342.93	342.93	105990
23	-5.00	Total>	288.45	75.00m	558.51	358.31	358.31	108811

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	4.00	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	10747
11	3.50	0.00	9.00	1.96	65.25	65.25	65.25p	10747
12	3.00	0.00	18.01	3.92	130.54	109.37	109.37	10747
13	2.30	6.86	24.46	5.33	177.34	90.77	97.63	10747
14	1.60	13.73	30.95	6.74	224.34	75.68	89.41	10747
15	0.80	21.57	38.40	8.36	278.39	62.77	84.34	10747
16	0.00	29.42	45.91	10.00	332.87	54.15	83.56	10747
		Total>	75.33	20.00m	275.36	243.31	243.31	28250
17	-0.80	Total>	91.56	24.00m	302.80	246.11	246.11	29832
18	-1.60	Total>	107.88	28.00m	330.31	255.16	255.16	31414
19	-2.40	Total>	124.27	32.00m	357.91	269.17	269.17	32996
20	-3.20	Total>	140.76	36.00m	385.60	286.54	286.54	34578
21	-4.00	Total>	157.34	40.00m	413.38	305.45	305.45	103168
22	-4.50	Total>	167.75	42.50m	430.79	317.20	317.20	105990
23	-5.00	Total>	178.19	45.00m	448.24	326.98	326.98	108811

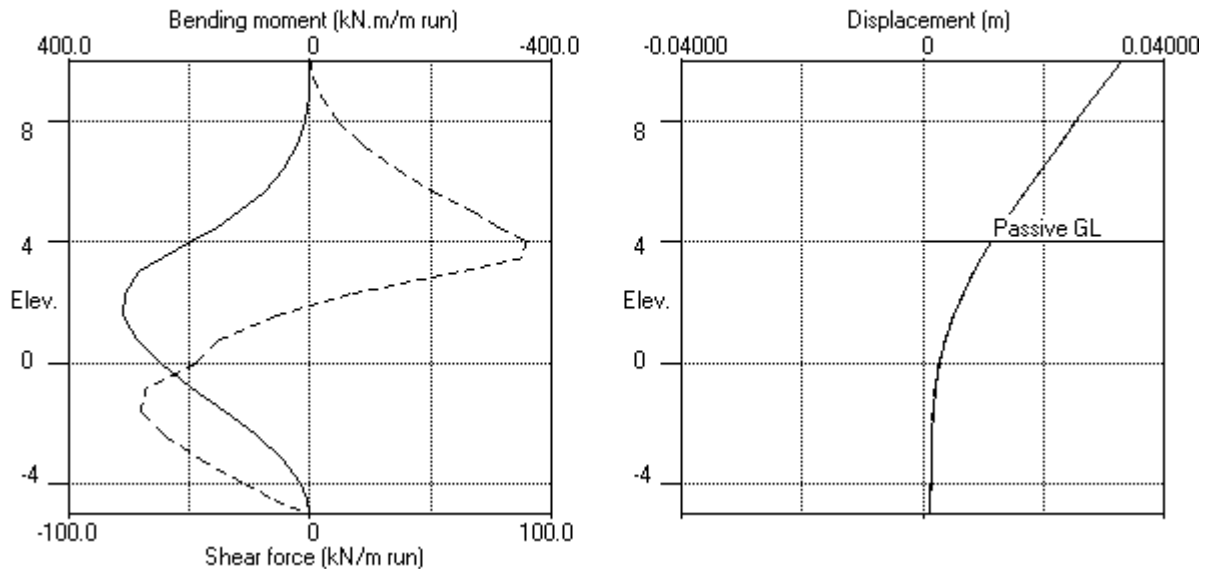
Note: 52.92a Soil pressure at active limit
65.25p Soil pressure at passive limit

APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

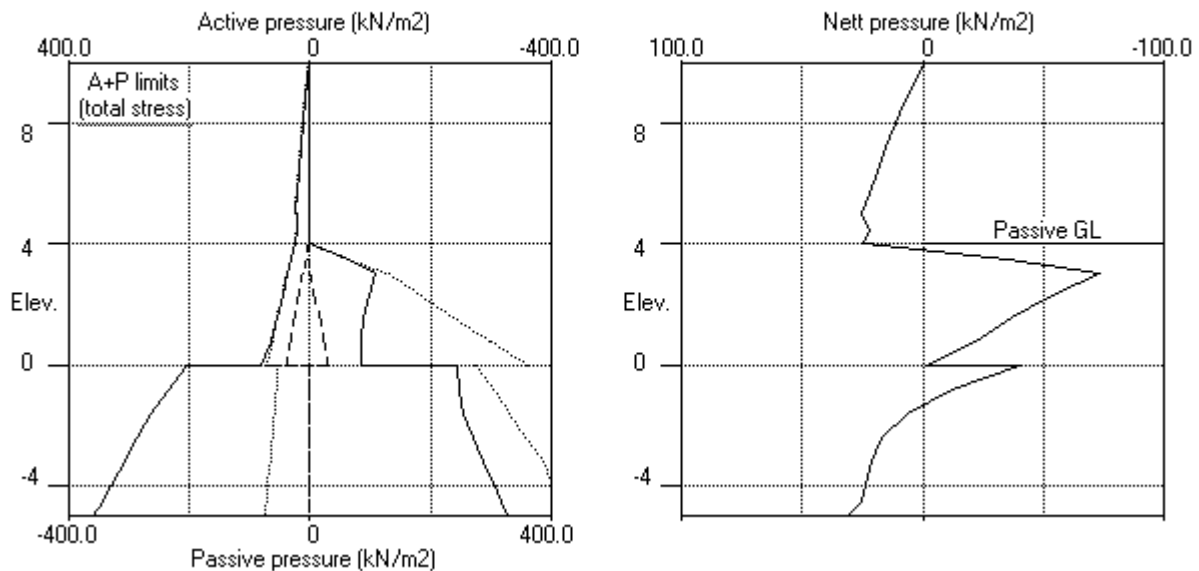
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No.4 Apply water pressure profile no.1 (Mod. Conserv.)

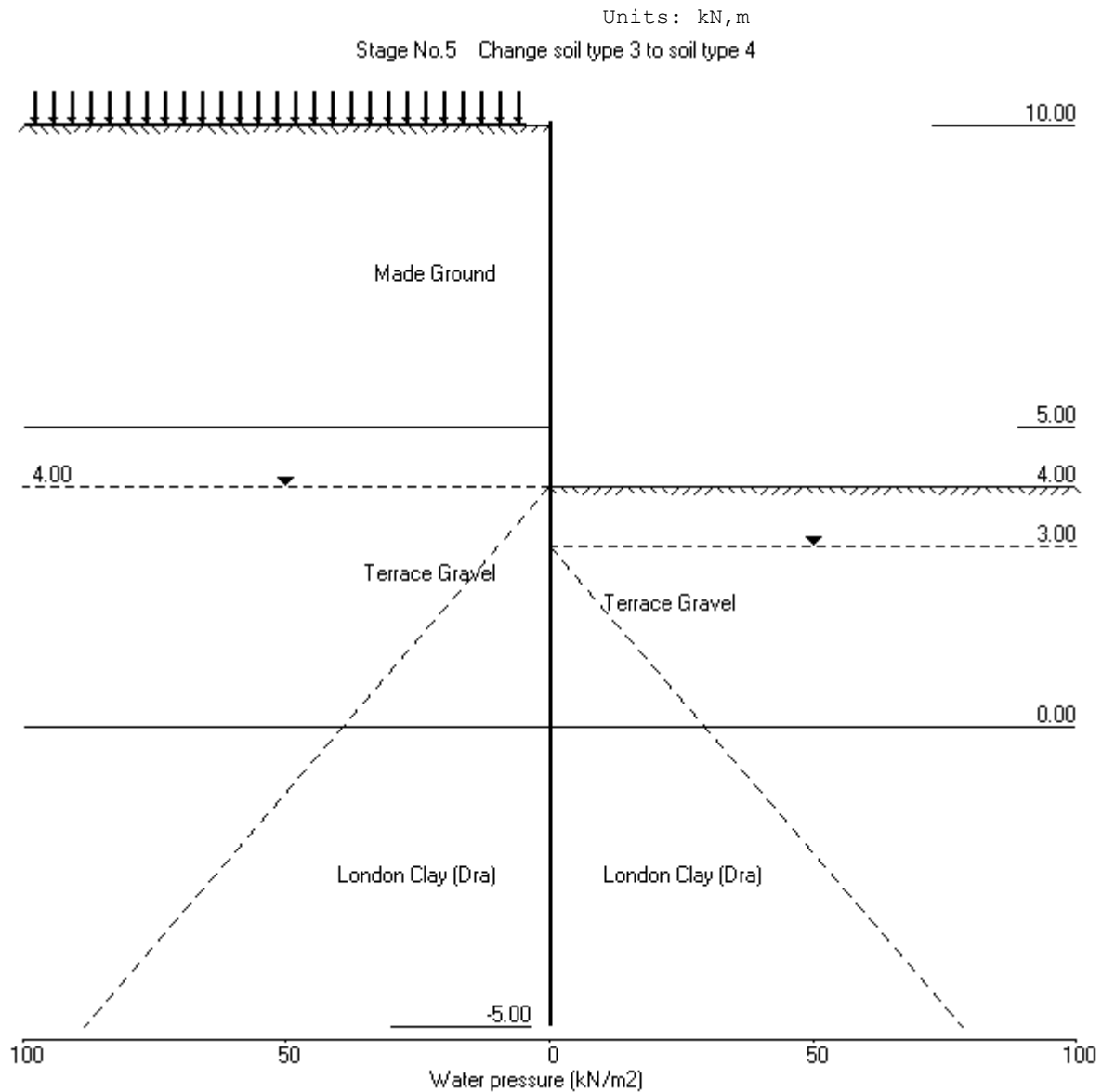


Stage No.4 Apply water pressure profile no.1 (Mod. Conserv.)



APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :



APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No. 5 Change properties of soil type 3 to soil type 4
 Ko pressures will not be reset

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: ULS DA1 Combination 1

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	10.00	0.00	0.034	3.73E-03	0.0	0.0	
2	9.40	3.52	0.031	3.73E-03	1.1	0.4	
3	8.80	7.14	0.029	3.72E-03	4.3	1.8	
4	8.00	11.37	0.026	3.72E-03	11.7	8.0	
5	7.20	15.33	0.023	3.69E-03	22.3	21.3	
6	6.40	19.19	0.020	3.64E-03	36.2	44.5	
7	5.70	22.52	0.018	3.57E-03	50.7	74.8	
8	5.00	25.82	0.015	3.44E-03	67.7	117.3	
		20.59	0.015	3.44E-03	67.7	117.3	
9	4.50	22.57	0.013	3.31E-03	78.5	153.8	
10	4.00	24.54	0.012	3.14E-03	90.2	195.9	
11	3.50	-34.79	0.010	2.93E-03	87.7	244.8	
12	3.00	-76.56	0.009	2.68E-03	59.8	283.6	
13	2.30	-56.49	0.007	2.29E-03	13.3	306.6	
14	1.60	-39.94	0.006	1.88E-03	-20.5	304.0	
15	0.80	-25.31	0.004	1.44E-03	-46.6	274.8	
16	0.00	-7.67	0.003	1.06E-03	-59.8	229.5	
		0.14	0.003	1.06E-03	-59.8	229.5	
17	-0.80	1.04	0.003	7.54E-04	-59.3	178.7	
18	-1.60	0.21	0.002	5.19E-04	-58.8	129.9	
19	-2.40	11.58	0.002	3.57E-04	-54.1	82.9	
20	-3.20	17.73	0.002	2.61E-04	-42.4	43.3	
21	-4.00	21.75	0.001	2.17E-04	-26.6	15.0	
22	-4.50	24.76	0.001	2.08E-04	-14.9	4.4	
23	-5.00	35.04	0.001	2.06E-04	0.0	0.0	

Node no.	Y coord	----- ACTIVE side -----					Total	Soil
		Water	Vertic	Active	Passive	Earth	earth	stiffness
		press.	-al	limit	limit	pressure	pressure	coeff.
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	943
2	9.40	0.00	12.89	3.52	64.79	3.52	3.52a	943
3	8.80	0.00	26.15	7.14	131.42	7.14	7.14a	943
4	8.00	0.00	41.63	11.37	209.25	11.37	11.37a	943
5	7.20	0.00	56.14	15.33	282.16	15.33	15.33a	943
6	6.40	0.00	70.25	19.19	353.11	19.19	19.19a	943
7	5.70	0.00	82.44	22.52	414.38	22.52	22.52a	943
8	5.00	0.00	94.55	25.82	475.20	25.82	25.82a	943
		0.00	94.55	20.59	685.43	20.59	20.59a	4716

APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.5 Change properties of soil type 3 to soil type 4
Ko pressures will not be reset

Node no.	Y coord	----- ACTIVE side -----					Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
9	4.50	0.00	103.65	22.57	751.44	22.57	22.57a	4716
10	4.00	0.00	112.73	24.54	817.28	24.54	24.54a	4716
11	3.50	4.90	117.39	25.56	851.06	25.56	30.46a	4716
12	3.00	9.81	122.03	26.57	884.71	26.57	36.38a	4716
13	2.30	16.67	128.51	27.98	931.67	27.98	44.65a	4716
14	1.60	23.54	134.97	29.39	978.47	29.39	52.92a	4716
15	0.80	31.38	142.32	30.99	1031.79	30.99	62.37a	4716
16	0.00	39.23	149.66	32.58	1084.97	39.81	79.03	4716
		39.23	149.66	47.24	450.64	160.95	200.17	6767
17	-0.80	47.07	157.77	50.66	472.55	184.48	231.55	7146
18	-1.60	54.92	165.88	54.08	494.42	204.25	259.17	7525
19	-2.40	62.76	173.97	57.49	516.26	221.05	283.81	7904
20	-3.20	70.61	182.04	60.90	538.06	235.85	306.46	8283
21	-4.00	78.45	190.11	64.30	559.84	249.95	328.41	8662
22	-4.50	83.36	195.15	66.43	573.44	259.16	342.52	8899
23	-5.00	88.26	200.19	68.55	587.04	271.90	360.16	183089

