

COMBI-GYRO WALL SYSTEM

- High Modulus Steel Combined Wall -

Design Case Study (Tube / Hat Wall)

APPENDICES

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APPENDIX A

APPENDIX A-1. Design Summary of Combi-Giro Wall System (Tube/Hat Pattern A)

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	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	$\gamma_{G,tav}$	1			1		
	Variable	Unfavourable	γ_Q	1.5			1.3		
		Favourable	$\gamma_{Q,tav}$	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_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	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)
Tube (900mm dia./ 16mm thick)	S390 GP	210	15.0	10.0	-5.0	Cantilever	1.8	5386	$2.412 \cdot 10^{-3}$	506554
Hat 25H	S390 GP	210	11.0	10.0	-1.0	Cantilever	-	1610	$0.244 \cdot 10^{-3}$	51240
Tube / Hat system								6987	$2.656 \cdot 10^{-3}$	557794

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: 264 kNm/m @ 2.30m AOD - Design $BM_d = BM_c \cdot \gamma_G = 264 \cdot 1.35 = 356$ kNm/m - Minimum required section modulus = $BM_d \cdot 10^3 / f_y = 356 \cdot 10^3 / 390 = 914$ cm³/m - Degree of utilisation = $914 / 5360 = 17.0\%$ [$< 100\%$, OK] Maximum shear force - Calculated SF_c: 83 kN/m @ 4.50m AOD - Design $SF_d = BM_c \cdot \gamma_G = 83 \cdot 1.35 = 112$ 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: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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

Soil type	Bulk density	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	0.283	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

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	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	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 = 2.1000E+08 kN/m2
 Moment of inertia of wall I = 2.4122E-03 m4/m run
 E.I = 506554 kN.m2/m run
 Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch	Distance	Length	Width	Surcharge		Equiv. Partial	
-arge	from	parallel	perpend.	-----	kN/m2	-----	soil factor/
no.	Elev.	wall	to wall	to wall	Near edge	Far edge	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 557794 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

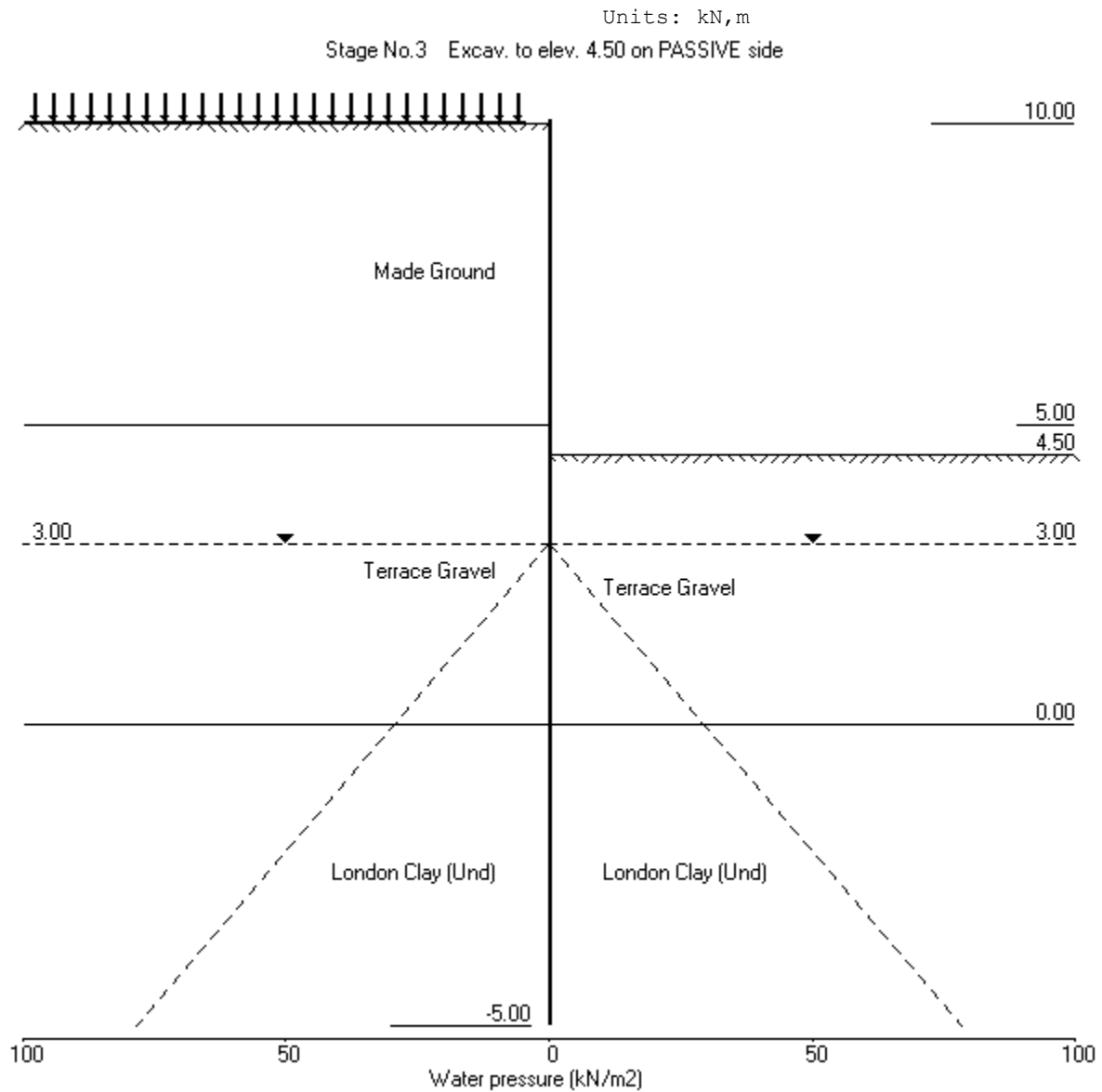
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options		
		Displacement	Active, Graph.	
		Bending mom.	Passive output	
		Shear force	pressures	
1	Change EI of wall to 557794kN.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

APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :



APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
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 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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 elev. = -5.00	Toe elev. for 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 4.50	Cant.	1.874	-3.66	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	2.86E-03	0.0	0.0		557794
2	9.40	3.59	0.023	2.86E-03	1.1	0.4		557794
3	8.80	7.26	0.021	2.86E-03	4.3	1.9		557794
4	8.00	11.61	0.019	2.86E-03	11.9	8.1		557794
5	7.20	15.70	0.016	2.83E-03	22.8	21.7		557794
6	6.40	19.68	0.014	2.79E-03	37.0	45.4		557794
7	5.70	23.13	0.012	2.71E-03	51.9	76.4		557794
8	5.00	29.69	0.010	2.59E-03	70.4	120.2		557794
		21.26	0.010	2.59E-03	70.4	120.2		
9	4.50	23.32	0.009	2.46E-03	81.6	158.1		557794
10	4.00	-34.65	0.008	2.30E-03	78.7	199.4		557794
11	3.50	-62.86	0.007	2.11E-03	54.4	236.5		557794
12	3.00	-52.52	0.006	1.88E-03	25.5	255.8		557794
13	2.30	-39.14	0.005	1.56E-03	-6.6	260.6		557794
14	1.60	-28.50	0.004	1.24E-03	-30.2	248.5		557794
15	0.80	-11.29	0.003	9.13E-04	-46.2	215.2		557794
16	0.00	0.94	0.002	6.34E-04	-50.3	174.7		557794
		-15.15	0.002	6.34E-04	-50.3	174.7		
17	-0.50	-4.01	0.002	4.89E-04	-55.1	147.6		557794
18	-1.00	4.37	0.002	3.69E-04	-55.0	119.6		506554
19	-1.70	11.89	0.001	2.30E-04	-49.3	82.1		506554
20	-2.40	15.42	0.001	1.39E-04	-39.7	50.5		506554
21	-3.20	16.26	0.001	8.05E-05	-27.1	23.5		506554
22	-4.00	15.34	0.001	5.64E-05	-14.4	7.0		506554
23	-4.50	14.44	0.001	5.21E-05	-7.0	1.7		506554
24	-5.00	13.51	0.001	5.12E-05	0.0	-0.0		---

APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	1596
2	9.40	0.00	12.65	3.59	59.38	3.59	3.59a	1596
3	8.80	0.00	25.63	7.26	120.33	7.26	7.26a	1596
4	8.00	0.00	40.94	11.61	192.24	11.61	11.61a	1596
5	7.20	0.00	55.36	15.70	259.97	15.70	15.70a	1596
6	6.40	0.00	69.43	19.68	326.03	19.68	19.68a	1596
7	5.70	0.00	81.60	23.13	383.15	23.13	23.13a	1596
8	5.00	0.00	93.68	26.56	439.89	29.69	29.69	1596
		0.00	93.68	21.26	624.83	21.26	21.26a	7980
9	4.50	0.00	102.77	23.32	685.50	23.32	23.32a	7980
10	4.00	0.00	111.85	25.38	746.02	25.38	25.38a	7980
11	3.50	0.00	120.90	27.44	806.43	27.44	27.44a	7980
12	3.00	0.00	129.95	29.49	866.73	29.49	29.49a	7980
13	2.30	6.86	136.42	30.96	909.91	30.96	37.82a	7980
14	1.60	13.73	142.87	32.42	952.96	32.45	46.18	7980
15	0.80	21.57	150.23	34.09	1002.01	42.45	64.02	7980
16	0.00	29.42	157.56	35.76	1050.95	50.48	79.90	7980
		Total>	186.98	50.00m	387.00	214.68	214.68	21352
17	-0.50	Total>	196.96	52.50m	403.98	231.74	231.74	22100
18	-1.00	Total>	206.94	55.00m	420.96	247.70	247.70	22847
19	-1.70	Total>	220.90	58.50m	444.72	268.38	268.38	23893
20	-2.40	Total>	234.84	62.00m	468.47	287.48	287.48	24939
21	-3.20	Total>	250.77	66.00m	495.60	308.06	308.06	26135
22	-4.00	Total>	266.70	70.00m	522.72	327.97	327.97	27331
23	-4.50	Total>	276.64	72.50m	539.67	340.29	340.29	28078
24	-5.00	Total>	286.59	75.00m	556.62	352.62	352.62	28826

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	12327
10	4.00	0.00	9.00	2.04	60.03	60.03	60.03p	12327
11	3.50	0.00	18.00	4.09	120.09	90.29	90.29	12327
12	3.00	0.00	27.02	6.13	180.20	82.01	82.01	12327
13	2.30	6.86	33.49	7.60	223.36	70.10	76.96	12327
14	1.60	13.73	39.99	9.07	266.73	60.96	74.69	12327
15	0.80	21.57	47.47	10.77	316.61	53.74	75.31	12327
16	0.00	29.42	55.01	12.48	366.91	49.54	78.96	12327
		Total>	84.43	22.50m	284.45	229.83	229.83	32206
17	-0.50	Total>	94.58	25.00m	301.60	235.75	235.75	33333
18	-1.00	Total>	104.76	27.50m	318.78	243.33	243.33	34460
19	-1.70	Total>	119.06	31.00m	342.89	256.49	256.49	36038
20	-2.40	Total>	133.43	34.50m	367.05	272.07	272.07	37616

APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :

(continued)

Stage No.3 Excavate to elevation 4.50 on PASSIVE side

Node Y		----- PASSIVE side -----					
no.	coord	----- Effective stresses -----				Total	Soil
		Water	Vertic	Active	Passive	Earth	
		press.	-al	limit	limit	pressure	earth stiffness
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	coeff.
							kN/m3
21	-3.20	Total>	149.93	38.50m	394.75	291.80	39420
22	-4.00	Total>	166.51	42.50m	422.53	312.63	41223
23	-4.50	Total>	176.91	45.00m	439.94	325.85	42350
24	-5.00	Total>	187.34	47.50m	457.37	339.10	43478

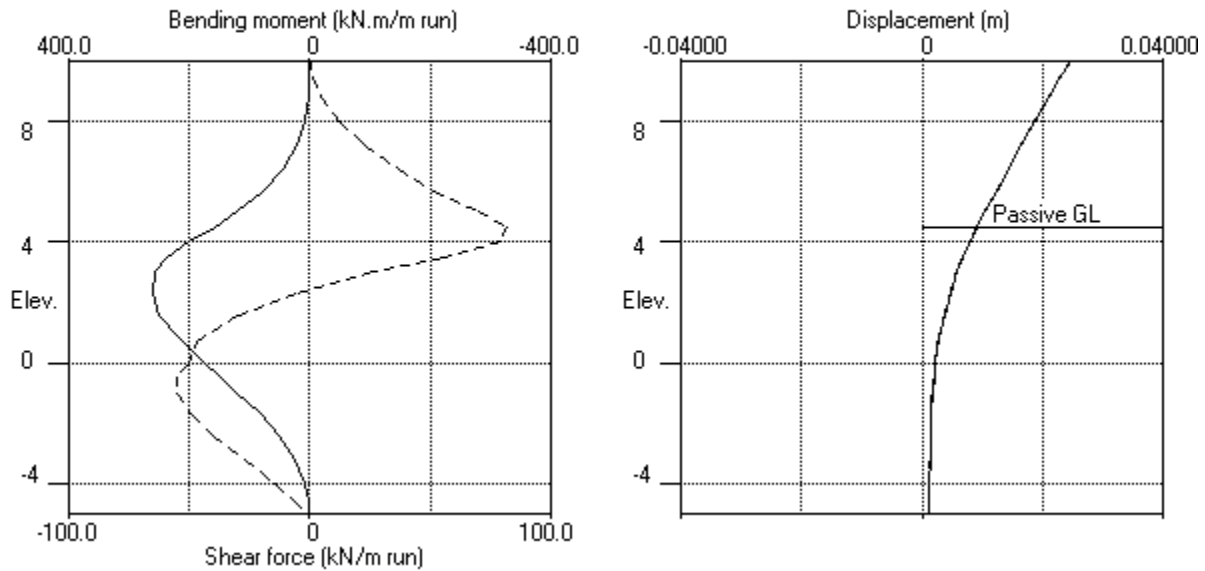
Note: 37.82a Soil pressure at active limit
 60.03p Soil pressure at passive limit

APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

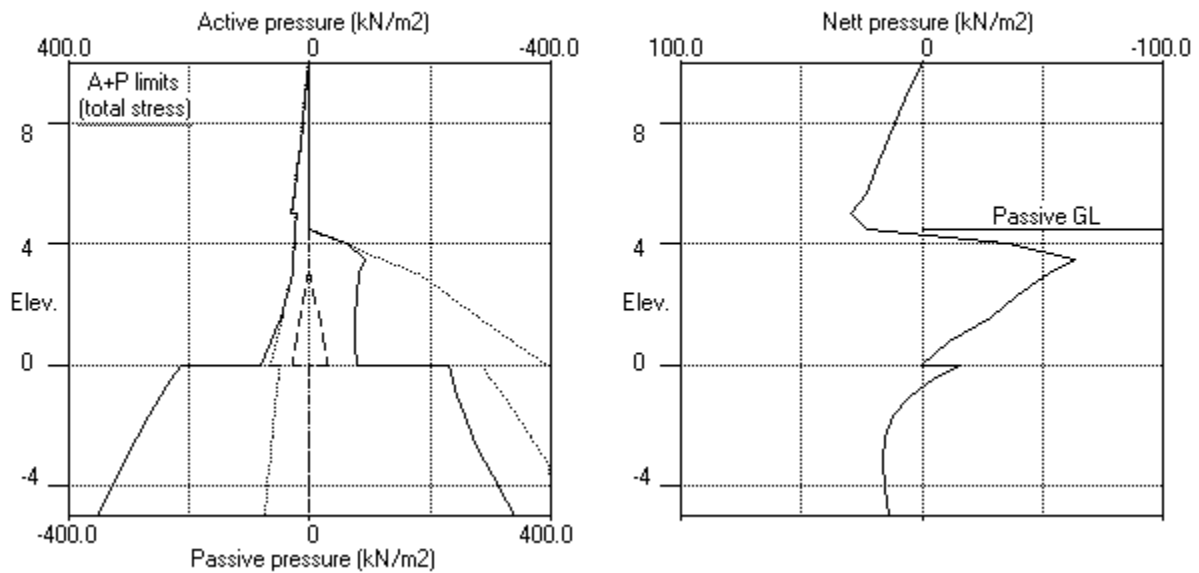
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :

Units: kN,m

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

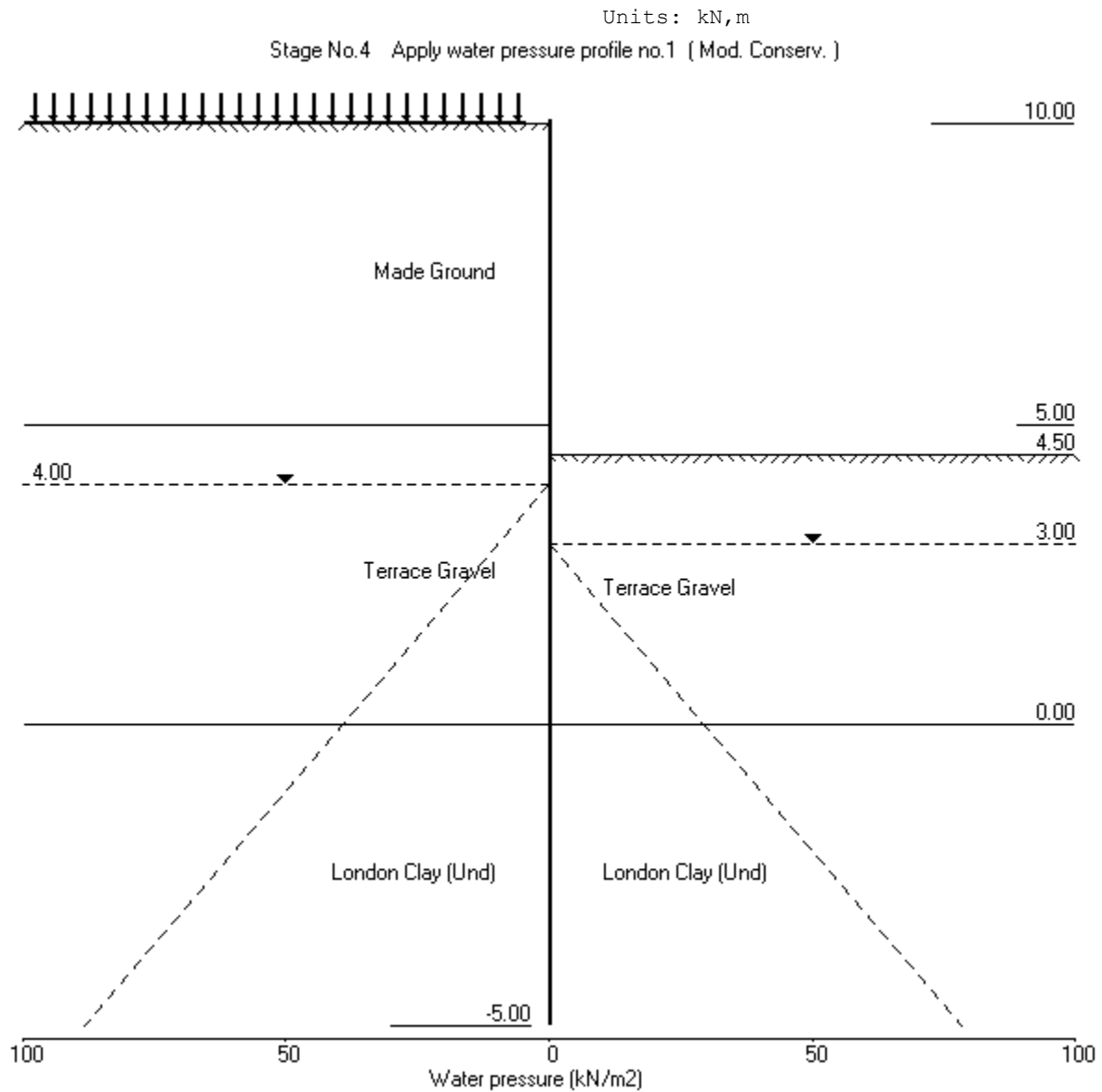


Stage No.3 Excav. to elev. 4.50 on PASSIVE side



APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :



APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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.	Toe Wall
				elev. Penetr
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	0.026	2.98E-03	0.0	0.0		557794
2	9.40	3.59	0.024	2.98E-03	1.1	0.4		557794
3	8.80	7.26	0.022	2.97E-03	4.3	1.9		557794
4	8.00	11.61	0.020	2.97E-03	11.9	8.1		557794
5	7.20	15.70	0.018	2.95E-03	22.8	21.7		557794
6	6.40	19.68	0.015	2.90E-03	37.0	45.4		557794
7	5.70	23.13	0.013	2.82E-03	51.9	76.4		557794
8	5.00	28.66	0.011	2.70E-03	70.1	120.2		557794
		21.26	0.011	2.70E-03	70.1	120.2		
9	4.50	23.32	0.010	2.57E-03	81.2	157.9		557794
10	4.00	-34.65	0.009	2.41E-03	78.4	199.0		557794
11	3.50	-64.84	0.007	2.22E-03	53.5	236.2		557794
12	3.00	-50.06	0.006	2.00E-03	24.8	254.9		557794
13	2.30	-35.92	0.005	1.67E-03	-5.3	259.8		557794
14	1.60	-24.56	0.004	1.36E-03	-26.5	249.4		557794
15	0.80	-10.27	0.003	1.02E-03	-40.4	220.2		557794
16	0.00	3.31	0.002	7.33E-04	-43.2	184.5		557794
		-23.60	0.002	7.33E-04	-43.2	184.5		
17	-0.50	-10.70	0.002	5.79E-04	-51.8	160.0		557794
18	-1.00	-0.67	0.002	4.47E-04	-54.6	132.7		506554
19	-1.70	8.88	0.002	2.90E-04	-51.7	94.3		506554
20	-2.40	14.07	0.001	1.84E-04	-43.7	60.2		506554
21	-3.20	16.40	0.001	1.13E-04	-31.5	29.7		506554
22	-4.00	16.69	0.001	8.20E-05	-18.3	9.7		506554
23	-4.50	17.87	0.001	7.59E-05	-9.6	2.6		506554
24	-5.00	20.71	0.001	7.46E-05	0.0	-0.0		---

APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	28.66	28.66	1311
		0.00	93.68	21.26	624.83	21.26	21.26a	6555
9	4.50	0.00	102.77	23.32	685.50	23.32	23.32a	6555
10	4.00	0.00	111.85	25.38	746.02	25.38	25.38a	6555
11	3.50	4.90	116.50	26.44	777.06	26.44	31.34a	6555
12	3.00	9.81	121.14	27.49	807.99	27.49	37.30a	6555
13	2.30	16.67	127.61	28.96	851.17	28.96	45.63a	6555
14	1.60	23.54	134.07	30.42	894.22	30.42	53.96a	6555
15	0.80	31.38	141.42	32.09	943.27	36.63	68.01	6555
16	0.00	39.23	148.76	33.76	992.21	45.22	84.44	6555
		Total>	187.98	50.00m	388.00	211.97	211.97	17852
17	-0.50	Total>	197.96	52.50m	404.98	229.75	229.75	18477
18	-1.00	Total>	207.94	55.00m	421.96	246.40	246.40	19101
19	-1.70	Total>	221.90	58.50m	445.72	267.92	267.92	19976
20	-2.40	Total>	235.84	62.00m	469.47	287.71	287.71	20851
21	-3.20	Total>	251.77	66.00m	496.60	308.91	308.91	21851
22	-4.00	Total>	267.70	70.00m	523.72	329.31	329.31	45520
23	-4.50	Total>	277.64	72.50m	540.67	342.53	342.53	73166
24	-5.00	Total>	287.59	75.00m	557.62	356.89	356.89	121717

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	9531
10	4.00	0.00	9.00	2.04	60.03	60.03	60.03p	9531
11	3.50	0.00	18.00	4.09	120.09	96.18	96.18	9531
12	3.00	0.00	27.02	6.13	180.20	87.36	87.36	9531
13	2.30	6.86	33.49	7.60	223.36	74.69	81.55	9531
14	1.60	13.73	39.99	9.07	266.73	64.79	78.51	9531
15	0.80	21.57	47.47	10.77	316.61	56.71	78.28	9531
16	0.00	29.42	55.01	12.48	366.91	51.71	81.13	9531
		Total>	84.43	22.50m	284.45	235.57	235.57	25212
17	-0.50	Total>	94.58	25.00m	301.60	240.46	240.46	26094
18	-1.00	Total>	104.76	27.50m	318.78	247.07	247.07	26977
19	-1.70	Total>	119.06	31.00m	342.89	259.04	259.04	28212
20	-2.40	Total>	133.43	34.50m	367.05	273.64	273.64	29448

APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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	
		press.	-al	limit	limit	pressure	earth stiffness
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	coeff.
							kN/m3
21	-3.20	Total>	149.93	38.50m	394.75	292.51	30860
22	-4.00	Total>	166.51	42.50m	422.53	312.63	63768
23	-4.50	Total>	176.91	45.00m	439.94	324.66	97226
24	-5.00	Total>	187.34	47.50m	457.37	336.18	121717

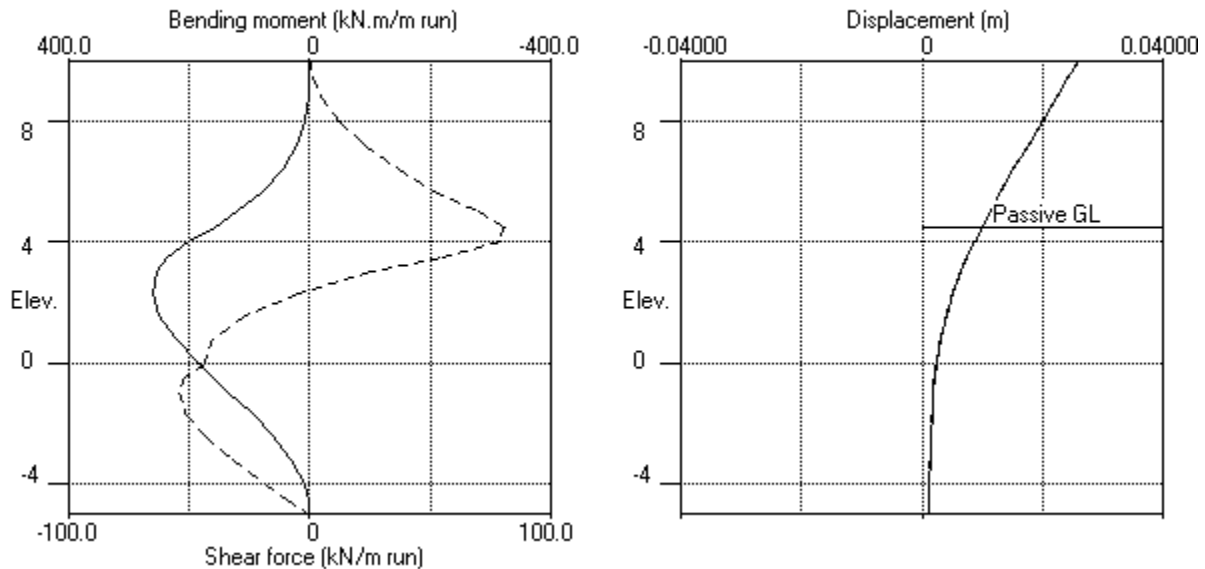
Note: 53.96a Soil pressure at active limit
 60.03p Soil pressure at passive limit

APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

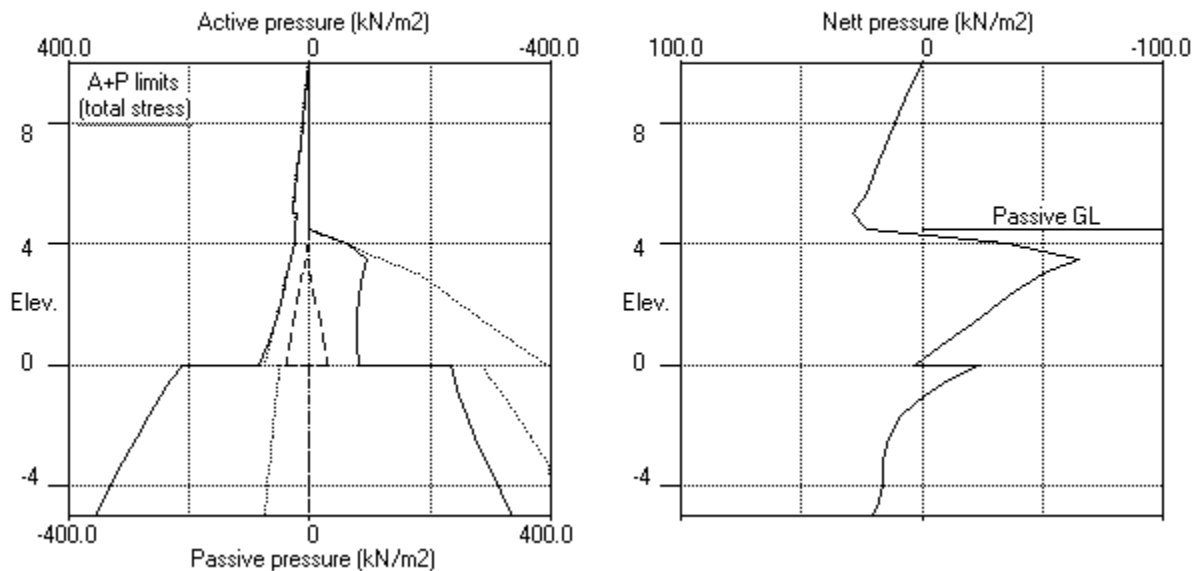
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :

Units: kN,m

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

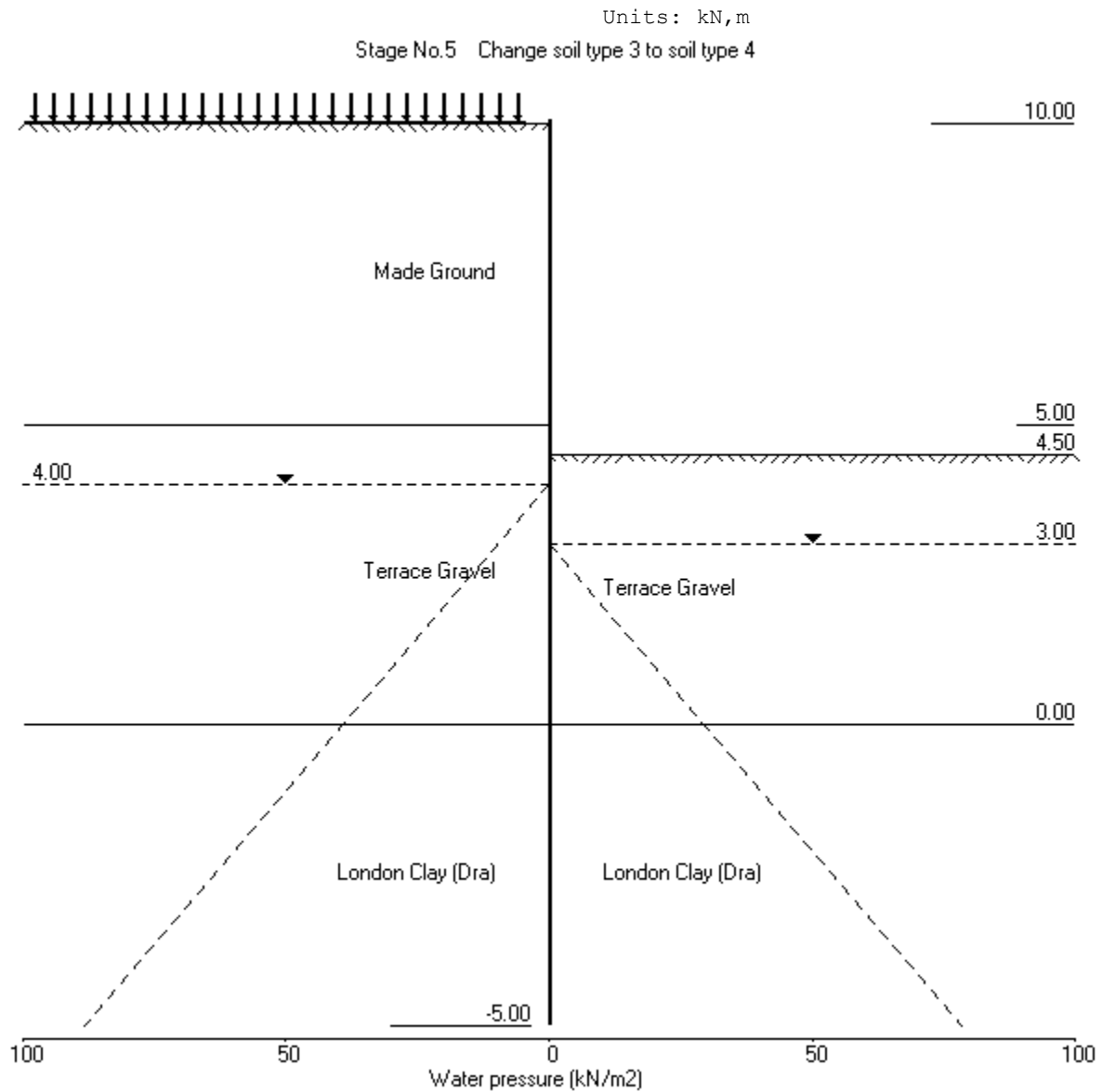


Stage No.4 Apply water pressure profile no.1 (Mod. Conserv.)



APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :



APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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
No.	Act. Pass.	Elev.	of	equilib.
			Safety	at elev.
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	2.97E-03	0.0	0.0		557794
2	9.40	3.59	0.024	2.97E-03	1.1	0.4		557794
3	8.80	7.26	0.022	2.97E-03	4.3	1.9		557794
4	8.00	11.61	0.020	2.96E-03	11.9	8.1		557794
5	7.20	15.70	0.018	2.94E-03	22.8	21.7		557794
6	6.40	19.68	0.015	2.89E-03	37.0	45.4		557794
7	5.70	23.13	0.013	2.81E-03	51.9	76.4		557794
8	5.00	28.43	0.011	2.69E-03	70.0	120.2		557794
		21.26	0.011	2.69E-03	70.0	120.2		
9	4.50	23.32	0.010	2.56E-03	81.1	157.9		557794
10	4.00	-34.65	0.009	2.40E-03	78.3	198.9		557794
11	3.50	-66.40	0.008	2.21E-03	53.0	236.0		557794
12	3.00	-51.64	0.007	1.99E-03	23.5	254.3		557794
13	2.30	-37.54	0.005	1.67E-03	-7.7	258.0		557794
14	1.60	-26.19	0.004	1.35E-03	-30.0	245.5		557794
15	0.80	-13.17	0.003	1.02E-03	-45.7	212.9		557794
16	0.00	0.51	0.003	7.52E-04	-50.8	172.1		557794
		3.04	0.003	7.52E-04	-50.8	172.1		
17	-0.50	2.90	0.002	6.09E-04	-49.3	146.6		557794
18	-1.00	1.58	0.002	4.89E-04	-48.2	121.8		506554
19	-1.70	5.45	0.002	3.44E-04	-45.7	88.1		506554
20	-2.40	11.19	0.002	2.43E-04	-39.9	57.4		506554
21	-3.20	14.30	0.001	1.75E-04	-29.7	28.9		506554
22	-4.00	15.47	0.001	1.45E-04	-17.8	9.7		506554
23	-4.50	17.26	0.001	1.39E-04	-9.6	2.7		506554
24	-5.00	21.28	0.001	1.37E-04	0.0	-0.0		---

APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	28.43	28.43	921
		0.00	93.68	21.26	624.83	21.26	21.26a	4605
9	4.50	0.00	102.77	23.32	685.50	23.32	23.32a	4605
10	4.00	0.00	111.85	25.38	746.02	25.38	25.38a	4605
11	3.50	4.90	116.50	26.44	777.06	26.44	31.34a	4605
12	3.00	9.81	121.14	27.49	807.99	27.49	37.30a	4605
13	2.30	16.67	127.61	28.96	851.17	28.96	45.63a	4605
14	1.60	23.54	134.07	30.42	894.22	30.42	53.96a	4605
15	0.80	31.38	141.42	32.09	943.27	35.36	66.74	4605
16	0.00	39.23	148.76	33.76	992.21	43.99	83.22	4605
		39.23	148.76	50.69	410.99	170.98	210.21	6595
17	-0.50	44.13	153.83	52.94	423.62	183.89	228.02	6826
18	-1.00	49.03	158.91	55.19	436.24	195.71	244.74	7057
19	-1.70	55.90	166.00	58.33	453.89	210.53	266.43	7380
20	-2.40	62.76	173.08	61.47	471.51	223.70	286.46	7703
21	-3.20	70.61	181.17	65.06	491.63	237.39	308.00	8072
22	-4.00	78.45	189.24	68.64	511.72	250.33	328.78	8442
23	-4.50	83.36	194.29	70.88	524.27	258.91	342.27	8673
24	-5.00	88.26	199.33	73.12	536.82	268.91	357.17	367732

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	5916
10	4.00	0.00	9.00	2.04	60.03	60.03	60.03p	5916
11	3.50	0.00	18.00	4.09	120.09	97.74	97.74	5916
12	3.00	0.00	27.02	6.13	180.20	88.94	88.94	5916
13	2.30	6.86	33.49	7.60	223.36	76.30	83.17	5916
14	1.60	13.73	39.99	9.07	266.73	66.42	80.15	5916
15	0.80	21.57	47.47	10.77	316.61	58.34	79.91	5916
16	0.00	29.42	55.01	12.48	366.91	53.28	82.70	5916
		29.42	55.01	9.11	177.74	177.74	207.16p	8594
17	-0.50	34.32	60.26	11.44	190.80	190.80	225.12p	8894
18	-1.00	39.23	65.53	13.78	203.93	203.93	243.16p	9195
19	-1.70	46.09	72.97	17.08	222.44	214.89	260.98	9616

APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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	Vertic	Active	Passive	Earth		
		press. kN/m2	-al kN/m2	limit kN/m2	limit kN/m2	pressure kN/m2		
20	-2.40	52.96	80.48	20.40	241.11	222.32	275.27	10037
21	-3.20	60.80	89.13	24.24	262.63	232.90	293.70	10519
22	-4.00	68.65	97.86	28.11	284.36	244.67	313.31	11000
23	-4.50	73.55	103.36	30.55	298.05	251.46	325.01	11301
24	-5.00	78.45	108.89	33.01	311.81	257.44	335.90	367732

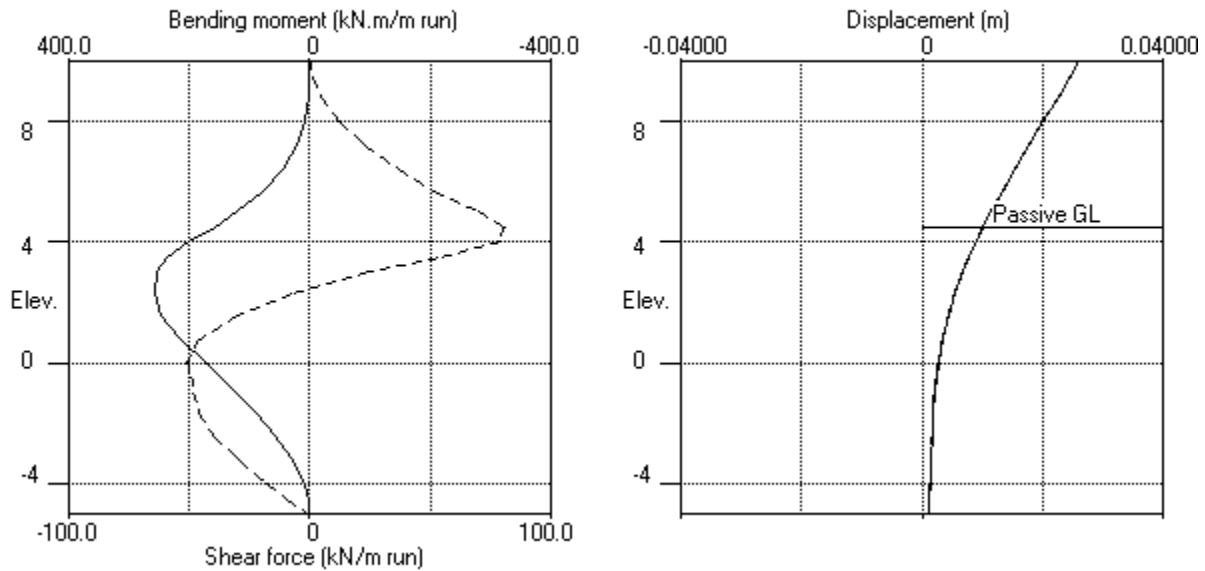
Note: 53.96a Soil pressure at active limit
 243.16p Soil pressure at passive limit

APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

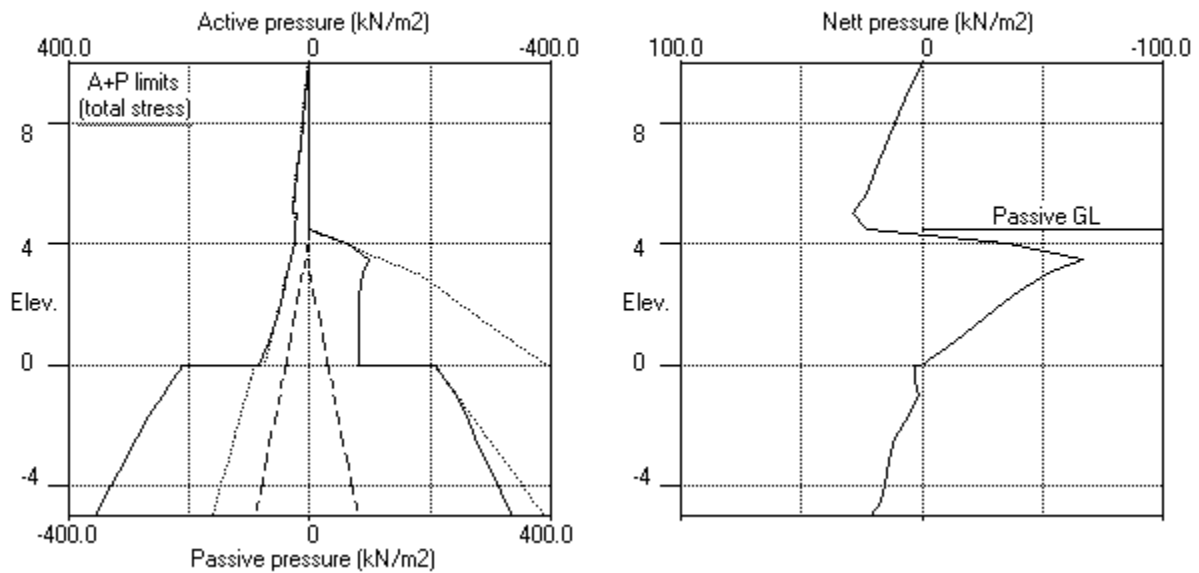
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :

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: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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	-2	23	0	31	0
6	6.40	0.015	0.000	45	-0	61	-1	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	213	-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	54	0	73	0
12	3.00	0.007	0.000	256	-0	345	-0	26	-0	34	-0
13	2.30	0.005	0.000	261	-0	352	-0	0	-8	0	-10
14	1.60	0.004	0.000	249	-0	337	-0	0	-30	0	-41
15	0.80	0.003	0.000	220	-0	297	-0	0	-46	0	-62
16	0.00	0.003	0.000	185	-0	249	-0	0	-51	0	-69
17	-0.50	0.002	0.000	160	-0	216	-0	0	-55	0	-74
18	-1.00	0.002	0.000	133	0	179	0	0	-55	0	-74
19	-1.70	0.002	0.000	94	0	127	0	0	-52	0	-70
20	-2.40	0.002	0.000	60	0	81	0	0	-44	0	-59
21	-3.20	0.001	0.000	30	0	40	0	0	-32	0	-43
22	-4.00	0.001	0.000	10	0	13	0	0	-18	0	-25
23	-4.50	0.001	-0.000	3	0	4	0	0	-10	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	-2	4	5.00	-1	0.80	6	-2
3	261	2.30	-0	-5.00	352	-0	82	4.50	-55	-0.50	110	-74
4	260	2.30	-0	-5.00	351	-0	81	4.50	-55	-1.00	110	-74
5	258	2.30	-0	-5.00	348	-0	81	4.50	-51	0.00	110	-69

APPENDIX A-2. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | Checked :

Summary of results (continued)

Maximum and minimum displacement at each stage

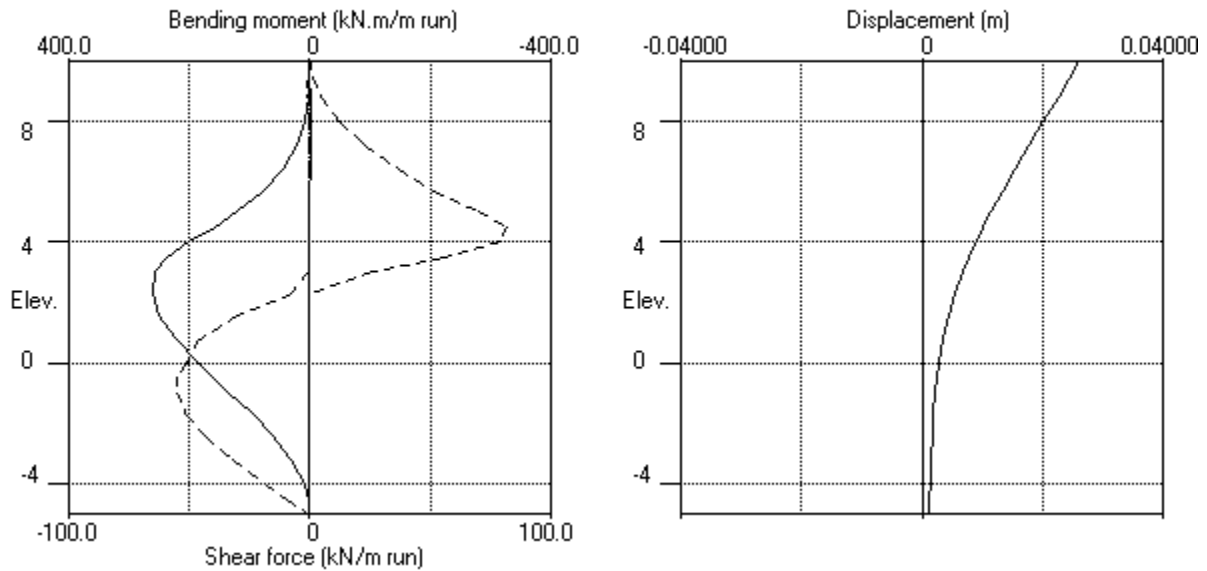
Stage	no.	maximum m	elev.	Displacement minimum m	elev.	Stage description
1	0.000	2.30	-0.000	-5.00	Change EI of wall to 557794kN.m2/m run	
2	0.001	10.00	0.000	10.00	Apply surcharge no.1 at elev. 10.00	
3	0.024	10.00	0.000	10.00	Excav. to elev. 4.50 on PASSIVE side	
4	0.026	10.00	0.000	10.00	Apply water 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: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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 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	0.283	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

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	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 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 = 2.1000E+08 kN/m2
Moment of inertia of wall I = 2.4122E-03 m4/m run
E.I = 506554 kN.m2/m run
Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch	Distance	Length	Width	Surcharge		Equiv. Partial	
-arge	from	parallel	perpend.	-----	kN/m2	-----	soil factor/
no.	Elev.	wall	to 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 no.	Stage description
1	Change EI of wall to 557794 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: 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

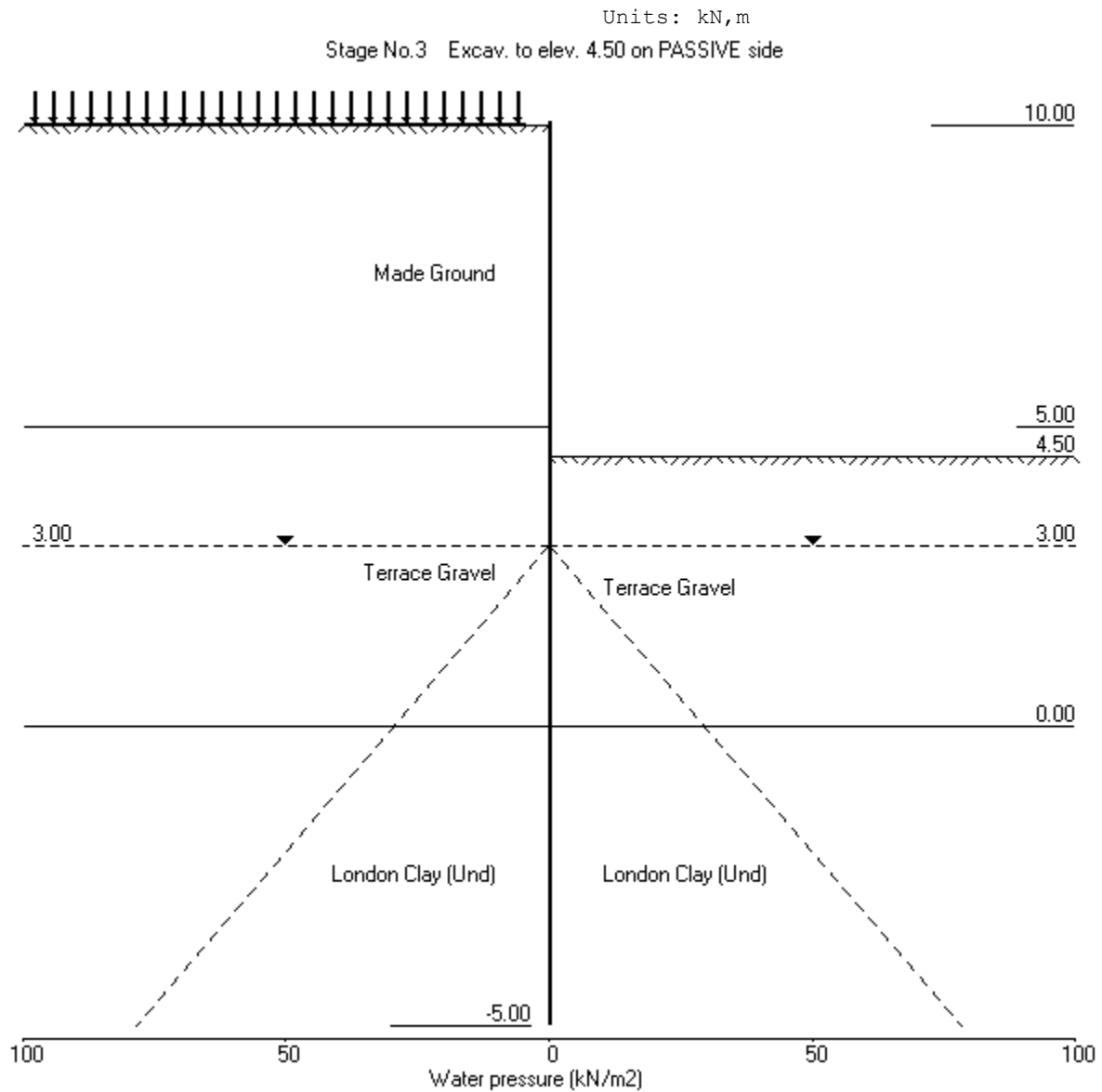
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Displacement	Active, Graph.	Output options
		Bending mom.	Passive output	
		Shear force	pressures	
1	Change EI of wall to 557794kN.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

APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :



APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	0.025	2.91E-03	0.0	-0.0		557794
2	9.40	3.65	0.023	2.91E-03	1.1	0.4		557794
3	8.80	7.41	0.021	2.90E-03	4.4	1.9		557794
4	8.00	11.80	0.019	2.90E-03	12.1	8.3		557794
5	7.20	15.91	0.017	2.88E-03	23.2	22.1		557794
6	6.40	19.92	0.014	2.83E-03	37.5	46.2		557794
7	5.70	23.37	0.012	2.75E-03	52.7	77.6		557794
8	5.00	29.82	0.011	2.62E-03	71.3	122.0		557794
		21.45	0.011	2.62E-03	71.3	122.0		
9	4.50	23.52	0.009	2.50E-03	82.5	160.4		557794
10	4.00	-34.45	0.008	2.33E-03	79.8	202.2		557794
11	3.50	-63.84	0.007	2.14E-03	55.2	239.9		557794
12	3.00	-53.31	0.006	1.91E-03	25.9	259.4		557794
13	2.30	-39.70	0.005	1.58E-03	-6.6	264.4		557794
14	1.60	-28.91	0.004	1.26E-03	-30.6	249.9		557794
15	0.80	-11.59	0.003	9.30E-04	-46.8	219.0		557794
16	0.00	0.87	0.002	6.45E-04	-51.1	177.8		557794
		-15.52	0.002	6.45E-04	-51.1	177.8		
17	-0.50	-4.15	0.002	4.98E-04	-56.0	150.3		557794
18	-1.00	4.40	0.002	3.76E-04	-56.0	121.8		506554
19	-1.70	12.08	0.002	2.34E-04	-50.2	83.6		506554
20	-2.40	15.69	0.001	1.41E-04	-40.5	51.4		506554
21	-3.20	16.56	0.001	8.16E-05	-27.6	24.0		506554
22	-4.00	15.63	0.001	5.70E-05	-14.7	7.2		506554
23	-4.50	14.71	0.001	5.26E-05	-7.1	1.7		506554
24	-5.00	13.77	0.001	5.17E-05	0.0	0.0		---

Node no.	Y coord	----- ACTIVE side -----						
		----- 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.
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1597
2	9.40	0.00	12.89	3.65	60.53	3.65	3.65a	1597
3	8.80	0.00	26.15	7.41	122.78	7.41	7.41a	1597
4	8.00	0.00	41.63	11.80	195.49	11.80	11.80a	1597
5	7.20	0.00	56.14	15.91	263.61	15.91	15.91a	1597
6	6.40	0.00	70.25	19.92	329.90	19.92	19.92a	1597
7	5.70	0.00	82.44	23.37	387.14	23.37	23.37a	1597

APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	
8	5.00	0.00	94.55	26.80	443.96	29.82	29.82	1597
		0.00	94.55	21.45	630.62	21.45	21.45a	7985
9	4.50	0.00	103.65	23.52	691.36	23.52	23.52a	7985
10	4.00	0.00	112.73	25.58	751.93	25.58	25.58a	7985
11	3.50	0.00	121.79	27.64	812.38	27.64	27.64a	7985
12	3.00	0.00	130.84	29.69	872.71	29.69	29.69a	7985
13	2.30	6.86	137.32	31.16	915.92	31.16	38.03a	7985
14	1.60	13.73	143.77	32.63	958.97	32.63	46.35a	7985
15	0.80	21.57	151.13	34.29	1008.03	42.54	64.12	7985
16	0.00	29.42	158.46	35.96	1056.95	50.66	80.08	7985
		Total>	187.88	50.00m	387.93	215.00	215.00	21365
17	-0.50	Total>	197.86	52.50m	404.91	232.14	232.14	22113
18	-1.00	Total>	207.83	55.00m	421.89	248.17	248.17	22861
19	-1.70	Total>	221.79	58.50m	445.64	268.91	268.91	23908
20	-2.40	Total>	235.73	62.00m	469.39	288.04	288.04	24954
21	-3.20	Total>	251.65	66.00m	496.51	308.63	308.63	26151
22	-4.00	Total>	267.57	70.00m	523.63	328.53	328.53	27347
23	-4.50	Total>	277.51	72.50m	540.57	340.84	340.84	28095
24	-5.00	Total>	287.45	75.00m	557.52	353.16	353.16	28843

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	12352
10	4.00	0.00	9.00	2.04	60.03	60.03	60.03p	12352
11	3.50	0.00	18.00	4.09	120.09	91.48	91.48	12352
12	3.00	0.00	27.02	6.13	180.20	83.00	83.00	12352
13	2.30	6.86	33.49	7.60	223.37	70.86	77.73	12352
14	1.60	13.73	39.99	9.07	266.73	61.53	75.26	12352
15	0.80	21.57	47.47	10.77	316.62	54.13	75.71	12352
16	0.00	29.42	55.01	12.48	366.91	49.80	79.22	12352
		Total>	84.43	22.50m	284.46	230.52	230.52	32267
17	-0.50	Total>	94.58	25.00m	301.61	236.30	236.30	33397
18	-1.00	Total>	104.76	27.50m	318.79	243.77	243.77	34526
19	-1.70	Total>	119.06	31.00m	342.90	256.83	256.83	36107
20	-2.40	Total>	133.43	34.50m	367.07	272.35	272.35	37688
21	-3.20	Total>	149.93	38.50m	394.77	292.07	292.07	39495
22	-4.00	Total>	166.51	42.50m	422.55	312.90	312.90	41302
23	-4.50	Total>	176.91	45.00m	439.96	326.13	326.13	42432
24	-5.00	Total>	187.34	47.50m	457.39	339.39	339.39	43561

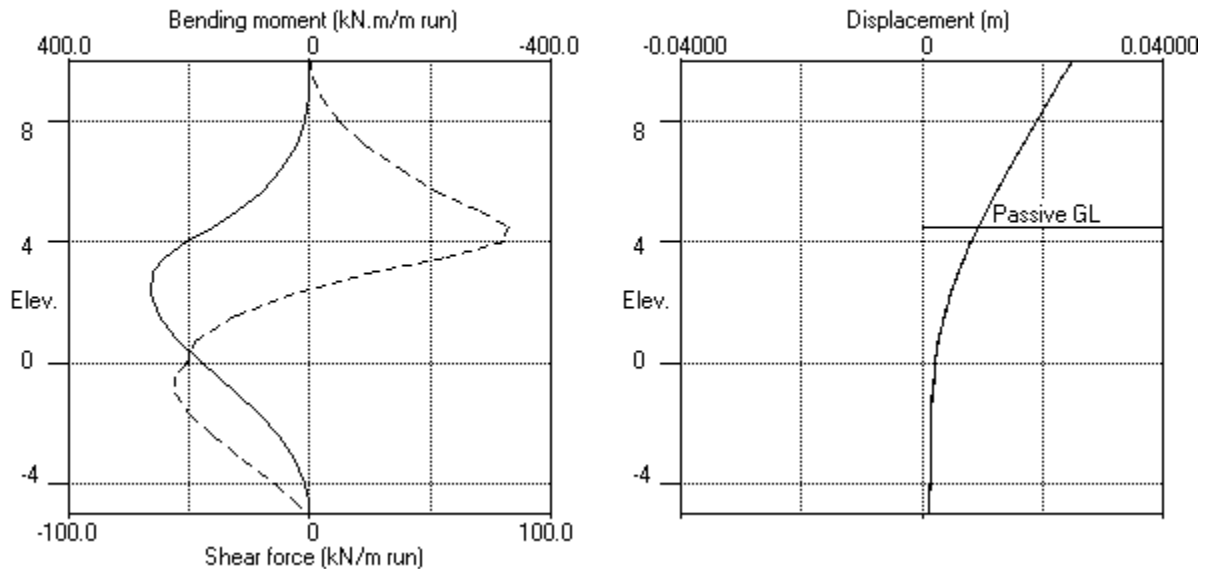
Note: 46.35a Soil pressure at active limit
60.03p Soil pressure at passive limit

APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

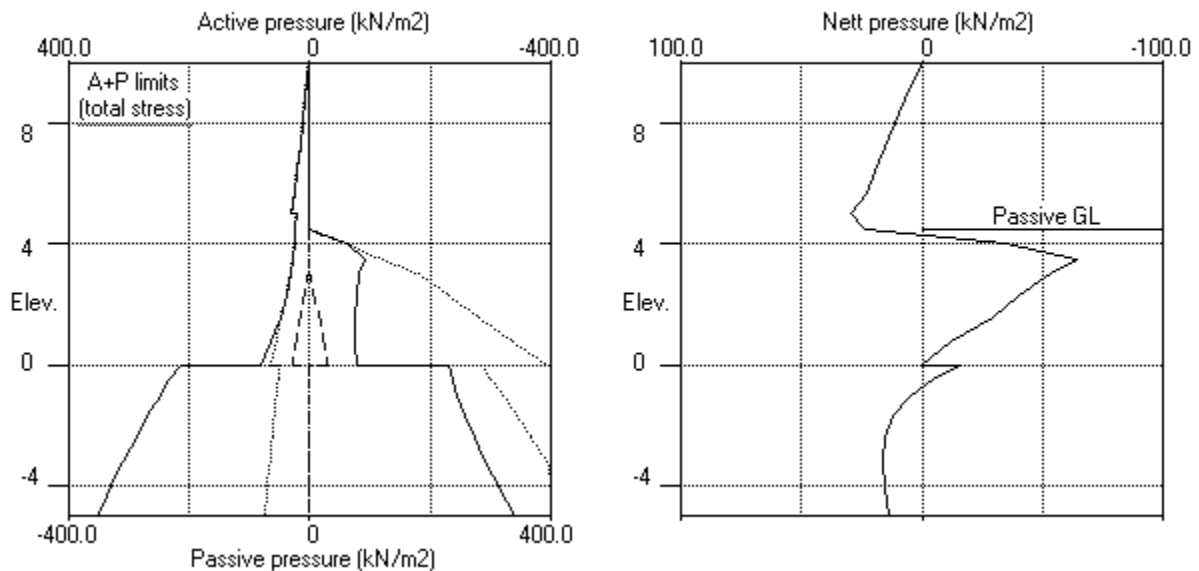
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :

Units: kN,m

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

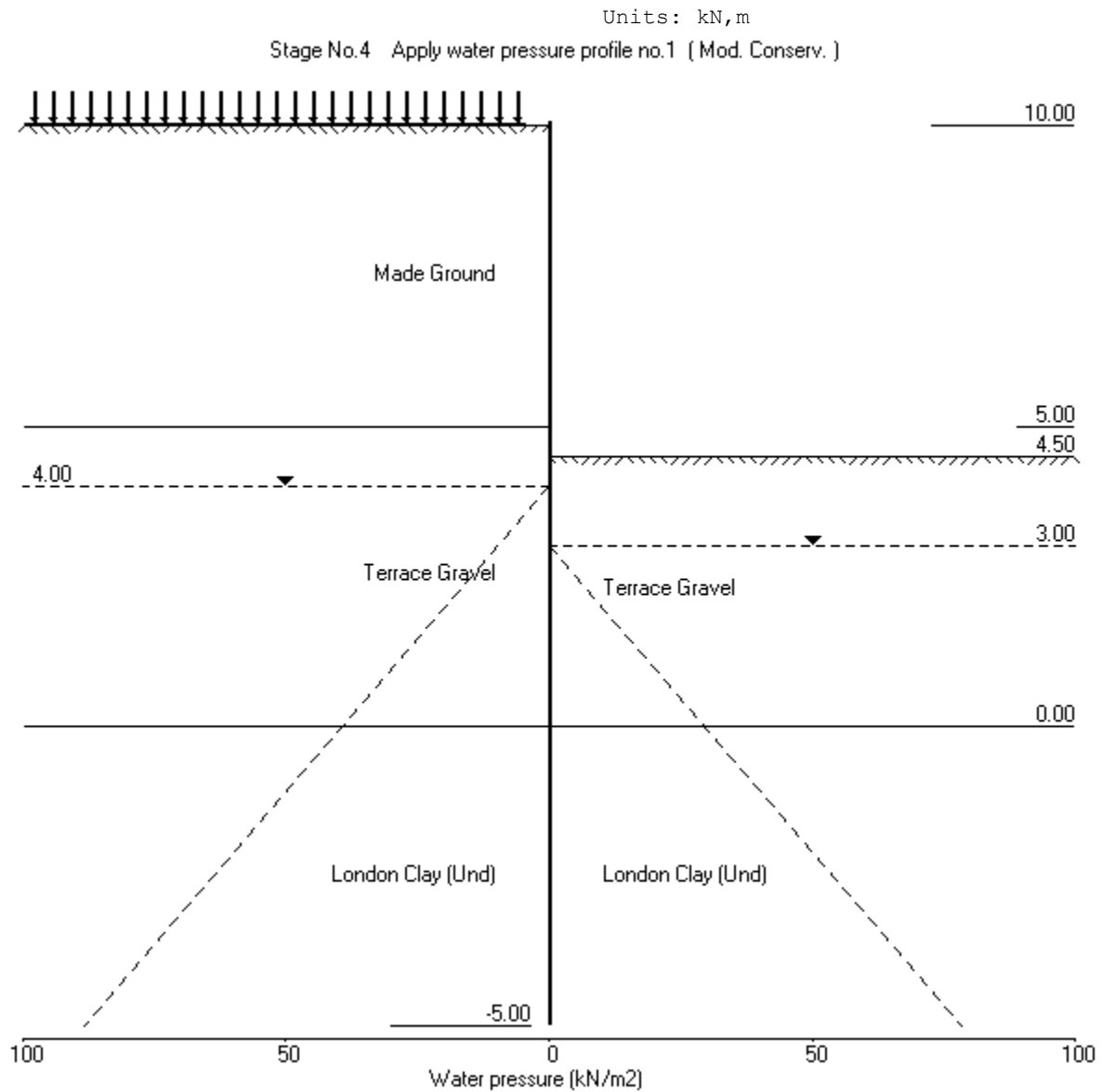


Stage No.3 Excav. to elev. 4.50 on PASSIVE side



APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :



APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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.

*** 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	0.026	3.02E-03	0.0	-0.0		557794
2	9.40	3.65	0.024	3.02E-03	1.1	0.4		557794
3	8.80	7.41	0.023	3.02E-03	4.4	1.9		557794
4	8.00	11.80	0.020	3.01E-03	12.1	8.3		557794
5	7.20	15.91	0.018	2.99E-03	23.2	22.1		557794
6	6.40	19.92	0.015	2.94E-03	37.5	46.2		557794
7	5.70	23.37	0.013	2.86E-03	52.7	77.6		557794
8	5.00	28.79	0.011	2.74E-03	70.9	122.0		557794
		21.45	0.011	2.74E-03	70.9	122.0		
9	4.50	23.52	0.010	2.61E-03	82.2	160.2		557794
10	4.00	-34.45	0.009	2.45E-03	79.4	201.8		557794
11	3.50	-65.82	0.008	2.25E-03	54.4	239.5		557794
12	3.00	-50.86	0.007	2.03E-03	25.2	258.5		557794
13	2.30	-36.49	0.005	1.70E-03	-5.4	263.6		557794
14	1.60	-24.93	0.004	1.38E-03	-26.9	250.7		557794
15	0.80	-10.58	0.003	1.04E-03	-41.1	224.0		557794
16	0.00	3.23	0.002	7.44E-04	-44.0	187.7		557794
		-23.99	0.002	7.44E-04	-44.0	187.7		
17	-0.50	-10.85	0.002	5.87E-04	-52.7	162.7		557794
18	-1.00	-0.64	0.002	4.54E-04	-55.6	135.0		506554
19	-1.70	9.07	0.002	2.94E-04	-52.6	95.9		506554
20	-2.40	14.34	0.001	1.86E-04	-44.5	61.2		506554
21	-3.20	16.70	0.001	1.14E-04	-32.0	30.2		506554
22	-4.00	16.98	0.001	8.26E-05	-18.6	9.8		506554
23	-4.50	18.15	0.001	7.64E-05	-9.8	2.6		506554
24	-5.00	20.97	0.001	7.51E-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	1311
2	9.40	0.00	12.89	3.65	60.53	3.65	3.65a	1311
3	8.80	0.00	26.15	7.41	122.78	7.41	7.41a	1311
4	8.00	0.00	41.63	11.80	195.49	11.80	11.80a	1311
5	7.20	0.00	56.14	15.91	263.61	15.91	15.91a	1311
6	6.40	0.00	70.25	19.92	329.90	19.92	19.92a	1311
7	5.70	0.00	82.44	23.37	387.14	23.37	23.37a	1311

APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	
8	5.00	0.00	94.55	26.80	443.96	28.79	28.79	1311
		0.00	94.55	21.45	630.62	21.45	21.45a	6555
9	4.50	0.00	103.65	23.52	691.36	23.52	23.52a	6555
10	4.00	0.00	112.73	25.58	751.93	25.58	25.58a	6555
11	3.50	4.90	117.39	26.64	783.01	26.64	31.54a	6555
12	3.00	9.81	122.03	27.69	813.97	27.69	37.50a	6555
13	2.30	16.67	128.51	29.16	857.18	29.16	45.83a	6555
14	1.60	23.54	134.97	30.63	900.23	30.63	54.16a	6555
15	0.80	31.38	142.32	32.30	949.29	36.72	68.10	6555
16	0.00	39.23	149.66	33.96	998.21	45.40	84.62	6555
		Total>	188.88	50.00m	388.93	212.27	212.27	17851
17	-0.50	Total>	198.86	52.50m	405.91	230.15	230.15	18476
18	-1.00	Total>	208.83	55.00m	422.89	246.87	246.87	19101
19	-1.70	Total>	222.79	58.50m	446.64	268.45	268.45	19975
20	-2.40	Total>	236.73	62.00m	470.39	288.27	288.27	20850
21	-3.20	Total>	252.65	66.00m	497.51	309.48	309.48	21850
22	-4.00	Total>	268.57	70.00m	524.63	329.87	329.87	45519
23	-4.50	Total>	278.51	72.50m	541.57	343.09	343.09	73166
24	-5.00	Total>	288.45	75.00m	558.51	357.44	357.44	121656

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	9531
10	4.00	0.00	9.00	2.04	60.03	60.03	60.03p	9531
11	3.50	0.00	18.00	4.09	120.09	97.37	97.37	9531
12	3.00	0.00	27.02	6.13	180.20	88.36	88.36	9531
13	2.30	6.86	33.49	7.60	223.37	75.46	82.32	9531
14	1.60	13.73	39.99	9.07	266.73	65.37	79.10	9531
15	0.80	21.57	47.47	10.77	316.62	57.10	78.68	9531
16	0.00	29.42	55.01	12.48	366.91	51.97	81.39	9531
		Total>	84.43	22.50m	284.46	236.26	236.26	25211
17	-0.50	Total>	94.58	25.00m	301.61	241.01	241.01	26093
18	-1.00	Total>	104.76	27.50m	318.79	247.51	247.51	26975
19	-1.70	Total>	119.06	31.00m	342.90	259.38	259.38	28211
20	-2.40	Total>	133.43	34.50m	367.07	273.93	273.93	29446
21	-3.20	Total>	149.93	38.50m	394.77	292.77	292.77	30858
22	-4.00	Total>	166.51	42.50m	422.55	312.90	312.90	63765
23	-4.50	Total>	176.91	45.00m	439.96	324.94	324.94	97226
24	-5.00	Total>	187.34	47.50m	457.39	336.46	336.46	121656

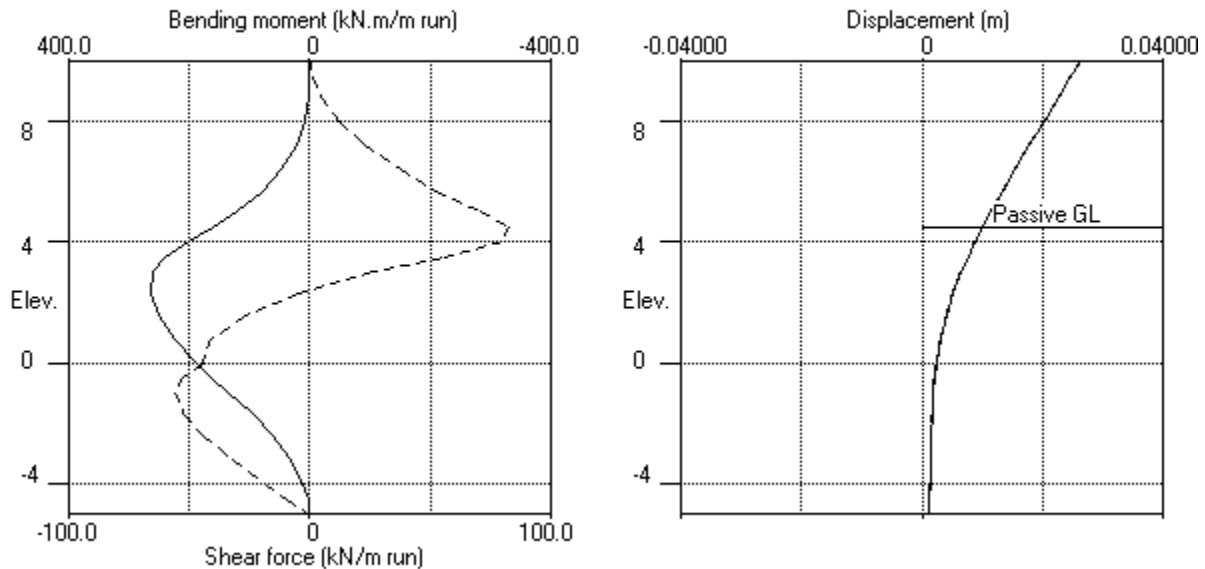
Note: 54.16a Soil pressure at active limit
60.03p Soil pressure at passive limit

APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

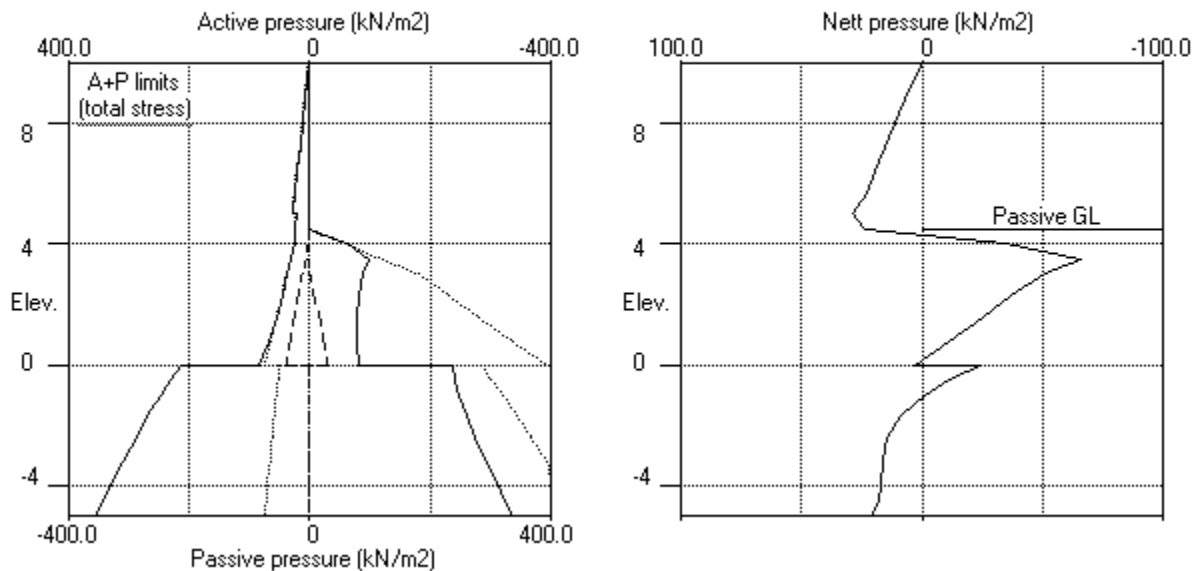
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :

Units: kN,m

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

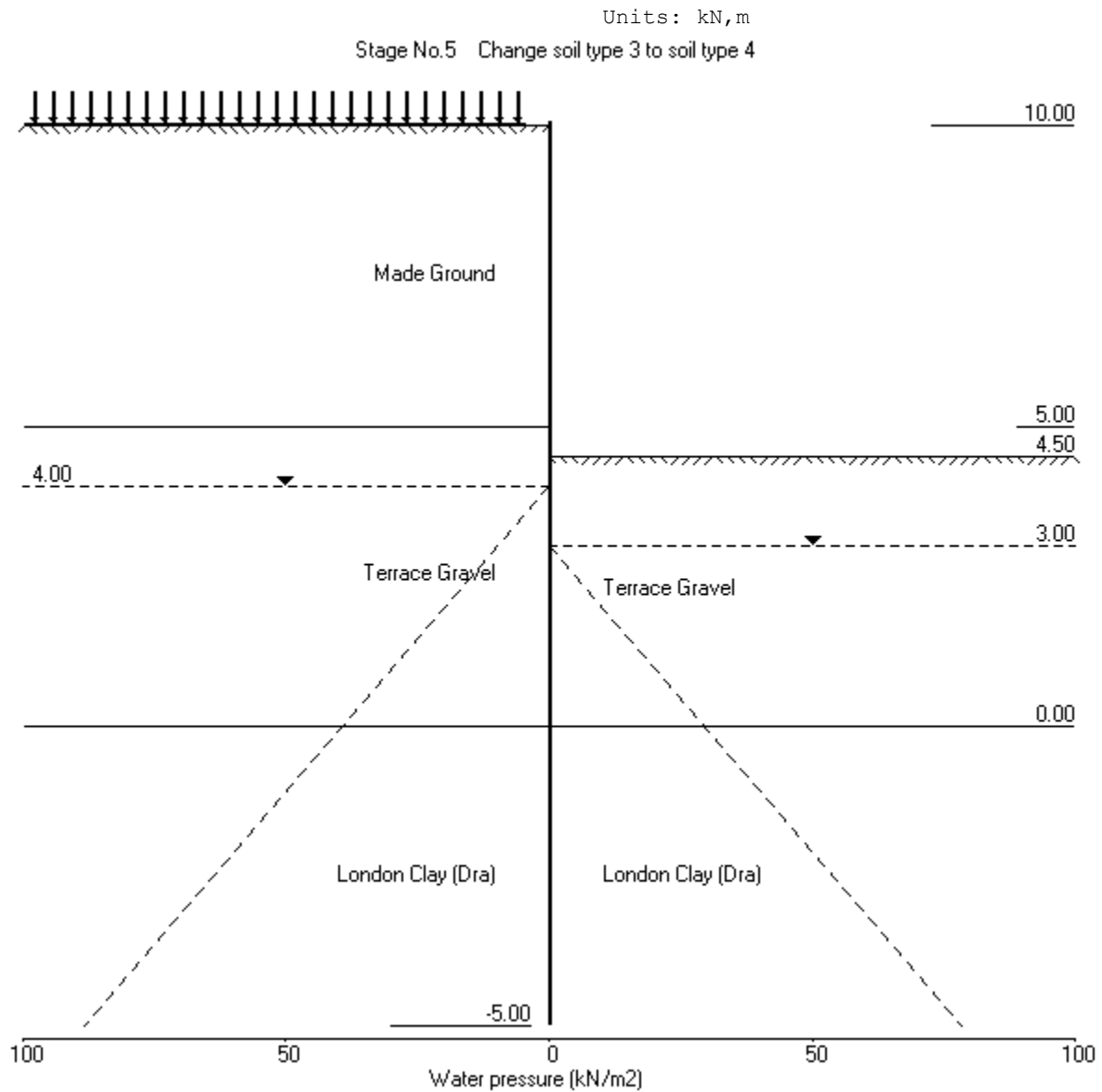


Stage No.4 Apply water pressure profile no.1 (Mod. Conserv.)



APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :



APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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.

*** 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	0.026	3.01E-03	0.0	-0.0		557794
2	9.40	3.65	0.025	3.01E-03	1.1	0.4		557794
3	8.80	7.41	0.023	3.01E-03	4.4	1.9		557794
4	8.00	11.80	0.020	3.00E-03	12.1	8.3		557794
5	7.20	15.91	0.018	2.98E-03	23.2	22.1		557794
6	6.40	19.92	0.016	2.93E-03	37.5	46.2		557794
7	5.70	23.37	0.014	2.85E-03	52.7	77.6		557794
8	5.00	28.55	0.012	2.73E-03	70.8	122.0		557794
		21.45	0.012	2.73E-03	70.8	122.0		
9	4.50	23.52	0.010	2.60E-03	82.1	160.2		557794
10	4.00	-34.45	0.009	2.44E-03	79.4	201.7		557794
11	3.50	-67.44	0.008	2.24E-03	53.9	239.4		557794
12	3.00	-52.50	0.007	2.02E-03	23.9	258.0		557794
13	2.30	-38.17	0.005	1.69E-03	-7.8	261.7		557794
14	1.60	-26.63	0.004	1.37E-03	-30.5	246.7		557794
15	0.80	-13.59	0.003	1.04E-03	-46.6	216.5		557794
16	0.00	0.32	0.003	7.64E-04	-51.9	174.8		557794
		3.28	0.003	7.64E-04	-51.9	174.8		
17	-0.50	3.22	0.002	6.19E-04	-50.3	148.7		557794
18	-1.00	1.98	0.002	4.97E-04	-49.0	123.5		506554
19	-1.70	5.49	0.002	3.50E-04	-46.4	89.3		506554
20	-2.40	11.34	0.002	2.48E-04	-40.5	58.1		506554
21	-3.20	14.51	0.001	1.79E-04	-30.1	29.3		506554
22	-4.00	15.71	0.001	1.48E-04	-18.1	9.8		506554
23	-4.50	17.51	0.001	1.42E-04	-9.8	2.7		506554
24	-5.00	21.50	0.001	1.41E-04	0.0	0.0		---

Node no.	Y coord	----- ACTIVE side -----						
		----- Effective stresses -----					Total earth	Soil
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure	pressure	stiffness
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	coeff.
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	921
2	9.40	0.00	12.89	3.65	60.53	3.65	3.65a	921
3	8.80	0.00	26.15	7.41	122.78	7.41	7.41a	921
4	8.00	0.00	41.63	11.80	195.49	11.80	11.80a	921
5	7.20	0.00	56.14	15.91	263.61	15.91	15.91a	921
6	6.40	0.00	70.25	19.92	329.90	19.92	19.92a	921

APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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 -----						
		----- 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	921
8	5.00	0.00	94.55	26.80	443.96	28.55	28.55	921
		0.00	94.55	21.45	630.62	21.45	21.45a	4604
9	4.50	0.00	103.65	23.52	691.36	23.52	23.52a	4604
10	4.00	0.00	112.73	25.58	751.93	25.58	25.58a	4604
11	3.50	4.90	117.39	26.64	783.01	26.64	31.54a	4604
12	3.00	9.81	122.03	27.69	813.97	27.69	37.50a	4604
13	2.30	16.67	128.51	29.16	857.18	29.16	45.83a	4604
14	1.60	23.54	134.97	30.63	900.23	30.63	54.16a	4604
15	0.80	31.38	142.32	32.30	949.29	35.40	66.78	4604
16	0.00	39.23	149.66	33.96	998.21	44.12	83.35	4604
		39.23	149.66	51.09	413.23	171.22	210.45	6594
17	-0.50	44.13	154.73	53.34	425.86	184.22	228.35	6824
18	-1.00	49.03	159.80	55.58	438.47	196.10	245.14	7055
19	-1.70	55.90	166.89	58.73	456.10	211.00	266.90	7378
20	-2.40	62.76	173.97	61.87	473.71	224.20	286.97	7701
21	-3.20	70.61	182.04	65.45	493.81	237.92	308.52	8071
22	-4.00	78.45	190.11	69.03	513.89	250.87	329.32	8440
23	-4.50	83.36	195.15	71.26	526.42	259.45	342.81	8671
24	-5.00	88.26	200.19	73.50	538.95	269.44	357.70	367741

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	5913
10	4.00	0.00	9.00	2.04	60.03	60.03	60.03p	5913
11	3.50	0.00	18.00	4.09	120.09	98.98	98.98	5913
12	3.00	0.00	27.02	6.13	180.20	90.00	90.00	5913
13	2.30	6.86	33.49	7.60	223.37	77.14	84.00	5913
14	1.60	13.73	39.99	9.07	266.73	67.06	80.79	5913
15	0.80	21.57	47.47	10.77	316.62	58.80	80.37	5913
16	0.00	29.42	55.01	12.48	366.91	53.61	83.03	5913
		29.42	55.01	9.11	177.75	177.75	207.16p	8589
17	-0.50	34.32	60.26	11.44	190.80	190.80	225.13p	8890
18	-1.00	39.23	65.53	13.78	203.93	203.93	243.16p	9190
19	-1.70	46.09	72.97	17.08	222.44	215.31	261.40	9611
20	-2.40	52.96	80.48	20.40	241.11	222.67	275.63	10032
21	-3.20	60.80	89.13	24.24	262.63	233.21	294.01	10513
22	-4.00	68.65	97.86	28.11	284.36	244.97	313.61	10994
23	-4.50	73.55	103.36	30.55	298.05	251.75	325.30	11295
24	-5.00	78.45	108.89	33.01	311.81	257.75	336.20	367741

APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | Checked :

(continued)

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

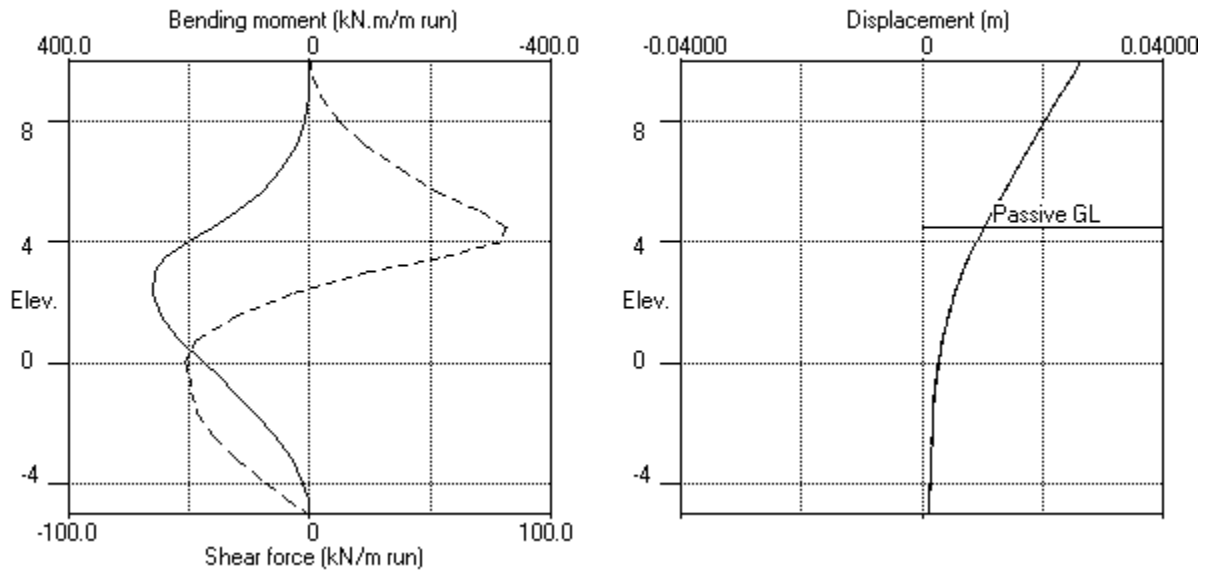
Note: 54.16a Soil pressure at active limit
243.16p Soil pressure at passive limit

APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

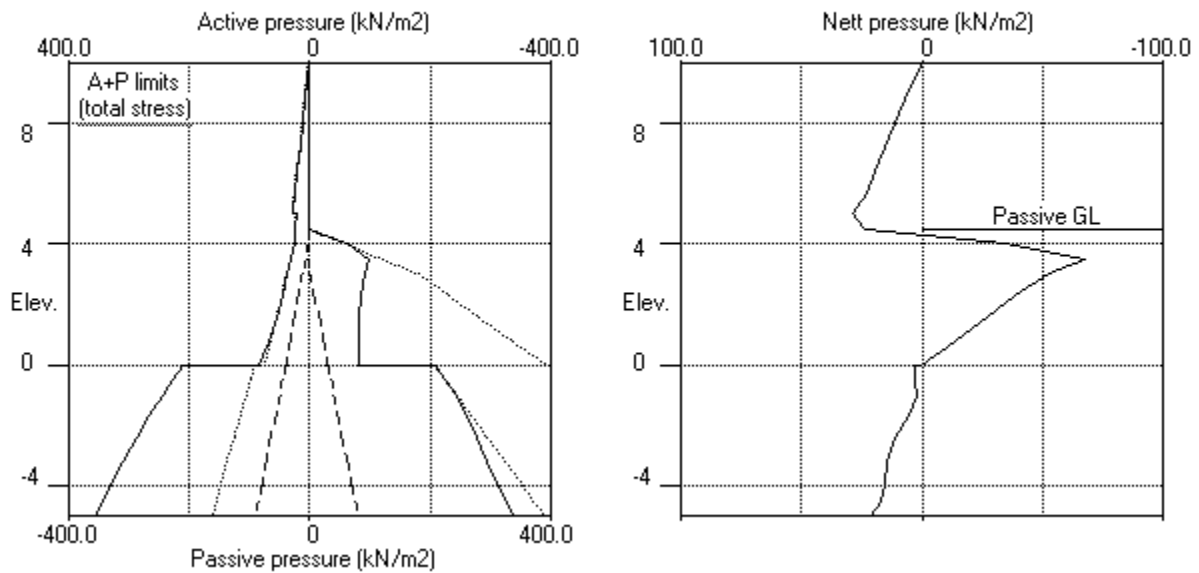
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | Checked :

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-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	0.026	0.000	0	-0	0	-0	0	0	0	0
2	9.40	0.025	0.000	0	0	1	0	1	-0	1	-1
3	8.80	0.023	0.000	2	-0	3	-1	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	30	-2	23	0	31	0
6	6.40	0.016	0.000	46	-0	62	-1	38	0	51	0
7	5.70	0.014	0.000	78	-0	105	-0	53	0	71	0
8	5.00	0.012	0.000	122	-0	165	-0	71	0	96	0
9	4.50	0.010	0.000	160	-0	217	-0	83	0	111	0
10	4.00	0.009	0.000	202	-0	273	-0	80	0	108	0
11	3.50	0.008	0.000	240	-0	324	-0	55	0	75	0
12	3.00	0.007	0.000	259	-0	350	-0	26	-0	35	-0
13	2.30	0.005	0.000	264	-0	357	-0	0	-8	0	-11
14	1.60	0.004	0.000	251	-0	339	-0	0	-31	0	-41
15	0.80	0.003	0.000	224	-0	302	-0	0	-47	0	-63
16	0.00	0.003	0.000	188	-0	253	-0	0	-52	0	-70
17	-0.50	0.002	0.000	163	-0	220	-0	0	-56	0	-76
18	-1.00	0.002	0.000	135	0	182	0	0	-56	0	-76
19	-1.70	0.002	0.000	96	0	129	0	0	-53	0	-71
20	-2.40	0.002	0.000	61	0	83	0	0	-44	0	-60
21	-3.20	0.001	0.000	30	0	41	0	0	-32	0	-43
22	-4.00	0.001	0.000	10	0	13	0	0	-19	0	-25
23	-4.50	0.001	-0.000	3	0	4	0	0	-10	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.	max.	elev.	min.	max.	min.	min.
	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	264	2.30	-0	10.00	357	-0	83	4.50	-56	-0.50	111	-76
4	264	2.30	-0	10.00	356	-0	82	4.50	-56	-1.00	111	-75
5	262	2.30	-0	10.00	353	-0	82	4.50	-52	0.00	111	-70

APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | Checked :

Summary of results (continued)

Maximum and minimum displacement at each stage

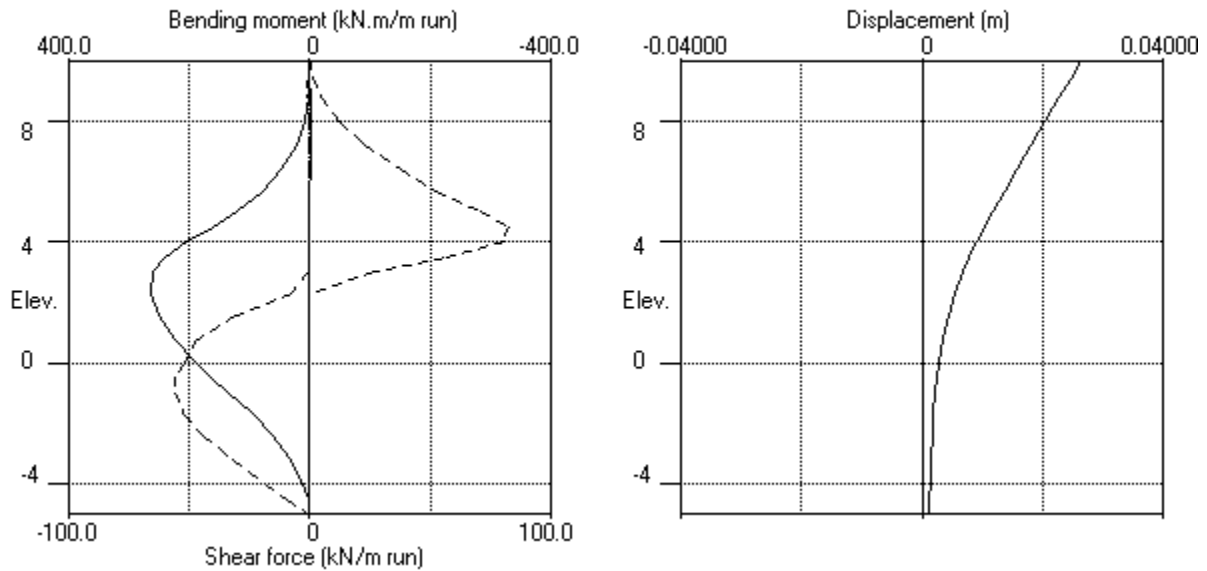
Stage	no.	maximum m	elev.	Displacement minimum m	elev.	Stage description
1	0.000	2.30	-0.000	-5.00	Change EI of wall to 557794kN.m2/m run	
2	0.001	10.00	0.000	10.00	Apply surcharge no.1 at elev. 10.00	
3	0.025	10.00	0.000	10.00	Excav. to elev. 4.50 on PASSIVE side	
4	0.026	10.00	0.000	10.00	Apply water pressure profile no.1	
5	0.026	10.00	0.000	10.00	Change soil type 3 to soil type 4	

APPENDIX A-3. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
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 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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 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	0.283	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

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	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 = 2.4122E-03 m4/m run
E.I = 506554 kN.m2/m run
Yield Moment of wall = Not defined

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
1	Change EI of wall to 557794 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

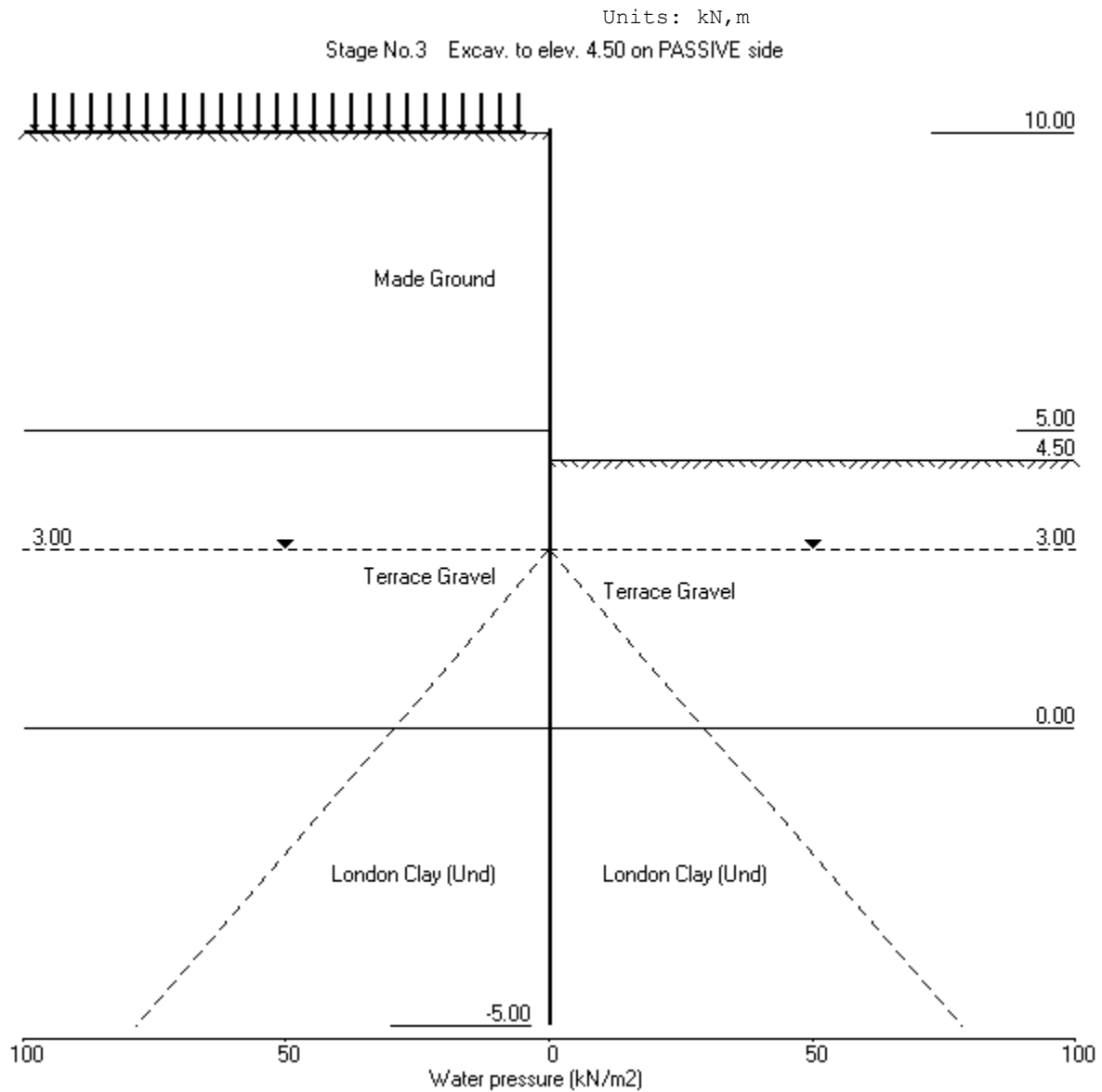
OUTPUT OPTIONS

Stage no.	Stage description	Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Change EI of wall to 557794kN.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	Excav. to elev. 4.00 on PASSIVE side	Yes	Yes	No
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: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
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 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :



APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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

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	4.50		Cant.	1.439	-3.74	-1.13	5.63

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	0.039	4.45E-03	0.0	0.0		557794
2	9.40	4.74	0.036	4.45E-03	1.4	0.5		557794
3	8.80	9.64	0.033	4.45E-03	5.7	2.5		557794
4	8.00	15.25	0.030	4.44E-03	15.7	10.7		557794
5	7.20	20.45	0.026	4.41E-03	30.0	28.7		557794
6	6.40	25.49	0.023	4.35E-03	48.4	59.7		557794
7	5.70	29.83	0.020	4.25E-03	67.7	100.2		557794
8	5.00	34.14	0.017	4.09E-03	90.1	155.2		557794
		28.19	0.017	4.09E-03	90.1	155.2		
9	4.50	30.87	0.015	3.93E-03	104.9	203.9		557794
10	4.00	-6.73	0.013	3.72E-03	110.9	258.6		557794
11	3.50	-44.35	0.011	3.47E-03	98.1	311.6		557794
12	3.00	-82.00	0.010	3.17E-03	66.6	353.5		557794
13	2.30	-64.40	0.007	2.70E-03	15.3	388.6		557794
14	1.60	-44.05	0.006	2.22E-03	-22.6	383.4		557794
15	0.80	-25.86	0.004	1.69E-03	-50.6	351.1		557794
16	0.00	-12.63	0.003	1.22E-03	-66.0	302.2		557794
		-26.64	0.003	1.22E-03	-66.0	302.2		
17	-0.50	-19.52	0.002	9.73E-04	-77.5	265.7		557794
18	-1.00	-11.06	0.002	7.53E-04	-85.2	227.1		506554
19	-1.70	8.77	0.002	4.82E-04	-86.0	164.7		506554
20	-2.40	20.78	0.001	2.94E-04	-75.6	106.6		506554
21	-3.20	27.91	0.001	1.69E-04	-56.2	52.7		506554
22	-4.00	31.20	0.001	1.14E-04	-32.5	16.6		506554
23	-4.50	32.53	0.001	1.04E-04	-16.6	4.2		506554
24	-5.00	33.81	0.001	1.02E-04	-0.0	0.0		---

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	1577
2	9.40	0.00	13.38	4.74	45.42	4.74	4.74a	1577
3	8.80	0.00	27.19	9.64	92.31	9.64	9.64a	1577
4	8.00	0.00	43.02	15.25	146.04	15.25	15.25a	1577
5	7.20	0.00	57.69	20.45	195.84	20.45	20.45a	1577
6	6.40	0.00	71.90	25.49	244.08	25.49	25.49a	1577
7	5.70	0.00	84.14	29.83	285.64	29.83	29.83a	1577
8	5.00	0.00	96.28	34.14	326.84	34.14	34.14a	1577
		0.00	96.28	28.19	430.65	28.19	28.19a	7883
9	4.50	0.00	105.41	30.87	471.46	30.87	30.87a	7883
10	4.00	0.00	114.50	33.53	512.15	33.53	33.53a	7883
11	3.50	0.00	123.57	36.19	552.73	36.19	36.19a	7883
12	3.00	0.00	132.63	38.84	593.23	38.84	38.84a	7883
13	2.30	6.86	139.11	40.74	622.24	40.74	47.60a	7883
14	1.60	13.73	145.57	42.63	651.13	42.63	56.36a	7883
15	0.80	21.57	152.93	44.78	684.02	44.78	66.36a	7883
16	0.00	29.42	160.26	46.93	716.81	46.93	76.35a	7883
		Total>	189.68	50.00m	332.58	200.67	200.67	21114
17	-0.50	Total>	199.65	52.50m	347.56	222.95	222.95	21853
18	-1.00	Total>	209.62	56.74	362.53	243.35	243.35	22592
19	-1.70	Total>	223.56	63.69	383.47	268.83	268.83	23626
20	-2.40	Total>	237.50	70.62	404.41	291.25	291.25	24661
21	-3.20	Total>	253.41	78.53	428.32	314.29	314.29	25843
22	-4.00	Total>	269.30	86.43	452.22	335.85	335.85	27025
23	-4.50	Total>	279.24	91.36	467.15	349.04	349.04	27764
24	-5.00	Total>	289.16	96.28	482.08	362.24	362.24	28503

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	12454
10	4.00	0.00	9.00	2.64	40.26	40.26	40.26p	12454
11	3.50	0.00	18.00	5.27	80.53	80.53	80.53p	12454
12	3.00	0.00	27.02	7.91	120.84	120.84	120.84p	12454
13	2.30	6.86	33.49	9.81	149.79	105.13	112.00	12454
14	1.60	13.73	39.99	11.71	178.87	86.68	100.41	12454
15	0.80	21.57	47.47	13.90	212.32	70.64	92.21	12454
16	0.00	29.42	55.01	16.11	246.05	59.56	88.98	12454
		Total>	84.43	22.50m	227.31	227.31	227.31p	32525
17	-0.50	Total>	94.58	25.00m	242.46	242.46	242.46p	33663
18	-1.00	Total>	104.76	27.50m	257.65	254.41	254.41	34802
19	-1.70	Total>	119.06	31.00m	278.95	260.06	260.06	36395
20	-2.40	Total>	133.43	34.50m	300.32	270.47	270.47	37989

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :

(continued)

Stage No.3 Excavate to elevation 4.50 on PASSIVE side

Node Y		----- PASSIVE side -----					
no.	coord	----- Effective stresses -----				Total	Soil
		Water	Vertic	Active	Passive	Earth	
		press.	-al	limit	limit	pressure	earth stiffness
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	coeff.
							kN/m3
21	-3.20	Total>	149.93	38.50m	324.82	286.38	39811
22	-4.00	Total>	166.51	42.50m	349.40	304.64	41632
23	-4.50	Total>	176.91	45.00m	364.81	316.52	42770
24	-5.00	Total>	187.34	47.50m	380.24	328.43	43909

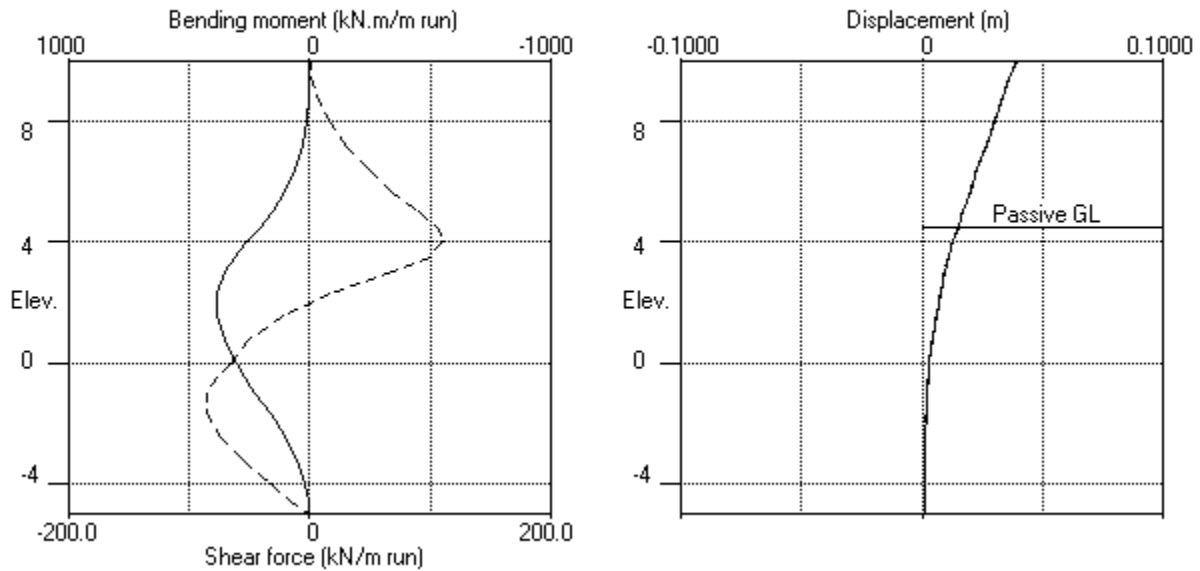
Note: 76.35a Soil pressure at active limit
 242.46p Soil pressure at passive limit

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

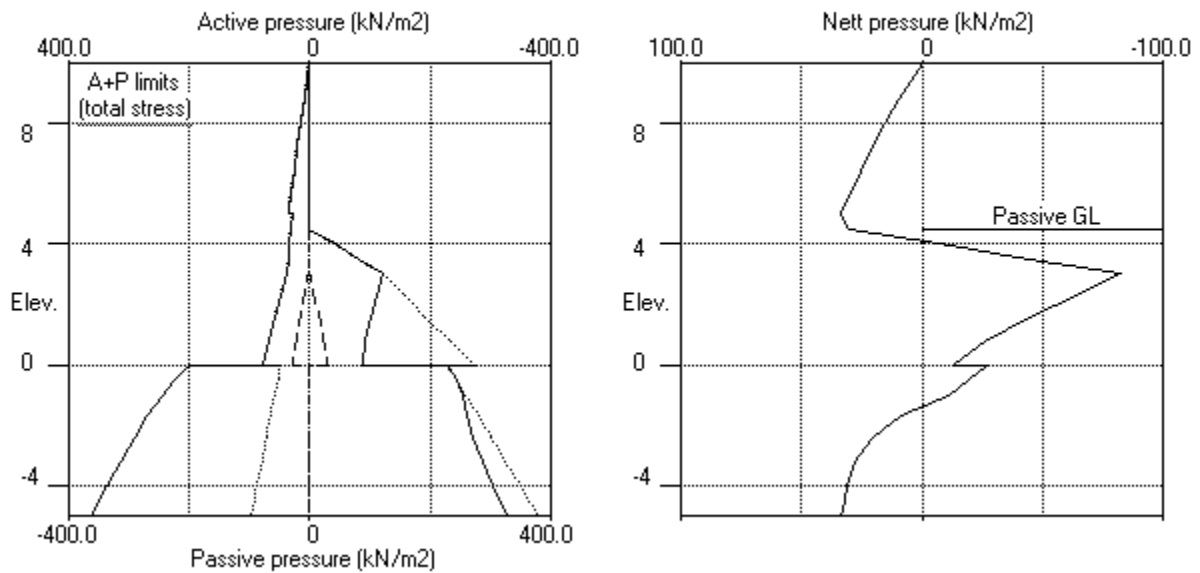
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | Checked :

Units: kN,m

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

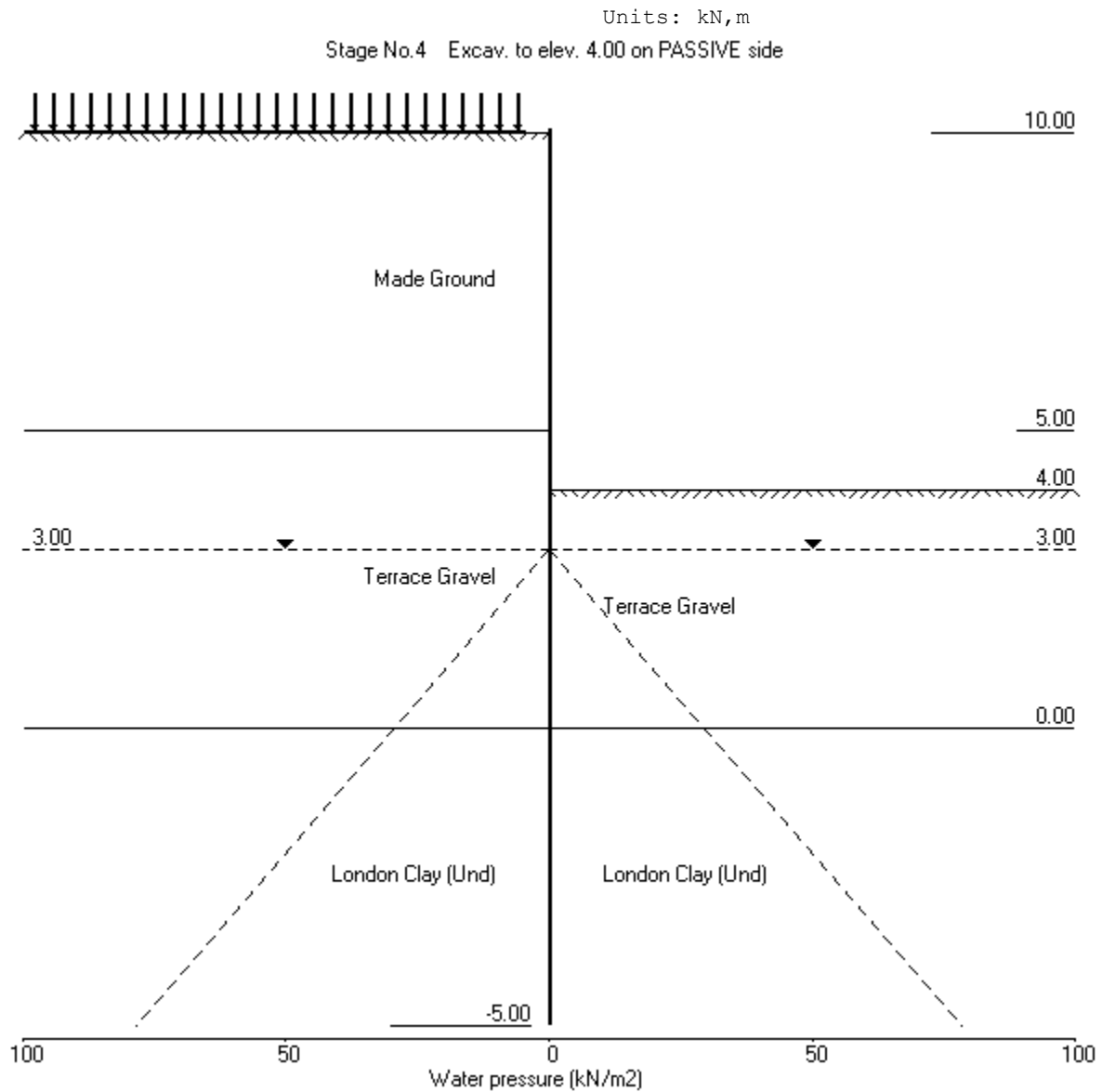


Stage No.3 Excav. to elev. 4.50 on PASSIVE side



APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :



APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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	0.056	6.03E-03	0.0	-0.0		557794
2	9.40	4.74	0.052	6.03E-03	1.4	0.5		557794
3	8.80	9.64	0.048	6.03E-03	5.7	2.5		557794
4	8.00	15.25	0.044	6.02E-03	15.7	10.7		557794
5	7.20	20.45	0.039	5.99E-03	30.0	28.7		557794
6	6.40	25.49	0.034	5.93E-03	48.4	59.7		557794
7	5.70	29.83	0.030	5.83E-03	67.7	100.2		557794
8	5.00	34.14	0.026	5.67E-03	90.1	155.2		557794
		28.19	0.026	5.67E-03	90.1	155.2		
9	4.50	30.87	0.023	5.51E-03	104.9	203.9		557794
10	4.00	33.53	0.020	5.30E-03	121.0	260.2		557794
11	3.50	-4.07	0.018	5.04E-03	128.3	323.3		557794
12	3.00	-41.70	0.015	4.72E-03	116.9	385.4		557794
13	2.30	-68.68	0.012	4.19E-03	78.3	461.9		557794
14	1.60	-83.36	0.010	3.58E-03	25.1	500.4		557794
15	0.80	-53.54	0.007	2.87E-03	-29.7	493.7		557794
16	0.00	-30.51	0.005	2.19E-03	-63.3	452.6		557794
		-53.73	0.005	2.19E-03	-63.3	452.6		
17	-0.50	-39.03	0.004	1.80E-03	-86.5	414.1		557794
18	-1.00	-26.99	0.003	1.45E-03	-103.0	368.4		506554
19	-1.70	-14.73	0.002	1.00E-03	-117.6	288.4		506554
20	-2.40	10.18	0.002	6.63E-04	-119.2	203.9		506554
21	-3.20	30.81	0.001	4.14E-04	-102.8	111.7		506554
22	-4.00	52.13	0.001	2.95E-04	-69.7	39.3		506554
23	-4.50	69.65	0.001	2.70E-04	-39.2	10.9		506554
24	-5.00	87.20	0.001	2.64E-04	-0.0	0.0		---

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	1399
2	9.40	0.00	13.38	4.74	45.42	4.74	4.74a	1399
3	8.80	0.00	27.19	9.64	92.31	9.64	9.64a	1399
4	8.00	0.00	43.02	15.25	146.04	15.25	15.25a	1399
5	7.20	0.00	57.69	20.45	195.84	20.45	20.45a	1399
6	6.40	0.00	71.90	25.49	244.08	25.49	25.49a	1399
7	5.70	0.00	84.14	29.83	285.64	29.83	29.83a	1399
8	5.00	0.00	96.28	34.14	326.84	34.14	34.14a	1399
		0.00	96.28	28.19	430.65	28.19	28.19a	6994
9	4.50	0.00	105.41	30.87	471.46	30.87	30.87a	6994
10	4.00	0.00	114.50	33.53	512.15	33.53	33.53a	6994
11	3.50	0.00	123.57	36.19	552.73	36.19	36.19a	6994
12	3.00	0.00	132.63	38.84	593.23	38.84	38.84a	6994
13	2.30	6.86	139.11	40.74	622.24	40.74	47.60a	6994
14	1.60	13.73	145.57	42.63	651.13	42.63	56.36a	6994
15	0.80	21.57	152.93	44.78	684.02	44.78	66.36a	6994
16	0.00	29.42	160.26	46.93	716.81	46.93	76.35a	6994
		Total>	189.68	50.00m	332.58	164.48	164.48	18922
17	-0.50	Total>	199.65	52.50m	347.56	194.32	194.32	19584
18	-1.00	Total>	209.62	56.74	362.53	221.53	221.53	20247
19	-1.70	Total>	223.56	63.69	383.47	255.07	255.07	21174
20	-2.40	Total>	237.50	70.62	404.41	283.72	283.72	22101
21	-3.20	Total>	253.41	78.53	428.32	312.00	312.00	23161
22	-4.00	Total>	269.30	86.43	452.22	341.90	341.90	89732
23	-4.50	Total>	279.24	91.36	467.15	363.20	363.20	92186
24	-5.00	Total>	289.16	96.28	482.08	384.53	384.53	94640

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	11390
11	3.50	0.00	9.00	2.64	40.26	40.26	40.26p	11390
12	3.00	0.00	18.01	5.27	80.54	80.54	80.54p	11390
13	2.30	6.86	24.46	7.16	109.41	109.41	116.28p	11390
14	1.60	13.73	30.95	9.06	138.41	125.99	139.72	11390
15	0.80	21.57	38.40	11.24	171.75	98.32	119.90	11390
16	0.00	29.42	45.91	13.44	205.37	77.44	106.86	11390
		Total>	75.33	20.00m	218.21	218.21	218.21p	29859
17	-0.50	Total>	85.47	22.50m	233.35	233.35	233.35p	30905
18	-1.00	Total>	95.64	25.00m	248.52	248.52	248.52p	31950
19	-1.70	Total>	109.92	28.50m	269.81	269.81	269.81p	33413
20	-2.40	Total>	124.27	32.00m	291.16	273.54	273.54	34876

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :

(continued)

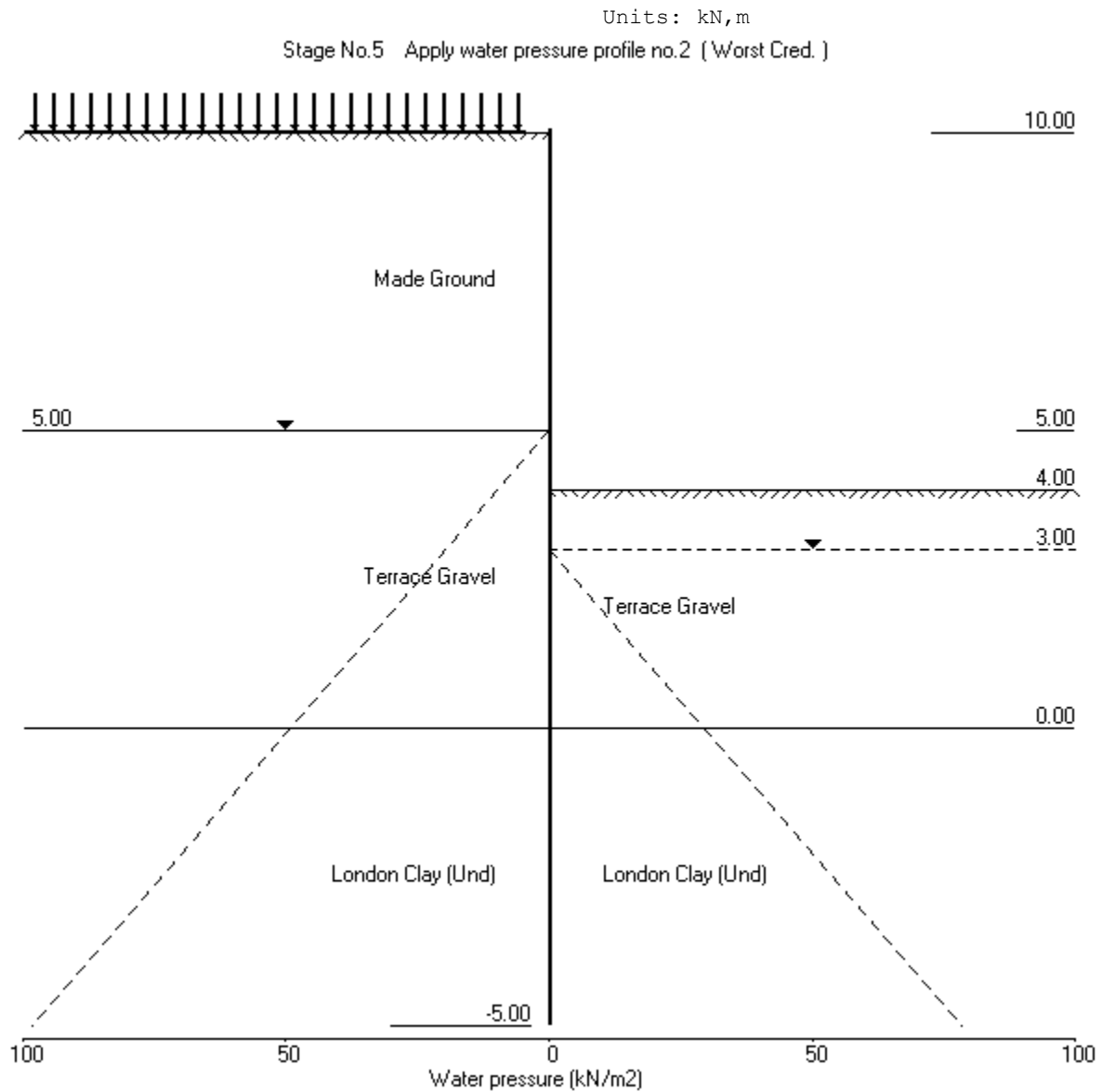
Stage No.4 Excavate to elevation 4.00 on PASSIVE side

Node Y		----- PASSIVE side -----					
no.	coord	----- Effective stresses -----				Total	Soil
		Water	Vertic	Active	Passive	Earth	
		press.	-al	limit	limit	pressure	earth stiffness
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	coeff.
							kN/m3
21	-3.20	Total>	140.76	36.00m	315.65	281.19	36548
22	-4.00	Total>	157.34	40.00m	340.23	289.78	89732
23	-4.50	Total>	167.75	42.50m	355.64	293.56	92186
24	-5.00	Total>	178.19	45.00m	371.09	297.33	94640

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

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :



APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	0.068	7.07E-03	0.0	-0.0		557794
2	9.40	4.74	0.063	7.07E-03	1.4	0.5		557794
3	8.80	9.64	0.059	7.06E-03	5.7	2.5		557794
4	8.00	15.25	0.053	7.05E-03	15.7	10.7		557794
5	7.20	20.45	0.048	7.03E-03	30.0	28.7		557794
6	6.40	25.49	0.042	6.96E-03	48.4	59.7		557794
7	5.70	29.83	0.037	6.86E-03	67.7	100.2		557794
8	5.00	34.14	0.033	6.70E-03	90.1	155.2		557794
		28.19	0.033	6.70E-03	90.1	155.2		
9	4.50	34.48	0.029	6.54E-03	105.8	204.0		557794
10	4.00	40.76	0.026	6.33E-03	124.6	261.5		557794
11	3.50	6.77	0.023	6.07E-03	136.5	327.4		557794
12	3.00	-27.24	0.020	5.74E-03	131.4	395.0		557794
13	2.30	-54.22	0.016	5.19E-03	102.8	485.2		557794
14	1.60	-81.33	0.013	4.55E-03	55.4	543.5		557794
15	0.80	-64.49	0.009	3.75E-03	-2.9	562.9		557794
16	0.00	-34.51	0.007	2.96E-03	-42.5	539.8		557794
		-83.33	0.007	2.96E-03	-42.5	539.8		
17	-0.50	-62.83	0.005	2.49E-03	-79.1	508.0		557794
18	-1.00	-45.33	0.004	2.06E-03	-106.1	463.1		506554
19	-1.70	-26.27	0.003	1.48E-03	-131.2	376.4		506554
20	-2.40	-8.52	0.002	1.02E-03	-143.4	279.6		506554
21	-3.20	25.13	0.001	6.80E-04	-136.7	162.1		506554
22	-4.00	62.34	0.001	5.04E-04	-101.7	60.7		506554
23	-4.50	101.73	0.001	4.65E-04	-60.7	17.7		506554
24	-5.00	141.06	0.000	4.57E-04	-0.0	0.0		---