Node no.	Y coord	----- PASSIVE side -----					Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	4.00	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	6365
11	3.50	0.00	9.00	1.96	65.25	65.25	65.25p	6365
12	3.00	0.00	18.01	3.92	130.54	112.94	112.94	6365
13	2.30	6.86	24.46	5.33	177.34	94.28	101.14	6365
14	1.60	13.73	30.95	6.74	224.34	79.13	92.86	6365
15	0.80	21.57	38.40	8.36	278.39	66.10	87.68	6365
16	0.00	29.42	45.91	10.00	332.87	57.28	86.70	6365
		29.42	45.91	3.48	170.62	170.62	200.04p	9270
17	-0.80	37.26	54.30	7.02	193.25	193.25	230.52p	9790
18	-1.60	45.11	62.77	10.59	216.10	213.85	258.96	10309
19	-2.40	52.96	71.32	14.19	239.19	219.28	272.23	10828
20	-3.20	60.80	79.96	17.84	262.52	227.93	288.73	11347
21	-4.00	68.65	88.69	21.52	286.09	238.01	306.66	11866
22	-4.50	73.55	94.20	23.84	300.94	244.21	317.76	12191
23	-5.00	78.45	99.74	26.18	315.90	246.67	325.12	184132

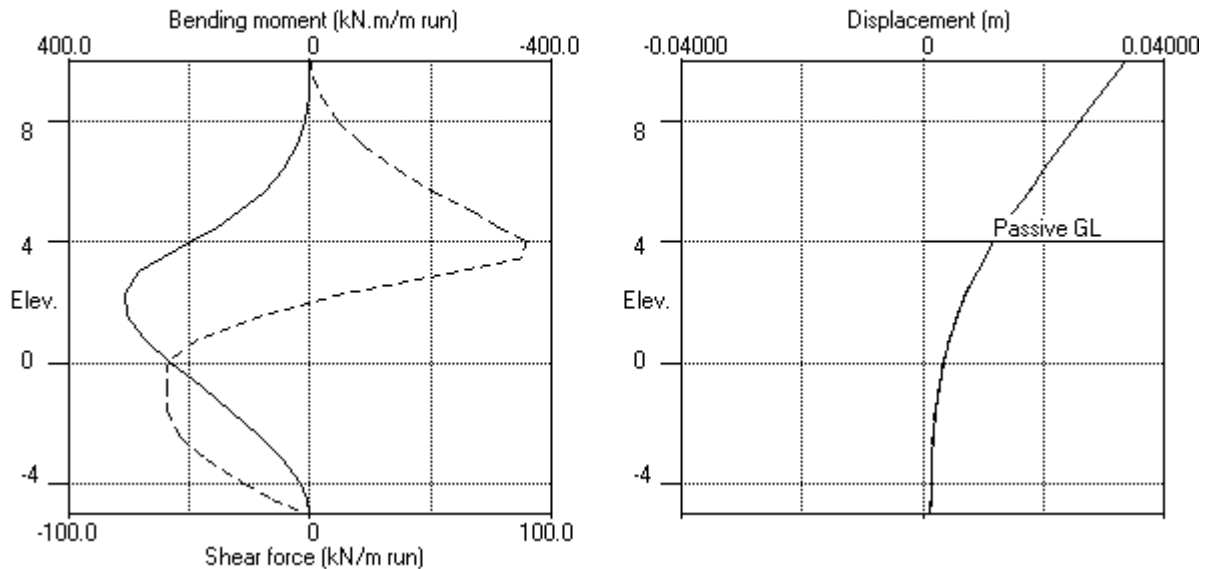
Note: 62.37a Soil pressure at active limit
230.52p Soil pressure at passive limit

APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

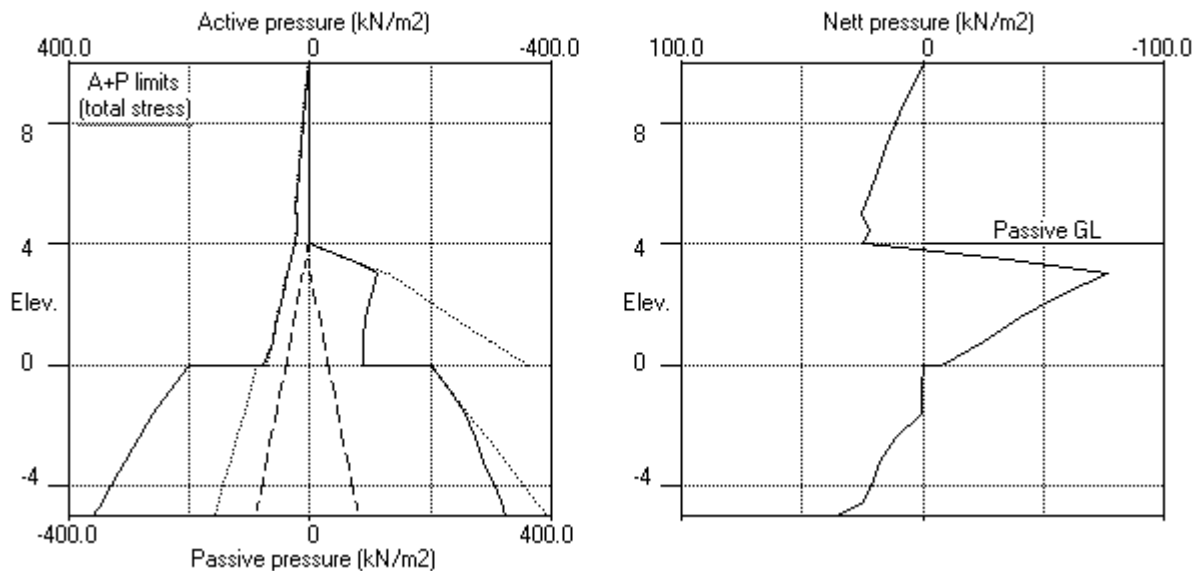
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No.5 Change soil type 3 to soil type 4



Stage No.5 Change soil type 3 to soil type 4



APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

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: ULS DA1 Combination 1

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				Shear force			
		max.	min.	Calculated		Factored		Calculated		Factored	
				max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m		kN/m	
1	10.00	0.034	0.000	0	0	0	0	0	0	0	0
2	9.40	0.031	0.000	0	0	1	0	1	-0	1	-1
3	8.80	0.029	0.000	2	-0	2	-1	4	-1	6	-1
4	8.00	0.026	0.000	8	-1	11	-2	12	-1	16	-1
5	7.20	0.023	0.000	21	-1	29	-2	22	0	30	0
6	6.40	0.020	0.000	45	-1	60	-1	36	0	49	0
7	5.70	0.018	0.000	75	0	101	0	51	0	69	0
8	5.00	0.015	0.000	118	0	159	0	69	0	94	0
9	4.50	0.013	0.000	155	0	209	0	80	0	108	0
10	4.00	0.012	0.000	196	0	264	0	90	0	122	0
11	3.50	0.010	0.000	245	0	330	0	88	0	118	0
12	3.00	0.009	0.000	284	0	383	0	61	-0	82	-0
13	2.30	0.007	0.000	308	0	416	0	17	-10	22	-13
14	1.60	0.006	0.000	309	0	417	0	0	-32	0	-43
15	0.80	0.004	0.000	285	0	385	0	0	-47	0	-63
16	0.00	0.003	0.000	248	0	335	0	0	-60	0	-81
17	-0.80	0.003	0.000	198	0	267	0	0	-68	0	-92
18	-1.60	0.002	0.000	140	0	189	0	0	-70	0	-94
19	-2.40	0.002	0.000	86	0	116	0	0	-60	0	-81
20	-3.20	0.002	0.000	43	0	58	0	0	-45	0	-60
21	-4.00	0.001	0.000	15	0	20	0	0	-27	0	-36
22	-4.50	0.001	0.000	4	0	6	0	0	-15	0	-20
23	-5.00	0.001	0.000	0	0	0	0	0	0	0	0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment						Shear force					
	Calculated			Factored			Calculated			Factored		
	max.	elev.	min.	max.	elev.	min.	max.	elev.	min.	max.	elev.	min.
	kN.m/m		kN.m/m	kN.m/m		kN/m	kN/m		kN/m	kN/m		kN/m
1	8	3.00	-1	7.20	11	-2	5	5.00	-1	0.80	7	-2
2	250	2.30	0	10.00	337	0	80	4.50	-52	-0.80	108	-70
3	305	2.30	0	10.00	412	0	90	4.00	-68	-0.80	122	-92
4	309	1.60	0	10.00	417	0	90	4.00	-70	-1.60	122	-94
5	307	2.30	0	10.00	414	0	90	4.00	-60	0.00	122	-81

APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

Summary of results (continued)

Maximum and minimum displacement at each stage

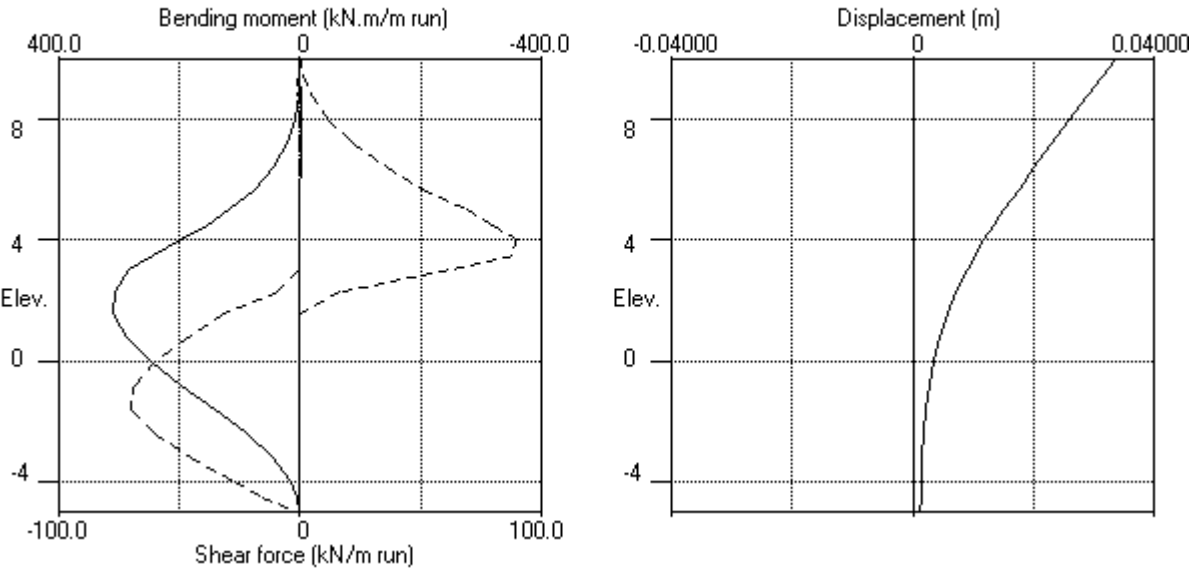
Stage	-----	Displacement	-----	Stage description	
no.	maximum	elev.	minimum	elev.	-----
	m		m		
1	0.001	10.00	0.000	10.00	Apply surcharge no.1 at elev. 10.00
2	0.024	10.00	0.000	10.00	Excav. to elev. 4.50 on PASSIVE side
3	0.031	10.00	0.000	10.00	Excav. to elev. 4.00 on PASSIVE side
4	0.033	10.00	0.000	10.00	Apply water pressure profile no.1
5	0.034	10.00	0.000	10.00	Change soil type 3 to soil type 4

APPENDIX C-3. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS1 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Active side	Soil types	Passive side
1	10.00	1 Made Ground	1 Made Ground	
2	5.00	2 Terrace Gravel	2 Terrace Gravel	
3	0.00	3 London Clay (Und)	3 London Clay (Und)	

SOIL PROPERTIES (Unfactored SLS soil strengths)

Soil type	density	Bulk Modulus	Young's Modulus	At rest coeff.	Consol. state.	Active limit	Passive limit	Cohesion
No. Description	kN/m3	Eh, kN/m2	Ko	NC/OC	Ka	Kp		kN/m2
(Datum elev.)		(dEh/dy)	(dKo/dy)	(Nu)	(Kac)	(Kpc)		(dc/dy)
1 Made Ground	17.00a	10000	0.500	OC	0.273	5.026		
	18.00b			(0.300)	(0.000)	(0.000)		
2 Terrace Gravel	18.00a	50000	0.430	OC	0.218	7.250		
	19.00b			(0.300)	(0.000)	(0.000)		
3 London Cl..	20.00	100000	1.500	OC	1.000	1.000	100.0u	
(0.00)	(7000)		(0.490)	(2.000)	(2.000)	(7.000)		
4 London Cl..	20.00	80000	1.500	OC	0.422	2.699	10.00d	
(0.00)	(5600)		(0.200)	(1.589)	(4.668)			

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

Additional soil parameters associated with Ka and Kp

Soil type	parameters for Ka			parameters for Kp		
	Soil friction angle	Wall coeff.	Back-fill	Soil friction angle	Wall coeff.	Back-fill
1 Made Ground	30.00	1.000	0.00	30.00	1.000	0.00
2 Terrace Gravel	35.00	1.000	0.00	35.00	1.000	0.00
3 London Clay (Und)	0.00	0.000	0.00	0.00	0.000	0.00
4 London Clay (Dra)	20.00	1.000	0.00	20.00	1.000	0.00