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	1350
2	9.40	0.00	13.38	4.74	45.42	4.74	4.74a	1350
3	8.80	0.00	27.19	9.64	92.31	9.64	9.64a	1350
4	8.00	0.00	43.02	15.25	146.04	15.25	15.25a	1350
5	7.20	0.00	57.69	20.45	195.84	20.45	20.45a	1350
6	6.40	0.00	71.90	25.49	244.08	25.49	25.49a	1350
7	5.70	0.00	84.14	29.83	285.64	29.83	29.83a	1350
8	5.00	0.00	96.28	34.14	326.84	34.14	34.14a	1350
		0.00	96.28	28.19	430.65	28.19	28.19a	6750
9	4.50	4.90	101.00	29.58	451.77	29.58	34.48a	6750
10	4.00	9.81	105.70	30.95	472.76	30.95	40.76a	6750
11	3.50	14.71	110.37	32.32	493.65	32.32	47.03a	6750
12	3.00	19.61	115.02	33.68	514.45	33.68	53.29a	6750
13	2.30	26.48	121.50	35.58	543.46	35.58	62.06a	6750
14	1.60	33.34	127.96	37.47	572.35	37.47	70.81a	6750
15	0.80	41.19	135.31	39.62	605.24	39.62	80.81a	6750
16	0.00	49.03	142.65	41.77	638.03	41.77	90.80a	6750
		Total>	191.68	50.00m	334.58	134.89	134.89	18325
17	-0.50	Total>	201.65	53.78	349.55	170.52	170.52	18967
18	-1.00	Total>	211.62	58.75	364.52	203.19	203.19	19608
19	-1.70	Total>	225.56	65.69	385.47	243.54	243.54	20506
20	-2.40	Total>	239.50	72.62	406.40	277.87	277.87	21404
21	-3.20	Total>	255.41	80.53	430.32	311.35	311.35	22430
22	-4.00	Total>	271.30	88.43	454.22	348.17	348.17	93178
23	-4.50	Total>	281.24	93.36	469.15	380.59	380.59	105705
24	-5.00	Total>	291.16	98.29	484.08	412.81	412.81	108519

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	10475
11	3.50	0.00	9.00	2.64	40.26	40.26	40.26p	10475
12	3.00	0.00	18.01	5.27	80.54	80.54	80.54p	10475
13	2.30	6.86	24.46	7.16	109.41	109.41	116.28p	10475
14	1.60	13.73	30.95	9.06	138.41	138.41	152.14p	10475
15	0.80	21.57	38.40	11.24	171.75	123.73	145.30	10475
16	0.00	29.42	45.91	13.44	205.37	95.90	125.32	10475
		Total>	75.33	20.00m	218.21	218.21	218.21p	27570
17	-0.50	Total>	85.47	22.50m	233.35	233.35	233.35p	28535
18	-1.00	Total>	95.64	25.00m	248.52	248.52	248.52p	29500
19	-1.70	Total>	109.92	28.50m	269.81	269.81	269.81p	30851
20	-2.40	Total>	124.27	32.00m	291.16	286.40	286.40	32202

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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
		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	286.21	286.21
22	-4.00	Total>	157.34	40.00m	340.23	285.83	285.83
23	-4.50	Total>	167.75	42.50m	355.64	278.86	278.86
24	-5.00	Total>	178.19	45.00m	371.09	271.75	271.75

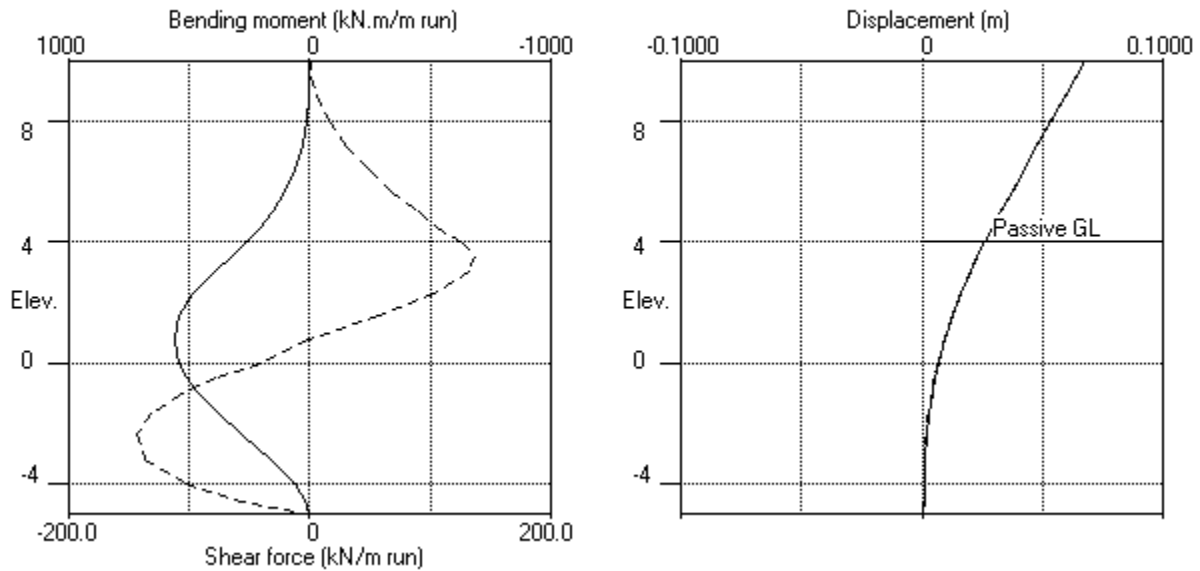
Note: 90.80a Soil pressure at active limit
 269.81p Soil pressure at passive limit

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

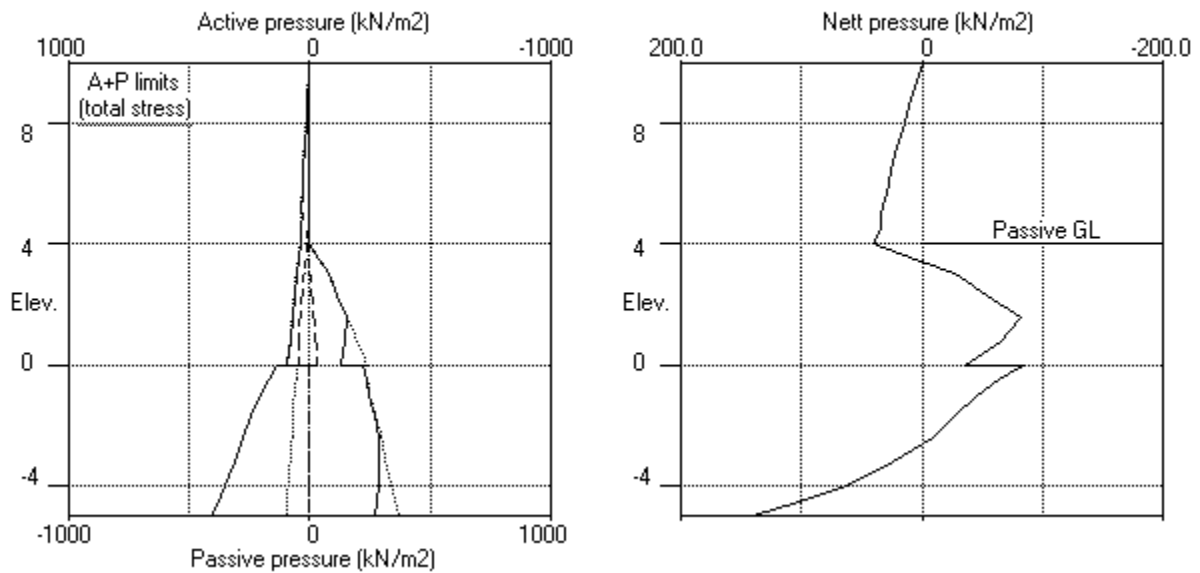
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | Checked :

Units: kN,m

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

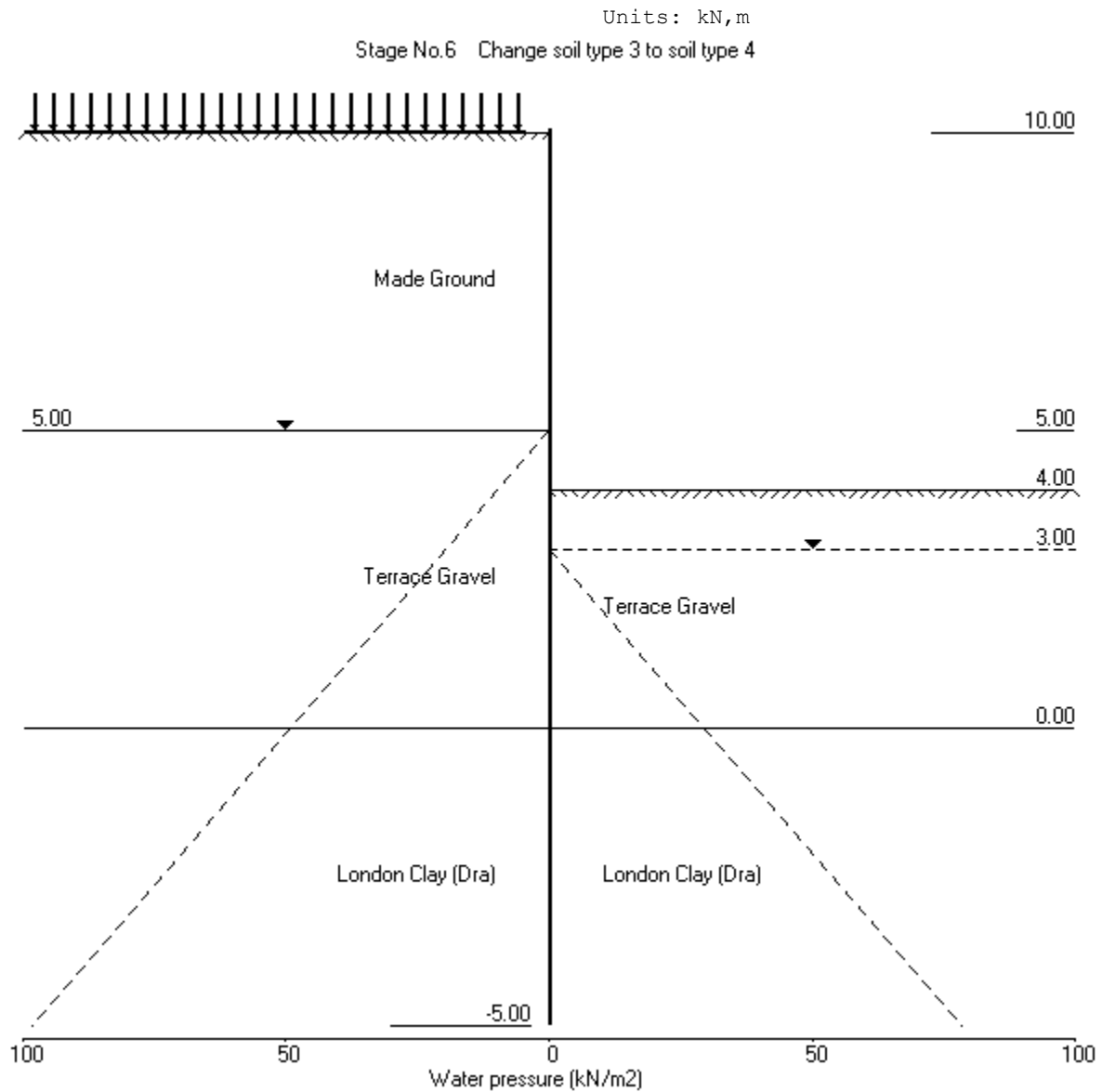


Stage No.5 Apply water pressure profile no.2 (Worst Cred.)



APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | Checked :



APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	Toe Wall
No.	Act. Pass.	Elev.	of	equilib.	elev. Penetr
		Safety at elev.		-ation	
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	0.080	7.73E-03	0.0	-0.0		557794
2	9.40	4.74	0.075	7.73E-03	1.4	0.5		557794
3	8.80	9.64	0.070	7.72E-03	5.7	2.5		557794
4	8.00	15.25	0.064	7.71E-03	15.7	10.7		557794
5	7.20	20.45	0.058	7.69E-03	30.0	28.7		557794
6	6.40	25.49	0.052	7.62E-03	48.4	59.7		557794
7	5.70	29.83	0.047	7.52E-03	67.7	100.2		557794
8	5.00	34.14	0.041	7.36E-03	90.1	155.2		557794
		28.19	0.041	7.36E-03	90.1	155.2		
9	4.50	34.48	0.038	7.20E-03	105.8	204.0		557794
10	4.00	40.76	0.034	6.99E-03	124.6	261.5		557794
11	3.50	6.77	0.031	6.73E-03	136.5	327.4		557794
12	3.00	-27.24	0.027	6.40E-03	131.4	395.0		557794
13	2.30	-54.22	0.023	5.85E-03	102.8	485.2		557794
14	1.60	-81.33	0.019	5.21E-03	55.4	543.5		557794
15	0.80	-104.39	0.015	4.41E-03	-18.9	562.9		557794
16	0.00	-70.87	0.012	3.64E-03	-89.0	514.3		557794
		-43.78	0.012	3.64E-03	-89.0	514.3		
17	-0.50	-39.01	0.010	3.20E-03	-109.7	465.2		557794
18	-1.00	-20.48	0.009	2.81E-03	-124.6	407.9		506554
19	-1.70	0.67	0.007	2.31E-03	-131.5	314.3		506554
20	-2.40	16.60	0.006	1.94E-03	-125.5	223.5		506554
21	-3.20	30.03	0.004	1.66E-03	-106.8	125.6		506554
22	-4.00	47.72	0.003	1.53E-03	-75.7	46.9		506554
23	-4.50	68.55	0.002	1.50E-03	-46.6	14.0		506554
24	-5.00	118.01	0.001	1.49E-03	-0.0	0.0		---

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	5294
9	4.50	4.90	101.00	29.58	451.77	29.58	34.48a	5294
10	4.00	9.81	105.70	30.95	472.76	30.95	40.76a	5294
11	3.50	14.71	110.37	32.32	493.65	32.32	47.03a	5294
12	3.00	19.61	115.02	33.68	514.45	33.68	53.29a	5294
13	2.30	26.48	121.50	35.58	543.46	35.58	62.06a	5294
14	1.60	33.34	127.96	37.47	572.35	37.47	70.81a	5294
15	0.80	41.19	135.31	39.62	605.24	39.62	80.81a	5294
16	0.00	49.03	142.65	41.77	638.03	41.77	90.80a	5294
		49.03	142.65	60.43	323.25	60.43	109.46a	7653
17	-0.50	53.94	147.72	63.05	333.70	75.98	129.92	7920
18	-1.00	58.84	152.78	65.67	344.14	105.36	164.20	8188
19	-1.70	65.70	159.86	69.32	358.73	141.81	207.52	8563
20	-2.40	72.57	166.93	72.98	373.30	173.18	245.75	8938
21	-3.20	80.41	174.99	77.14	389.93	204.43	284.84	9367
22	-4.00	88.26	183.05	81.30	406.53	240.12	328.38	9795
23	-4.50	93.16	188.07	83.90	416.90	272.30	365.46	10063
24	-5.00	98.07	193.10	86.50	427.26	304.57	402.64	10331

Node no.	Y coord	----- PASSIVE 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
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	6643
11	3.50	0.00	9.00	2.64	40.26	40.26	40.26p	6643
12	3.00	0.00	18.01	5.27	80.54	80.54	80.54p	6643
13	2.30	6.86	24.46	7.16	109.41	109.41	116.28p	6643
14	1.60	13.73	30.95	9.06	138.41	138.41	152.14p	6643
15	0.80	21.57	38.40	11.24	171.75	163.62	185.20	6643
16	0.00	29.42	45.91	13.44	205.37	132.25	161.67	6643
		29.42	45.91	10.45	123.82	123.82	153.24p	9688
17	-0.50	34.32	51.15	13.15	134.61	134.61	168.93p	10027
18	-1.00	39.23	56.41	15.87	145.46	145.46	184.69p	10366
19	-1.70	46.09	63.83	19.70	160.76	160.76	206.85p	10840

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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	11315
21	-3.20	60.80	79.96	28.04	194.01	194.01	254.81p	11858
22	-4.00	68.65	88.69	32.55	212.02	212.02	280.66p	12400
23	-4.50	73.55	94.20	35.40	223.36	223.36	296.91p	12739
24	-5.00	78.45	99.74	38.26	234.78	206.17	284.63	13078

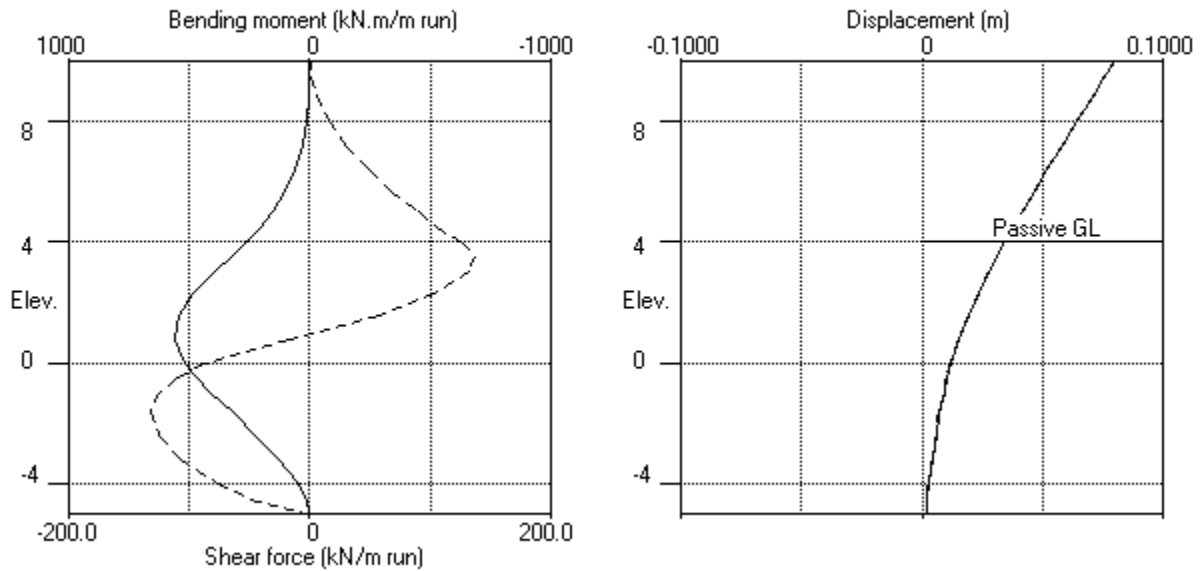
Note: 109.46a Soil pressure at active limit
 296.91p Soil pressure at passive limit

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

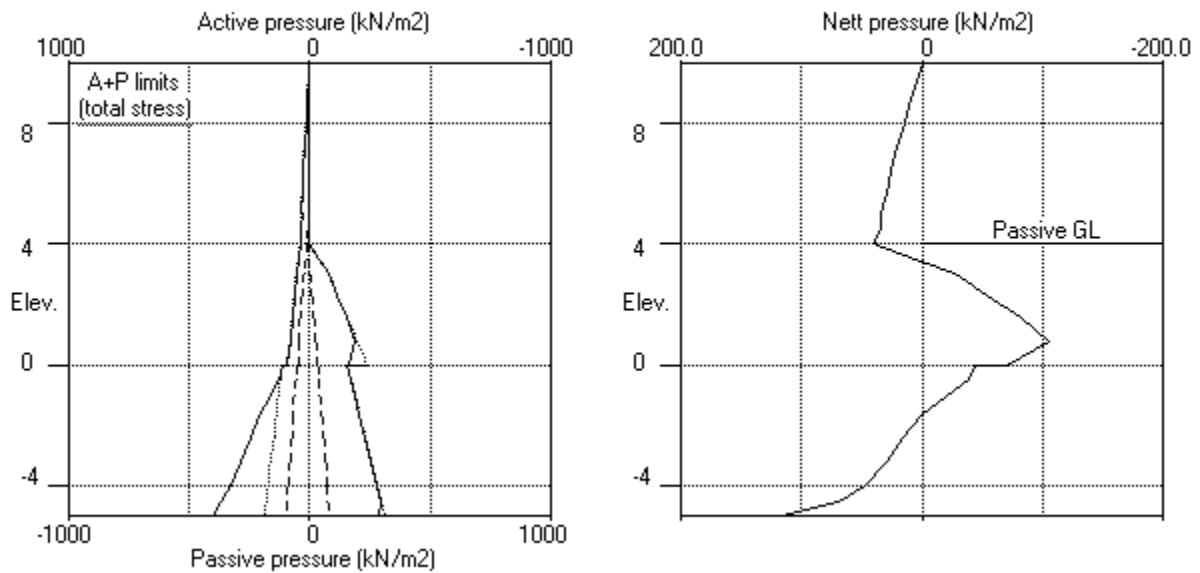
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
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Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | Checked :

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: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
 D900-16 / 25H | 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: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | 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	0.080	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	-1.5	30.0	0.0
6	6.40	0.052	0.000	59.7	-0.5	48.4	0.0
7	5.70	0.047	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	0.027	0.000	395.0	-0.0	131.4	-0.2
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	-22.6
15	0.80	0.015	0.000	562.9	-0.0	0.0	-50.6
16	0.00	0.012	0.000	539.8	-0.0	0.0	-89.0
17	-0.50	0.010	0.000	508.0	-0.0	0.0	-109.7
18	-1.00	0.009	0.000	463.1	0.0	0.0	-124.6
19	-1.70	0.007	0.000	376.4	0.0	0.0	-131.5
20	-2.40	0.006	0.000	279.6	0.0	0.0	-143.4
21	-3.20	0.004	0.000	162.1	0.0	0.0	-136.7
22	-4.00	0.003	0.000	60.7	0.0	0.0	-101.7
23	-4.50	0.002	-0.000	17.7	0.0	0.0	-60.7
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	9.5	3.00	-1.5	7.20	5.8	5.00	-1.6	0.80
3	388.6	2.30	0.0	10.00	110.9	4.00	-86.0	-1.70
4	500.4	1.60	-0.0	10.00	128.3	3.50	-119.2	-2.40
5	562.9	0.80	-0.0	10.00	136.5	3.50	-143.4	-2.40
6	562.9	0.80	-0.0	10.00	136.5	3.50	-131.5	-1.70

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Run ID. Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | Checked :

Summary of results (continued)

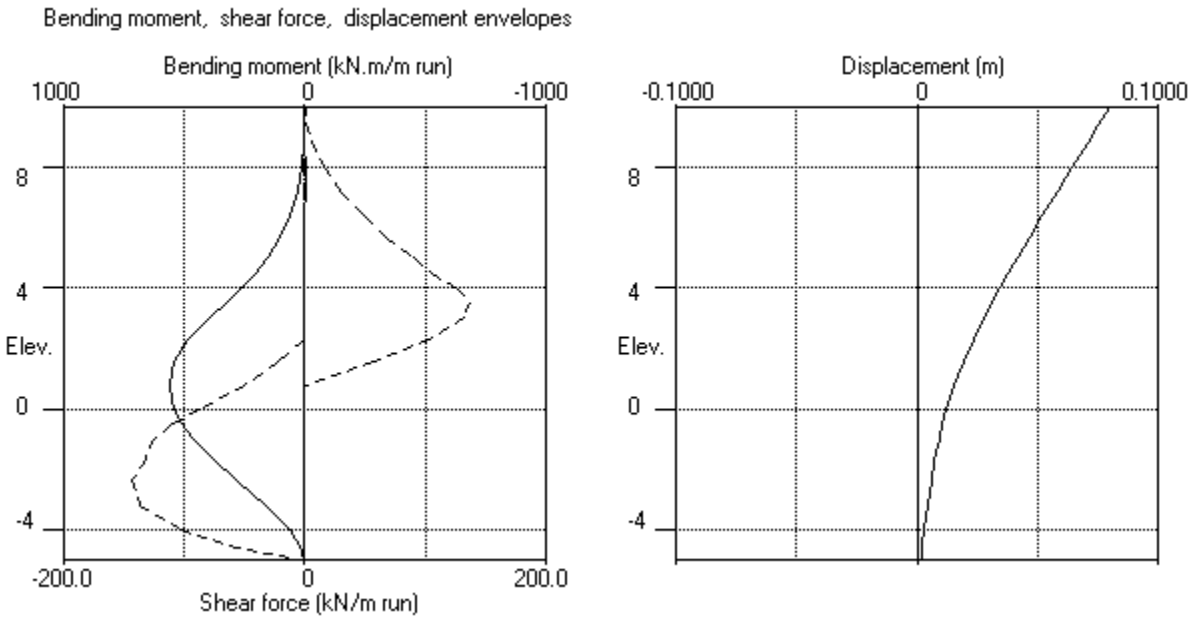
Maximum and minimum displacement at each stage

Stage	no.	maximum m	elev.	Displacement minimum m	elev.	Stage description
1	0.000	2.30	-0.000	-5.00	Change EI of wall to 557794kN.m2/m run	
2	0.001	10.00	0.000	10.00	Apply surcharge no.1 at elev. 10.00	
3	0.039	10.00	0.000	10.00	Excav. to elev. 4.50 on PASSIVE side	
4	0.056	10.00	0.000	10.00	Excav. to elev. 4.00 on PASSIVE side	
5	0.068	10.00	0.000	10.00	Apply water pressure profile no.2	
6	0.080	10.00	0.000	10.00	Change soil type 3 to soil type 4	

APPENDIX A-4. WALLAP run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD LT ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: Tube-Hat_D900-16-25H_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Combi-Giro Wall System (Tube/Hat Pattern A) | Date: 3-06-2015
D900-16 / 25H | Checked :