GROUND WATER CONDITIONS

Density of water = 9.807 kN/m3

	Active side	Passive side
Initial water table elevation	3.00	3.00

Automatic water pressure balancing at toe of wall : No

Active side				Passive side					
Water press.	Point no.	Elev. m	Piezo Water elev. kN/m2	Water press.	Point no.	Elev. m	Piezo Water elev. kN/m2		
	1	4.00	4.00	0.0	1	3.00	3.00	0.0 MC	
	2	1	5.00	5.00	0.0	1	3.00	3.00	0.0 WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = -5.00
Maximum finite element length = 0.80 m
Youngs modulus of wall E = 1.9600E+07 kN/m2
Moment of inertia of wall I = 0.026839 m4/m run
E.I = 526035 kN.m2/m run
Yield Moment of wall = Not defined

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

SURCHARGE LOADS

Surch -arge no.	Distance from Elev.	Length parallel wall	Width perpend. to wall	Surcharge Near edge	Far edge	Equiv. Partial soil factor/ type	Category
1	10.00	0.50 (A)	1000.00	20.00	10.00	=	N/A 1.30 Var

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 10.00
2	Excavate to elevation 4.50 on PASSIVE side
3	Excavate to elevation 4.00 on PASSIVE side
4	Apply water pressure profile no.2 (Worst Cred.)
5	Change properties of soil type 3 to soil type 4 Ko pressures will not be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

Limit State options: ULS DA1 Combination 2
Water pressures : Worst Credible
Partial factor on C' = 1.250
Partial factor on Phi' = 1.250
Partial factor on Cu = 1.400
Partial factor on Soil Modulus = 1.000
Partial factor on Permanent Unfavourable loads = 1.000
Partial factor on Permanent Favourable loads = 1.000
Partial factor on Permanent Variable loads = 1.300

Stability analysis:
Method of analysis - Strength Factor method
Overall 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

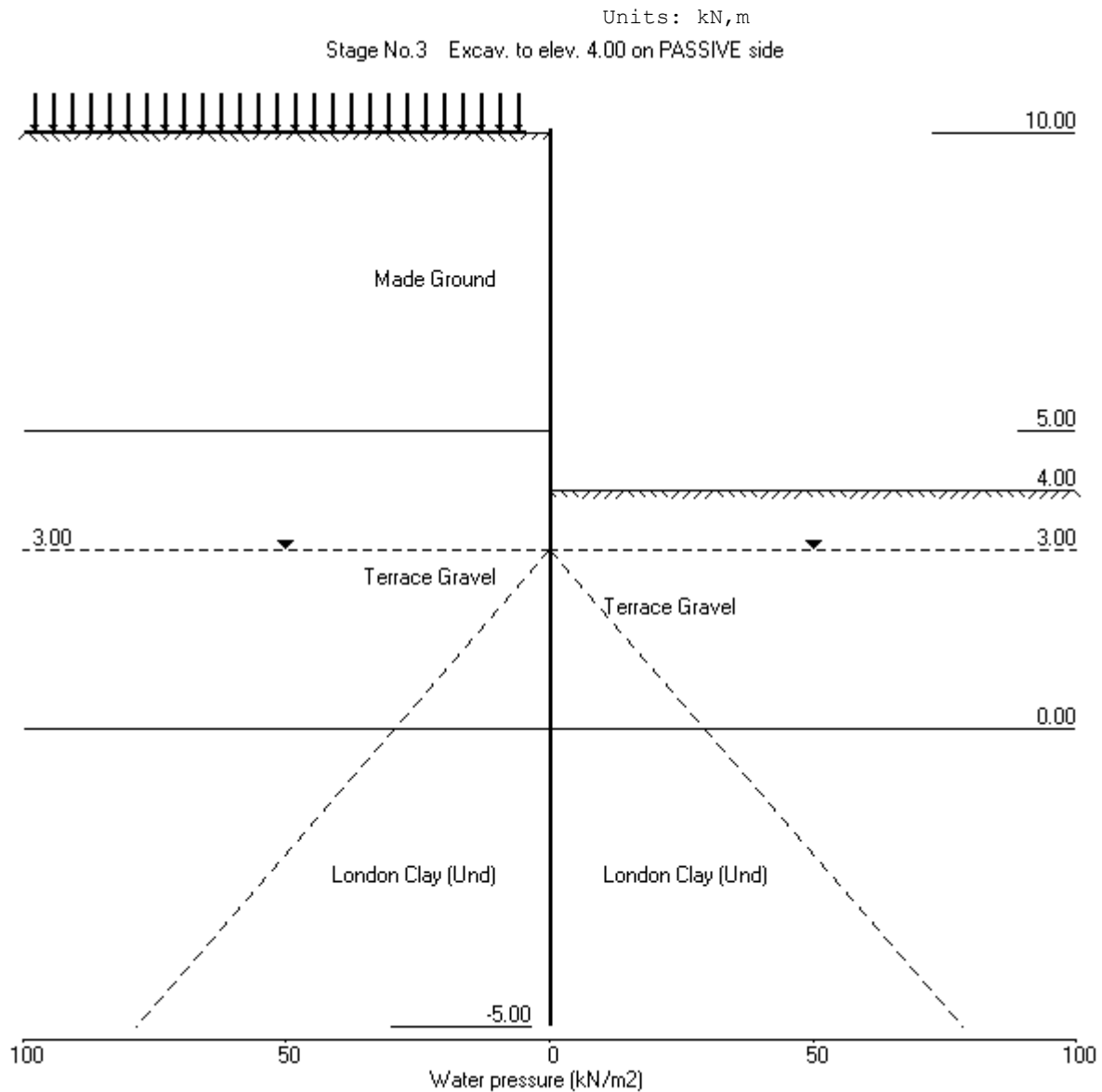
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output pressures
1	Apply surcharge no.1 at elev. 10.00	No	No	No
2	Excav. to elev. 4.50 on PASSIVE side	No	No	No
3	Excav. to elev. 4.00 on PASSIVE side	Yes	Yes	Yes
4	Apply water pressure profile no.2	Yes	Yes	Yes
5	Change soil type 3 to soil type 4	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

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APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :



APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No. 3 Excavate to elevation 4.00 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

				Overall			
				FoS for toe		Toe elev. for	
				elev. = -5.00		FoS = 1.000	
				-----		-----	
Stage	--- G.L. ---	Strut	Factor	Moment		Toe	Wall
No.	Act. Pass.	Elev.	of	equilib.		elev.	Penetr
			Safety	at elev.		-ation	
3	10.00 4.00	Cant.	1.308	-3.72		-2.04	6.04

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: ULS DA1 Combination 2

Node no.	Y coord	Nett pressure kN/m ²	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	10.00	0.00	0.052	5.74E-03	0.0	0.0	
2	9.40	4.59	0.049	5.74E-03	1.4	0.5	
3	8.80	9.33	0.045	5.74E-03	5.6	2.4	
4	8.00	14.77	0.041	5.73E-03	15.2	10.4	
5	7.20	19.80	0.036	5.70E-03	29.0	27.8	
6	6.40	24.68	0.031	5.63E-03	46.8	57.8	
7	5.70	28.88	0.028	5.53E-03	65.6	97.0	
8	5.00	33.05	0.024	5.37E-03	87.2	150.3	
		27.18	0.024	5.37E-03	87.2	150.3	
9	4.50	29.76	0.021	5.20E-03	101.5	197.4	
10	4.00	32.33	0.019	4.99E-03	117.0	251.9	
11	3.50	-8.11	0.016	4.72E-03	123.1	312.7	
12	3.00	-48.57	0.014	4.39E-03	108.9	375.9	
13	2.30	-77.59	0.011	3.85E-03	64.7	435.8	
14	1.60	-73.87	0.008	3.25E-03	11.7	463.9	
15	0.80	-46.66	0.006	2.56E-03	-36.5	449.4	
16	0.00	-26.14	0.004	1.91E-03	-65.6	407.2	
		-42.72	0.004	1.91E-03	-65.6	407.2	
17	-0.80	-24.15	0.003	1.33E-03	-92.4	347.1	
18	-1.60	-12.24	0.002	8.74E-04	-106.9	263.7	
19	-2.40	13.33	0.002	5.40E-04	-106.5	176.2	
20	-3.20	29.46	0.001	3.34E-04	-89.4	95.2	
21	-4.00	45.81	0.001	2.36E-04	-59.3	33.0	
22	-4.50	59.26	0.001	2.16E-04	-33.0	9.1	
23	-5.00	72.71	0.001	2.12E-04	0.0	0.0	

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.3 Excavate to elevation 4.00 on PASSIVE side

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1412
2	9.40	0.00	13.38	4.59	47.91	4.59	4.59a	1412
3	8.80	0.00	27.19	9.33	97.37	9.33	9.33a	1412
4	8.00	0.00	43.02	14.77	154.04	14.77	14.77a	1412
5	7.20	0.00	57.69	19.80	206.57	19.80	19.80a	1412
6	6.40	0.00	71.90	24.68	257.45	24.68	24.68a	1412
7	5.70	0.00	84.14	28.88	301.29	28.88	28.88a	1412
8	5.00	0.00	96.28	33.05	344.74	33.05	33.05a	1412
		0.00	96.28	27.18	459.95	27.18	27.18a	7062
9	4.50	0.00	105.41	29.76	503.54	29.76	29.76a	7062
10	4.00	0.00	114.50	32.33	546.99	32.33	32.33a	7062
11	3.50	0.00	123.57	34.89	590.34	34.89	34.89a	7062
12	3.00	0.00	132.63	37.44	633.59	37.44	37.44a	7062
13	2.30	6.86	139.11	39.27	664.57	39.27	46.14a	7062
14	1.60	13.73	145.57	41.10	695.43	41.10	54.83a	7062
15	0.80	21.57	152.93	43.17	730.56	43.17	64.75a	7062
16	0.00	29.42	160.26	45.24	765.59	45.24	74.66a	7062
		Total>	189.68	50.00m	332.58	175.50	175.50	19090
17	-0.80	Total>	205.63	54.76	356.54	218.30	218.30	20159
18	-1.60	Total>	221.57	62.70	380.48	254.52	254.52	21228
19	-2.40	Total>	237.50	70.62	404.41	285.10	285.10	22297
20	-3.20	Total>	253.41	78.53	428.32	311.57	311.57	23366
21	-4.00	Total>	269.30	86.43	452.22	339.26	339.26	89631
22	-4.50	Total>	279.24	91.36	467.15	358.60	358.60	92082
23	-5.00	Total>	289.16	96.28	482.08	377.97	377.97	94533

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	4.00	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	11671
11	3.50	0.00	9.00	2.54	43.00	43.00	43.00p	11671
12	3.00	0.00	18.01	5.08	86.02	86.02	86.02p	11671
13	2.30	6.86	24.46	6.91	116.86	116.86	123.72p	11671
14	1.60	13.73	30.95	8.74	147.83	114.97	128.70	11671
15	0.80	21.57	38.40	10.84	183.44	89.84	111.41	11671
16	0.00	29.42	45.91	12.96	219.34	71.38	100.80	11671
		Total>	75.33	20.00m	218.21	218.21	218.21p	30563
17	-0.80	Total>	91.56	24.00m	242.45	242.45	242.45p	32274
18	-1.60	Total>	107.88	28.00m	266.76	266.76	266.76p	33986
19	-2.40	Total>	124.27	32.00m	291.16	271.77	271.77	35697
20	-3.20	Total>	140.76	36.00m	315.65	282.11	282.11	37409
21	-4.00	Total>	157.34	40.00m	340.23	293.44	293.44	89631

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.3 Excavate to elevation 4.00 on PASSIVE side

Node no.	Y coord	----- PASSIVE side -----					Total earth pressure	Soil stiffness
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		coeff. kN/m3
22	-4.50	Total>	167.75	42.50m	355.64	299.35	299.35	92082
23	-5.00	Total>	178.19	45.00m	371.09	305.26	305.26	94533

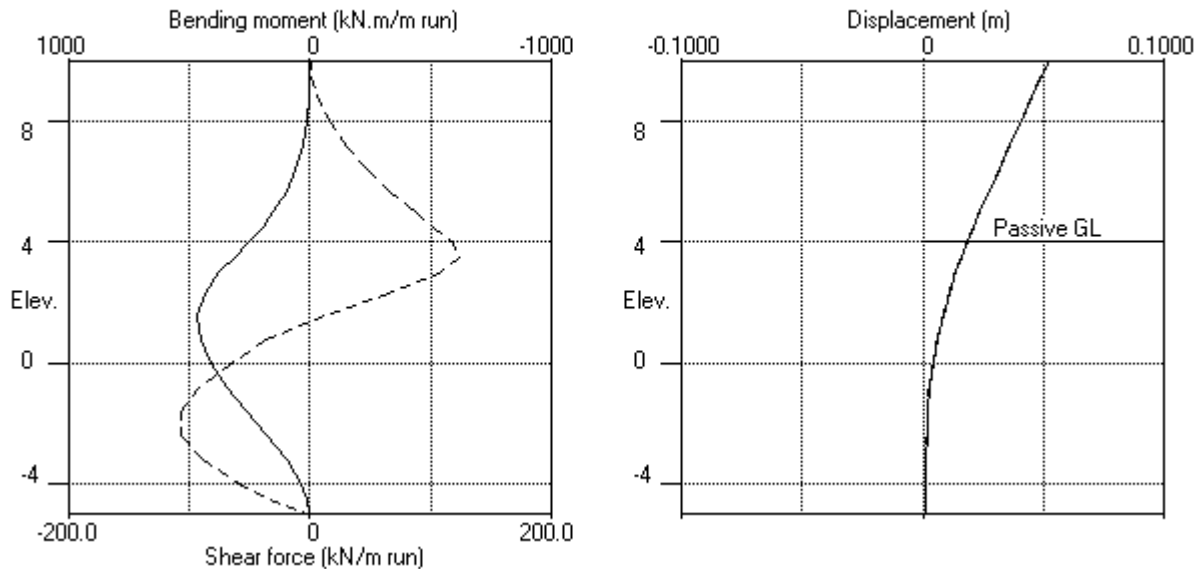
Note: 74.66a Soil pressure at active limit
 266.76p Soil pressure at passive limit

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

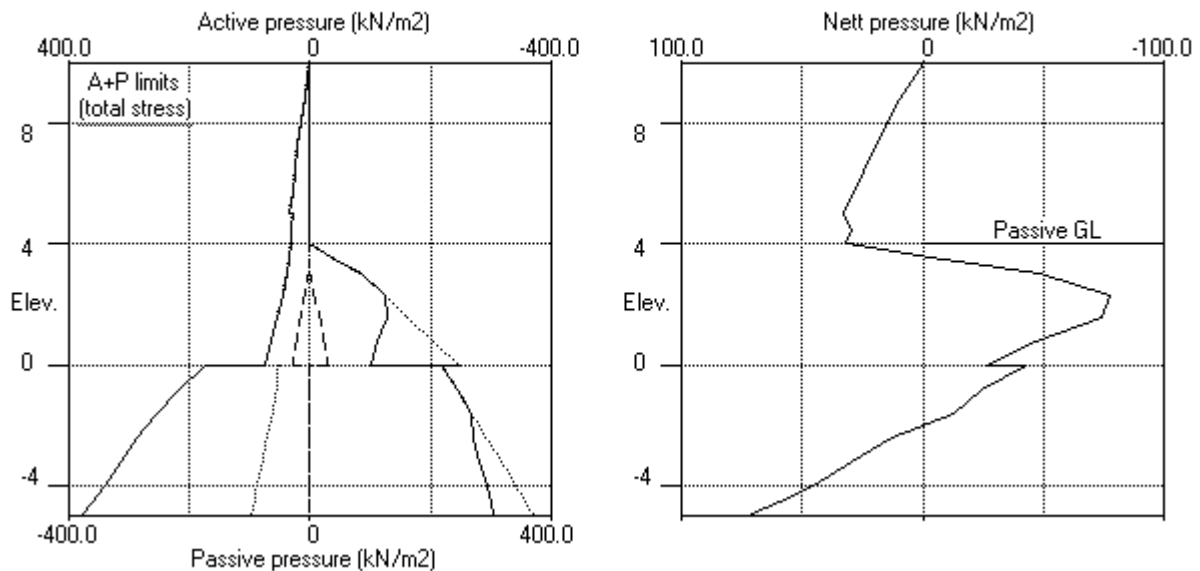
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No.3 Excav. to elev. 4.00 on PASSIVE side



Stage No.3 Excav. to elev. 4.00 on PASSIVE side

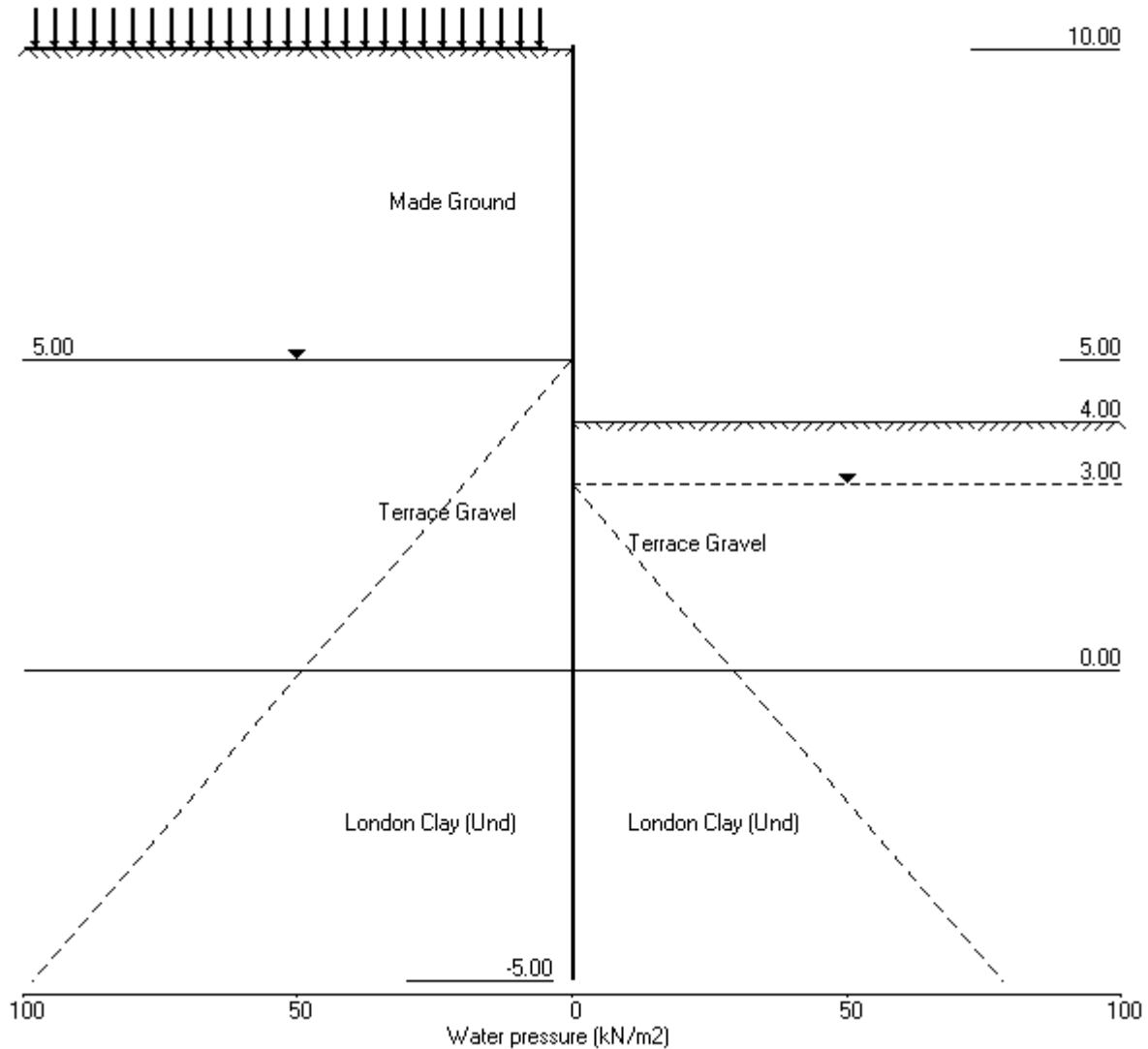


APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No.4 Apply water pressure profile no.2 (Worst Cred.)



APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No. 4 Apply water pressure profile no.2 (Worst Cred.)

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

		Overall			
		FoS for toe		Toe elev. for	
		elev. = -5.00		FoS = 1.000	
		-----		-----	
Stage	--- G.L. ---	Strut	Factor	Moment	Toe Wall
No.	Act. Pass.	Elev.	of	equilib.	elev. Penetr
		Safety at elev.		-ation	
4	10.00 4.00	Cant.	1.238	-3.68	-2.54 6.54

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: ULS DA1 Combination 2

Node	Y	Nett	Wall	Wall	Shear	Bending	Strut
no.	coord	pressure	disp.	rotation	force	moment	forces
		kN/m ²	m	rad.	kN/m	kN.m/m	kN/m
1	10.00	0.00	0.062	6.62E-03	0.0	0.0	
2	9.40	4.59	0.058	6.62E-03	1.4	0.5	
3	8.80	9.33	0.054	6.62E-03	5.6	2.4	
4	8.00	14.77	0.049	6.61E-03	15.2	10.4	
5	7.20	19.80	0.043	6.58E-03	29.0	27.8	
6	6.40	24.68	0.038	6.52E-03	46.8	57.8	
7	5.70	28.88	0.034	6.42E-03	65.6	97.0	
8	5.00	33.05	0.029	6.25E-03	87.2	150.3	
		27.18	0.029	6.25E-03	87.2	150.3	
9	4.50	33.42	0.026	6.09E-03	102.4	197.5	
10	4.00	39.65	0.023	5.87E-03	120.7	253.1	
11	3.50	2.87	0.020	5.60E-03	131.3	316.8	
12	3.00	-33.93	0.018	5.27E-03	123.5	385.6	
13	2.30	-62.94	0.014	4.70E-03	89.6	459.4	
14	1.60	-86.55	0.011	4.06E-03	37.3	508.5	
15	0.80	-52.79	0.008	3.29E-03	-18.4	510.5	
16	0.00	-26.49	0.006	2.53E-03	-50.2	480.7	
		-66.01	0.006	2.53E-03	-50.2	480.7	
17	-0.80	-40.06	0.004	1.84E-03	-92.6	425.5	
18	-1.60	-21.75	0.003	1.26E-03	-117.3	336.9	
19	-2.40	-1.44	0.002	8.31E-04	-126.6	237.9	
20	-3.20	25.19	0.001	5.46E-04	-117.1	136.2	
21	-4.00	54.24	0.001	4.04E-04	-85.3	50.5	
22	-4.50	85.25	0.001	3.73E-04	-50.4	14.6	
23	-5.00	116.51	0.001	3.66E-04	0.0	0.0	

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.4 Apply water pressure profile no.2 (Worst Cred.)

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1361
2	9.40	0.00	13.38	4.59	47.91	4.59	4.59a	1361
3	8.80	0.00	27.19	9.33	97.37	9.33	9.33a	1361
4	8.00	0.00	43.02	14.77	154.04	14.77	14.77a	1361
5	7.20	0.00	57.69	19.80	206.57	19.80	19.80a	1361
6	6.40	0.00	71.90	24.68	257.45	24.68	24.68a	1361
7	5.70	0.00	84.14	28.88	301.29	28.88	28.88a	1361
8	5.00	0.00	96.28	33.05	344.74	33.05	33.05a	1361
		0.00	96.28	27.18	459.95	27.18	27.18a	6807
9	4.50	4.90	101.00	28.51	482.50	28.51	33.42a	6807
10	4.00	9.81	105.70	29.84	504.92	29.84	39.65a	6807
11	3.50	14.71	110.37	31.16	527.23	31.16	45.87a	6807
12	3.00	19.61	115.02	32.47	549.45	32.47	52.08a	6807
13	2.30	26.48	121.50	34.30	580.43	34.30	60.78a	6807
14	1.60	33.34	127.96	36.12	611.29	36.12	69.47a	6807
15	0.80	41.19	135.31	38.20	646.42	38.20	79.39a	6807
16	0.00	49.03	142.65	40.27	681.44	40.27	89.30a	6807
		Total>	191.68	50.00m	334.58	152.20	152.20	18464
17	-0.80	Total>	207.63	56.76	358.54	202.39	202.39	19498
18	-1.60	Total>	223.57	64.70	382.48	245.02	245.02	20532
19	-2.40	Total>	239.50	72.62	406.40	280.85	280.85	21566
20	-3.20	Total>	255.41	80.53	430.32	311.50	311.50	22600
21	-4.00	Total>	271.30	88.43	454.22	344.81	344.81	104868
22	-4.50	Total>	281.24	93.36	469.15	372.94	372.94	107736
23	-5.00	Total>	291.16	98.29	484.08	401.22	401.22	110603

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	4.00	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	10655
11	3.50	0.00	9.00	2.54	43.00	43.00	43.00p	10655
12	3.00	0.00	18.01	5.08	86.02	86.02	86.02p	10655
13	2.30	6.86	24.46	6.91	116.86	116.86	123.72p	10655
14	1.60	13.73	30.95	8.74	147.83	142.29	156.02	10655
15	0.80	21.57	38.40	10.84	183.44	110.60	132.18	10655
16	0.00	29.42	45.91	12.96	219.34	86.38	115.80	10655
		Total>	75.33	20.00m	218.21	218.21	218.21p	28021
17	-0.80	Total>	91.56	24.00m	242.45	242.45	242.45p	29590
18	-1.60	Total>	107.88	28.00m	266.76	266.76	266.76p	31159
19	-2.40	Total>	124.27	32.00m	291.16	282.30	282.30	32728
20	-3.20	Total>	140.76	36.00m	315.65	286.31	286.31	34297
21	-4.00	Total>	157.34	40.00m	340.23	290.58	290.58	104868

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.4 Apply water pressure profile no.2 (Worst Cred.)

Node no.	Y coord	Water press. kN/m2	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
22	-4.50	Total>	167.75	42.50m	355.64	287.69	287.69	107736
23	-5.00	Total>	178.19	45.00m	371.09	284.70	284.70	110603

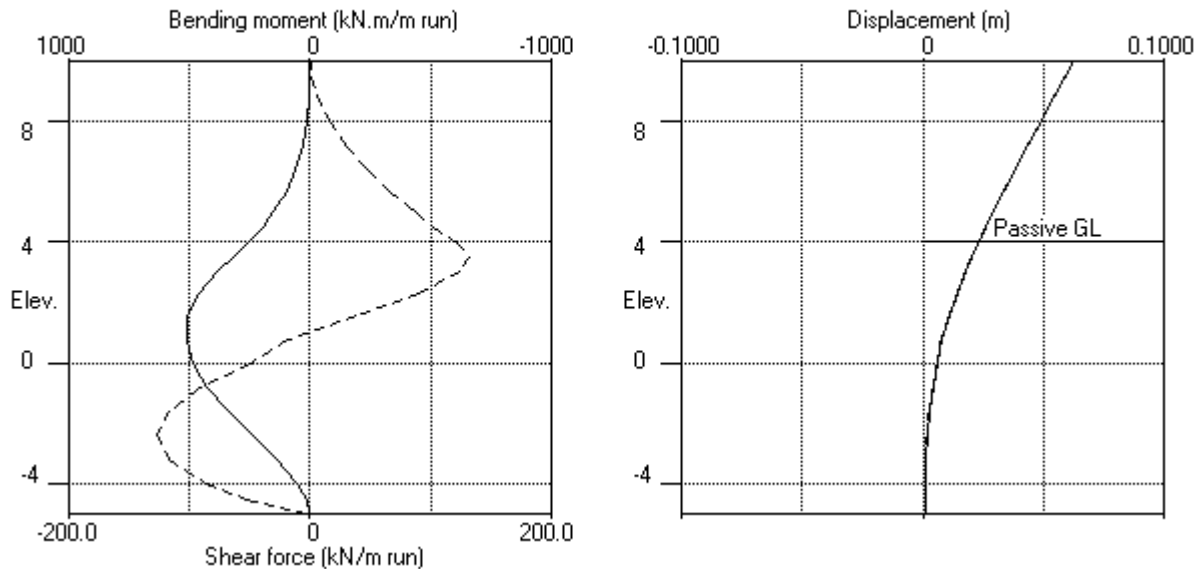
Note: 89.30a Soil pressure at active limit
 266.76p Soil pressure at passive limit