Units: kN,m



APPENDIX B

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

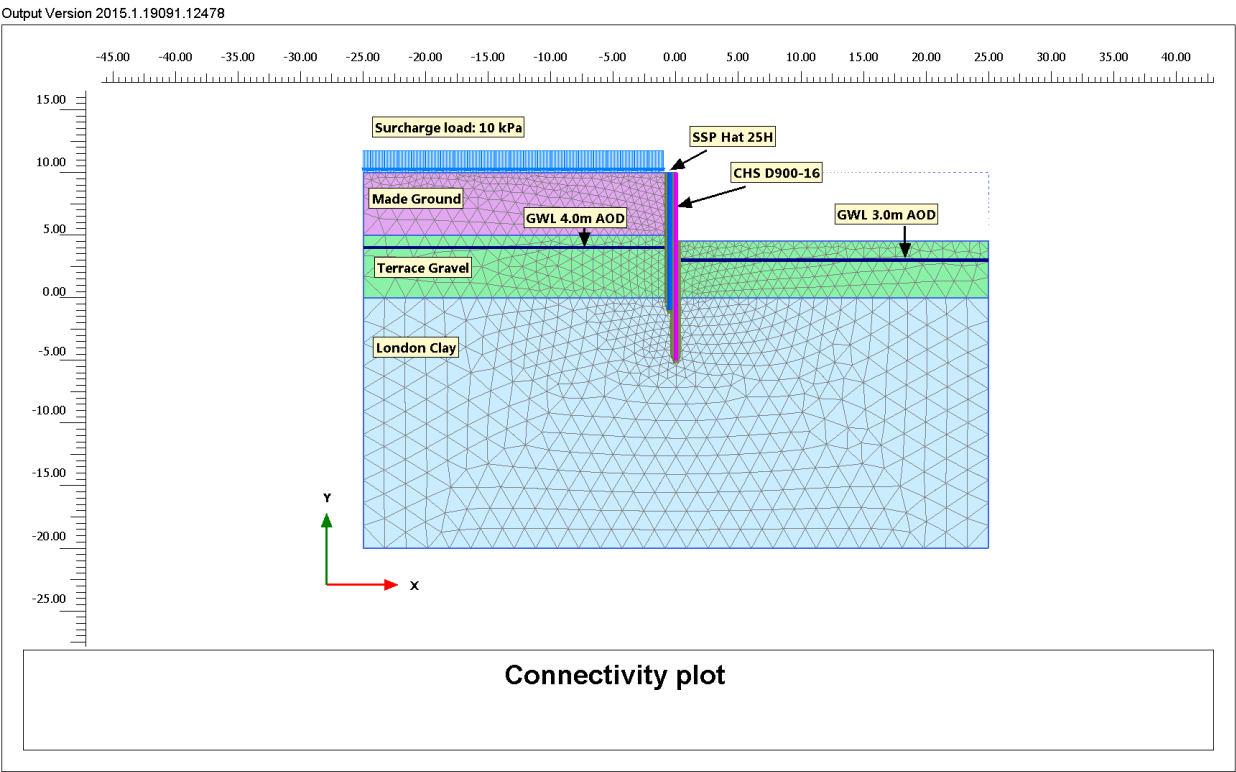


Figure B.1 Connectivity plot

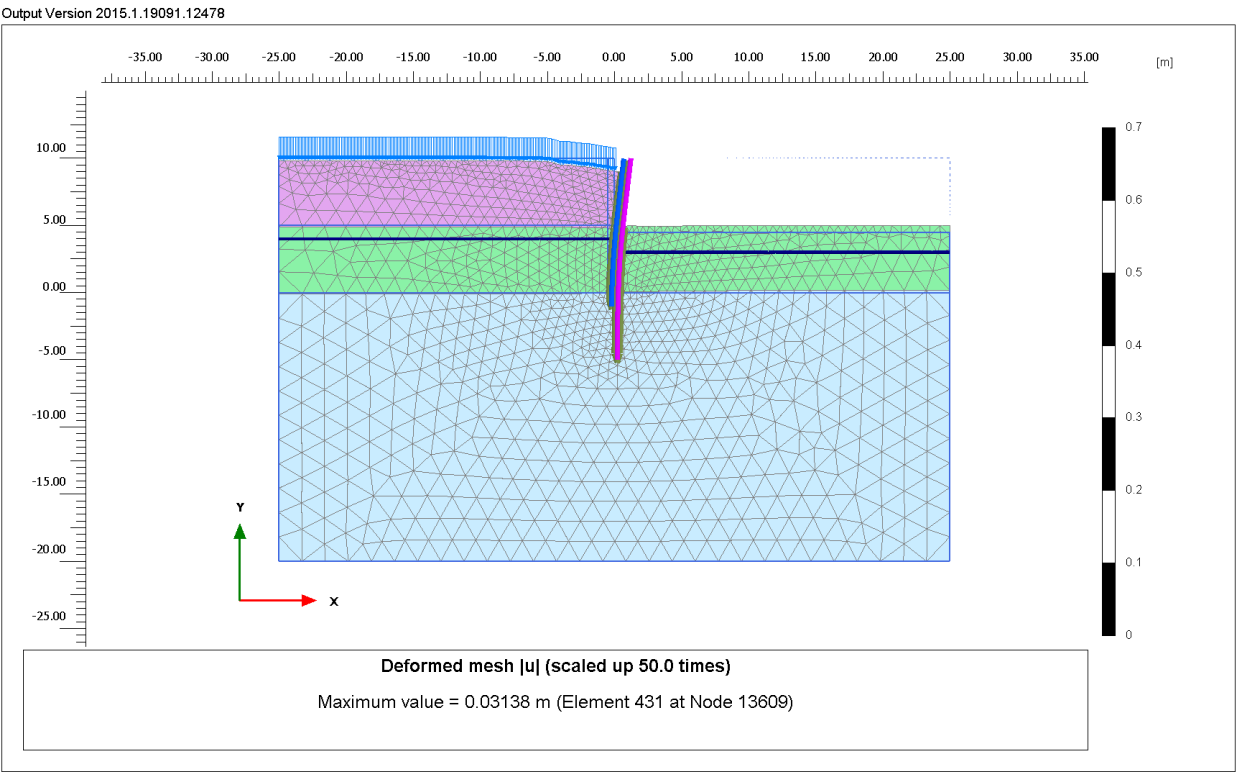


Figure B.2 Deformed mesh |u|

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

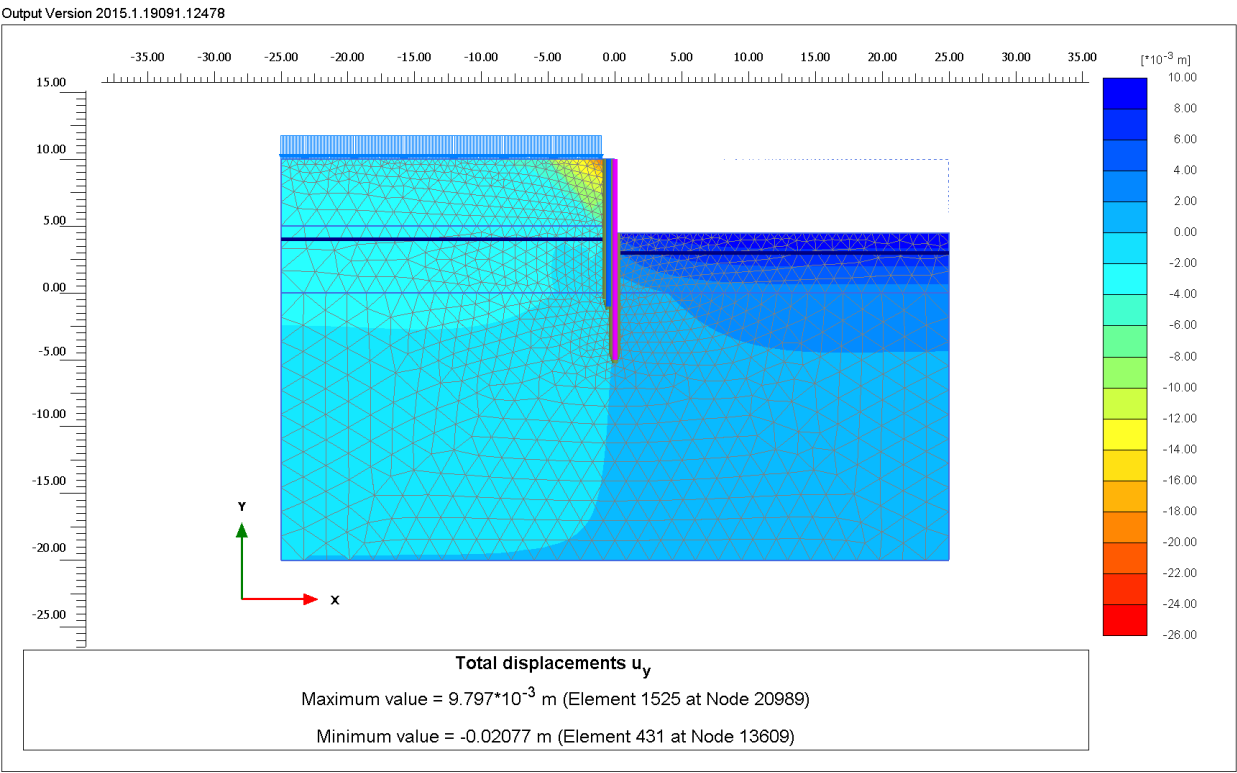


Figure B.3 Total vertical displacements

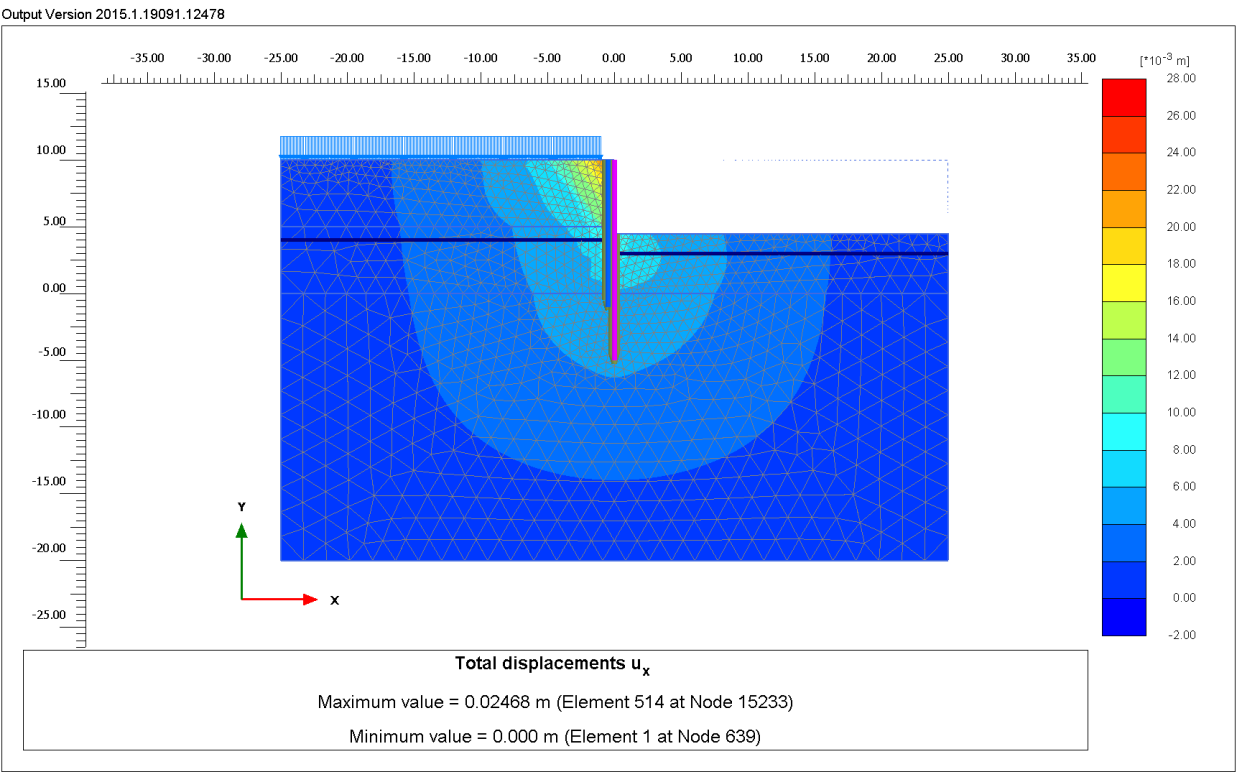


Figure B.4 Total horizontal displacements

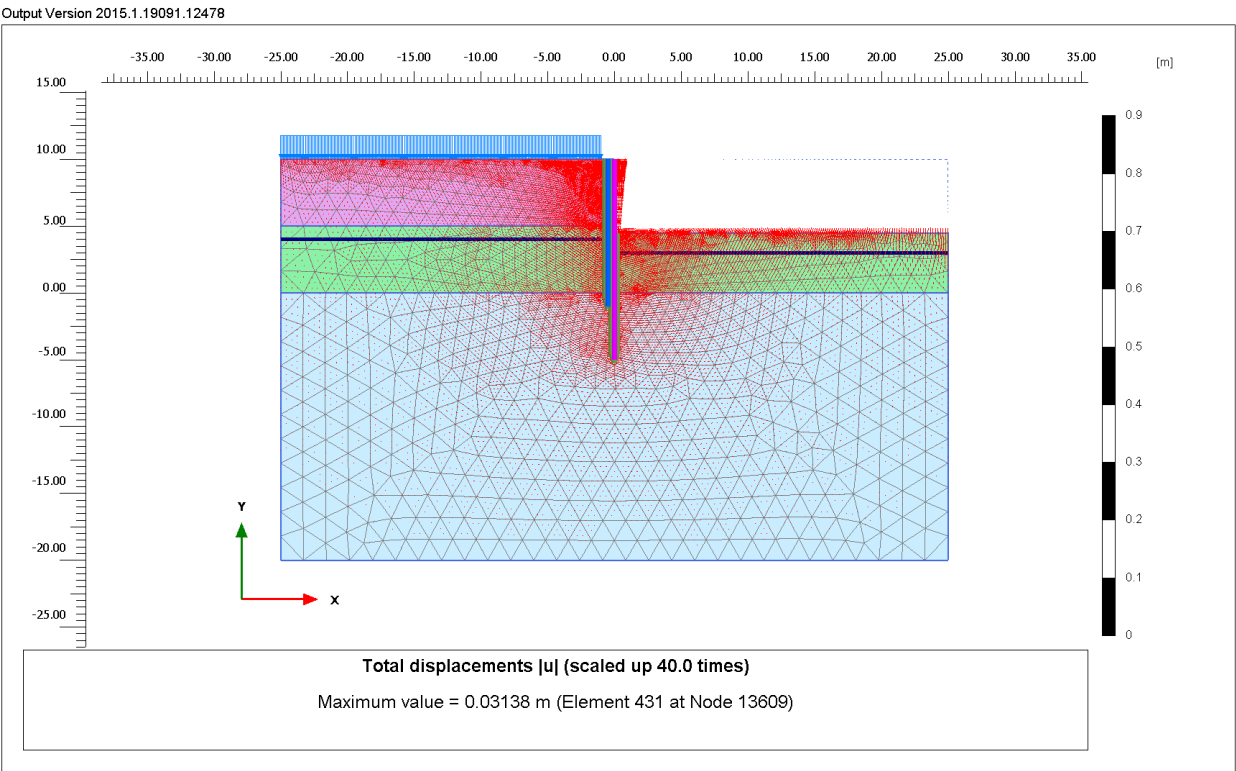


Figure B.5 Vector of total displacements

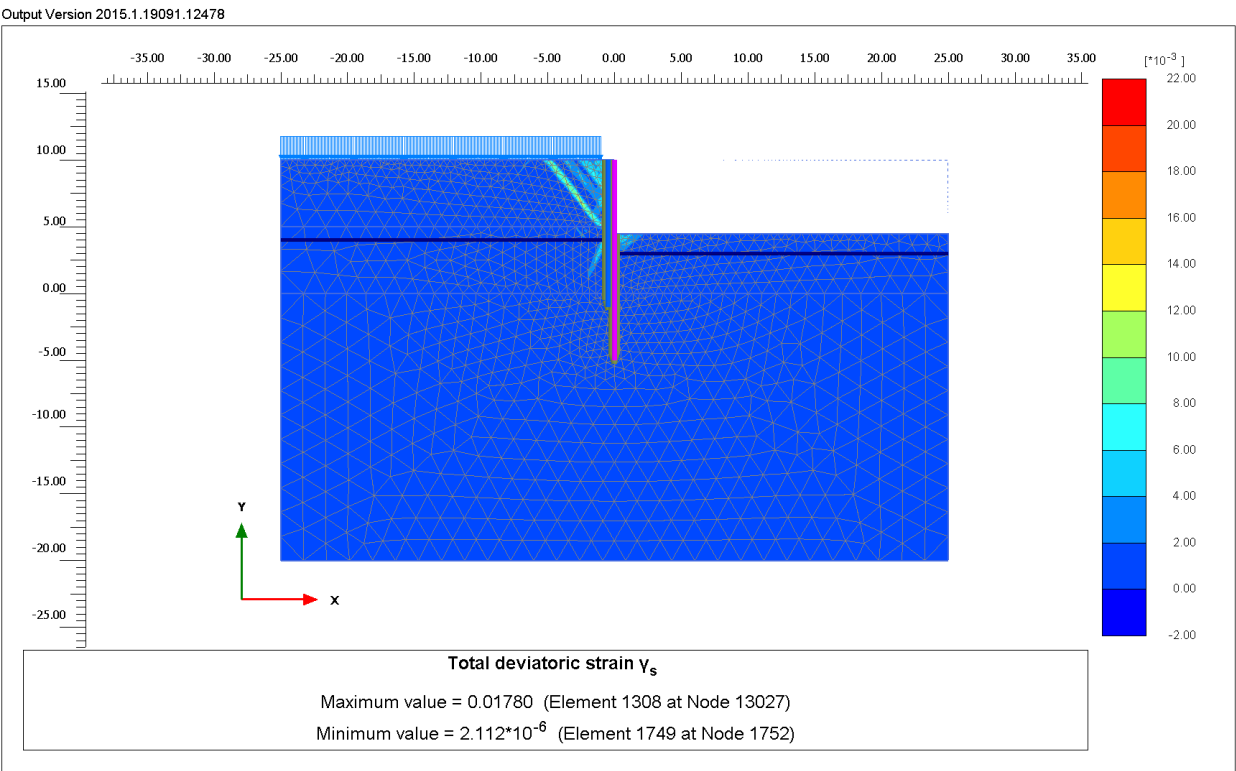


Figure B.6 Total shear strain, γ_s

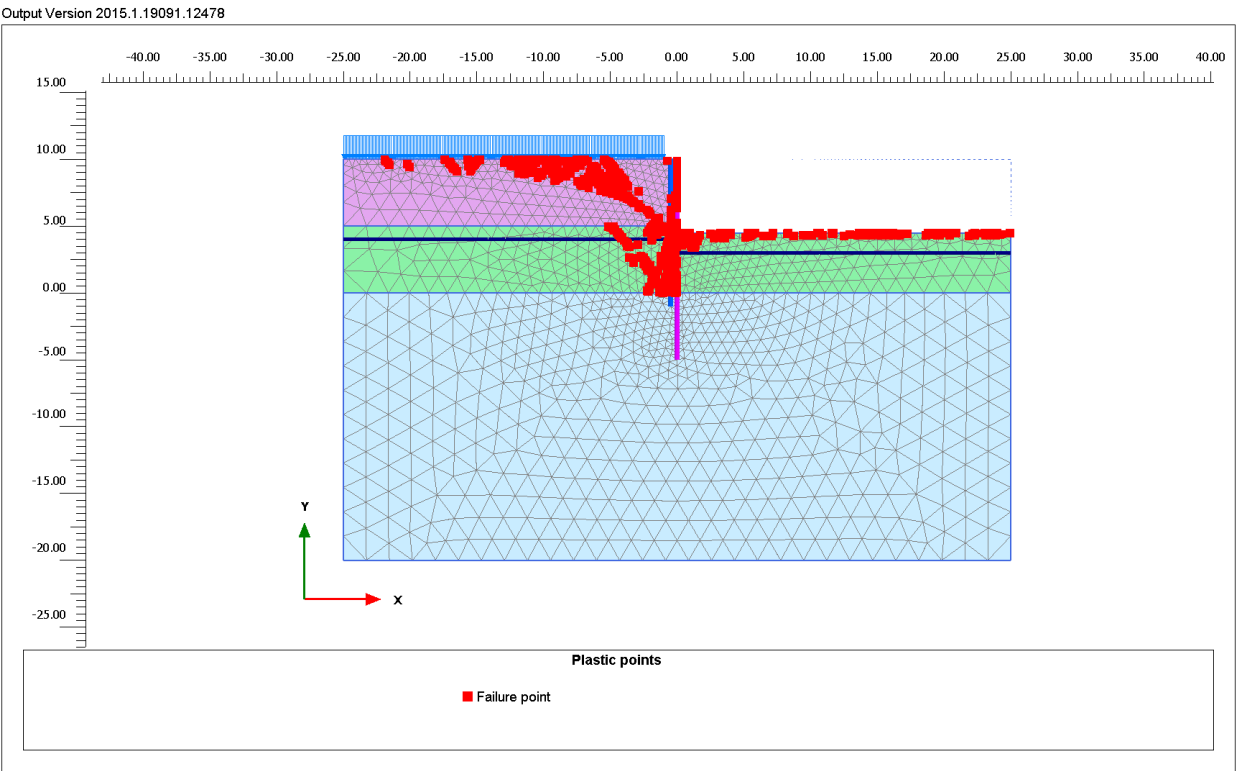


Figure B.7 Distribution of plastic points

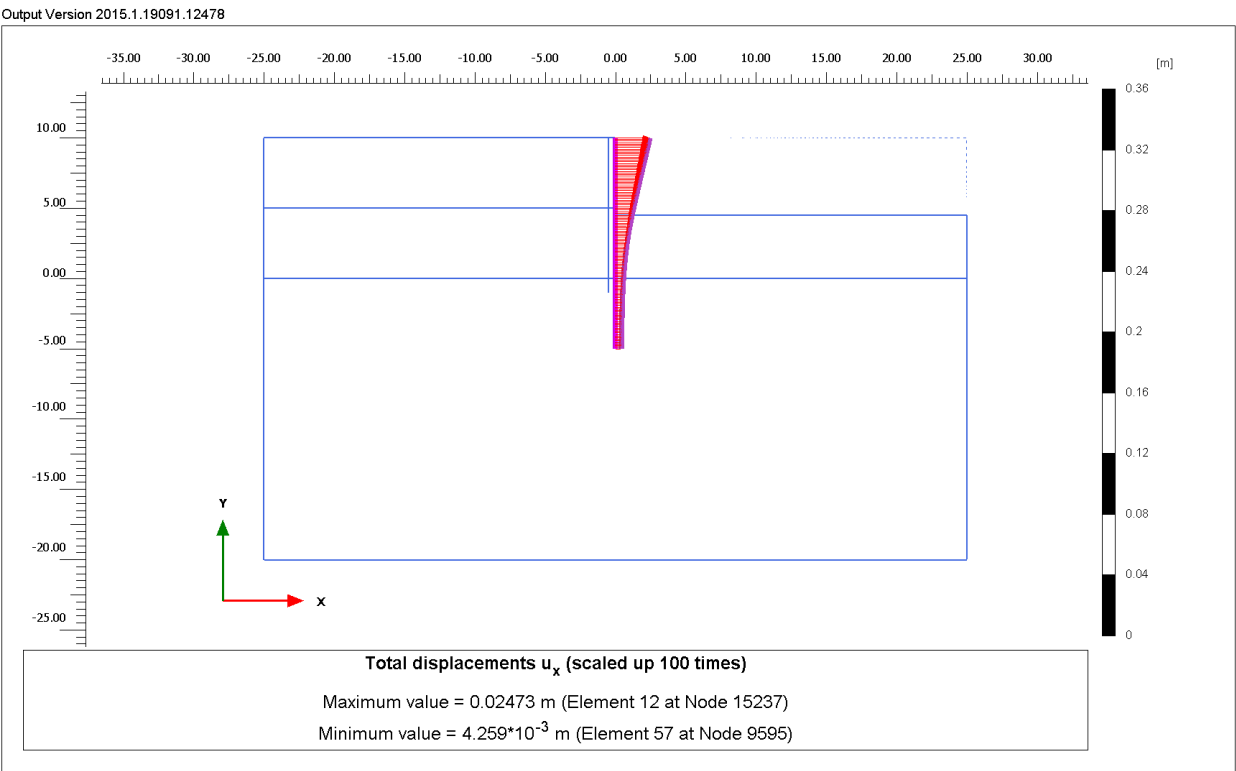


Figure B.8 Profile of horizontal wall displacements for CHS D900-16

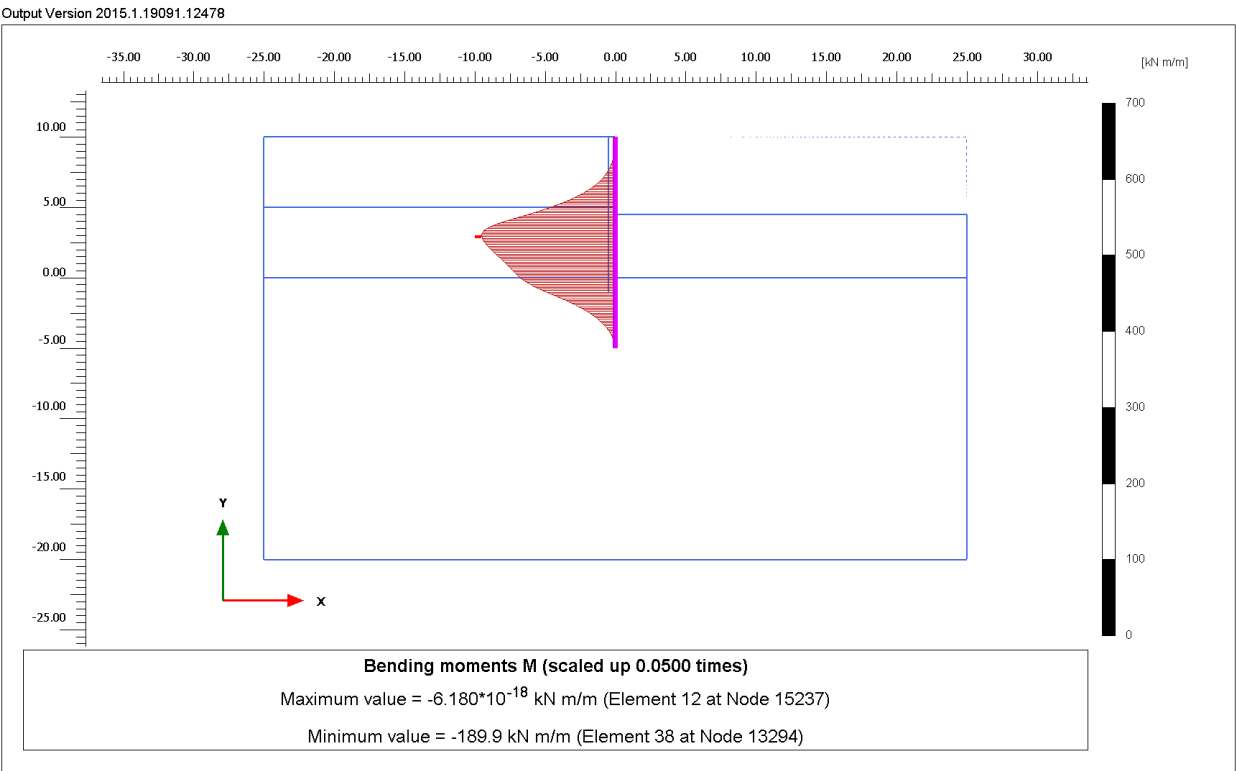


Figure B.9 Profile of wall bending moment for CHS D900-16

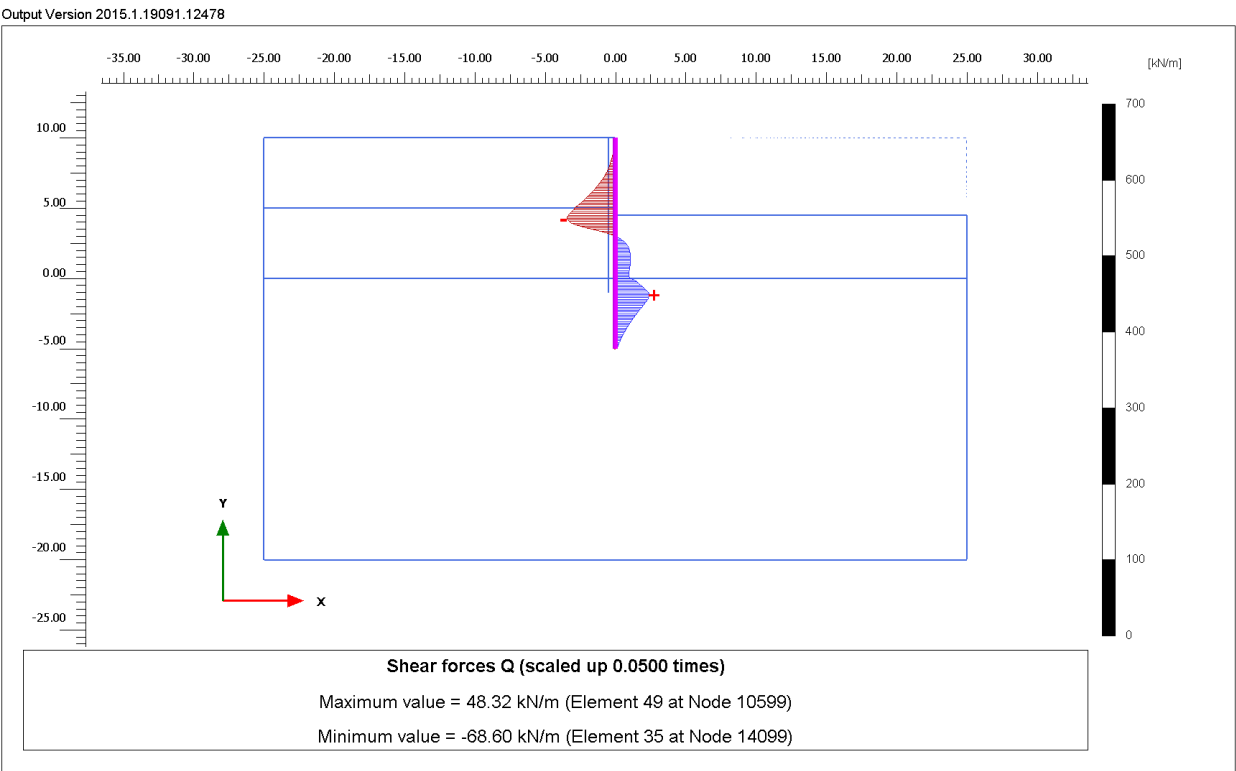


Figure B.10 Profile of wall shear force for CHS D900-16

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

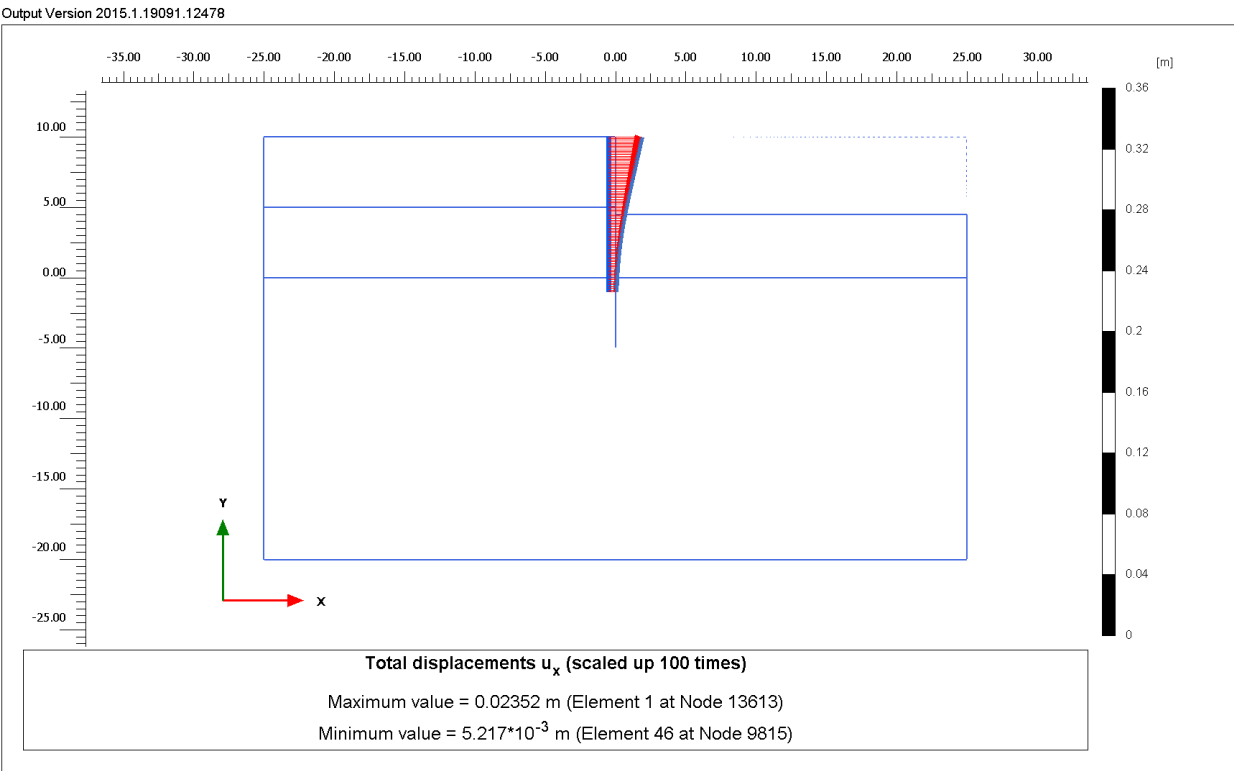


Figure B.11 Profile of horizontal wall displacements for Hat SSP 25H

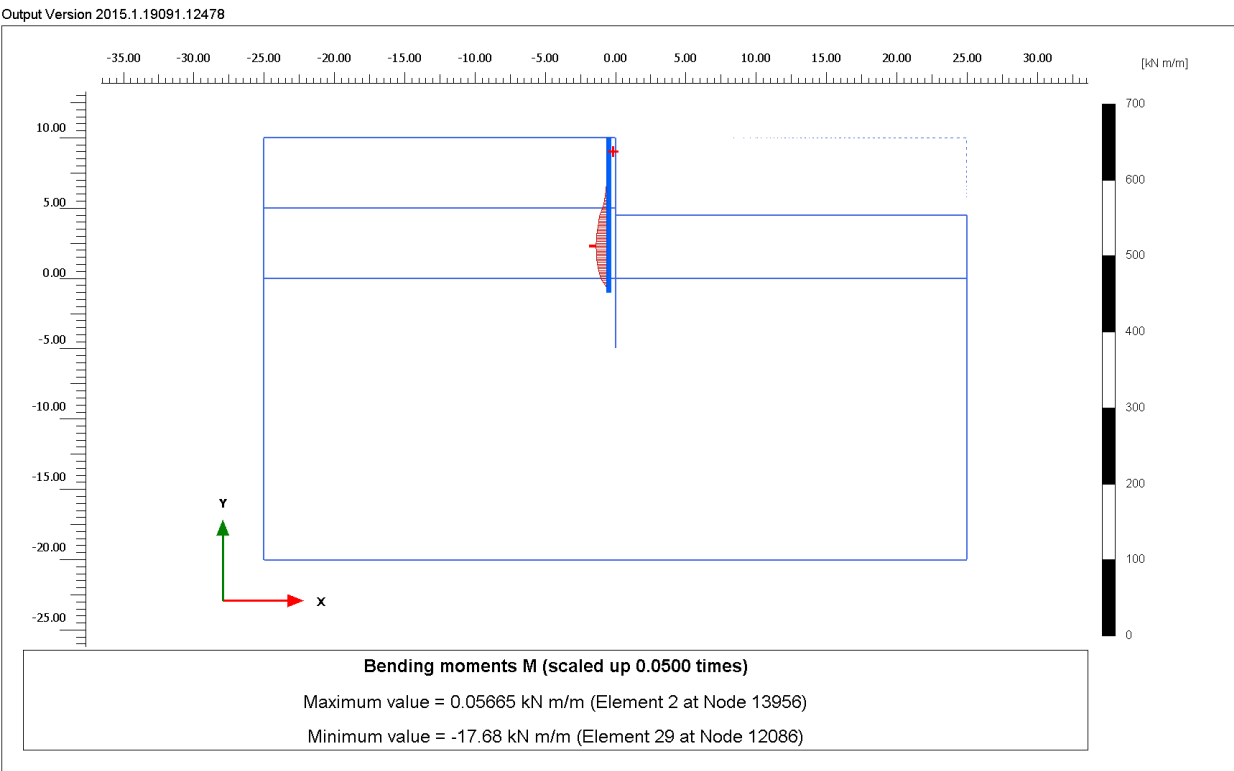


Figure B.12 Profile of wall bending moment for Hat SSP 25H

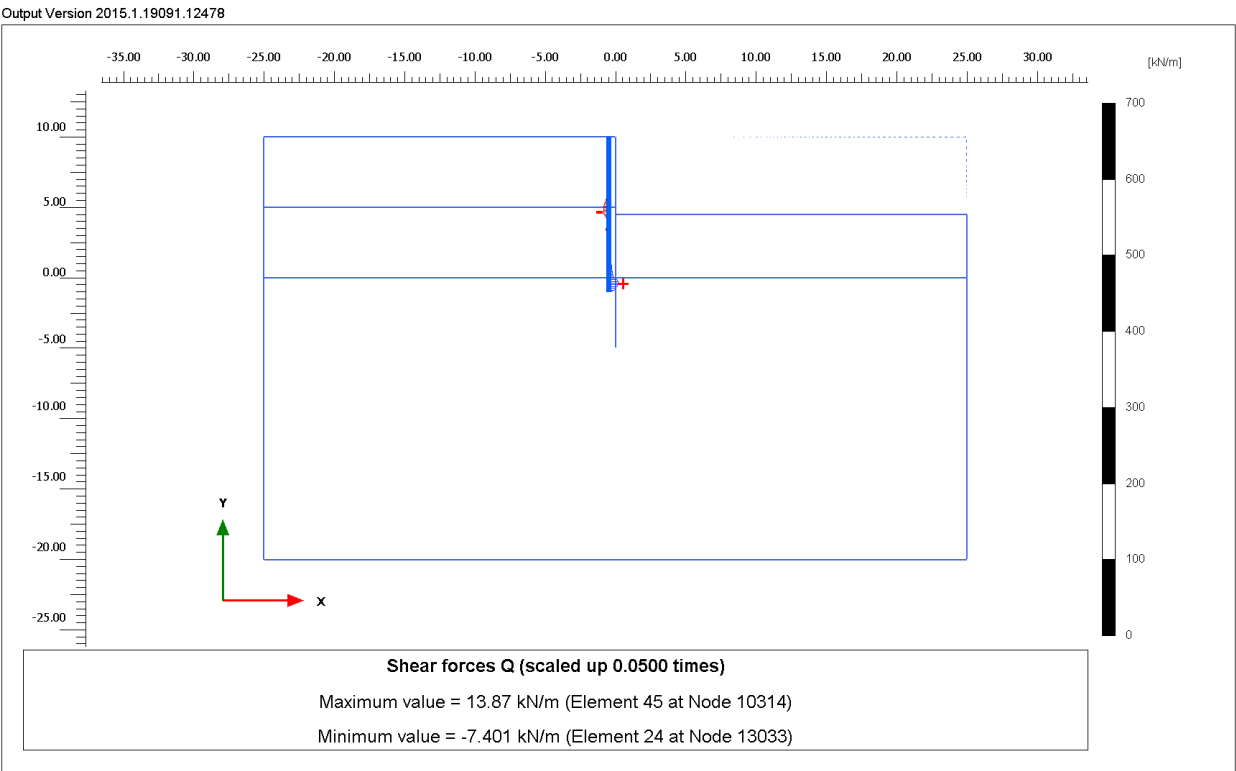


Figure B.13 Profile of wall shear force for Hat SSP 25H

APPENDIX C

APPENDIX C-1. Design Summary of SPW (Dia.900mm_1250mmCC).docx

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	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	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, $0.7EI$ (kNm ² /m)
Hard (male pile) C30/37, 900mm dia.	28	15.0	10.0	-5.0	Cantilever	1.25	57256	$25.77 \cdot 10^{-3}$	504994

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: 307 kNm/m @ 2.30m AOD - Design $BM_d = BM_c \cdot \gamma_G = 307 \cdot 1.35 = 414$ 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: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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

Soil type	density	Bulk Modulus	Young's	At rest	Consol	Active	Passive	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	Wall	Back-	Soil	Wall	Back-
friction	adhesion	fill	friction	adhesion	fill	
angle	coeff.	angle	angle	coeff.	angle	
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 elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m
	1	4.00	4.00	0.0	1	3.00	3.00
	2	5.00	5.00	0.0	1	3.00	3.00

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 = 0.025765 m4/m run
E.I = 504994 kN.m2/m run
Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	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

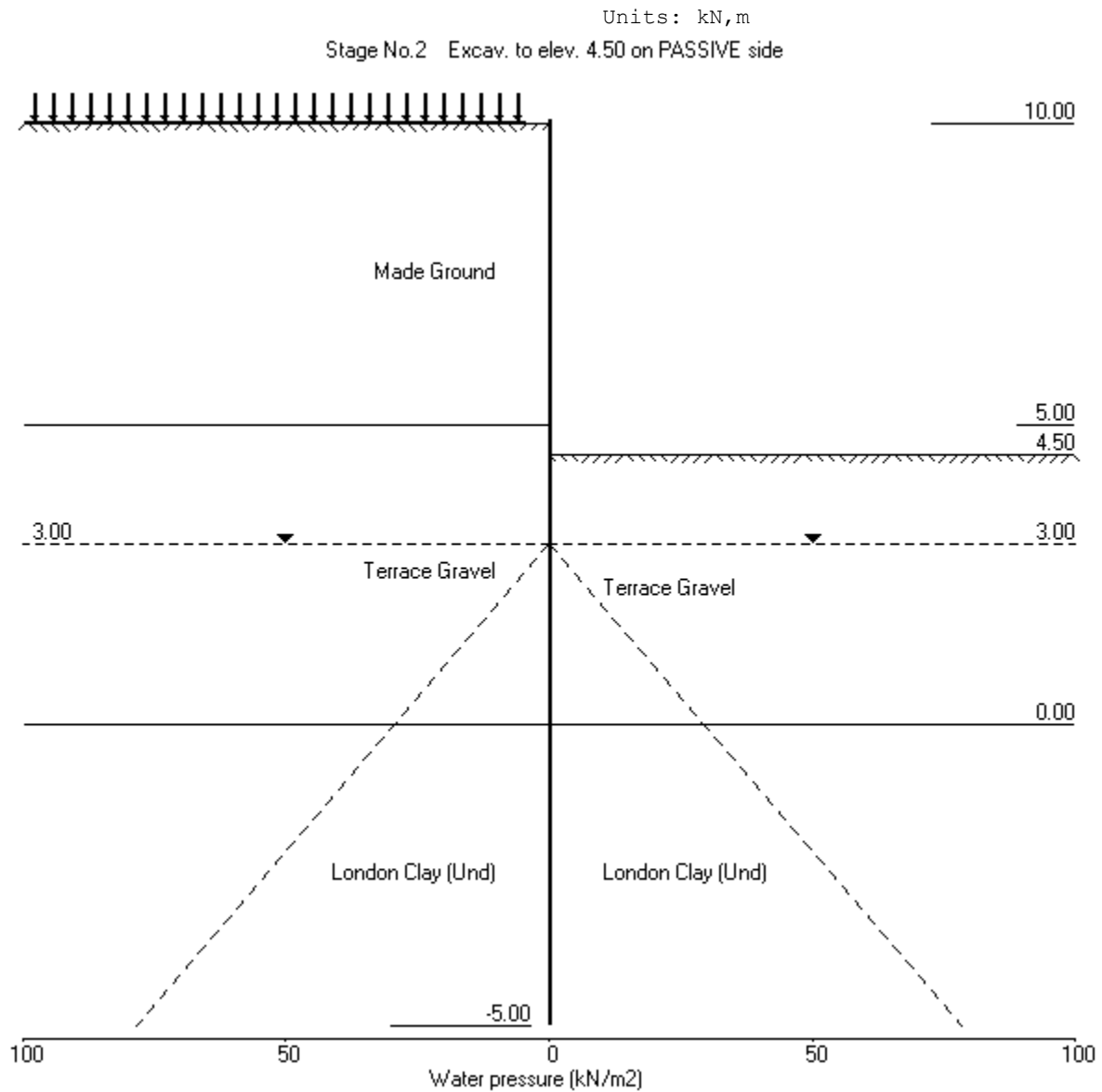
OUTPUT OPTIONS

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

Program WALLAP - Copyright (C) 2013 by DL Borin, distributed by GEOSOLVE
69 Rodenhurst Road, London SW4, UK. Tel: +44 20 8674 7251

APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :



APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm 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 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	0.024	2.89E-03	0.0	-0.0	
2	9.40	3.45	0.023	2.89E-03	1.0	0.4	
3	8.80	7.00	0.021	2.88E-03	4.2	1.8	
4	8.00	11.18	0.018	2.88E-03	11.4	7.8	
5	7.20	15.12	0.016	2.85E-03	22.0	20.9	
6	6.40	18.96	0.014	2.80E-03	35.6	43.7	
7	5.70	22.29	0.012	2.72E-03	50.0	73.6	
8	5.00	30.04	0.010	2.59E-03	68.4	115.9	
		20.40	0.010	2.59E-03	68.4	115.9	
9	4.50	22.38	0.009	2.46E-03	79.0	152.7	
10	4.00	-40.90	0.008	2.29E-03	74.4	192.4	
11	3.50	-61.75	0.007	2.08E-03	48.8	226.8	
12	3.00	-51.43	0.006	1.85E-03	20.5	243.4	
13	2.30	-38.19	0.004	1.51E-03	-10.9	245.0	
14	1.60	-24.99	0.003	1.18E-03	-33.0	230.1	
15	0.80	-8.54	0.003	8.46E-04	-46.4	195.7	
16	0.00	2.81	0.002	5.67E-04	-48.7	155.8	
		-10.13	0.002	5.67E-04	-48.7	155.8	
17	-0.80	4.10	0.002	3.54E-04	-51.1	113.6	
18	-1.60	11.76	0.001	2.05E-04	-44.8	73.9	
19	-2.40	14.62	0.001	1.14E-04	-34.2	41.8	
20	-3.20	14.51	0.001	6.60E-05	-22.6	19.0	
21	-4.00	12.91	0.001	4.65E-05	-11.6	5.5	
22	-4.50	11.63	0.001	4.32E-05	-5.5	1.3	
23	-5.00	10.34	0.001	4.25E-05	0.0	-0.0	

APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	1615
2	9.40	0.00	12.65	3.45	63.56	3.45	3.45a	1615
3	8.80	0.00	25.63	7.00	128.80	7.00	7.00a	1615
4	8.00	0.00	40.94	11.18	205.76	11.18	11.18a	1615
5	7.20	0.00	55.36	15.12	278.26	15.12	15.12a	1615
6	6.40	0.00	69.43	18.96	348.97	18.96	18.96a	1615
7	5.70	0.00	81.60	22.29	410.11	22.29	22.29a	1615
8	5.00	0.00	93.68	25.59	470.84	30.04	30.04	1615
		0.00	93.68	20.40	679.14	20.40	20.40a	8075
9	4.50	0.00	102.77	22.38	745.08	22.38	22.38a	8075
10	4.00	0.00	111.85	24.35	810.87	24.35	24.35a	8075
11	3.50	0.00	120.90	26.33	876.52	26.33	26.33a	8075
12	3.00	0.00	129.95	28.29	942.07	28.29	28.29a	8075
13	2.30	6.86	136.42	29.70	989.00	29.70	36.57a	8075
14	1.60	13.73	142.87	31.11	1035.79	34.00	47.73	8075
15	0.80	21.57	150.23	32.71	1089.11	43.65	65.23	8075
16	0.00	29.42	157.56	34.31	1142.30	51.31	80.73	8075
		Total>	186.98	50.00m	387.00	216.94	216.94	21590
17	-0.80	Total>	202.95	54.00m	414.17	242.77	242.77	22799
18	-1.60	Total>	218.90	58.00m	441.32	266.00	266.00	24008
19	-2.40	Total>	234.84	62.00m	468.47	287.35	287.35	25217
20	-3.20	Total>	250.77	66.00m	495.60	307.55	307.55	26426
21	-4.00	Total>	266.70	70.00m	522.72	327.18	327.18	27635
22	-4.50	Total>	276.64	72.50m	539.67	339.36	339.36	28390
23	-5.00	Total>	286.59	75.00m	556.62	351.54	351.54	29146

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	12608
10	4.00	0.00	9.00	1.96	65.25	65.25	65.25p	12608
11	3.50	0.00	18.00	3.92	130.53	88.08	88.08	12608
12	3.00	0.00	27.02	5.88	195.86	79.73	79.73	12608
13	2.30	6.86	33.49	7.29	242.78	67.89	74.75	12608
14	1.60	13.73	39.99	8.71	289.91	58.99	72.72	12608
15	0.80	21.57	47.47	10.34	344.13	52.20	73.77	12608
16	0.00	29.42	55.01	11.98	398.80	48.51	77.93	12608
		Total>	84.43	22.50m	284.45	227.08	227.08	32910
17	-0.80	Total>	100.68	26.50m	311.91	238.66	238.66	34753
18	-1.60	Total>	117.02	30.50m	339.44	254.24	254.24	36596
19	-2.40	Total>	133.43	34.50m	367.05	272.73	272.73	38439
20	-3.20	Total>	149.93	38.50m	394.75	293.04	293.04	40282
21	-4.00	Total>	166.51	42.50m	422.53	314.28	314.28	42125

APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm 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	327.73	43277
23	-5.00	Total>	187.34	47.50m	457.37	341.20	44429

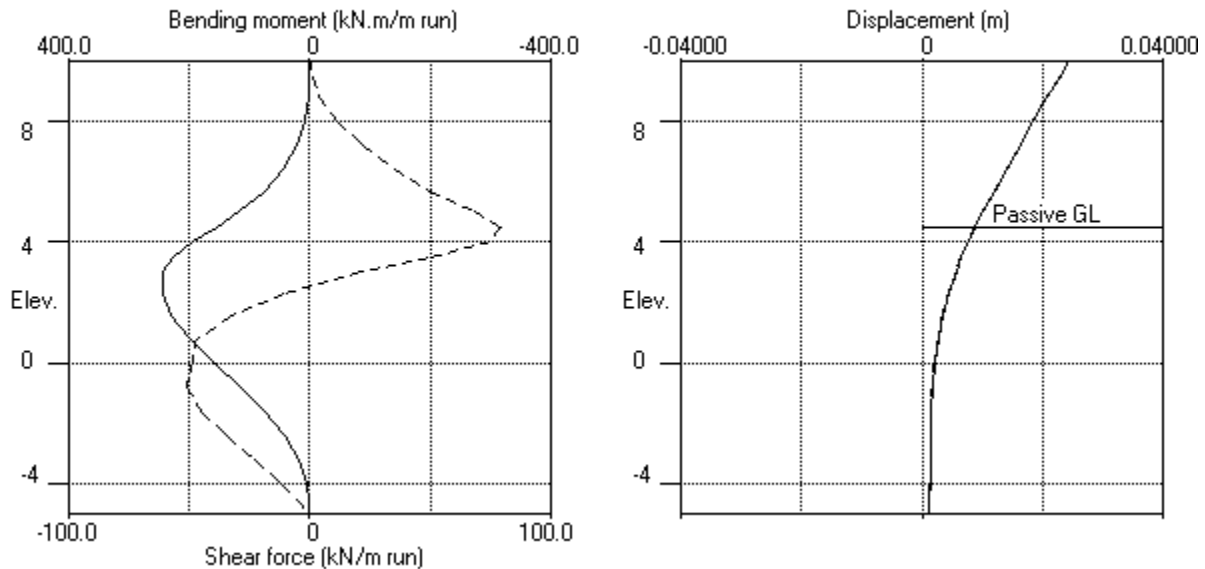
Note: 36.57a Soil pressure at active limit
 65.25p Soil pressure at passive limit

APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

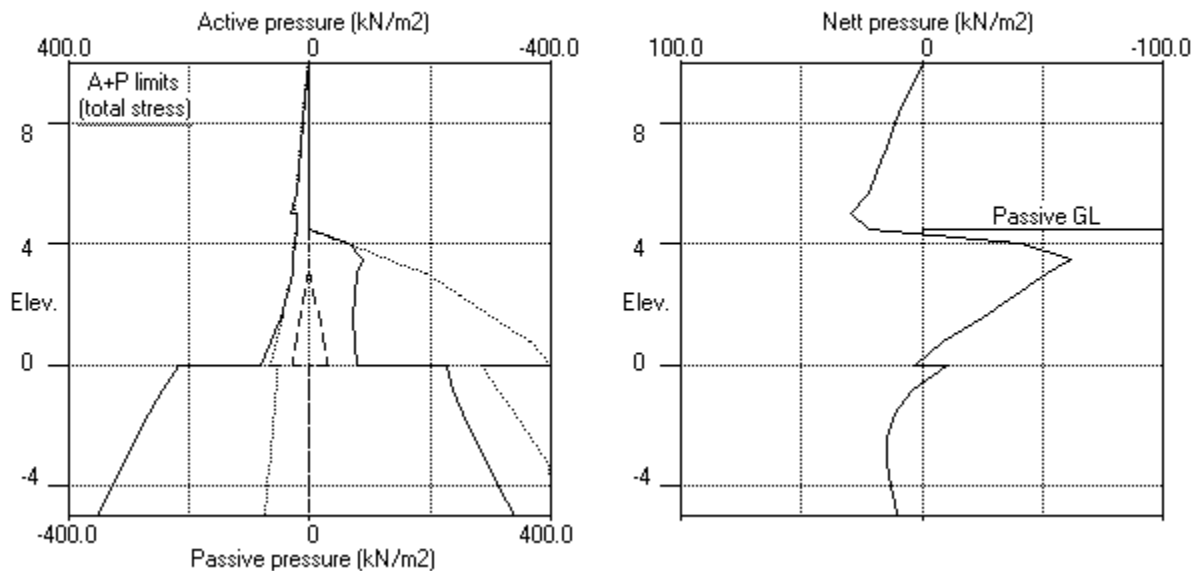
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :

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

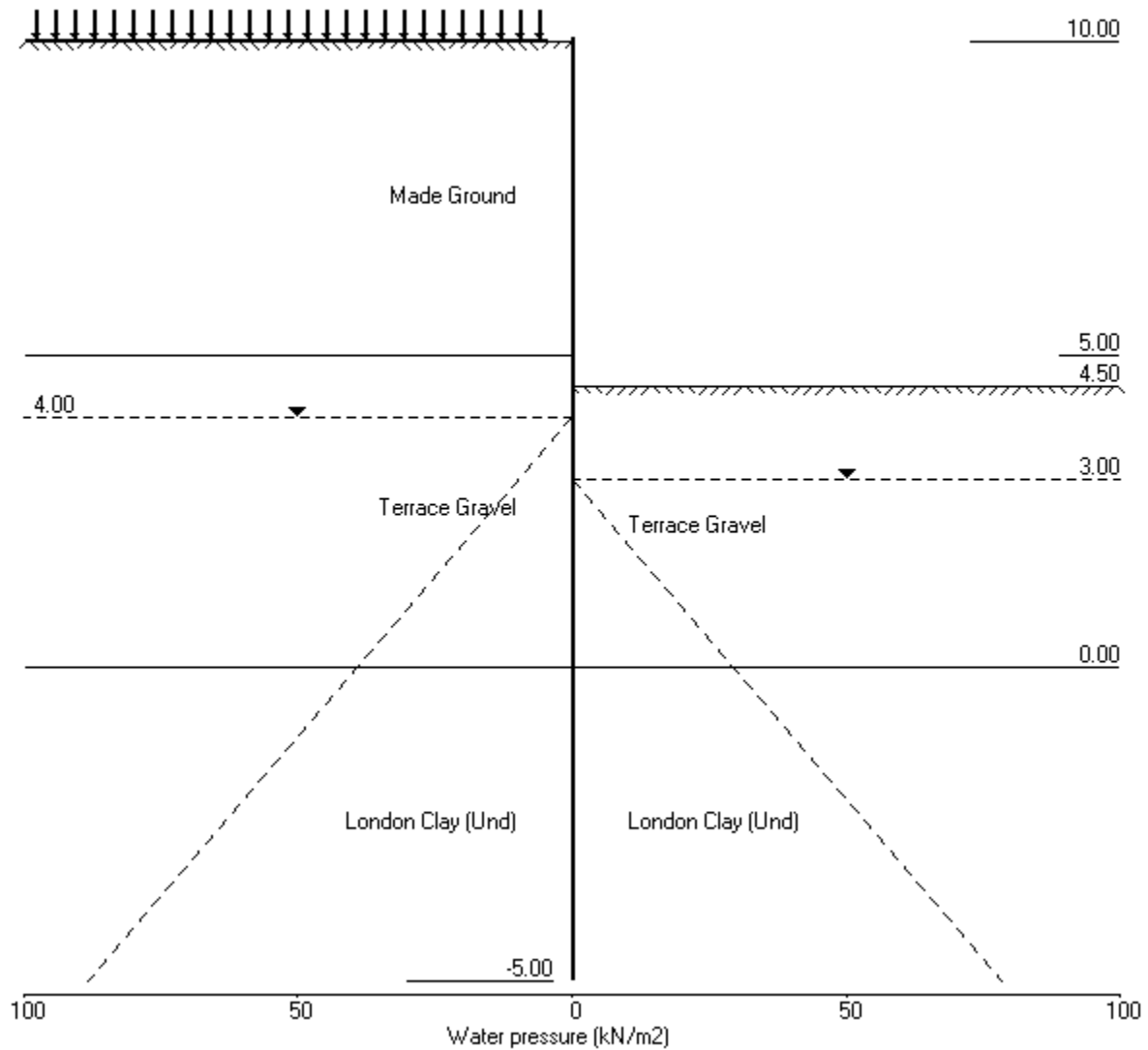


APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :