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

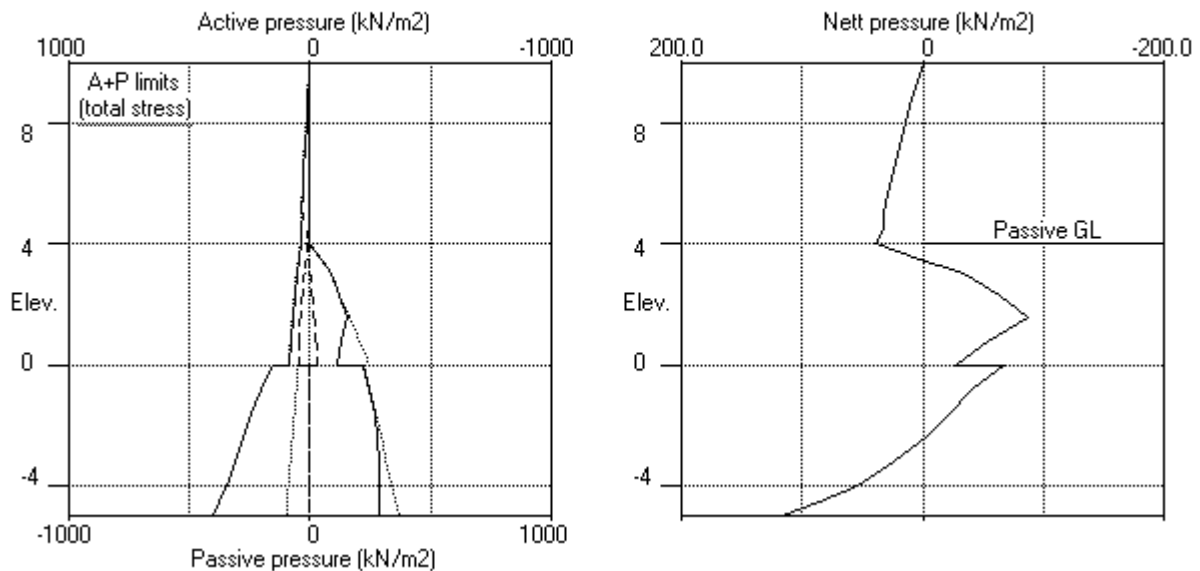
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No.4 Apply water pressure profile no.2 (Worst Cred.)

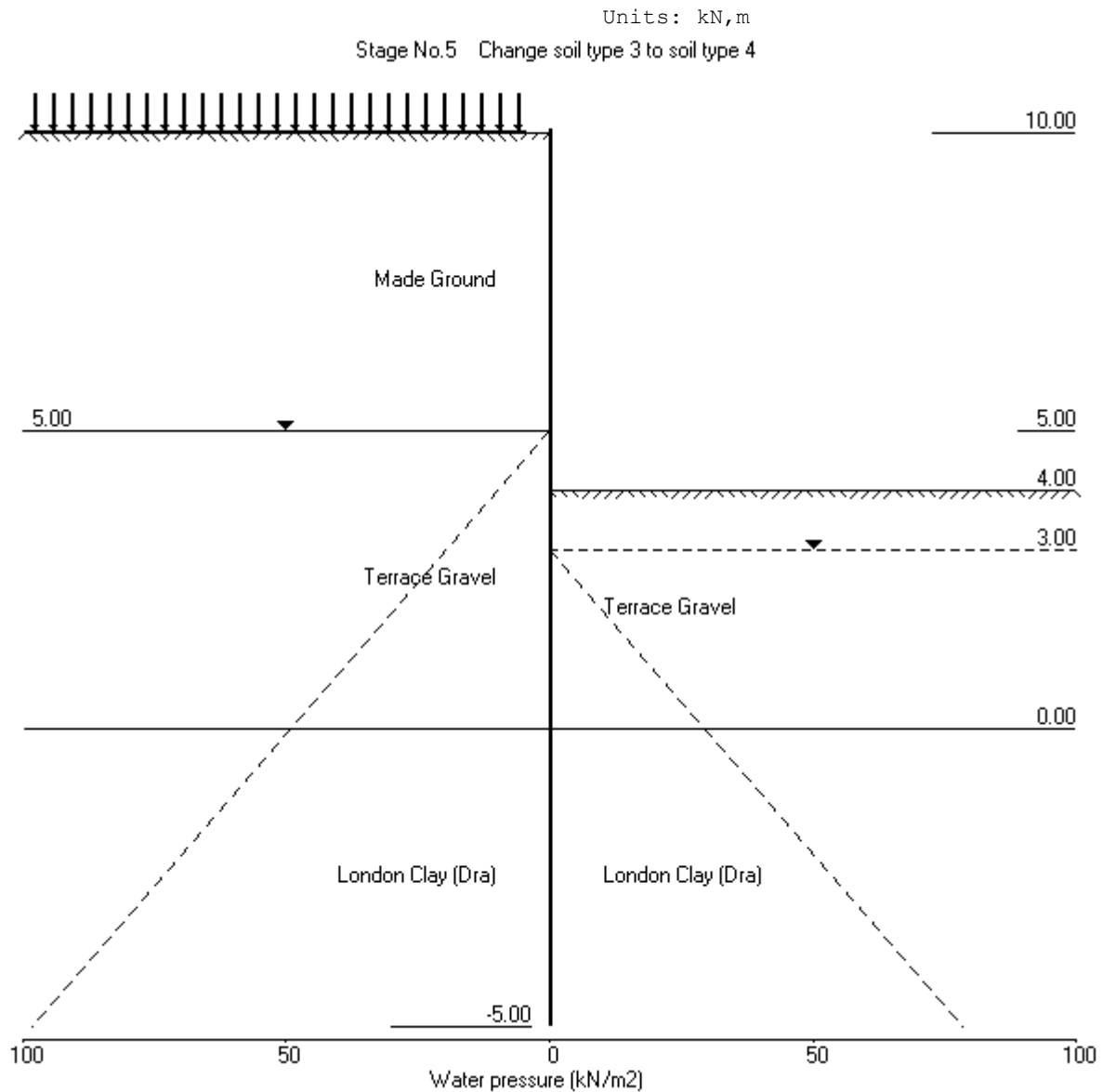


Stage No.4 Apply water pressure profile no.2 (Worst Cred.)



APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :



APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No. 5 Change properties of soil type 3 to soil type 4
 Ko pressures will not be reset

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method
 Factor of safety on soil strength

		Overall			
		FoS for toe		Toe elev. for	
		elev. = -5.00		FoS = 1.000	
		-----		-----	
Stage	--- G.L. ---	Strut	Factor	Moment	Toe Wall
No.	Act. Pass.	Elev.	of	equilib.	elev. Penetr
		Safety at elev.		-ation	
5	10.00 4.00	Cant.	1.135	-4.15	-2.55 6.55

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: ULS DA1 Combination 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	10.00	0.00	0.071	7.09E-03	0.0	0.0	
2	9.40	4.59	0.066	7.09E-03	1.4	0.5	
3	8.80	9.33	0.062	7.09E-03	5.6	2.4	
4	8.00	14.77	0.056	7.08E-03	15.2	10.4	
5	7.20	19.80	0.051	7.05E-03	29.0	27.8	
6	6.40	24.68	0.045	6.99E-03	46.8	57.8	
7	5.70	28.88	0.040	6.89E-03	65.6	97.0	
8	5.00	33.05	0.036	6.72E-03	87.2	150.3	
		27.18	0.036	6.72E-03	87.2	150.3	
9	4.50	33.42	0.032	6.56E-03	102.4	197.5	
10	4.00	39.65	0.029	6.34E-03	120.7	253.1	
11	3.50	2.87	0.026	6.07E-03	131.3	316.8	
12	3.00	-33.93	0.023	5.74E-03	123.5	385.6	
13	2.30	-62.94	0.019	5.17E-03	89.6	459.4	
14	1.60	-92.09	0.016	4.53E-03	35.4	508.0	
15	0.80	-81.62	0.012	3.76E-03	-34.1	507.3	
16	0.00	-52.75	0.010	3.03E-03	-87.9	455.8	
		-40.87	0.010	3.03E-03	-87.9	455.8	
17	-0.80	-15.27	0.008	2.39E-03	-110.3	378.2	
18	-1.60	3.41	0.006	1.89E-03	-115.1	283.0	
19	-2.40	16.06	0.004	1.53E-03	-107.3	192.8	
20	-3.20	24.28	0.003	1.30E-03	-91.2	109.6	
21	-4.00	35.79	0.002	1.18E-03	-67.1	41.9	
22	-4.50	64.27	0.002	1.16E-03	-42.1	13.0	
23	-5.00	104.22	0.001	1.15E-03	0.0	0.0	

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.5 Change properties of soil type 3 to soil type 4
Ko pressures will not be reset

Node no.	Y coord	----- ACTIVE side -----						Soil stiffness coeff. kN/m3
		----- Effective stresses -----				Total earth pressure kN/m2		
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2		Earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1056
2	9.40	0.00	13.38	4.59	47.91	4.59	4.59a	1056
3	8.80	0.00	27.19	9.33	97.37	9.33	9.33a	1056
4	8.00	0.00	43.02	14.77	154.04	14.77	14.77a	1056
5	7.20	0.00	57.69	19.80	206.57	19.80	19.80a	1056
6	6.40	0.00	71.90	24.68	257.45	24.68	24.68a	1056
7	5.70	0.00	84.14	28.88	301.29	28.88	28.88a	1056
8	5.00	0.00	96.28	33.05	344.74	33.05	33.05a	1056
		0.00	96.28	27.18	459.95	27.18	27.18a	5282
9	4.50	4.90	101.00	28.51	482.50	28.51	33.42a	5282
10	4.00	9.81	105.70	29.84	504.92	29.84	39.65a	5282
11	3.50	14.71	110.37	31.16	527.23	31.16	45.87a	5282
12	3.00	19.61	115.02	32.47	549.45	32.47	52.08a	5282
13	2.30	26.48	121.50	34.30	580.43	34.30	60.78a	5282
14	1.60	33.34	127.96	36.12	611.29	36.12	69.47a	5282
15	0.80	41.19	135.31	38.20	646.42	38.20	79.39a	5282
16	0.00	49.03	142.65	40.27	681.44	40.27	89.30a	5282
		49.03	142.65	56.77	346.03	73.17	122.20	7635
17	-0.80	56.88	150.76	60.79	363.83	117.18	174.05	8063
18	-1.60	64.72	158.85	64.79	381.60	154.44	219.17	8490
19	-2.40	72.57	166.93	68.79	399.34	185.88	258.45	8918
20	-3.20	80.41	174.99	72.79	417.04	213.06	293.48	9345
21	-4.00	88.26	183.05	76.78	434.72	243.75	332.00	9773
22	-4.50	93.16	188.07	79.27	445.76	270.57	363.73	10040
23	-5.00	98.07	193.10	81.75	456.80	297.75	395.82	10307

Node no.	Y coord	----- PASSIVE side -----						Soil stiffness coeff. kN/m3
		----- Effective stresses -----				Total earth pressure kN/m2		
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2		Earth pressure kN/m2	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	8.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	6.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	4.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	4.00	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	6683
11	3.50	0.00	9.00	2.54	43.00	43.00	43.00p	6683
12	3.00	0.00	18.01	5.08	86.02	86.02	86.02p	6683
13	2.30	6.86	24.46	6.91	116.86	116.86	123.72p	6683
14	1.60	13.73	30.95	8.74	147.83	147.83	161.56p	6683
15	0.80	21.57	38.40	10.84	183.44	139.43	161.01	6683
16	0.00	29.42	45.91	12.96	219.34	112.64	142.06	6683
		29.42	45.91	8.87	133.65	133.65	163.07p	9748
17	-0.80	37.26	54.30	13.02	152.06	152.06	189.33p	10294
18	-1.60	45.11	62.77	17.21	170.65	170.65	215.76p	10840
19	-2.40	52.96	71.32	21.45	189.43	189.43	242.38p	11386
20	-3.20	60.80	79.96	25.73	208.40	208.40	269.20p	11932

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

(continued)

Stage No.5 Change properties of soil type 3 to soil type 4
 Ko pressures will not be reset

Node no.	Y coord	----- PASSIVE side -----					Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2		
21	-4.00	68.65	88.69	30.05	227.57	227.57	296.22p	12478
22	-4.50	73.55	94.20	32.78	239.66	225.91	299.46	12819
23	-5.00	78.45	99.74	35.52	251.82	213.15	291.60	13160