Units: kN,m

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



APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm 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		Toe	Wall
No.	Act. Pass.	Elev.	of	equilib.		elev.	Penetr
			Safety	at elev.		-ation	
3	10.00 4.50	Cant.	1.890	-3.68		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	0.026	2.99E-03	0.0	-0.0	
2	9.40	3.45	0.024	2.99E-03	1.0	0.4	
3	8.80	7.00	0.022	2.99E-03	4.2	1.8	
4	8.00	11.18	0.020	2.98E-03	11.4	7.8	
5	7.20	15.12	0.017	2.96E-03	22.0	20.9	
6	6.40	18.96	0.015	2.91E-03	35.6	43.7	
7	5.70	22.29	0.013	2.83E-03	50.0	73.6	
8	5.00	29.07	0.011	2.70E-03	68.0	115.9	
		20.40	0.011	2.70E-03	68.0	115.9	
9	4.50	22.38	0.010	2.56E-03	78.7	152.6	
10	4.00	-40.90	0.008	2.39E-03	74.1	192.0	
11	3.50	-63.36	0.007	2.19E-03	48.0	226.5	
12	3.00	-48.57	0.006	1.95E-03	20.0	242.6	
13	2.30	-34.60	0.005	1.62E-03	-9.1	244.6	
14	1.60	-23.56	0.004	1.29E-03	-29.4	231.7	
15	0.80	-7.14	0.003	9.48E-04	-41.7	200.7	
16	0.00	5.48	0.002	6.59E-04	-42.4	165.1	
		-17.79	0.002	6.59E-04	-42.4	165.1	
17	-0.80	-0.99	0.002	4.29E-04	-49.9	125.4	
18	-1.60	8.85	0.002	2.62E-04	-46.8	85.2	
19	-2.40	13.45	0.001	1.54E-04	-37.8	50.6	
20	-3.20	14.68	0.001	9.52E-05	-26.6	24.5	
21	-4.00	14.16	0.001	6.95E-05	-15.0	7.9	
22	-4.50	14.59	0.001	6.46E-05	-7.9	2.1	
23	-5.00	16.85	0.001	6.35E-05	0.0	-0.0	

APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	1319
2	9.40	0.00	12.65	3.45	63.56	3.45	3.45a	1319
3	8.80	0.00	25.63	7.00	128.80	7.00	7.00a	1319
4	8.00	0.00	40.94	11.18	205.76	11.18	11.18a	1319
5	7.20	0.00	55.36	15.12	278.26	15.12	15.12a	1319
6	6.40	0.00	69.43	18.96	348.97	18.96	18.96a	1319
7	5.70	0.00	81.60	22.29	410.11	22.29	22.29a	1319
8	5.00	0.00	93.68	25.59	470.84	29.07	29.07	1319
		0.00	93.68	20.40	679.14	20.40	20.40a	6595
9	4.50	0.00	102.77	22.38	745.08	22.38	22.38a	6595
10	4.00	0.00	111.85	24.35	810.87	24.35	24.35a	6595
11	3.50	4.90	116.50	25.37	844.60	25.37	30.27a	6595
12	3.00	9.81	121.14	26.38	878.23	26.38	36.18a	6595
13	2.30	16.67	127.61	27.79	925.16	27.79	44.46a	6595
14	1.60	23.54	134.07	29.19	971.94	29.19	52.73a	6595
15	0.80	31.38	141.42	30.79	1025.27	38.00	69.38	6595
16	0.00	39.23	148.76	32.39	1078.45	46.17	85.40	6595
		Total>	187.98	50.00m	388.00	214.57	214.57	17949
17	-0.80	Total>	203.95	54.00m	415.17	241.45	241.45	18954
18	-1.60	Total>	219.90	58.00m	442.32	265.59	265.59	19959
19	-2.40	Total>	235.84	62.00m	469.47	287.66	287.66	20964
20	-3.20	Total>	251.77	66.00m	496.60	308.41	308.41	21969
21	-4.00	Total>	267.70	70.00m	523.72	328.49	328.49	22974
22	-4.50	Total>	277.64	72.50m	540.67	341.40	341.40	73142
23	-5.00	Total>	287.59	75.00m	557.62	355.47	355.47	128924

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	9643
10	4.00	0.00	9.00	1.96	65.25	65.25	65.25p	9643
11	3.50	0.00	18.00	3.92	130.53	93.63	93.63	9643
12	3.00	0.00	27.02	5.88	195.86	84.76	84.76	9643
13	2.30	6.86	33.49	7.29	242.78	72.19	79.05	9643
14	1.60	13.73	39.99	8.71	289.91	62.56	76.29	9643
15	0.80	21.57	47.47	10.34	344.13	54.95	76.52	9643
16	0.00	29.42	55.01	11.98	398.80	50.50	79.92	9643
		Total>	84.43	22.50m	284.45	232.36	232.36	25491
17	-0.80	Total>	100.68	26.50m	311.91	242.44	242.44	26919
18	-1.60	Total>	117.02	30.50m	339.44	256.74	256.74	28346
19	-2.40	Total>	133.43	34.50m	367.05	274.21	274.21	29774
20	-3.20	Total>	149.93	38.50m	394.75	293.73	293.73	31201
21	-4.00	Total>	166.51	42.50m	422.53	314.33	314.33	32629

APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :

(continued)

Stage No.3 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
22	-4.50	Total>	176.91	45.00m	439.94	326.81	326.81	97121
23	-5.00	Total>	187.34	47.50m	457.37	338.62	338.62	128924

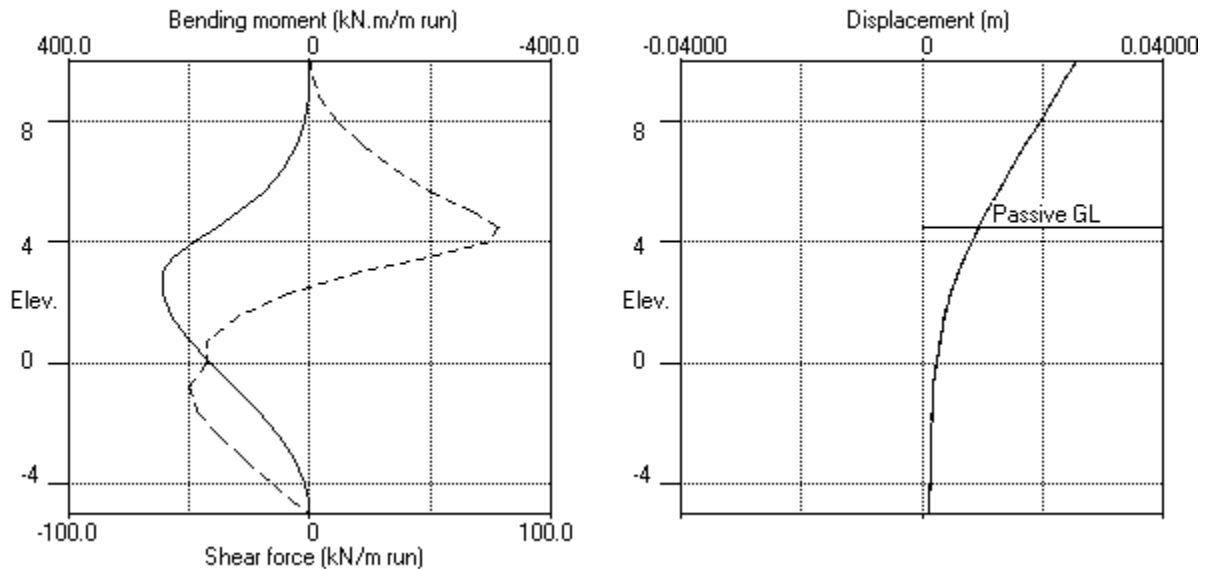
Note: 52.73a Soil pressure at active limit
 65.25p Soil pressure at passive limit

APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

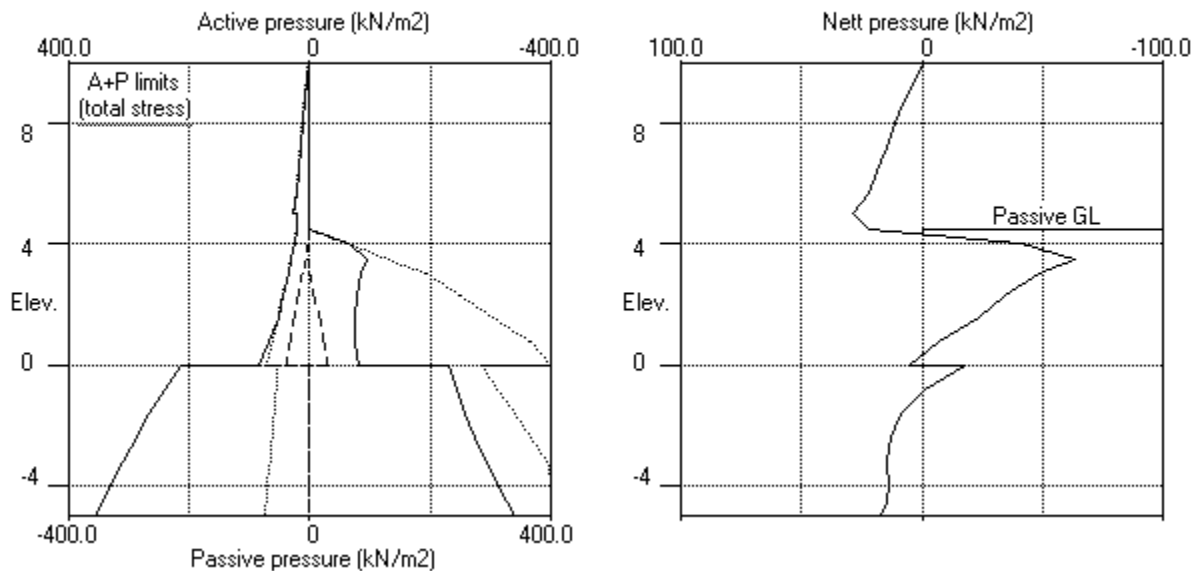
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :

Units: kN,m

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

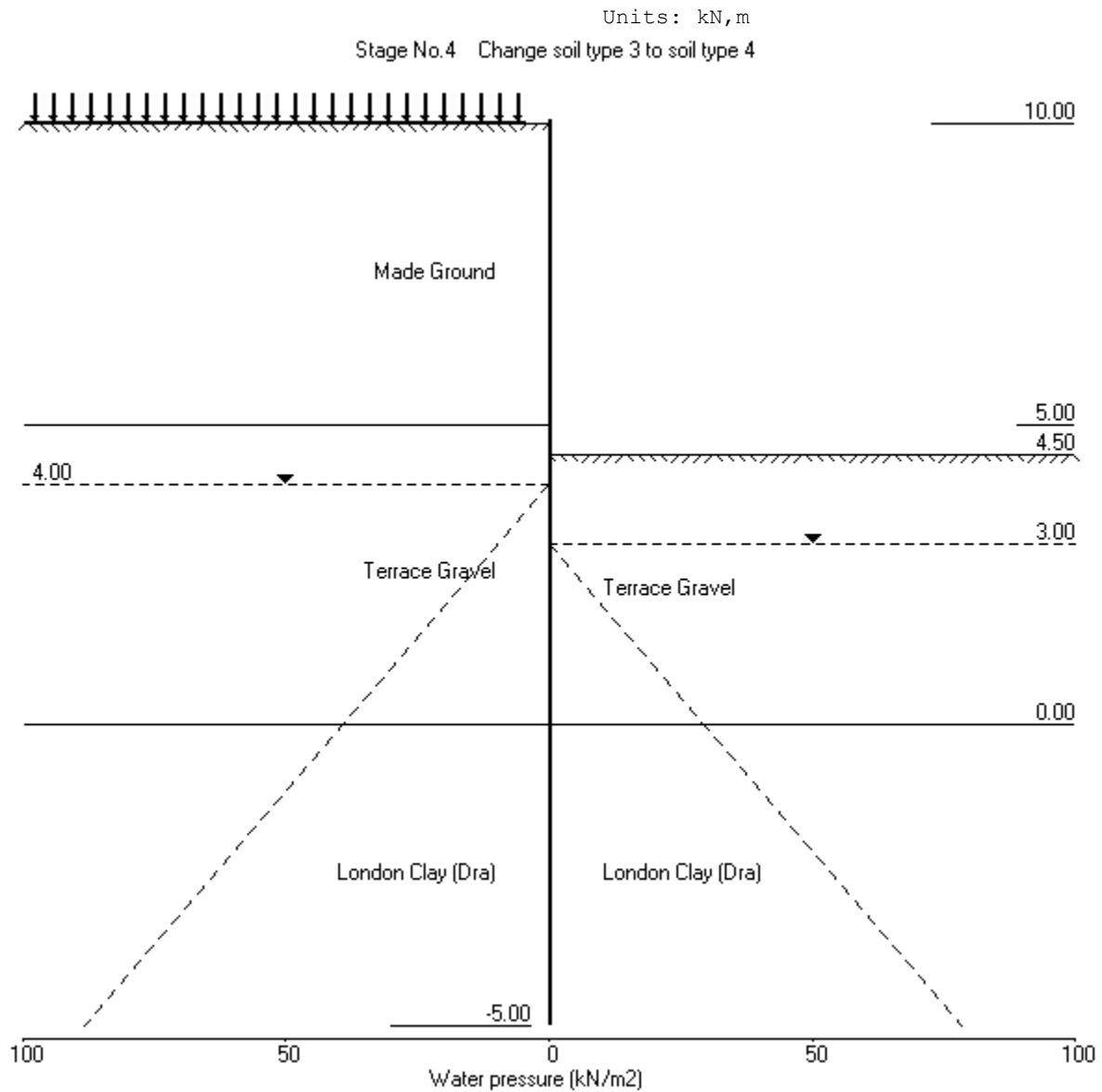


Stage No.3 Apply water pressure profile no.1 (Mod. Conserv.)



APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :



APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm 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	Toe	Wall
No.	Act.	Pass.	Elev.	of equilib.	elev.	Penetr
				Safety at elev.		-ation
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	0.026	2.99E-03	0.0	-0.0	
2	9.40	3.45	0.024	2.99E-03	1.0	0.4	
3	8.80	7.00	0.022	2.99E-03	4.2	1.8	
4	8.00	11.18	0.020	2.98E-03	11.4	7.8	
5	7.20	15.12	0.017	2.96E-03	22.0	20.9	
6	6.40	18.96	0.015	2.91E-03	35.6	43.7	
7	5.70	22.29	0.013	2.83E-03	50.0	73.6	
8	5.00	29.03	0.011	2.70E-03	68.0	115.9	
		20.40	0.011	2.70E-03	68.0	115.9	
9	4.50	22.38	0.010	2.56E-03	78.7	152.5	
10	4.00	-40.90	0.008	2.39E-03	74.1	192.0	
11	3.50	-63.64	0.007	2.19E-03	47.9	226.4	
12	3.00	-48.85	0.006	1.95E-03	19.8	242.5	
13	2.30	-34.88	0.005	1.62E-03	-9.5	244.3	
14	1.60	-23.85	0.004	1.29E-03	-30.1	231.0	
15	0.80	-7.64	0.003	9.50E-04	-42.7	199.5	
16	0.00	5.00	0.002	6.63E-04	-43.7	162.9	
		-10.31	0.002	6.63E-04	-43.7	162.9	
17	-0.80	-1.64	0.002	4.36E-04	-48.5	123.8	
18	-1.60	8.28	0.002	2.71E-04	-45.8	84.4	
19	-2.40	12.99	0.001	1.64E-04	-37.3	50.3	
20	-3.20	14.35	0.001	1.05E-04	-26.4	24.6	
21	-4.00	13.99	0.001	7.97E-05	-15.1	8.0	
22	-4.50	14.51	0.001	7.47E-05	-7.9	2.2	
23	-5.00	17.24	0.001	7.36E-05	0.0	-0.0	

APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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 -----						
		----- 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
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	29.03	29.03	928
		0.00	93.68	20.40	679.14	20.40	20.40a	4639
9	4.50	0.00	102.77	22.38	745.08	22.38	22.38a	4639
10	4.00	0.00	111.85	24.35	810.87	24.35	24.35a	4639
11	3.50	4.90	116.50	25.37	844.60	25.37	30.27a	4639
12	3.00	9.81	121.14	26.38	878.23	26.38	36.18a	4639
13	2.30	16.67	127.61	27.79	925.16	27.79	44.46a	4639
14	1.60	23.54	134.07	29.19	971.94	29.19	52.73a	4639
15	0.80	31.38	141.42	30.79	1025.27	37.78	69.16	4639
16	0.00	39.23	148.76	32.39	1078.45	45.96	85.19	4639
		39.23	148.76	46.86	448.21	175.05	214.27	6649
17	-0.80	47.07	156.88	50.28	470.13	194.10	241.17	7021
18	-1.60	54.92	164.99	53.70	492.01	210.42	265.34	7393
19	-2.40	62.76	173.08	57.12	513.86	224.70	287.46	7766
20	-3.20	70.61	181.17	60.53	535.69	237.66	308.27	8138
21	-4.00	78.45	189.24	63.93	557.49	249.96	328.42	8510
22	-4.50	83.36	194.29	66.06	571.10	258.01	341.36	8743
23	-5.00	88.26	199.33	68.19	584.71	267.41	355.67	185670

Node no.	Y coord	----- PASSIVE 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
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	6026
10	4.00	0.00	9.00	1.96	65.25	65.25	65.25p	6026
11	3.50	0.00	18.00	3.92	130.53	93.91	93.91	6026
12	3.00	0.00	27.02	5.88	195.86	85.04	85.04	6026
13	2.30	6.86	33.49	7.29	242.78	72.47	79.34	6026
14	1.60	13.73	39.99	8.71	289.91	62.84	76.57	6026
15	0.80	21.57	47.47	10.34	344.13	55.23	76.80	6026
16	0.00	29.42	55.01	11.98	398.80	50.77	80.19	6026
		29.42	55.01	7.32	195.16	195.16	224.58p	8759
17	-0.80	37.26	63.42	10.86	217.87	205.55	242.82	9250
18	-1.60	45.11	71.91	14.44	240.77	211.95	257.06	9740
19	-2.40	52.96	80.48	18.06	263.90	221.51	274.47	10231
20	-3.20	60.80	89.13	21.71	287.25	233.12	293.92	10721

APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :

(continued)

Stage No.4 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		
21	-4.00	68.65	97.86	25.39	310.83	245.78	314.43	11212
22	-4.50	73.55	103.36	27.71	325.68	253.31	326.86	11518
23	-5.00	78.45	108.89	30.04	340.60	259.98	338.43	185670

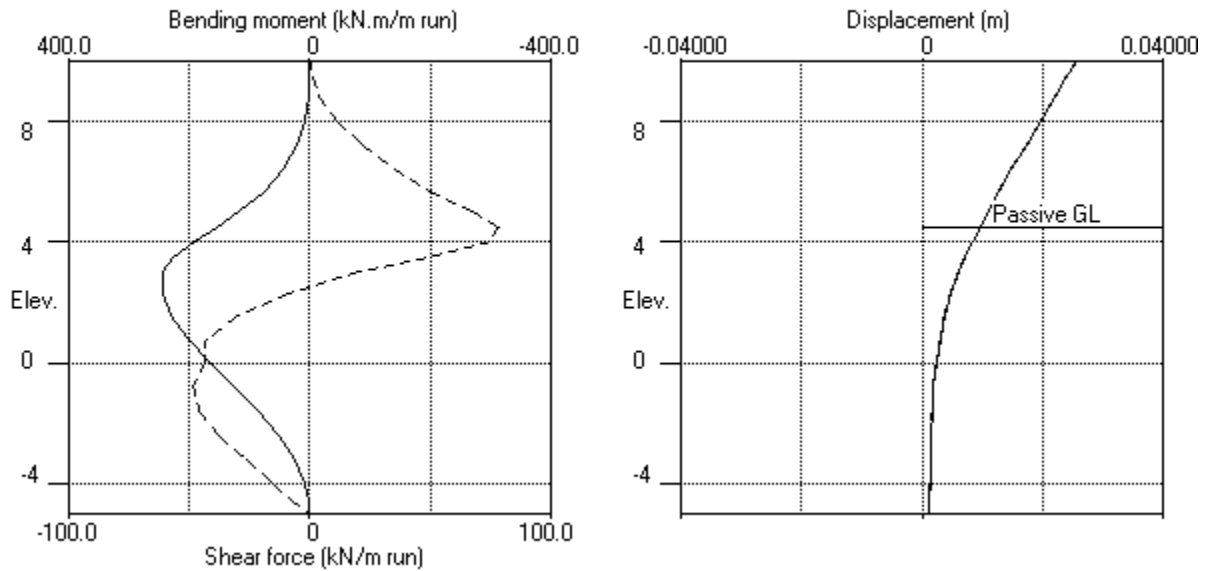
Note: 52.73a Soil pressure at active limit
 224.58p Soil pressure at passive limit

APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

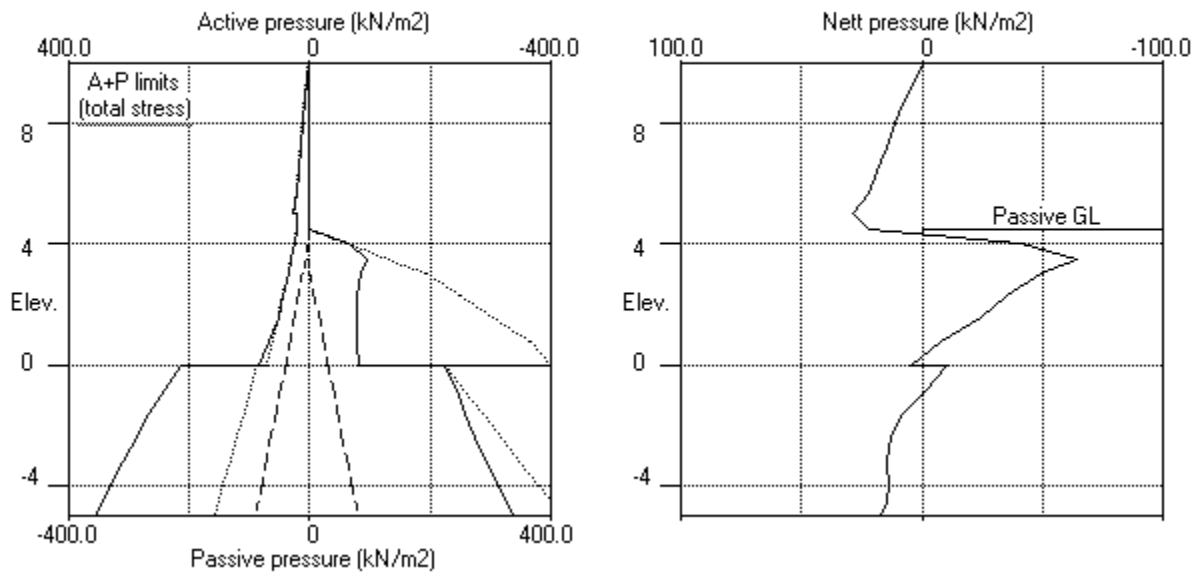
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
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 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :

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: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
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 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm 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: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	0.026	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	2	-1	4	-1	6	-1
4	8.00	0.020	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	-1	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	0.010	0.000	153	0	206	0	79	0	107	0
10	4.00	0.008	0.000	192	0	260	0	74	0	100	0
11	3.50	0.007	0.000	227	0	306	0	49	0	66	0
12	3.00	0.006	0.000	243	0	329	0	20	-0	28	-0
13	2.30	0.005	0.000	245	0	331	0	0	-11	0	-15
14	1.60	0.004	0.000	232	0	313	0	0	-33	0	-45
15	0.80	0.003	0.000	201	0	271	0	0	-46	0	-63
16	0.00	0.002	0.000	165	0	223	0	0	-49	0	-66
17	-0.80	0.002	0.000	125	0	169	0	0	-51	0	-69
18	-1.60	0.002	0.000	85	0	115	0	0	-47	0	-63
19	-2.40	0.001	0.000	51	0	68	0	0	-38	0	-51
20	-3.20	0.001	0.000	25	0	33	0	0	-27	0	-36
21	-4.00	0.001	0.000	8	0	11	0	0	-15	0	-20
22	-4.50	0.001	0.000	2	0	3	0	0	-8	0	-11
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. elev.	max. elev.	min. elev.	max. elev.	min. elev.	max. elev.	min. elev.
	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	9	-2	4	5.00
2	245	2.30	-0	10.00	331	-0	79	4.50
3	245	2.30	-0	10.00	330	-0	79	4.50
4	244	2.30	-0	10.00	330	-0	79	4.50

APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

Summary of results (continued)

Maximum and minimum displacement at each stage

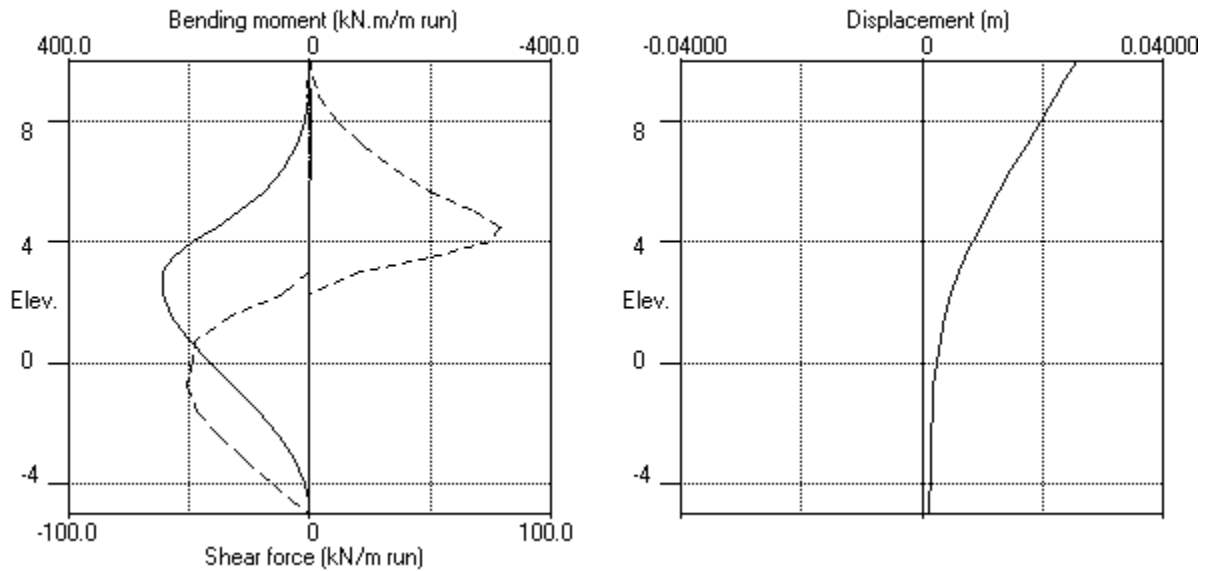
Stage	no.	maximum m	elev.	Displacement minimum m	elev.	Stage description
1	0.001	10.00	0.000	10.00	Apply surcharge no.1 at elev. 10.00	
2	0.024	10.00	0.000	10.00	Excav. to elev. 4.50 on PASSIVE side	
3	0.026	10.00	0.000	10.00	Apply water pressure profile no.1	
4	0.026	10.00	0.000	10.00	Change soil type 3 to soil type 4	

APPENDIX C-2. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
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 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_SLS
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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)

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 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		
profile no.	Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Point no.	Elev. m	Piezo elev. m
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 = 0.025765 m4/m run
E.I = 504994 kN.m2/m run
Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch	Distance	Length	Width	Surcharge		Equiv. Partial	
-arge	from	parallel	perpend.	----- kN/m2 -----		soil factor/	
no.	Elev.	wall	to 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 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.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

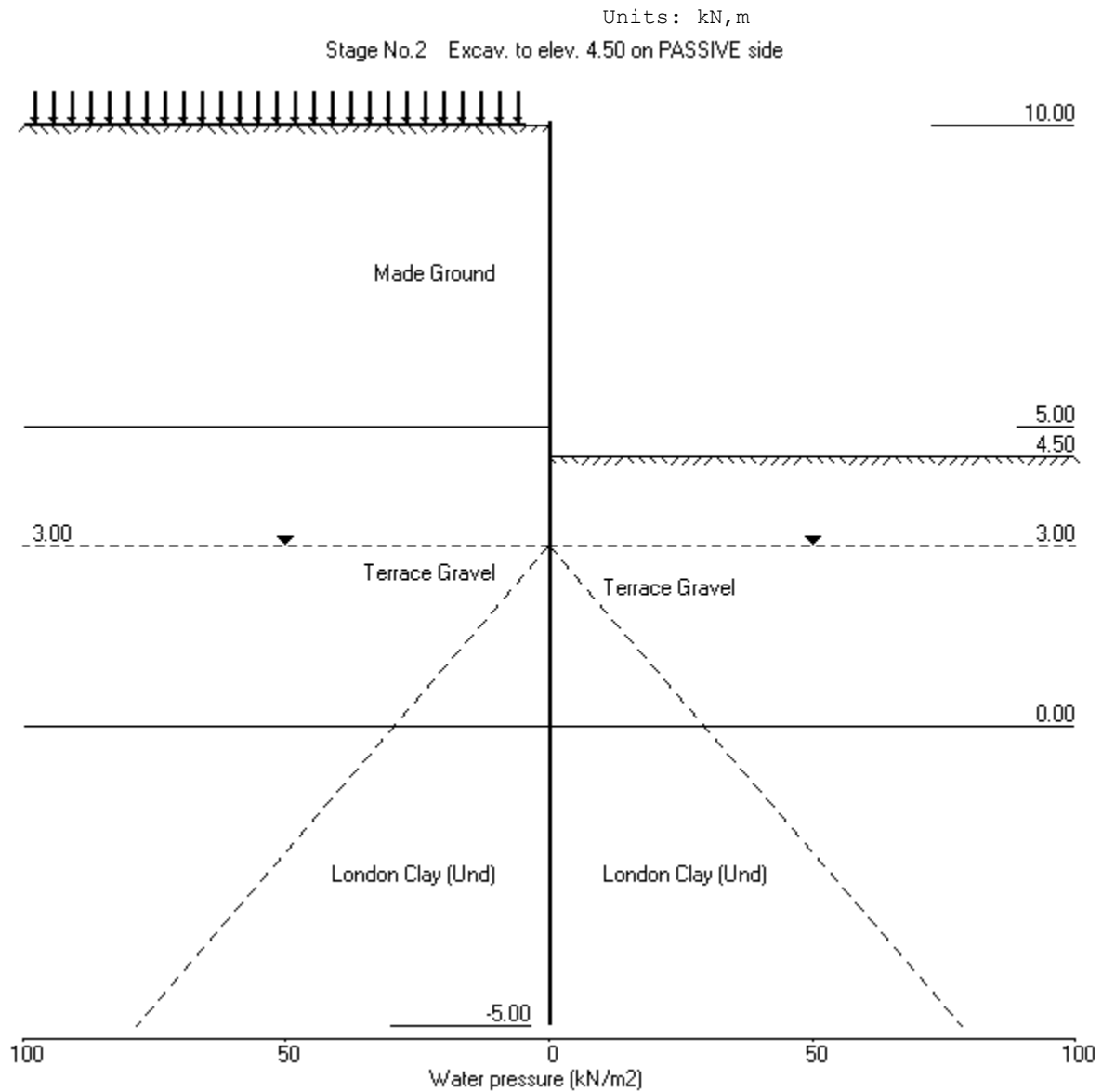
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage 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	Excav. to elev. 4.00 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

APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :



APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

Units: kN,m

Stage No. 2 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.

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	2.93E-03	0.0	-0.0	
2	9.40	3.52	0.023	2.93E-03	1.1	0.4	
3	8.80	7.14	0.021	2.93E-03	4.3	1.9	
4	8.00	11.37	0.019	2.92E-03	11.7	8.0	
5	7.20	15.33	0.016	2.90E-03	22.3	21.3	
6	6.40	19.19	0.014	2.85E-03	36.2	44.5	
7	5.70	22.52	0.012	2.76E-03	50.7	74.8	
8	5.00	30.17	0.010	2.63E-03	69.2	117.7	
		20.59	0.010	2.63E-03	69.2	117.7	
9	4.50	22.57	0.009	2.49E-03	80.0	154.9	
10	4.00	-40.71	0.008	2.32E-03	75.4	195.1	
11	3.50	-62.69	0.007	2.11E-03	49.6	230.0	
12	3.00	-52.17	0.006	1.87E-03	20.9	246.9	
13	2.30	-38.69	0.004	1.53E-03	-10.9	248.6	
14	1.60	-25.47	0.003	1.20E-03	-33.4	233.6	
15	0.80	-8.75	0.003	8.59E-04	-47.1	198.8	
16	0.00	2.78	0.002	5.76E-04	-49.4	158.3	
		-10.37	0.002	5.76E-04	-49.4	158.3	
17	-0.80	4.13	0.002	3.59E-04	-51.9	115.4	
18	-1.60	11.93	0.002	2.09E-04	-45.5	75.1	
19	-2.40	14.85	0.001	1.15E-04	-34.8	42.5	
20	-3.20	14.74	0.001	6.68E-05	-23.0	19.3	
21	-4.00	13.12	0.001	4.70E-05	-11.8	5.6	
22	-4.50	11.83	0.001	4.36E-05	-5.6	1.3	
23	-5.00	10.51	0.001	4.29E-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	1616
2	9.40	0.00	12.89	3.52	64.79	3.52	3.52a	1616
3	8.80	0.00	26.15	7.14	131.42	7.14	7.14a	1616
4	8.00	0.00	41.63	11.37	209.25	11.37	11.37a	1616
5	7.20	0.00	56.14	15.33	282.16	15.33	15.33a	1616
6	6.40	0.00	70.25	19.19	353.11	19.19	19.19a	1616
7	5.70	0.00	82.44	22.52	414.38	22.52	22.52a	1616
8	5.00	0.00	94.55	25.82	475.20	30.17	30.17	1616
		0.00	94.55	20.59	685.43	20.59	20.59a	8081
9	4.50	0.00	103.65	22.57	751.44	22.57	22.57a	8081

APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	
10	4.00	0.00	112.73	24.54	817.28	24.54	24.54a	8081
11	3.50	0.00	121.79	26.52	882.98	26.52	26.52a	8081
12	3.00	0.00	130.84	28.49	948.56	28.49	28.49a	8081
13	2.30	6.86	137.32	29.90	995.52	29.90	36.76a	8081
14	1.60	13.73	143.77	31.30	1042.32	34.03	47.76	8081
15	0.80	21.57	151.13	32.90	1095.64	43.79	65.36	8081
16	0.00	29.42	158.46	34.50	1148.81	51.51	80.93	8081
Total>		187.88		50.00m	387.93	217.31	217.31	21603
17	-0.80	Total>	203.84	54.00m	415.10	243.24	243.24	22813
18	-1.60	Total>	219.79	58.00m	442.25	266.52	266.52	24022
19	-2.40	Total>	235.73	62.00m	469.39	287.90	287.90	25232
20	-3.20	Total>	251.65	66.00m	496.51	308.09	308.09	26442
21	-4.00	Total>	267.57	70.00m	523.63	327.72	327.72	27652
22	-4.50	Total>	277.51	72.50m	540.57	339.89	339.89	28408
23	-5.00	Total>	287.45	75.00m	557.52	352.06	352.06	29164

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	12636
10	4.00	0.00	9.00	1.96	65.25	65.25	65.25p	12636
11	3.50	0.00	18.00	3.92	130.53	89.21	89.21	12636
12	3.00	0.00	27.02	5.88	195.86	80.66	80.66	12636
13	2.30	6.86	33.49	7.29	242.78	68.58	75.45	12636
14	1.60	13.73	39.99	8.71	289.91	59.50	73.23	12636
15	0.80	21.57	47.47	10.34	344.13	52.54	74.11	12636
16	0.00	29.42	55.01	11.98	398.80	48.73	78.15	12636
Total>		84.43		22.50m	284.46	227.68	227.68	32979
17	-0.80	Total>	100.68	26.50m	311.92	239.11	239.11	34826
18	-1.60	Total>	117.02	30.50m	339.45	254.60	254.60	36673
19	-2.40	Total>	133.43	34.50m	367.07	273.04	273.04	38519
20	-3.20	Total>	149.93	38.50m	394.77	293.35	293.35	40366
21	-4.00	Total>	166.51	42.50m	422.55	314.60	314.60	42213
22	-4.50	Total>	176.91	45.00m	439.96	328.06	328.06	43367
23	-5.00	Total>	187.34	47.50m	457.39	341.54	341.54	44522

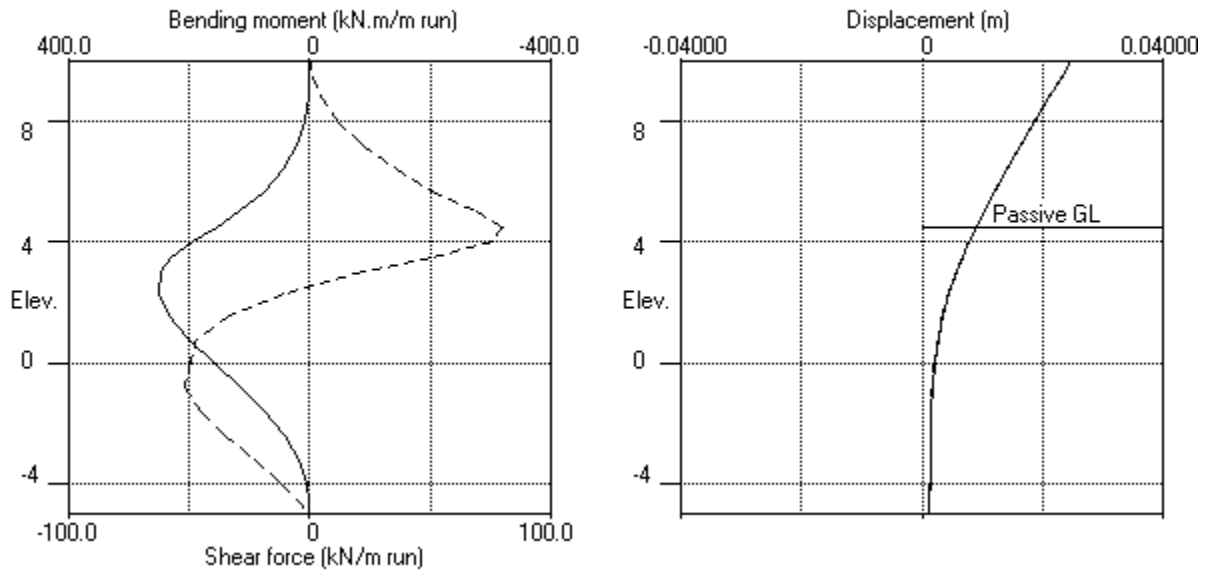
Note: 36.76a Soil pressure at active limit
65.25p Soil pressure at passive limit

APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

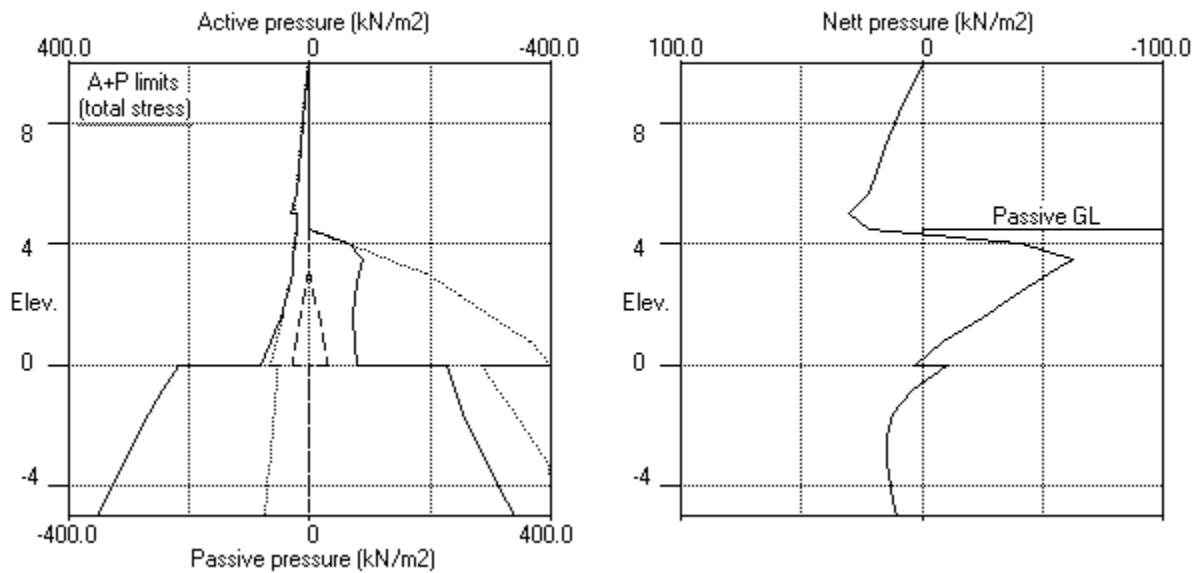
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

Units: kN,m

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

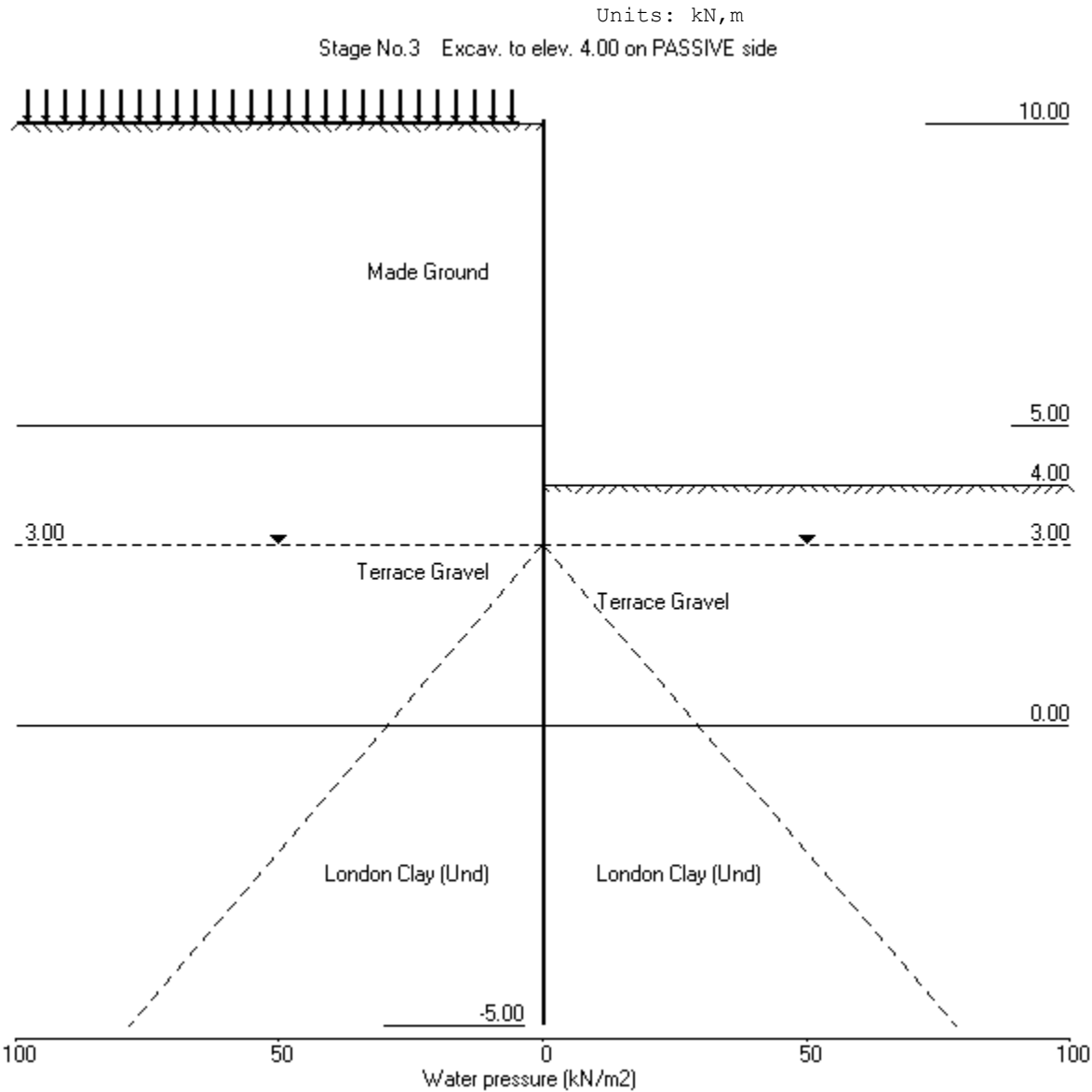


Stage No.2 Excav. to elev. 4.50 on PASSIVE side



APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :



APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	0.032	3.66E-03	0.0	-0.0	
2	9.40	3.52	0.030	3.66E-03	1.1	0.4	
3	8.80	7.14	0.027	3.66E-03	4.3	1.9	
4	8.00	11.37	0.024	3.65E-03	11.7	8.0	
5	7.20	15.33	0.022	3.62E-03	22.3	21.3	
6	6.40	19.19	0.019	3.57E-03	36.2	44.5	
7	5.70	22.52	0.016	3.49E-03	50.7	74.8	
8	5.00	25.82	0.014	3.36E-03	67.7	117.3	
		20.59	0.014	3.36E-03	67.7	117.3	
9	4.50	22.57	0.012	3.22E-03	78.5	153.8	
10	4.00	24.54	0.011	3.05E-03	90.2	195.9	
11	3.50	-38.73	0.009	2.83E-03	86.7	244.7	
12	3.00	-75.07	0.008	2.57E-03	58.2	282.3	
13	2.30	-55.59	0.006	2.16E-03	12.5	304.5	
14	1.60	-39.78	0.005	1.74E-03	-20.9	301.6	
15	0.80	-21.26	0.003	1.29E-03	-45.3	272.5	
16	0.00	-3.64	0.003	8.96E-04	-55.2	229.4	
		-28.87	0.003	8.96E-04	-55.2	229.4	
17	-0.80	-3.91	0.002	5.75E-04	-68.4	176.0	
18	-1.60	11.13	0.002	3.40E-04	-65.5	120.0	
19	-2.40	18.58	0.001	1.89E-04	-53.6	71.1	
20	-3.20	21.08	0.001	1.05E-04	-37.7	34.1	
21	-4.00	20.98	0.001	7.05E-05	-20.9	10.6	
22	-4.50	20.31	0.001	6.39E-05	-10.6	2.8	
23	-5.00	22.01	0.001	6.25E-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	1468
2	9.40	0.00	12.89	3.52	64.79	3.52	3.52a	1468
3	8.80	0.00	26.15	7.14	131.42	7.14	7.14a	1468
4	8.00	0.00	41.63	11.37	209.25	11.37	11.37a	1468
5	7.20	0.00	56.14	15.33	282.16	15.33	15.33a	1468
6	6.40	0.00	70.25	19.19	353.11	19.19	19.19a	1468
7	5.70	0.00	82.44	22.52	414.38	22.52	22.52a	1468
8	5.00	0.00	94.55	25.82	475.20	25.82	25.82a	1468
		0.00	94.55	20.59	685.43	20.59	20.59a	7338
9	4.50	0.00	103.65	22.57	751.44	22.57	22.57a	7338

APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :

(continued)

Stage No.3 Excavate to elevation 4.00 on PASSIVE side

Node Y		----- ACTIVE side -----						
no.	coord	----- Effective stresses -----					Total earth pressure	Soil stiffness
		Water press.	Vertic -al	Active limit	Passive limit	Earth pressure		
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	kN/m3
10	4.00	0.00	112.73	24.54	817.28	24.54	24.54a	7338
11	3.50	0.00	121.79	26.52	882.98	26.52	26.52a	7338
12	3.00	0.00	130.84	28.49	948.56	28.49	28.49a	7338
13	2.30	6.86	137.32	29.90	995.52	29.90	36.76a	7338
14	1.60	13.73	143.77	31.30	1042.32	31.30	45.03a	7338
15	0.80	21.57	151.13	32.90	1095.64	37.82	59.40	7338
16	0.00	29.42	158.46	34.50	1148.81	47.76	77.18	7338
		Total>	187.88	50.00m	387.93	207.20	207.20	19767
17	-0.80	Total>	203.84	54.00m	415.10	237.00	237.00	20874
18	-1.60	Total>	219.79	58.00m	442.25	262.97	262.97	21981
19	-2.40	Total>	235.73	62.00m	469.39	286.02	286.02	23088
20	-3.20	Total>	251.65	66.00m	496.51	307.18	307.18	24195
21	-4.00	Total>	267.57	70.00m	523.63	327.36	327.36	25302
22	-4.50	Total>	277.51	72.50m	540.57	339.76	339.76	40656
23	-5.00	Total>	287.45	75.00m	557.52	353.19	353.19	166952

Node Y		----- PASSIVE side -----						
no.	coord	----- Effective stresses -----					Total earth pressure	Soil stiffness
		Water press.	Vertic -al	Active limit	Passive limit	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	12832
11	3.50	0.00	9.00	1.96	65.25	65.25	65.25p	12832
12	3.00	0.00	18.01	3.92	130.54	103.55	103.55	12832
13	2.30	6.86	24.46	5.33	177.34	85.49	92.35	12832
14	1.60	13.73	30.95	6.74	224.34	71.09	84.82	12832
15	0.80	21.57	38.40	8.36	278.39	59.08	80.65	12832
16	0.00	29.42	45.91	10.00	332.87	51.40	80.82	12832
		Total>	75.33	20.00m	275.36	236.07	236.07	33472
17	-0.80	Total>	91.56	24.00m	302.80	240.91	240.91	35346
18	-1.60	Total>	107.88	28.00m	330.31	251.84	251.84	37221
19	-2.40	Total>	124.27	32.00m	357.91	267.43	267.43	39095
20	-3.20	Total>	140.76	36.00m	385.60	286.10	286.10	40969
21	-4.00	Total>	157.34	40.00m	413.38	306.38	306.38	42844
22	-4.50	Total>	167.75	42.50m	430.79	319.45	319.45	63419
23	-5.00	Total>	178.19	45.00m	448.24	331.18	331.18	230873

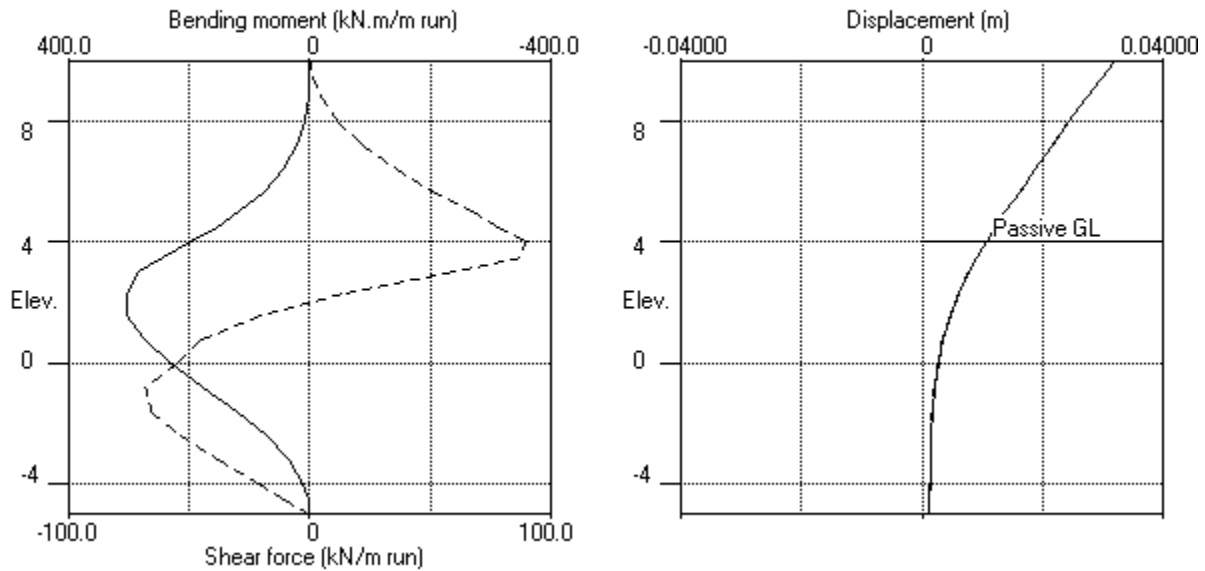
Note: 45.03a Soil pressure at active limit
 65.25p Soil pressure at passive limit

APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

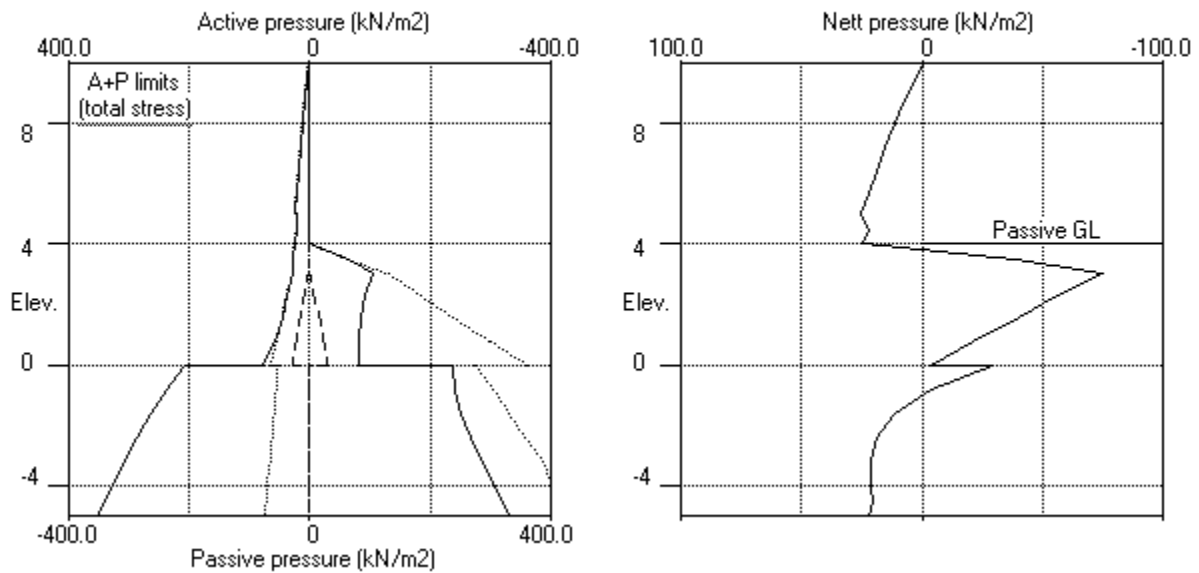
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

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

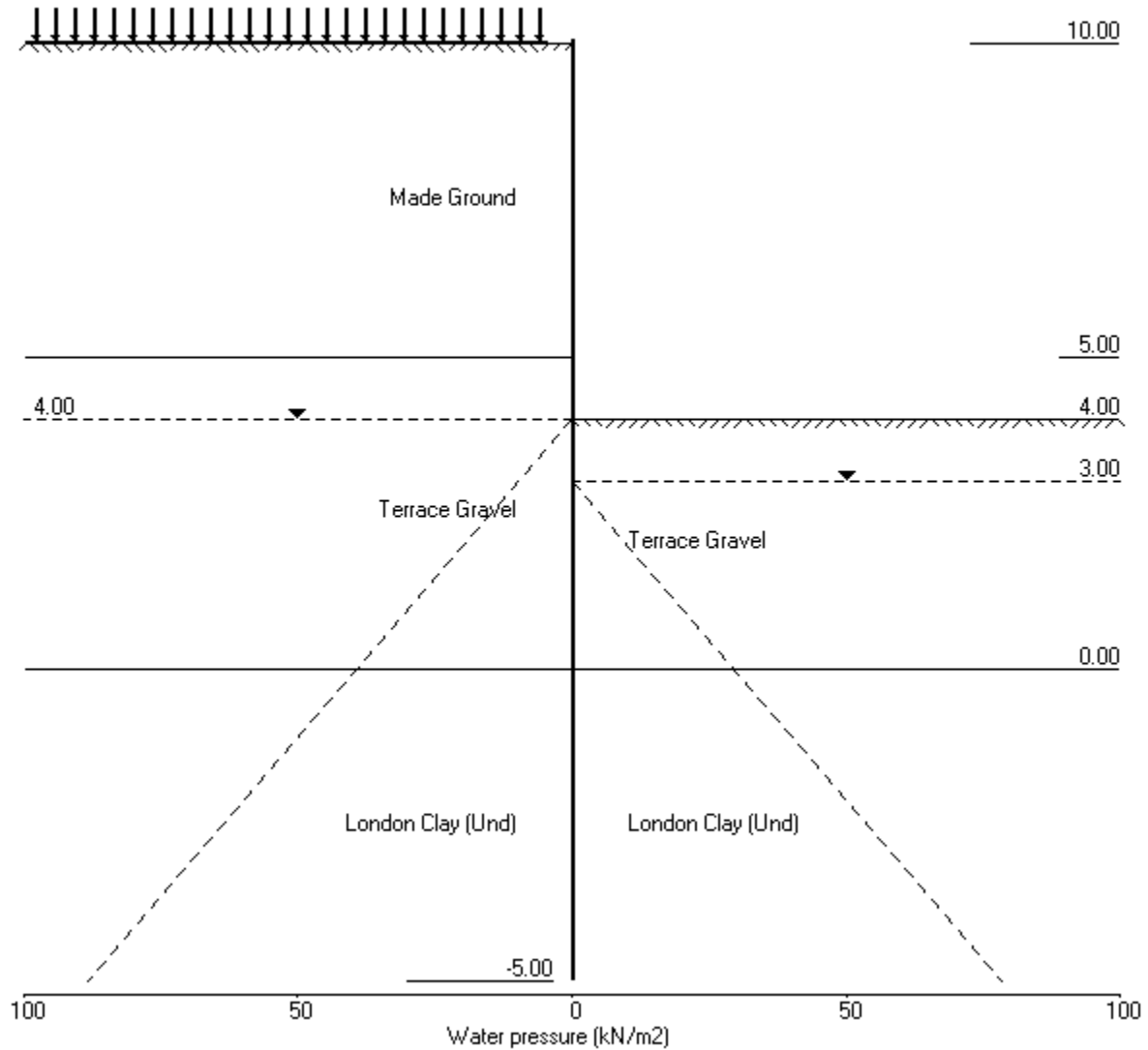


APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :

Units: kN,m

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



APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	0.034	3.82E-03	0.0	-0.0	
2	9.40	3.52	0.031	3.82E-03	1.1	0.4	
3	8.80	7.14	0.029	3.81E-03	4.3	1.9	
4	8.00	11.37	0.026	3.81E-03	11.7	8.0	
5	7.20	15.33	0.023	3.78E-03	22.3	21.3	
6	6.40	19.19	0.020	3.73E-03	36.2	44.5	
7	5.70	22.52	0.017	3.65E-03	50.7	74.8	
8	5.00	25.82	0.015	3.52E-03	67.7	117.3	
		20.59	0.015	3.52E-03	67.7	117.3	
9	4.50	22.57	0.013	3.38E-03	78.5	153.8	
10	4.00	24.54	0.011	3.21E-03	90.2	195.9	
11	3.50	-34.79	0.010	2.99E-03	87.7	244.9	
12	3.00	-74.40	0.008	2.73E-03	60.4	283.6	
13	2.30	-53.74	0.007	2.32E-03	15.5	307.5	
14	1.60	-36.79	0.005	1.89E-03	-16.2	307.1	
15	0.80	-21.18	0.004	1.43E-03	-39.3	282.5	
16	0.00	-1.77	0.003	1.01E-03	-48.5	244.3	
		-38.58	0.003	1.01E-03	-48.5	244.3	
17	-0.80	-10.10	0.002	6.66E-04	-68.0	193.1	
18	-1.60	7.82	0.002	4.06E-04	-68.9	135.4	
19	-2.40	17.44	0.002	2.34E-04	-58.8	82.7	
20	-3.20	21.50	0.001	1.35E-04	-43.2	41.2	
21	-4.00	23.20	0.001	9.26E-05	-25.4	13.4	
22	-4.50	24.76	0.001	8.42E-05	-13.4	3.6	
23	-5.00	28.71	0.001	8.24E-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	1363
2	9.40	0.00	12.89	3.52	64.79	3.52	3.52a	1363
3	8.80	0.00	26.15	7.14	131.42	7.14	7.14a	1363
4	8.00	0.00	41.63	11.37	209.25	11.37	11.37a	1363
5	7.20	0.00	56.14	15.33	282.16	15.33	15.33a	1363
6	6.40	0.00	70.25	19.19	353.11	19.19	19.19a	1363
7	5.70	0.00	82.44	22.52	414.38	22.52	22.52a	1363
8	5.00	0.00	94.55	25.82	475.20	25.82	25.82a	1363
		0.00	94.55	20.59	685.43	20.59	20.59a	6816
9	4.50	0.00	103.65	22.57	751.44	22.57	22.57a	6816

APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	6816
11	3.50	4.90	117.39	25.56	851.06	25.56	30.46a	6816
12	3.00	9.81	122.03	26.57	884.71	26.57	36.38a	6816
13	2.30	16.67	128.51	27.98	931.67	27.98	44.65a	6816
14	1.60	23.54	134.97	29.39	978.47	29.39	52.92a	6816
15	0.80	31.38	142.32	30.99	1031.79	31.74	63.12	6816
16	0.00	39.23	149.66	32.58	1084.97	42.38	81.60	6816
		Total>	188.88	50.00m	388.93	204.18	204.18	18486
17	-0.80	Total>	204.84	54.00m	416.10	235.37	235.37	19521
18	-1.60	Total>	220.79	58.00m	443.25	262.47	262.47	20556
19	-2.40	Total>	236.73	62.00m	470.39	286.38	286.38	21591
20	-3.20	Total>	252.65	66.00m	497.51	308.16	308.16	22626
21	-4.00	Total>	268.57	70.00m	524.63	329.14	329.14	102474
22	-4.50	Total>	278.51	72.50m	541.57	342.66	342.66	105276
23	-5.00	Total>	288.45	75.00m	558.51	357.21	357.21	108078

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	10791
11	3.50	0.00	9.00	1.96	65.25	65.25	65.25p	10791
12	3.00	0.00	18.01	3.92	130.54	110.78	110.78	10791
13	2.30	6.86	24.46	5.33	177.34	91.53	98.40	10791
14	1.60	13.73	30.95	6.74	224.34	75.98	89.71	10791
15	0.80	21.57	38.40	8.36	278.39	62.73	84.30	10791
16	0.00	29.42	45.91	10.00	332.87	53.95	83.37	10791
		Total>	75.33	20.00m	275.36	242.76	242.76	28361
17	-0.80	Total>	91.56	24.00m	302.80	245.47	245.47	29949
18	-1.60	Total>	107.88	28.00m	330.31	254.66	254.66	31537
19	-2.40	Total>	124.27	32.00m	357.91	268.94	268.94	33126
20	-3.20	Total>	140.76	36.00m	385.60	286.66	286.66	34714
21	-4.00	Total>	157.34	40.00m	413.38	305.95	305.95	102474
22	-4.50	Total>	167.75	42.50m	430.79	317.90	317.90	105276
23	-5.00	Total>	178.19	45.00m	448.24	328.50	328.50	108078

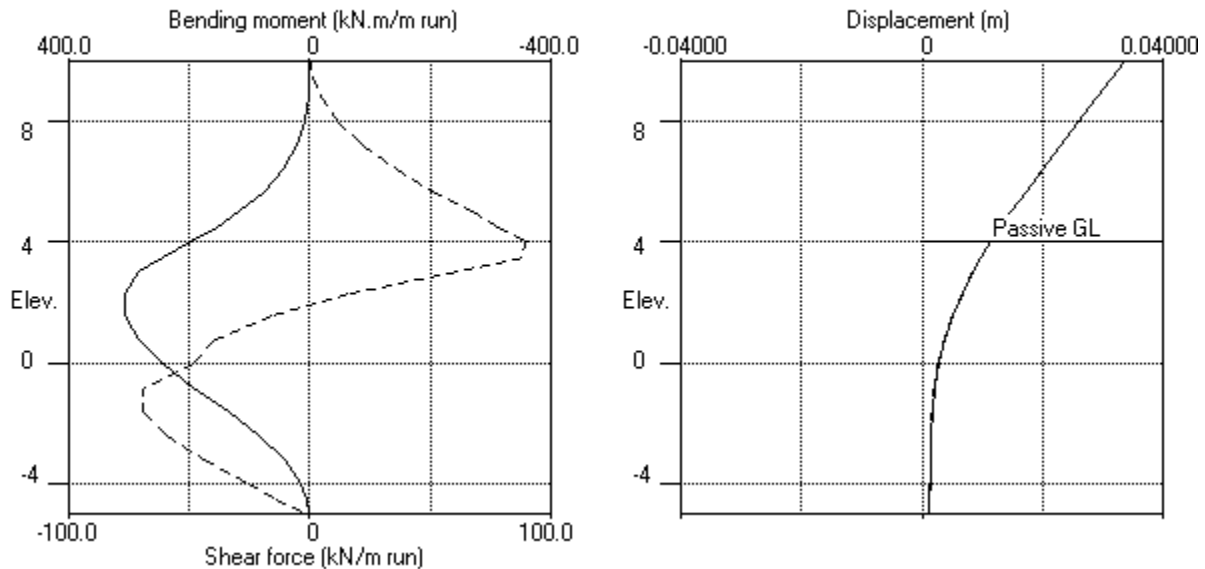
Note: 52.92a Soil pressure at active limit
65.25p Soil pressure at passive limit

APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

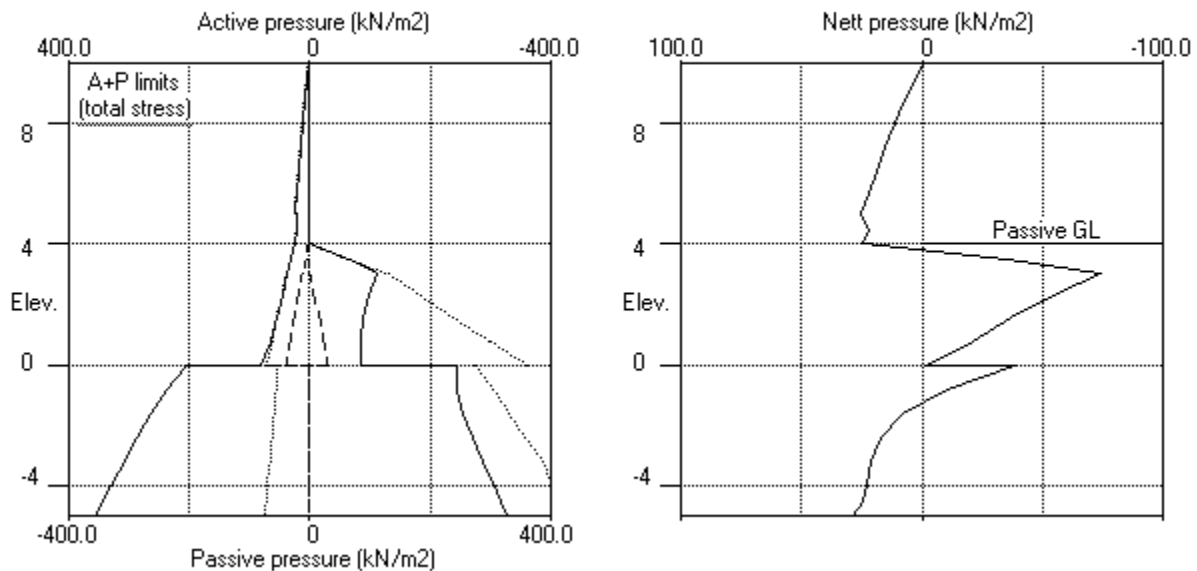
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

Units: kN,m

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

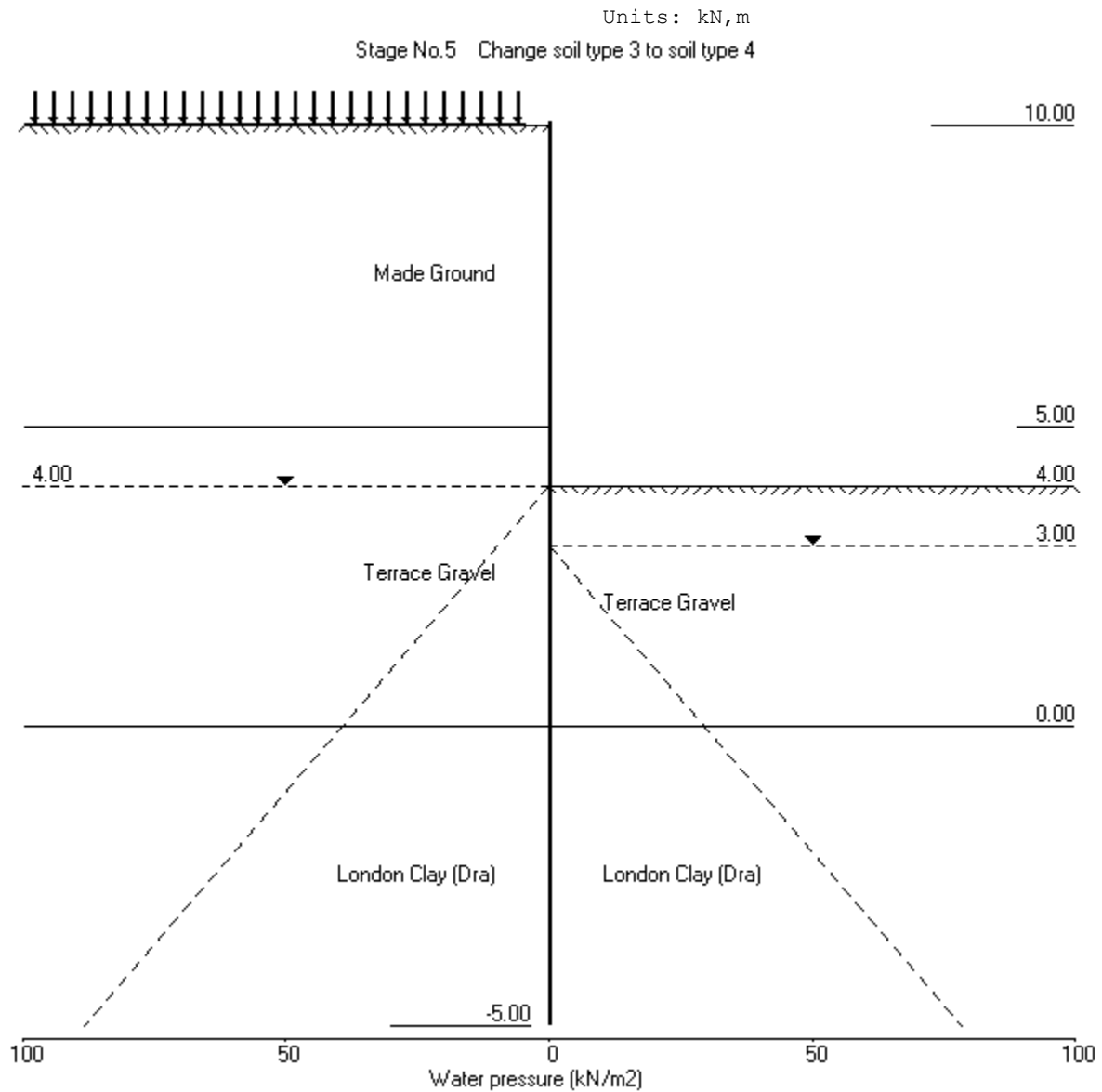


Stage No.4 Apply water pressure profile no.1 (Mod. Conserv.)



APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :



APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	3.82E-03	0.0	-0.0	
2	9.40	3.52	0.032	3.82E-03	1.1	0.4	
3	8.80	7.14	0.030	3.82E-03	4.3	1.9	
4	8.00	11.37	0.027	3.82E-03	11.7	8.0	
5	7.20	15.33	0.023	3.79E-03	22.3	21.3	
6	6.40	19.19	0.020	3.74E-03	36.2	44.5	
7	5.70	22.52	0.018	3.66E-03	50.7	74.8	
8	5.00	25.82	0.015	3.52E-03	67.7	117.3	
		20.59	0.015	3.52E-03	67.7	117.3	
9	4.50	22.57	0.014	3.39E-03	78.5	153.8	
10	4.00	24.54	0.012	3.22E-03	90.2	195.9	
11	3.50	-34.79	0.010	3.00E-03	87.7	244.9	
12	3.00	-77.83	0.009	2.74E-03	59.5	283.6	
13	2.30	-57.13	0.007	2.33E-03	12.3	306.0	
14	1.60	-40.12	0.006	1.91E-03	-21.7	302.6	
15	0.80	-25.17	0.004	1.45E-03	-47.9	272.4	
16	0.00	-7.08	0.003	1.06E-03	-60.8	226.1	
		0.90	0.003	1.06E-03	-60.8	226.1	
17	-0.80	1.78	0.003	7.43E-04	-59.7	174.8	
18	-1.60	1.42	0.002	5.05E-04	-58.4	126.0	
19	-2.40	12.28	0.002	3.42E-04	-52.9	79.7	
20	-3.20	17.81	0.002	2.46E-04	-40.9	41.2	
21	-4.00	21.15	0.001	2.03E-04	-25.3	14.1	
22	-4.50	23.82	0.001	1.94E-04	-14.1	4.1	
23	-5.00	32.43	0.001	1.92E-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	939
2	9.40	0.00	12.89	3.52	64.79	3.52	3.52a	939
3	8.80	0.00	26.15	7.14	131.42	7.14	7.14a	939
4	8.00	0.00	41.63	11.37	209.25	11.37	11.37a	939
5	7.20	0.00	56.14	15.33	282.16	15.33	15.33a	939
6	6.40	0.00	70.25	19.19	353.11	19.19	19.19a	939
7	5.70	0.00	82.44	22.52	414.38	22.52	22.52a	939
8	5.00	0.00	94.55	25.82	475.20	25.82	25.82a	939
		0.00	94.55	20.59	685.43	20.59	20.59a	4697

APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

(continued)

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

Node	Y	----- ACTIVE side -----						
no.	coord	----- Effective stresses -----				Total	Soil	
		Water	Vertic	Active	Passive	Earth		
		press.	-al	limit	limit	pressure	earth	
		kN/m2	kN/m2	kN/m2	kN/m2	kN/m2	pressure	stiffness
							kN/m2	coeff.
								kN/m3
9	4.50	0.00	103.65	22.57	751.44	22.57	22.57a	4697
10	4.00	0.00	112.73	24.54	817.28	24.54	24.54a	4697
11	3.50	4.90	117.39	25.56	851.06	25.56	30.46a	4697
12	3.00	9.81	122.03	26.57	884.71	26.57	36.38a	4697
13	2.30	16.67	128.51	27.98	931.67	27.98	44.65a	4697
14	1.60	23.54	134.97	29.39	978.47	29.39	52.92a	4697
15	0.80	31.38	142.32	30.99	1031.79	30.99	62.37a	4697
16	0.00	39.23	149.66	32.58	1084.97	40.12	79.34	4697
		39.23	149.66	47.24	450.64	161.71	200.93	6738
17	-0.80	47.07	157.77	50.66	472.55	185.23	232.30	7115
18	-1.60	54.92	165.88	54.08	494.42	204.86	259.77	7493
19	-2.40	62.76	173.97	57.49	516.26	221.44	284.20	7870
20	-3.20	70.61	182.04	60.90	538.06	235.99	306.60	8247
21	-4.00	78.45	190.11	64.30	559.84	249.83	328.28	8624
22	-4.50	83.36	195.15	66.43	573.44	258.91	342.26	8860
23	-5.00	88.26	200.19	68.55	587.04	270.81	359.07	184293

Node no.	Y coord	----- PASSIVE 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
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	6338
11	3.50	0.00	9.00	1.96	65.25	65.25	65.25p	6338
12	3.00	0.00	18.01	3.92	130.54	114.20	114.20	6338
13	2.30	6.86	24.46	5.33	177.34	94.91	101.78	6338
14	1.60	13.73	30.95	6.74	224.34	79.31	93.04	6338
15	0.80	21.57	38.40	8.36	278.39	65.96	87.54	6338
16	0.00	29.42	45.91	10.00	332.87	57.00	86.42	6338
		29.42	45.91	3.48	170.62	170.62	200.04p	9229
17	-0.80	37.26	54.30	7.02	193.25	193.25	230.52p	9746
18	-1.60	45.11	62.77	10.59	216.10	213.25	258.36	10263
19	-2.40	52.96	71.32	14.19	239.19	218.97	271.92	10780
20	-3.20	60.80	79.96	17.84	262.52	227.99	288.79	11297
21	-4.00	68.65	88.69	21.52	286.09	238.48	307.13	11813
22	-4.50	73.55	94.20	23.84	300.94	244.89	318.44	12136
23	-5.00	78.45	99.74	26.18	315.90	248.19	326.64	184593

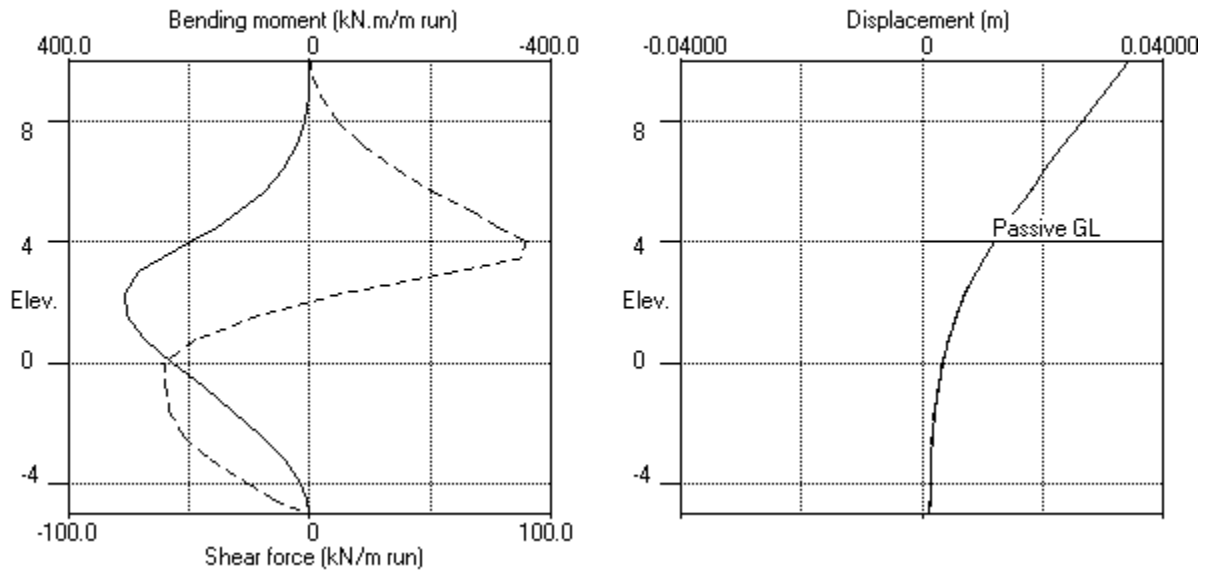
Note: 62.37a Soil pressure at active limit
230.52p Soil pressure at passive limit

APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

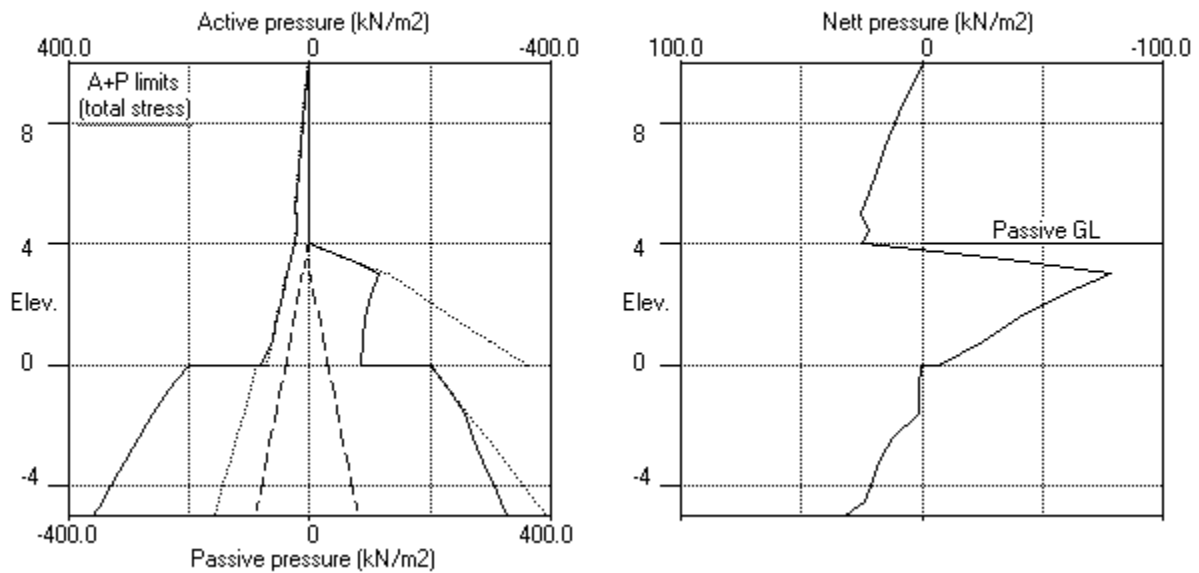
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