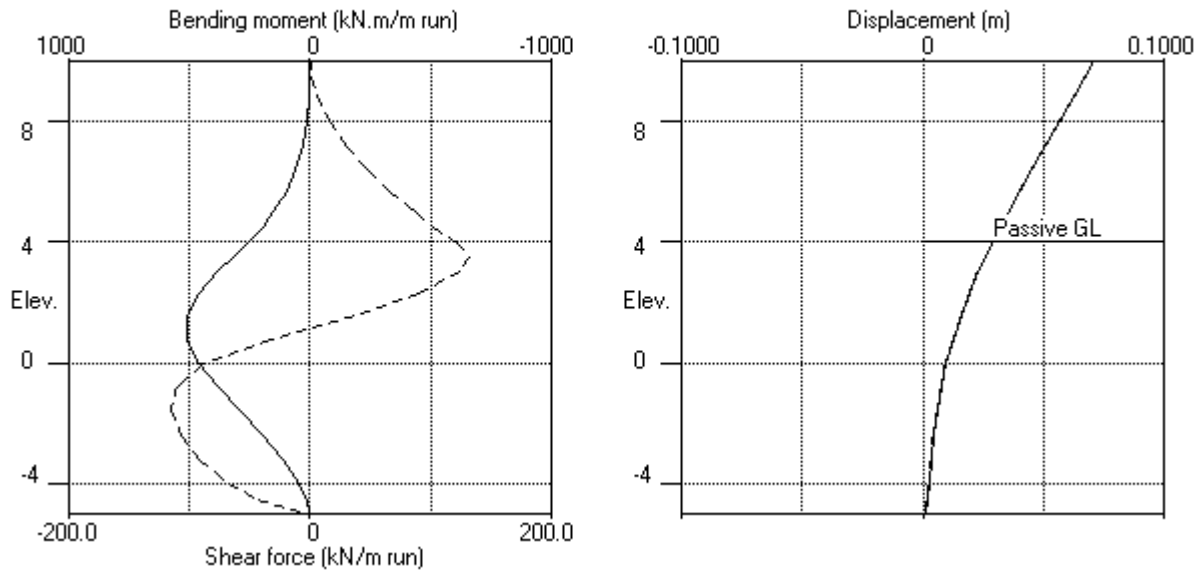
Note: 89.30a Soil pressure at active limit
 296.22p Soil pressure at passive limit

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

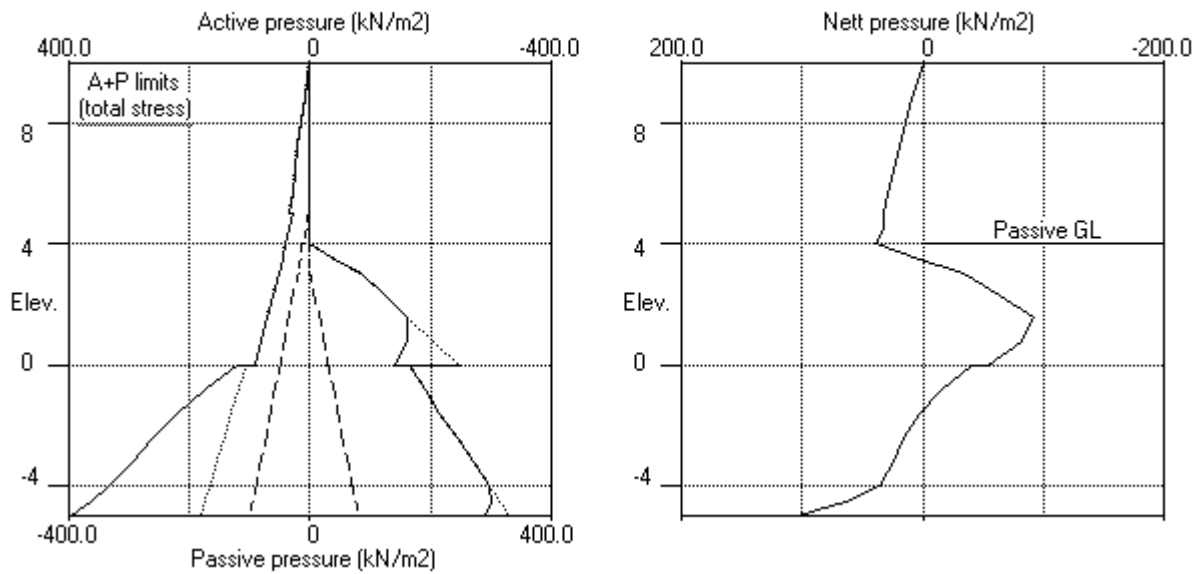
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Stage No.5 Change soil type 3 to soil type 4



Stage No.5 Change soil type 3 to soil type 4



APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
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 Secant Piled Wall | Date:18-03-2015
 900mm dia. @ 1200mm c/c | Checked :

Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: ULS DA1 Combination 2
 Water pressures : Worst Credible
 Partial factor on C' = 1.250
 Partial factor on Phi' = 1.250
 Partial factor on Cu = 1.400
 Partial factor on Soil Modulus = 1.000
 Partial factor on Permanent Unfavourable loads = 1.000
 Partial factor on Permanent Favourable loads = 1.000
 Partial factor on Permanent Variable loads = 1.300

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

			Overall				
			FoS for toe		Toe elev. for		
			elev. = -5.00		FoS = 1.000		
			-----		-----		
Stage	--- G.L. ---		Strut	Factor	Moment	Toe	Wall
No.	Act.	Pass.	Elev.	of	equilib.	elev.	Penetr
			Safety at elev.			-ation	
1	10.00	10.00	Cant.	Conditions not suitable for FoS calc.			
2	10.00	4.50	Cant.	1.483	-3.76	-0.39	4.89
3	10.00	4.00	Cant.	1.308	-3.72	-2.04	6.04
4	10.00	4.00	Cant.	1.238	-3.68	-2.54	6.54
5	10.00	4.00	Cant.	1.135	-4.15	-2.55	6.55

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

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: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment		Shear force	
		maximum	minimum	maximum	minimum	maximum	minimum
		m	m	kN.m/m	kN.m/m	kN/m	kN/m
1	10.00	0.071	0.000	0.0	0.0	0.0	0.0
2	9.40	0.066	0.000	0.5	0.0	1.4	-0.6
3	8.80	0.062	0.000	2.4	-0.5	5.6	-1.1
4	8.00	0.056	0.000	10.4	-1.3	15.2	-0.7
5	7.20	0.051	0.000	27.8	-1.5	29.0	0.0
6	6.40	0.045	0.000	57.8	-0.6	46.8	0.0
7	5.70	0.040	0.000	97.0	0.0	65.6	0.0
8	5.00	0.036	0.000	150.3	0.0	87.2	0.0
9	4.50	0.032	0.000	197.5	0.0	102.4	0.0
10	4.00	0.029	0.000	253.1	0.0	120.7	0.0
11	3.50	0.026	0.000	316.8	0.0	131.3	0.0
12	3.00	0.023	0.000	385.6	0.0	123.5	-0.2
13	2.30	0.019	0.000	459.4	0.0	89.6	-1.1
14	1.60	0.016	0.000	508.5	0.0	37.3	-26.7
15	0.80	0.012	0.000	510.5	0.0	0.0	-52.1
16	0.00	0.010	0.000	480.7	0.0	0.0	-87.9
17	-0.80	0.008	0.000	425.5	0.0	0.0	-110.3
18	-1.60	0.006	0.000	336.9	0.0	0.0	-117.3
19	-2.40	0.004	0.000	237.9	0.0	0.0	-126.6
20	-3.20	0.003	0.000	136.2	0.0	0.0	-117.1
21	-4.00	0.002	0.000	50.5	0.0	0.0	-85.3
22	-4.50	0.002	0.000	14.6	0.0	0.0	-50.4
23	-5.00	0.001	0.000	0.0	0.0	0.0	-0.0

Maximum and minimum bending moment and shear force at each stage

Stage no.	Bending moment				Shear force			
	maximum	elev.	minimum	elev.	maximum	elev.	minimum	elev.
	kN.m/m		kN.m/m		kN/m		kN/m	
1	9.2	3.00	-1.5	7.20	5.8	5.00	-1.5	0.80
2	362.2	2.30	0.0	10.00	106.2	4.00	-79.1	-1.60
3	463.9	1.60	0.0	10.00	123.1	3.50	-106.9	-1.60
4	510.5	0.80	0.0	10.00	131.3	3.50	-126.6	-2.40
5	508.0	1.60	0.0	10.00	131.3	3.50	-115.1	-1.60

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Run ID. Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

Summary of results (continued)

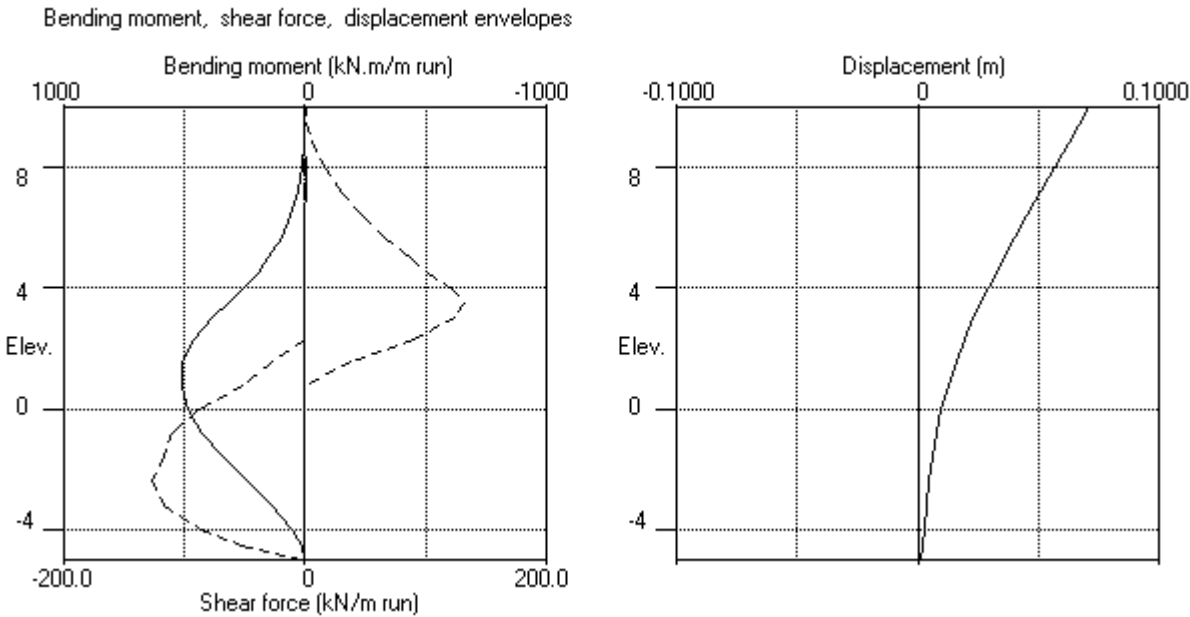
Maximum and minimum displacement at each stage

Stage	-----	Displacement	-----	Stage description	
no.	maximum	elev.	minimum	elev.	-----
	m		m		
1	0.001	10.00	0.000	10.00	Apply surcharge no.1 at elev. 10.00
2	0.037	10.00	0.000	10.00	Excav. to elev. 4.50 on PASSIVE side
3	0.052	10.00	0.000	10.00	Excav. to elev. 4.00 on PASSIVE side
4	0.062	10.00	0.000	10.00	Apply water pressure profile no.2
5	0.071	10.00	0.000	10.00	Change soil type 3 to soil type 4

APPENDIX C-4. WALLAP run ID: Secant Piled Wall Toe-5mOD Fmn+4 5mOD LT ULS2 (Rev.2)

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1502
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Data filename/Run ID: Secant Piled Wall_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date:18-03-2015
900mm dia. @ 1200mm c/c | Checked :

Units: kN,m



APPENDIX D

APPENDIX D Plaxis 2D FE Analysis of Secant Piled Wall

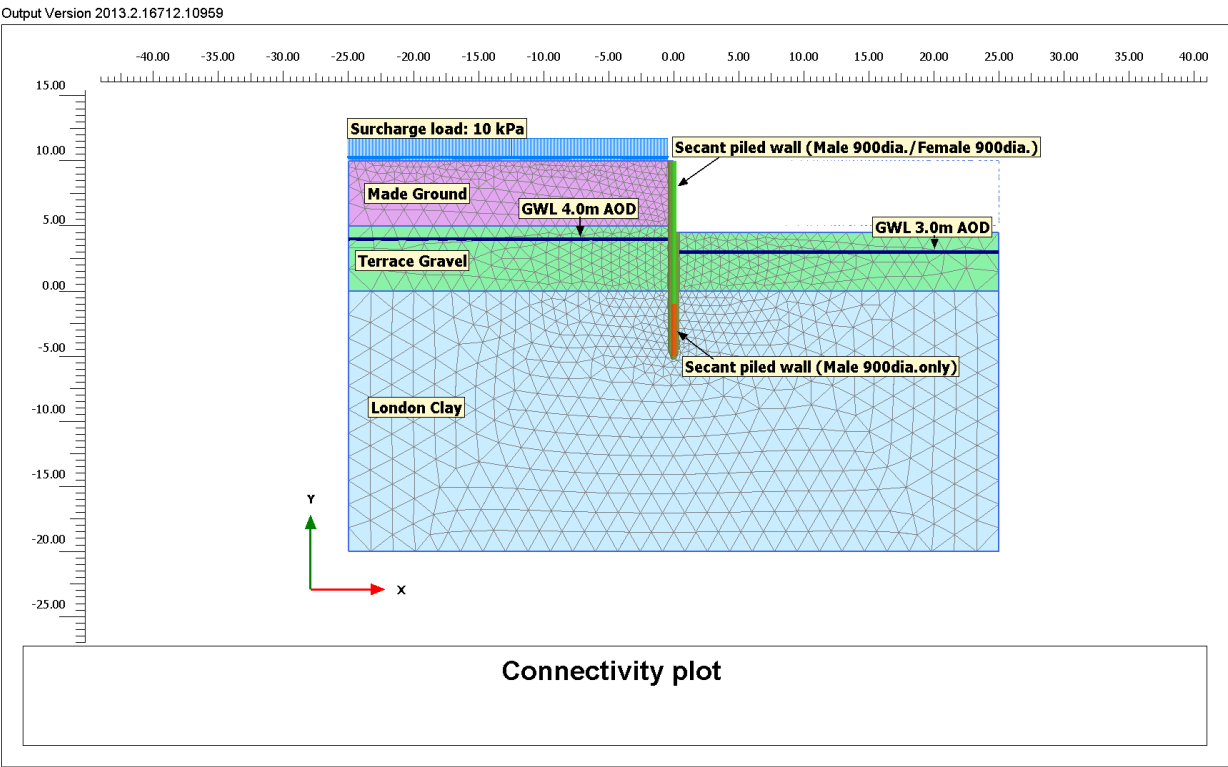


Figure D.1 Connectivity plot

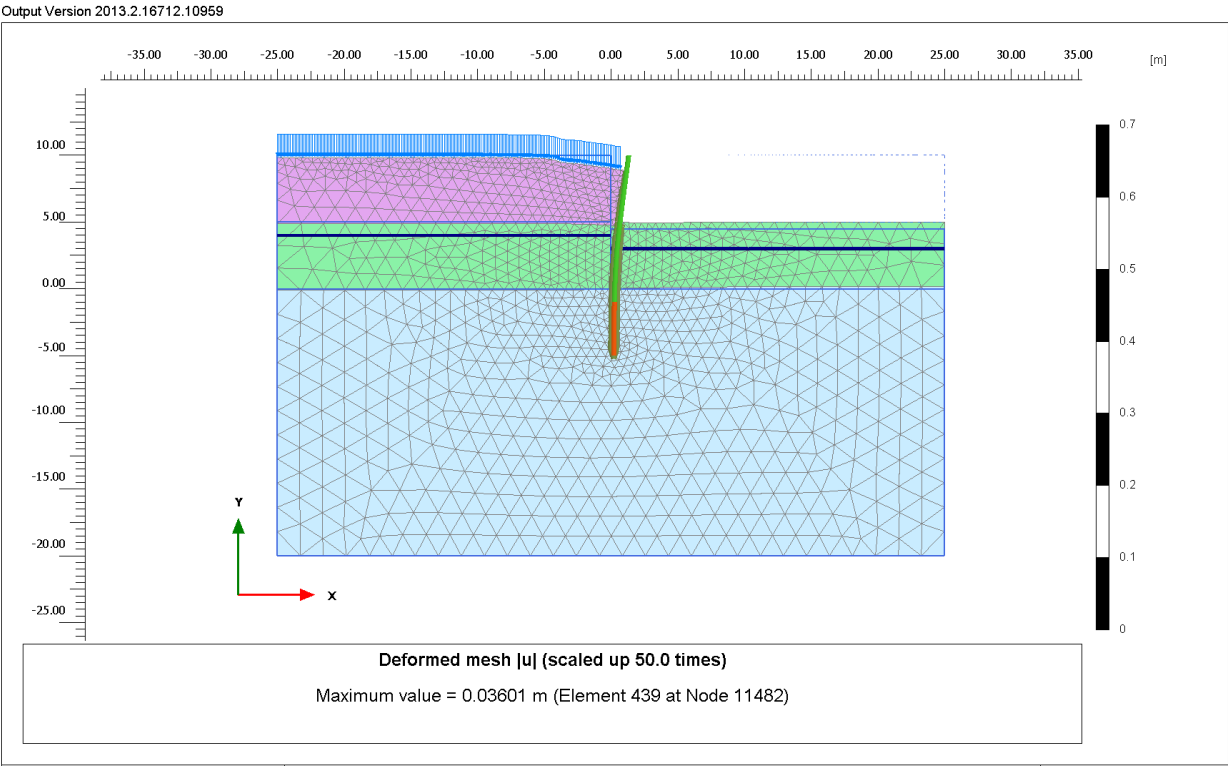


Figure D.2 Deformed mesh | u |

APPENDIX D Plaxis 2D FE Analysis of Secant Piled Wall

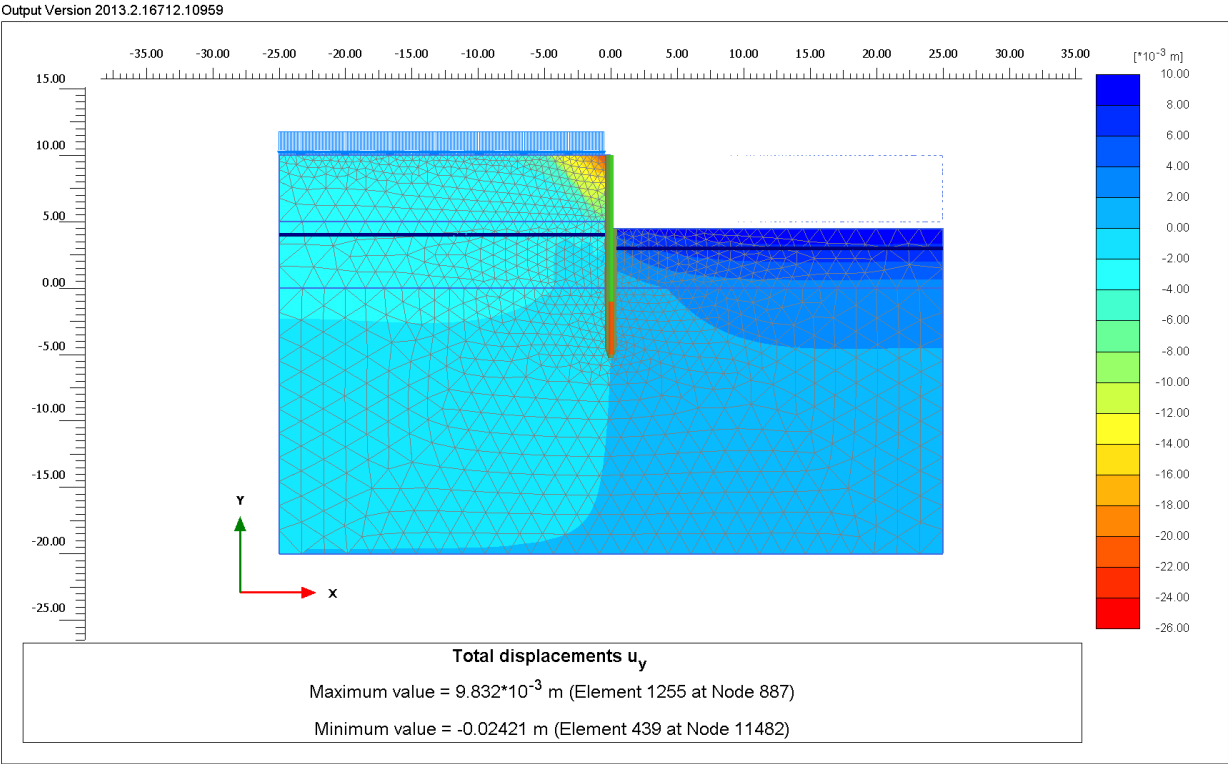


Figure D.3 Total vertical displacements

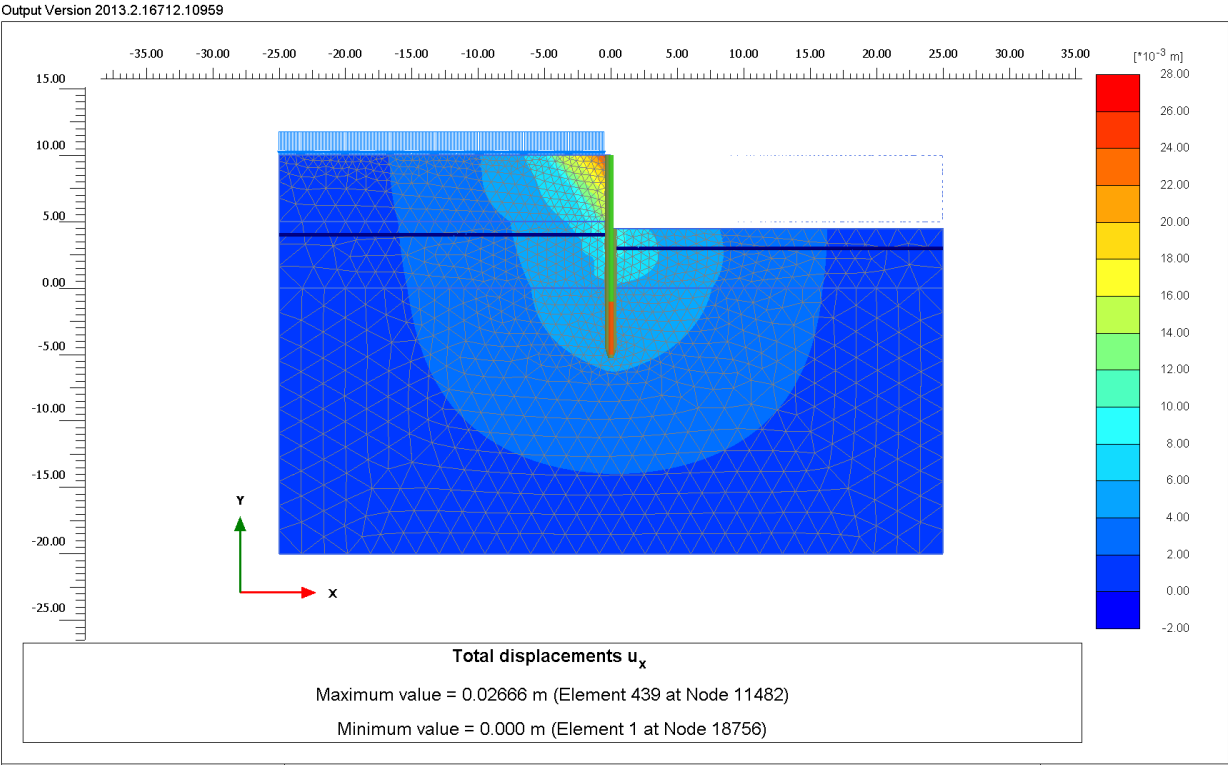


Figure D.4 Total horizontal displacements

APPENDIX D Plaxis 2D FE Analysis of Secant Piled Wall

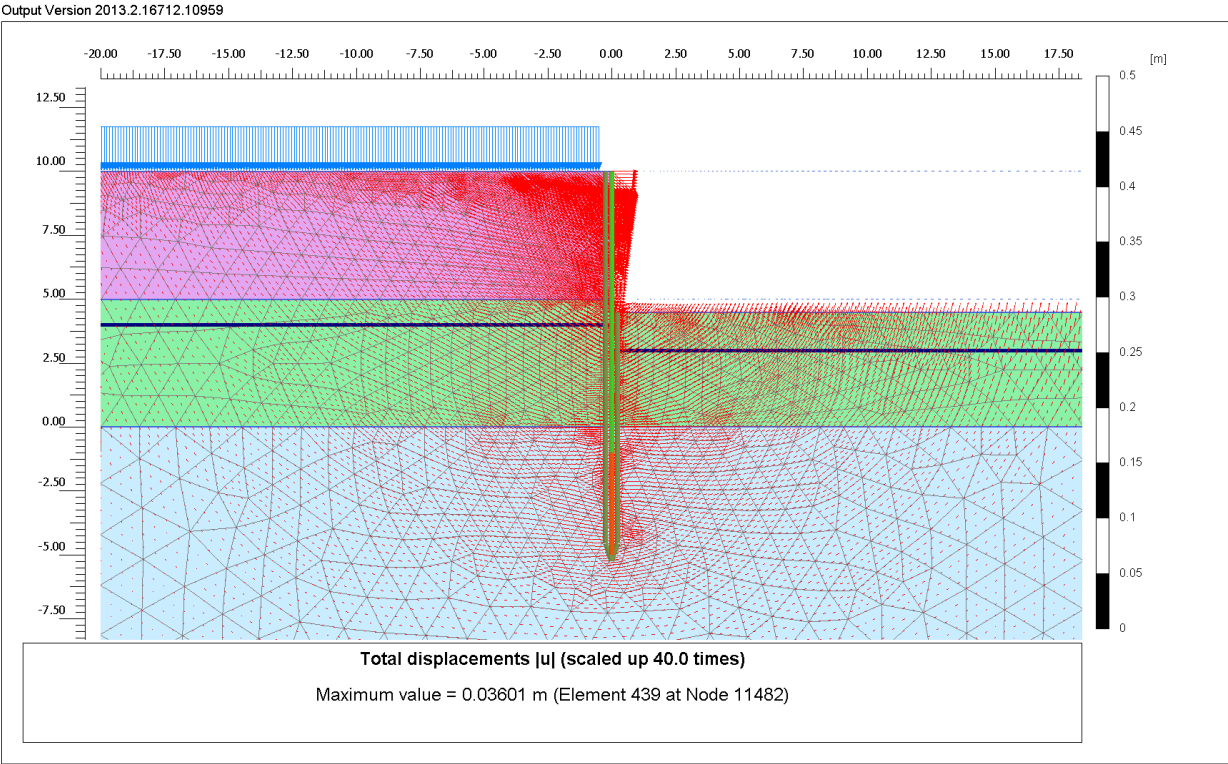


Figure D.5 Vector of total displacements

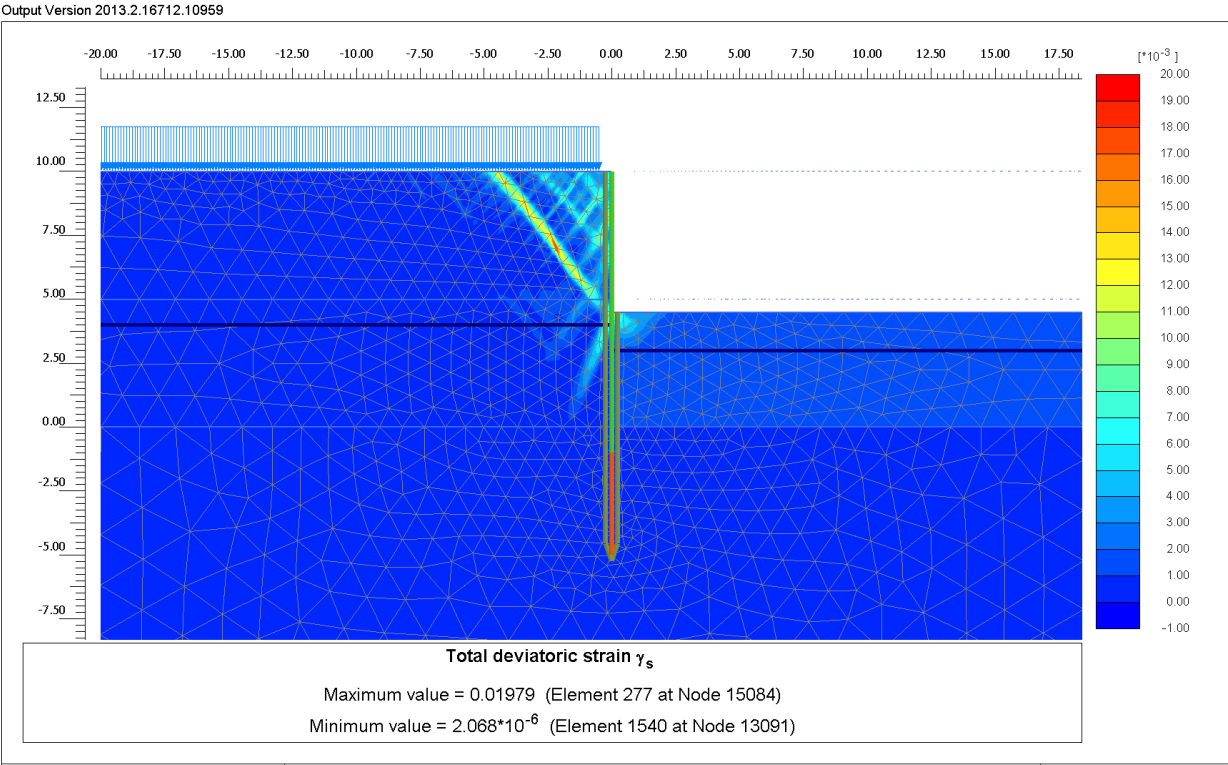


Figure D.6 Total shear strain, γ_s

APPENDIX D Plaxis 2D FE Analysis of Secant Piled Wall

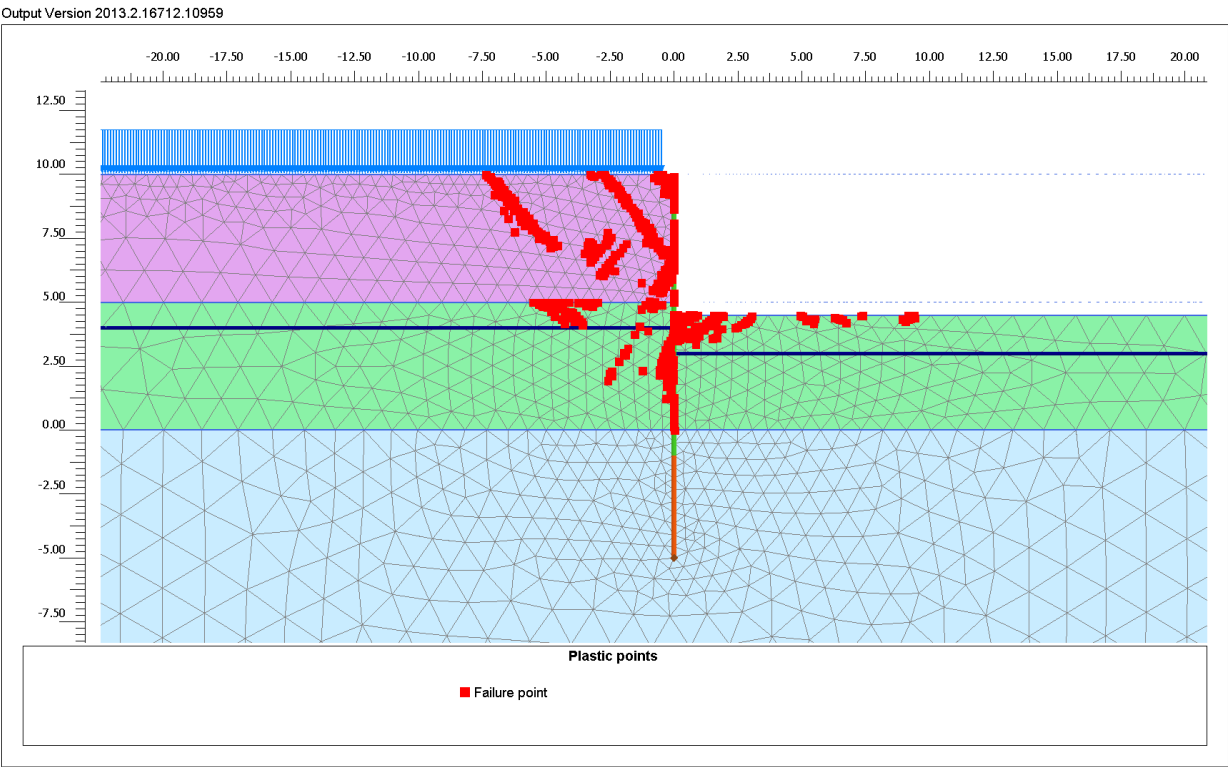


Figure D.7 Distribution of plastic points

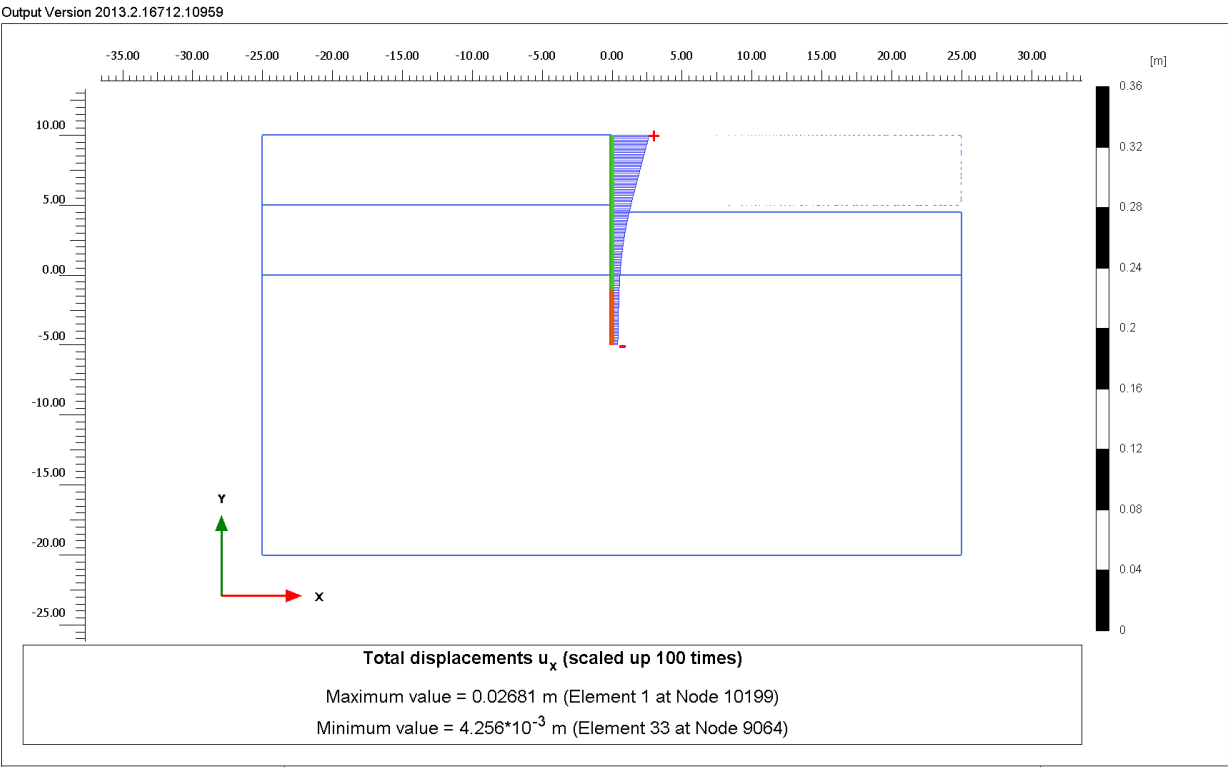


Figure D.8 Profile of horizontal wall displacements for Secant Piles

APPENDIX D Plaxis 2D FE Analysis of Secant Piled Wall

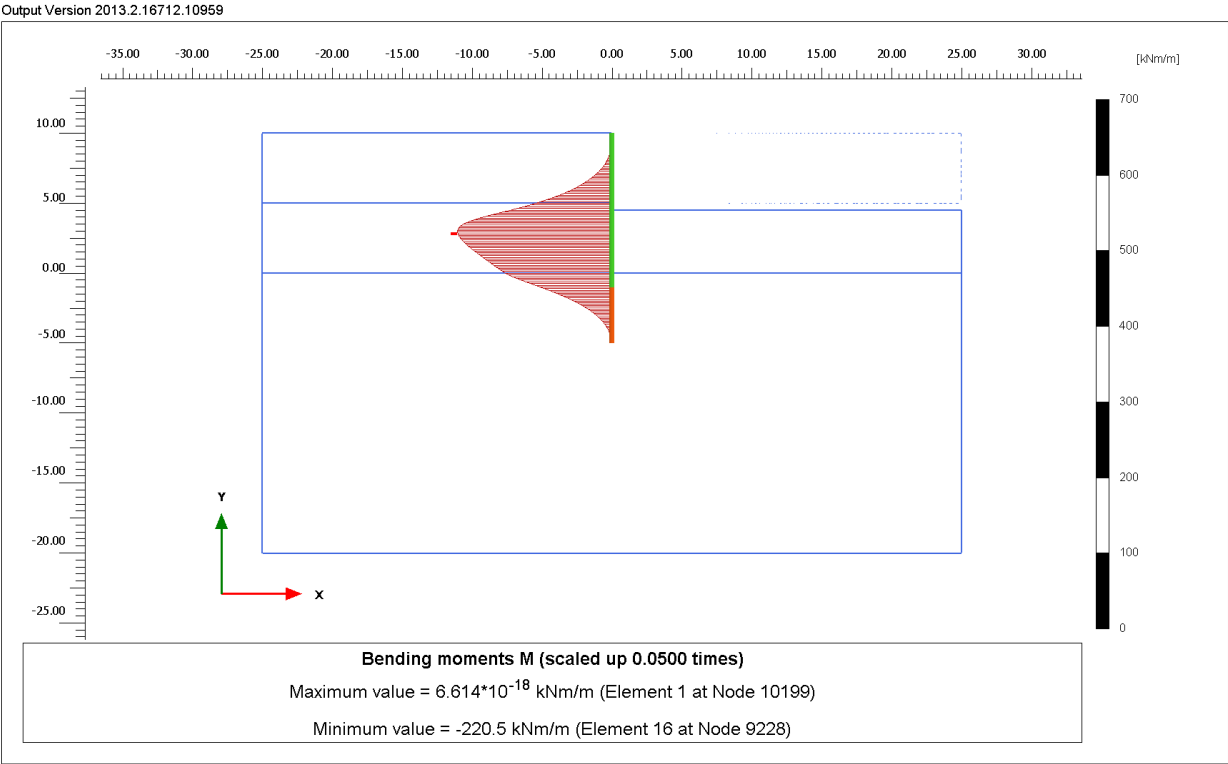


Figure D.9 Profile of wall bending moment for Secant Piles

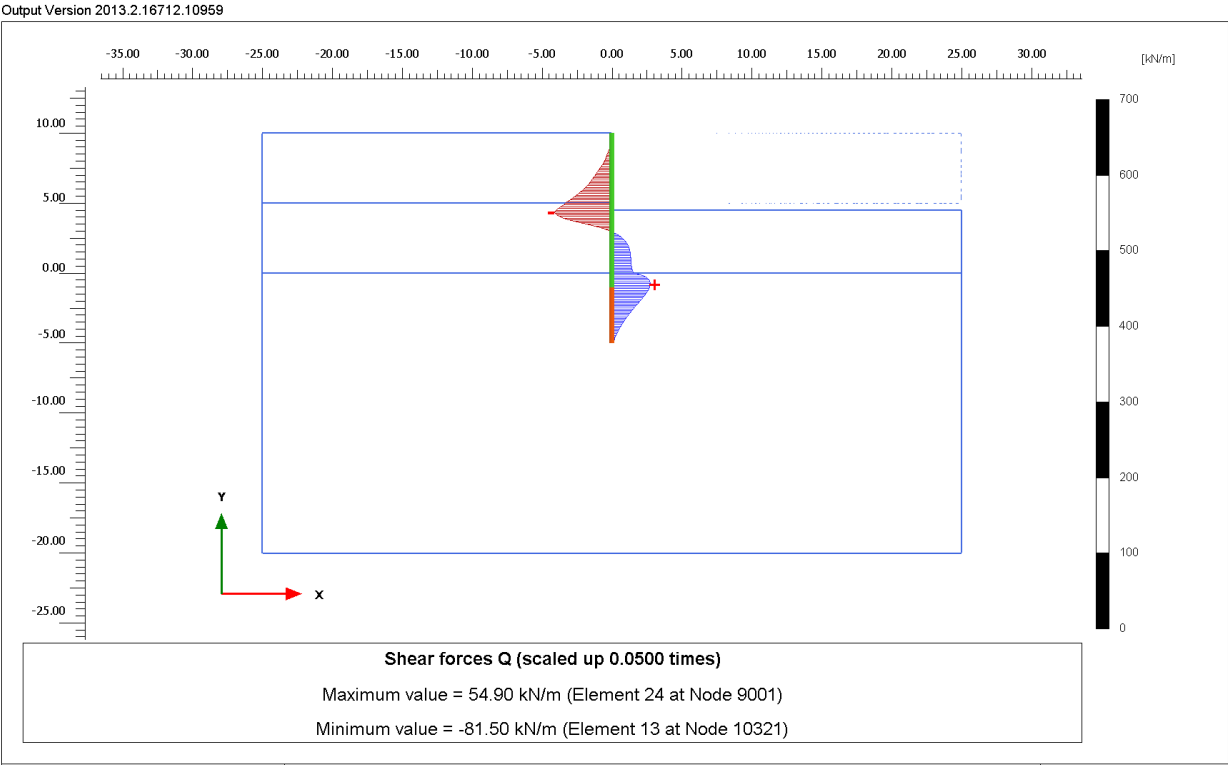


Figure D.10 Profile of wall shear force for Secant Piles

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