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: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	0.032	0.000	0	0	1	0	1	-0	1	-1
3	8.80	0.030	0.000	2	-0	2	-1	4	-1	6	-1
4	8.00	0.027	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	93	0
9	4.50	0.014	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	331	0	88	0	118	0
12	3.00	0.009	0.000	284	0	383	0	60	-0	82	-0
13	2.30	0.007	0.000	307	0	415	0	16	-11	21	-15
14	1.60	0.006	0.000	307	0	415	0	0	-33	0	-45
15	0.80	0.004	0.000	283	0	381	0	0	-48	0	-65
16	0.00	0.003	0.000	244	0	330	0	0	-61	0	-82
17	-0.80	0.003	0.000	193	0	261	0	0	-68	0	-92
18	-1.60	0.002	0.000	135	0	183	0	0	-69	0	-93
19	-2.40	0.002	0.000	83	0	112	0	0	-59	0	-79
20	-3.20	0.002	0.000	41	0	56	0	0	-43	0	-58
21	-4.00	0.001	0.000	14	0	19	0	0	-25	0	-34
22	-4.50	0.001	0.000	4	0	6	0	0	-14	0	-19
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	8	3.00	-1	7.20	10	-2	5	5.00	-1	0.80	7	-2
2	249	2.30	-0	10.00	336	-0	80	4.50	-52	-0.80	108	-70
3	305	2.30	-0	10.00	411	-0	90	4.00	-68	-0.80	122	-92
4	307	2.30	-0	10.00	415	-0	90	4.00	-69	-1.60	122	-93
5	306	2.30	-0	10.00	413	-0	90	4.00	-61	0.00	122	-82

APPENDIX C-3. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1 | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

Summary of results (continued)

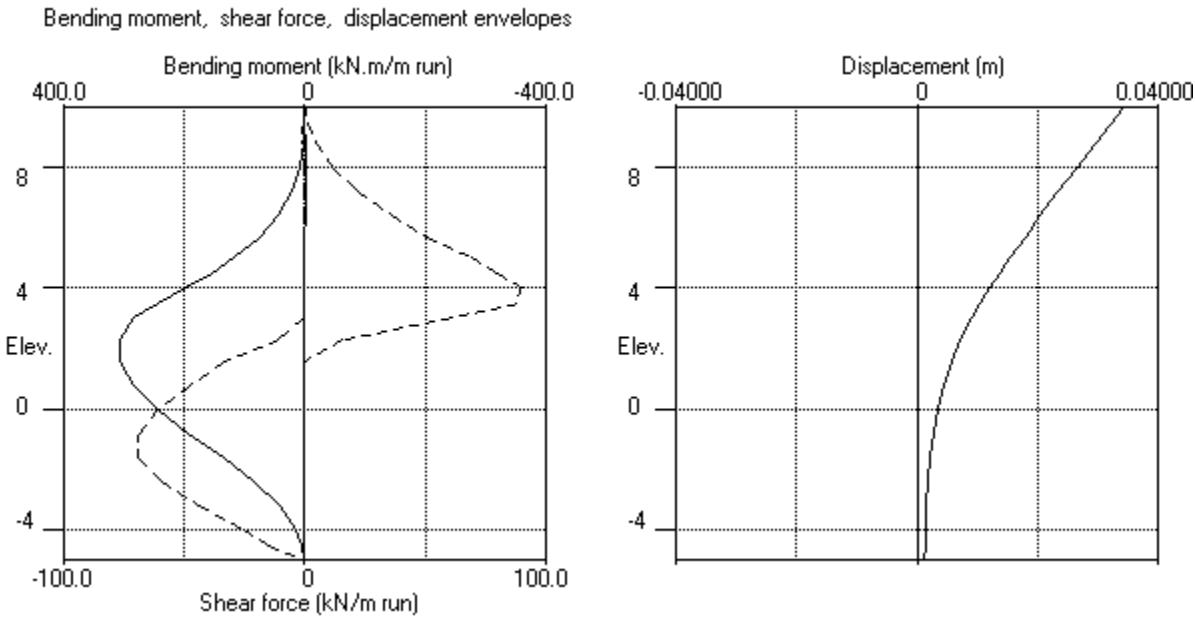
Maximum and minimum displacement at each stage

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	0.025	10.00	0.000	10.00	Excav. to elev. 4.50 on PASSIVE side	
3	0.032	10.00	0.000	10.00	Excav. to elev. 4.00 on PASSIVE side	
4	0.034	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: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS1
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

Units: kN,m



APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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 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 = 0.025765 m4/m run
E.I = 504994 kN.m2/m run
Yield Moment of wall = Not defined

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- Near edge	Surcharge ----- Far edge	Equiv. Partial soil factor/ type	Partial 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

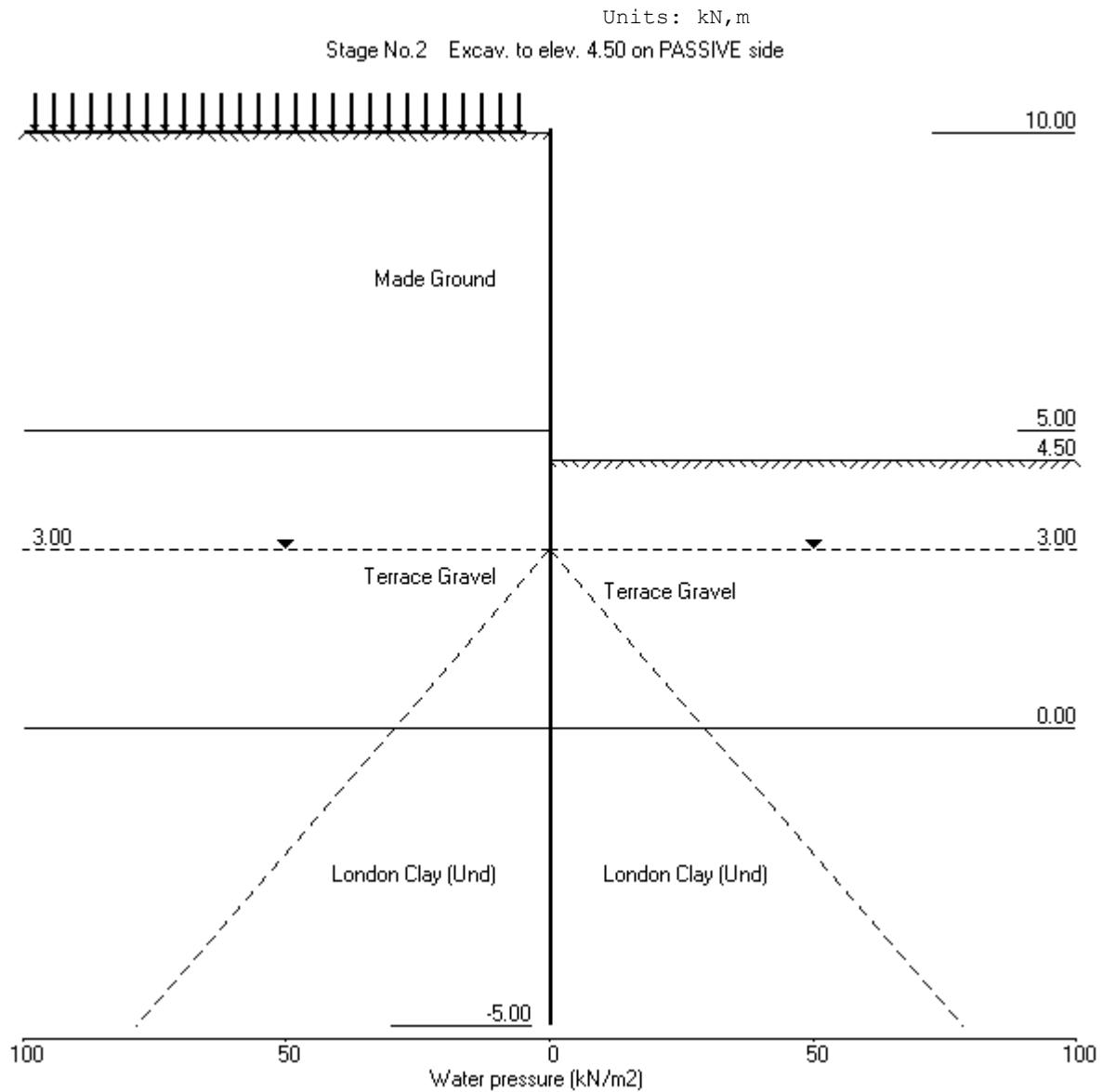
Distance to rigid boundary on passive side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Displacement	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	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

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :



APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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

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
2	10.00	4.50		Cant.	1.483	-3.76	-0.39	4.89

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/m2	m	rad.	kN/m	kN.m/m	kN/m
1	10.00	0.00	0.038	4.42E-03	0.0	0.0	
2	9.40	4.59	0.035	4.42E-03	1.4	0.5	
3	8.80	9.33	0.032	4.42E-03	5.6	2.4	
4	8.00	14.77	0.029	4.41E-03	15.2	10.4	
5	7.20	19.80	0.025	4.38E-03	29.0	27.8	
6	6.40	24.68	0.022	4.31E-03	46.8	57.8	
7	5.70	28.88	0.019	4.21E-03	65.6	97.0	
8	5.00	33.05	0.016	4.03E-03	87.2	150.3	
		27.18	0.016	4.03E-03	87.2	150.3	
9	4.50	29.76	0.014	3.86E-03	101.5	197.4	
10	4.00	-10.67	0.012	3.64E-03	106.2	250.1	
11	3.50	-51.13	0.010	3.37E-03	90.8	300.2	
12	3.00	-83.74	0.009	3.05E-03	57.1	342.2	
13	2.30	-59.84	0.007	2.56E-03	6.8	361.6	
14	1.60	-40.33	0.005	2.07E-03	-28.2	351.6	
15	0.80	-23.28	0.004	1.54E-03	-53.7	315.9	
16	0.00	-8.94	0.003	1.08E-03	-66.6	267.7	
		-20.85	0.003	1.08E-03	-66.6	267.7	
17	-0.80	-9.51	0.002	7.00E-04	-78.7	214.0	
18	-1.60	10.51	0.002	4.13E-04	-78.3	148.0	
19	-2.40	21.09	0.001	2.25E-04	-65.7	88.7	
20	-3.20	25.40	0.001	1.21E-04	-47.1	42.8	
21	-4.00	26.40	0.001	7.74E-05	-26.4	13.2	
22	-4.50	26.37	0.001	6.92E-05	-13.2	3.3	
23	-5.00	26.29	0.001	6.76E-05	0.0	0.0	

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	1598
2	9.40	0.00	13.38	4.59	47.91	4.59	4.59a	1598
3	8.80	0.00	27.19	9.33	97.37	9.33	9.33a	1598
4	8.00	0.00	43.02	14.77	154.04	14.77	14.77a	1598
5	7.20	0.00	57.69	19.80	206.57	19.80	19.80a	1598
6	6.40	0.00	71.90	24.68	257.45	24.68	24.68a	1598
7	5.70	0.00	84.14	28.88	301.29	28.88	28.88a	1598
8	5.00	0.00	96.28	33.05	344.74	33.05	33.05a	1598
		0.00	96.28	27.18	459.95	27.18	27.18a	7991
9	4.50	0.00	105.41	29.76	503.54	29.76	29.76a	7991
10	4.00	0.00	114.50	32.33	546.99	32.33	32.33a	7991
11	3.50	0.00	123.57	34.89	590.34	34.89	34.89a	7991
12	3.00	0.00	132.63	37.44	633.59	37.44	37.44a	7991
13	2.30	6.86	139.11	39.27	664.57	39.27	46.14a	7991
14	1.60	13.73	145.57	41.10	695.43	41.10	54.83a	7991
15	0.80	21.57	152.93	43.17	730.56	43.17	64.75a	7991
16	0.00	29.42	160.26	45.24	765.59	47.60	77.02	7991
		Total>	189.68	50.00m	332.58	206.46	206.46	21381
17	-0.80	Total>	205.63	54.76	356.54	239.19	239.19	22578
18	-1.60	Total>	221.57	62.70	380.48	267.21	267.21	23776
19	-2.40	Total>	237.50	70.62	404.41	291.56	291.56	24973
20	-3.20	Total>	253.41	78.53	428.32	313.47	313.47	26170
21	-4.00	Total>	269.30	86.43	452.22	334.12	334.12	27368
22	-4.50	Total>	279.24	91.36	467.15	346.79	346.79	28116
23	-5.00	Total>	289.16	96.28	482.08	359.44	359.44	28865

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	12775
10	4.00	0.00	9.00	2.54	43.00	43.00	43.00p	12775
11	3.50	0.00	18.00	5.08	86.01	86.01	86.01p	12775
12	3.00	0.00	27.02	7.63	129.06	121.18	121.18	12775
13	2.30	6.86	33.49	9.45	159.98	99.11	105.98	12775
14	1.60	13.73	39.99	11.29	191.04	81.43	95.16	12775
15	0.80	21.57	47.47	13.40	226.76	66.46	88.03	12775
16	0.00	29.42	55.01	15.53	262.79	56.54	85.96	12775
		Total>	84.43	22.50m	227.31	227.31	227.31p	33328
17	-0.80	Total>	100.68	26.50m	251.57	248.70	248.70	35194
18	-1.60	Total>	117.02	30.50m	275.90	256.70	256.70	37060
19	-2.40	Total>	133.43	34.50m	300.32	270.47	270.47	38927
20	-3.20	Total>	149.93	38.50m	324.82	288.08	288.08	40793
21	-4.00	Total>	166.51	42.50m	349.40	307.73	307.73	42659

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	364.81	320.41	43826
23	-5.00	Total>	187.34	47.50m	380.24	333.15	44992

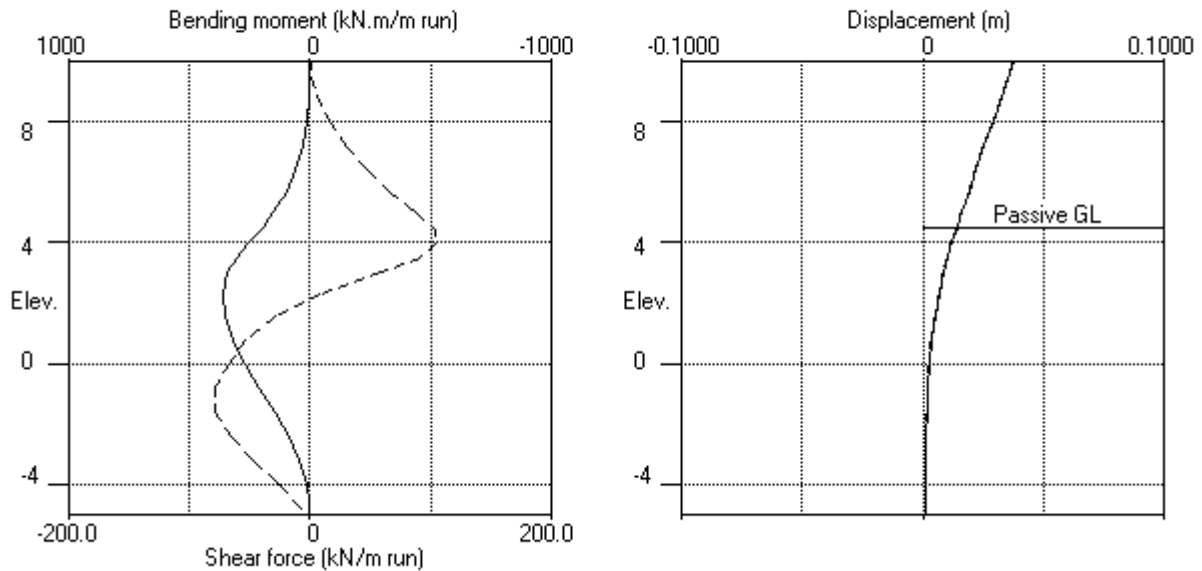
Note: 64.75a Soil pressure at active limit
227.31p Soil pressure at passive limit

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

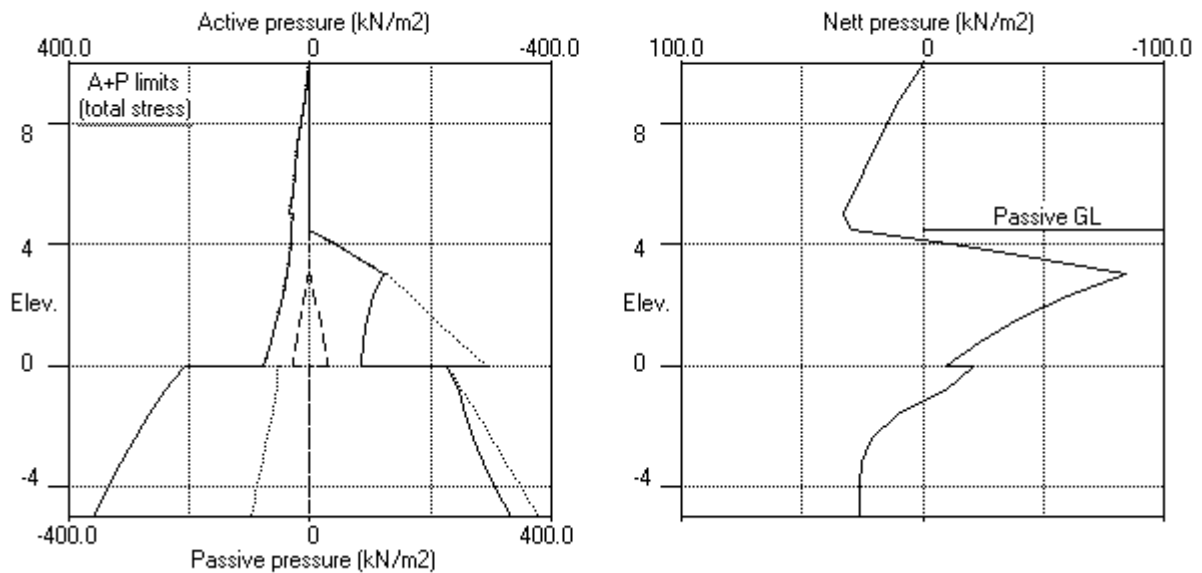
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
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Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

Units: kN,m

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

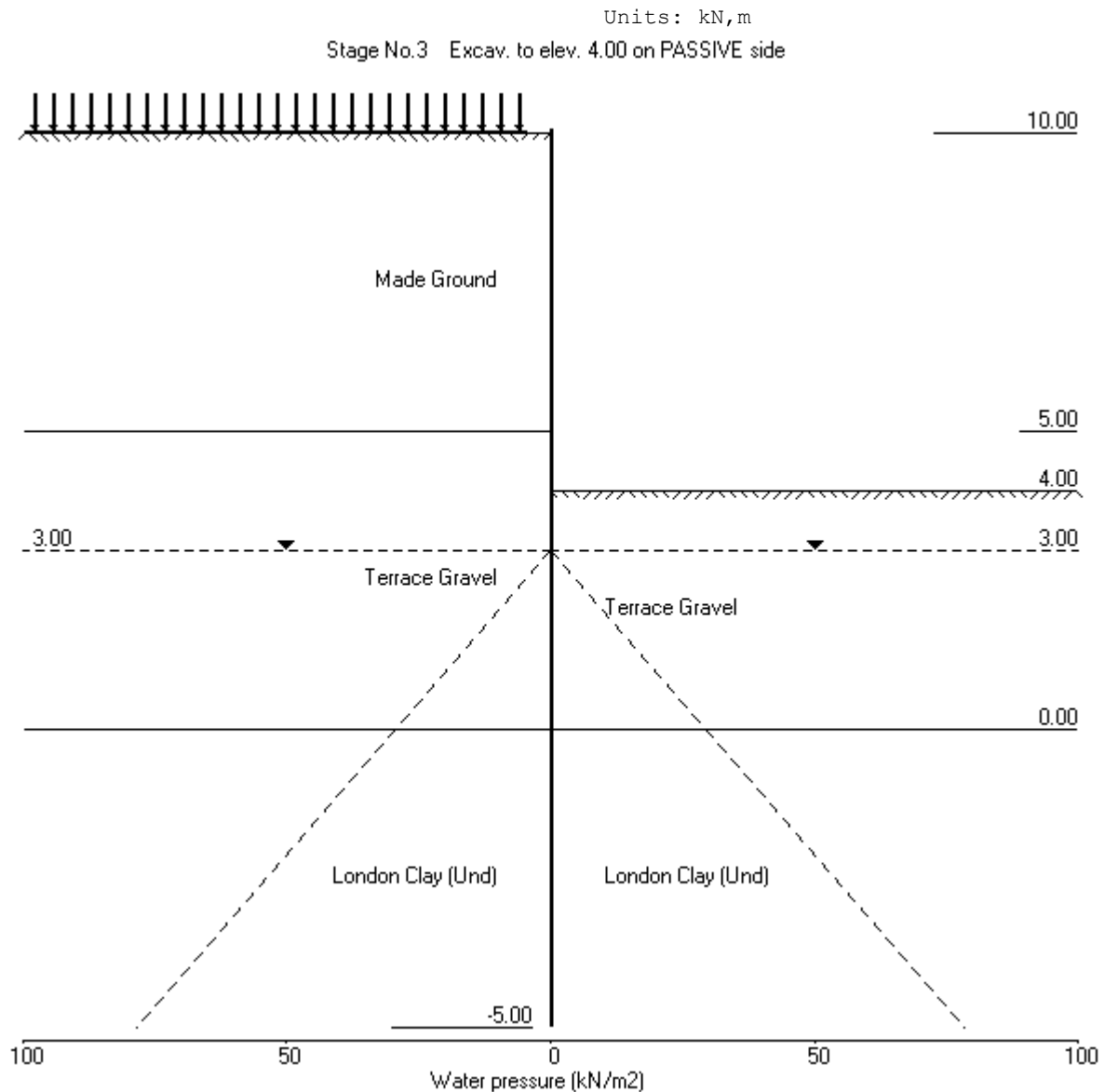


Stage No.2 Excav. to elev. 4.50 on PASSIVE side



APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :



APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	Y	Nett	Wall	Wall	Shear	Bending	Strut
no.	coord	pressure	disp.	rotation	force	moment	forces
		kN/m2	m	rad.	kN/m	kN.m/m	kN/m
1	10.00	0.00	0.053	5.92E-03	0.0	0.0	
2	9.40	4.59	0.050	5.92E-03	1.4	0.5	
3	8.80	9.33	0.046	5.92E-03	5.6	2.4	
4	8.00	14.77	0.042	5.91E-03	15.2	10.4	
5	7.20	19.80	0.037	5.88E-03	29.0	27.8	
6	6.40	24.68	0.032	5.81E-03	46.8	57.8	
7	5.70	28.88	0.028	5.70E-03	65.6	97.0	
8	5.00	33.05	0.024	5.53E-03	87.2	150.3	
		27.18	0.024	5.53E-03	87.2	150.3	
9	4.50	29.76	0.022	5.36E-03	101.5	197.4	
10	4.00	32.33	0.019	5.14E-03	117.0	251.9	
11	3.50	-8.11	0.016	4.86E-03	123.1	312.7	
12	3.00	-48.57	0.014	4.52E-03	108.9	375.9	
13	2.30	-77.59	0.011	3.96E-03	64.7	435.8	
14	1.60	-75.24	0.008	3.33E-03	11.2	463.8	
15	0.80	-47.18	0.006	2.61E-03	-37.7	448.6	
16	0.00	-26.13	0.004	1.93E-03	-67.1	405.2	
		-42.25	0.004	1.93E-03	-67.1	405.2	
17	-0.80	-23.35	0.003	1.34E-03	-93.3	344.0	
18	-1.60	-11.40	0.002	8.66E-04	-107.2	260.1	
19	-2.40	14.74	0.002	5.23E-04	-105.9	172.6	
20	-3.20	30.07	0.001	3.13E-04	-87.9	92.6	
21	-4.00	45.73	0.001	2.14E-04	-57.6	31.8	
22	-4.50	57.63	0.001	1.94E-04	-31.8	8.7	
23	-5.00	69.47	0.001	1.90E-04	0.0	-0.0	

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	
1	10.00	0.00	0.00	0.00	0.00	0.00	0.00	1416
2	9.40	0.00	13.38	4.59	47.91	4.59	4.59a	1416
3	8.80	0.00	27.19	9.33	97.37	9.33	9.33a	1416
4	8.00	0.00	43.02	14.77	154.04	14.77	14.77a	1416
5	7.20	0.00	57.69	19.80	206.57	19.80	19.80a	1416
6	6.40	0.00	71.90	24.68	257.45	24.68	24.68a	1416
7	5.70	0.00	84.14	28.88	301.29	28.88	28.88a	1416
8	5.00	0.00	96.28	33.05	344.74	33.05	33.05a	1416
		0.00	96.28	27.18	459.95	27.18	27.18a	7079
9	4.50	0.00	105.41	29.76	503.54	29.76	29.76a	7079
10	4.00	0.00	114.50	32.33	546.99	32.33	32.33a	7079
11	3.50	0.00	123.57	34.89	590.34	34.89	34.89a	7079
12	3.00	0.00	132.63	37.44	633.59	37.44	37.44a	7079
13	2.30	6.86	139.11	39.27	664.57	39.27	46.14a	7079
14	1.60	13.73	145.57	41.10	695.43	41.10	54.83a	7079
15	0.80	21.57	152.93	43.17	730.56	43.17	64.75a	7079
16	0.00	29.42	160.26	45.24	765.59	45.24	74.66a	7079
		Total>	189.68	50.00m	332.58	175.97	175.97	19130
17	-0.80	Total>	205.63	54.76	356.54	219.10	219.10	20201
18	-1.60	Total>	221.57	62.70	380.48	255.36	255.36	21273
19	-2.40	Total>	237.50	70.62	404.41	285.75	285.75	22344
20	-3.20	Total>	253.41	78.53	428.32	311.89	311.89	23415
21	-4.00	Total>	269.30	86.43	452.22	339.39	339.39	86764
22	-4.50	Total>	279.24	91.36	467.15	358.01	358.01	89136
23	-5.00	Total>	289.16	96.28	482.08	376.63	376.63	91508

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	11749
11	3.50	0.00	9.00	2.54	43.00	43.00	43.00p	11749
12	3.00	0.00	18.01	5.08	86.02	86.02	86.02p	11749
13	2.30	6.86	24.46	6.91	116.86	116.86	123.72p	11749
14	1.60	13.73	30.95	8.74	147.83	116.34	130.07	11749
15	0.80	21.57	38.40	10.84	183.44	90.36	111.93	11749
16	0.00	29.42	45.91	12.96	219.34	71.37	100.79	11749
		Total>	75.33	20.00m	218.21	218.21	218.21p	30757
17	-0.80	Total>	91.56	24.00m	242.45	242.45	242.45p	32479
18	-1.60	Total>	107.88	28.00m	266.76	266.76	266.76p	34201
19	-2.40	Total>	124.27	32.00m	291.16	271.01	271.01	35924
20	-3.20	Total>	140.76	36.00m	315.65	281.82	281.82	37646
21	-4.00	Total>	157.34	40.00m	340.23	293.65	293.65	86764

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :

(continued)

Stage No.3 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	
22	-4.50	Total>	167.75	42.50m	355.64	300.39	300.39	89136
23	-5.00	Total>	178.19	45.00m	371.09	307.17	307.17	91508

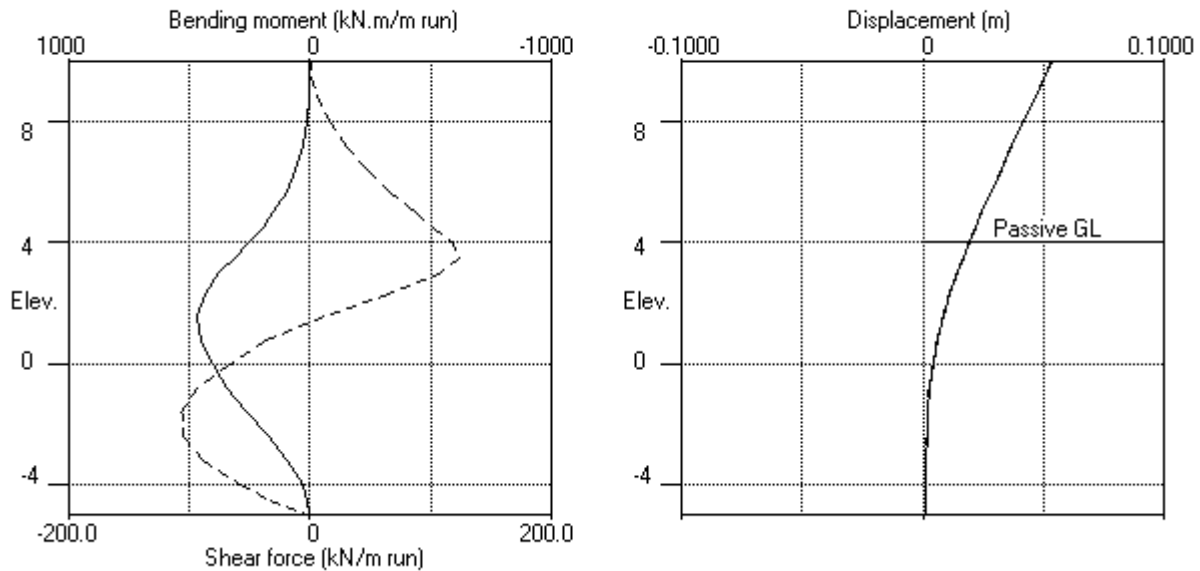
Note: 74.66a Soil pressure at active limit
 266.76p Soil pressure at passive limit

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

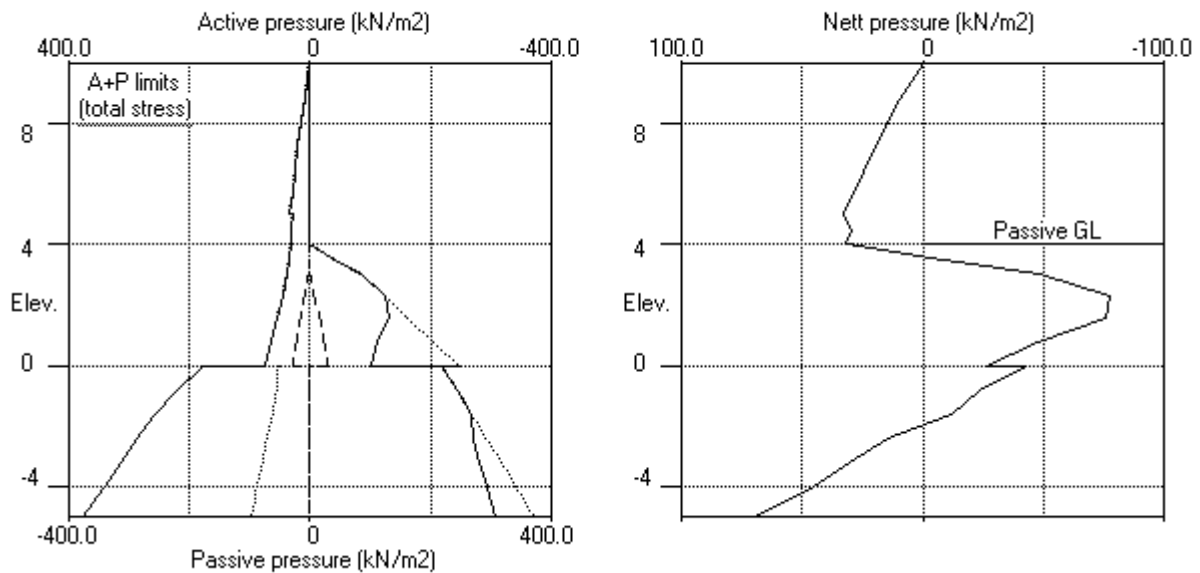
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

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

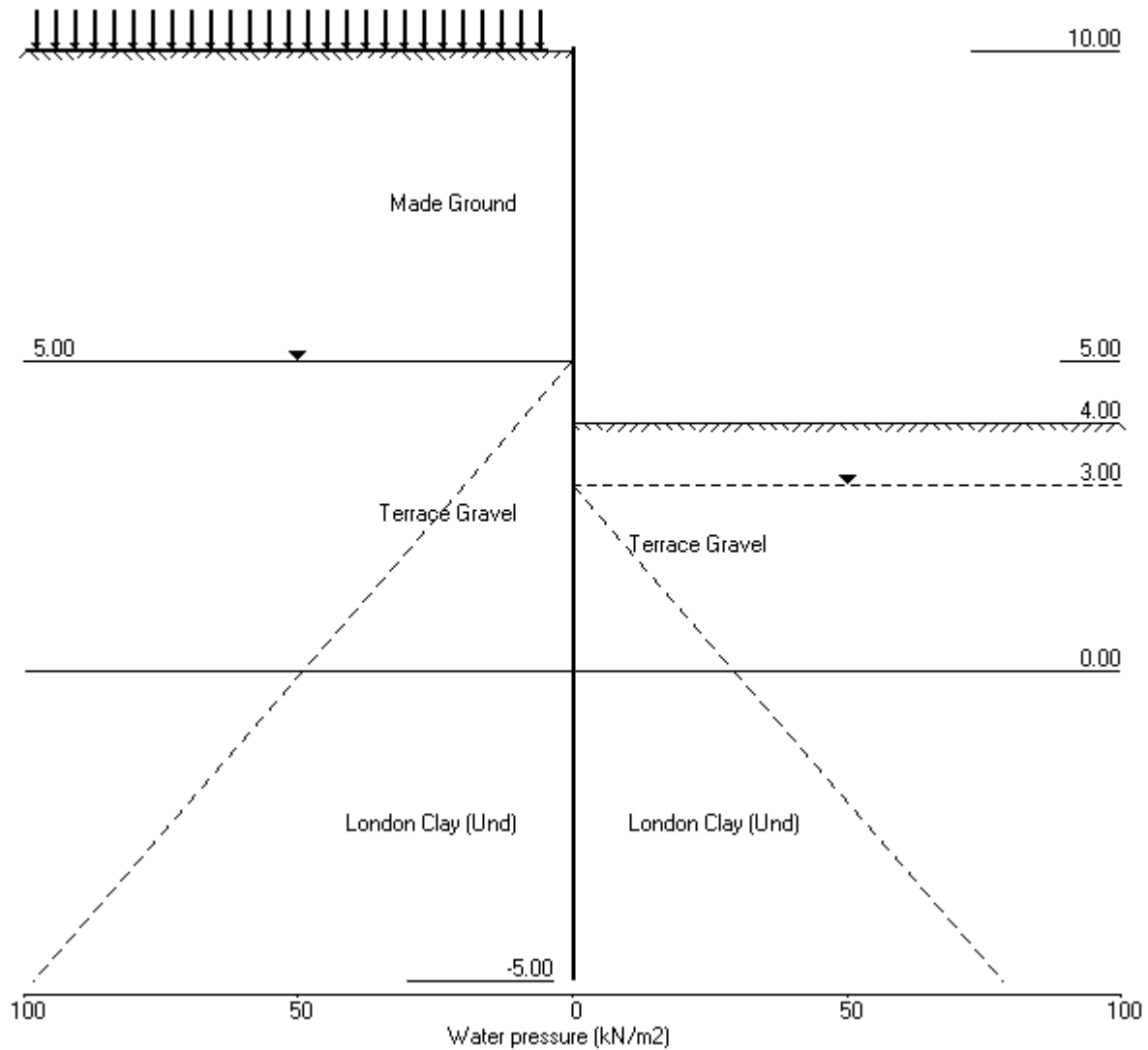


APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
 Licensed from GEOSOLVE | Made by : HGC
 Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :

Units: kN,m

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



APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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 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	0.064	6.82E-03	0.0	-0.0	
2	9.40	4.59	0.059	6.82E-03	1.4	0.5	
3	8.80	9.33	0.055	6.82E-03	5.6	2.4	
4	8.00	14.77	0.050	6.81E-03	15.2	10.4	
5	7.20	19.80	0.044	6.78E-03	29.0	27.8	
6	6.40	24.68	0.039	6.71E-03	46.8	57.8	
7	5.70	28.88	0.034	6.61E-03	65.6	97.0	
8	5.00	33.05	0.030	6.43E-03	87.2	150.3	
		27.18	0.030	6.43E-03	87.2	150.3	
9	4.50	33.42	0.027	6.26E-03	102.4	197.5	
10	4.00	39.65	0.024	6.04E-03	120.7	253.1	
11	3.50	2.87	0.021	5.76E-03	131.3	316.8	
12	3.00	-33.93	0.018	5.41E-03	123.5	385.7	
13	2.30	-62.94	0.014	4.82E-03	89.6	459.4	
14	1.60	-88.21	0.011	4.15E-03	36.7	508.4	
15	0.80	-53.46	0.008	3.35E-03	-20.0	509.4	
16	0.00	-26.52	0.006	2.56E-03	-51.9	478.2	
		-65.52	0.006	2.56E-03	-51.9	478.2	
17	-0.80	-39.13	0.004	1.85E-03	-93.8	421.7	
18	-1.60	-20.73	0.003	1.25E-03	-117.8	332.3	
19	-2.40	0.37	0.002	8.11E-04	-125.9	233.4	
20	-3.20	26.08	0.001	5.21E-04	-115.3	132.8	
21	-4.00	54.39	0.001	3.77E-04	-83.1	48.8	
22	-4.50	83.09	0.001	3.46E-04	-48.8	14.0	
23	-5.00	111.93	0.001	3.39E-04	0.0	0.0	

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	1364
2	9.40	0.00	13.38	4.59	47.91	4.59	4.59a	1364
3	8.80	0.00	27.19	9.33	97.37	9.33	9.33a	1364
4	8.00	0.00	43.02	14.77	154.04	14.77	14.77a	1364
5	7.20	0.00	57.69	19.80	206.57	19.80	19.80a	1364
6	6.40	0.00	71.90	24.68	257.45	24.68	24.68a	1364
7	5.70	0.00	84.14	28.88	301.29	28.88	28.88a	1364
8	5.00	0.00	96.28	33.05	344.74	33.05	33.05a	1364
		0.00	96.28	27.18	459.95	27.18	27.18a	6821
9	4.50	4.90	101.00	28.51	482.50	28.51	33.42a	6821
10	4.00	9.81	105.70	29.84	504.92	29.84	39.65a	6821
11	3.50	14.71	110.37	31.16	527.23	31.16	45.87a	6821
12	3.00	19.61	115.02	32.47	549.45	32.47	52.08a	6821
13	2.30	26.48	121.50	34.30	580.43	34.30	60.78a	6821
14	1.60	33.34	127.96	36.12	611.29	36.12	69.47a	6821
15	0.80	41.19	135.31	38.20	646.42	38.20	79.39a	6821
16	0.00	49.03	142.65	40.27	681.44	40.27	89.30a	6821
		Total>	191.68	50.00m	334.58	152.69	152.69	18500
17	-0.80	Total>	207.63	56.76	358.54	203.32	203.32	19536
18	-1.60	Total>	223.57	64.70	382.48	246.03	246.03	20572
19	-2.40	Total>	239.50	72.62	406.40	281.68	281.68	21608
20	-3.20	Total>	255.41	80.53	430.32	311.93	311.93	22644
21	-4.00	Total>	271.30	88.43	454.22	345.06	345.06	103789
22	-4.50	Total>	281.24	93.36	469.15	372.09	372.09	106627
23	-5.00	Total>	291.16	98.29	484.08	399.21	399.21	109465

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	10713
11	3.50	0.00	9.00	2.54	43.00	43.00	43.00p	10713
12	3.00	0.00	18.01	5.08	86.02	86.02	86.02p	10713
13	2.30	6.86	24.46	6.91	116.86	116.86	123.72p	10713
14	1.60	13.73	30.95	8.74	147.83	143.95	157.68	10713
15	0.80	21.57	38.40	10.84	183.44	111.27	132.85	10713
16	0.00	29.42	45.91	12.96	219.34	86.41	115.82	10713
		Total>	75.33	20.00m	218.21	218.21	218.21p	28165
17	-0.80	Total>	91.56	24.00m	242.45	242.45	242.45p	29742
18	-1.60	Total>	107.88	28.00m	266.76	266.76	266.76p	31320
19	-2.40	Total>	124.27	32.00m	291.16	281.31	281.31	32897
20	-3.20	Total>	140.76	36.00m	315.65	285.85	285.85	34474
21	-4.00	Total>	157.34	40.00m	340.23	290.67	290.67	103789

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | Checked :

(continued)

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

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>	167.75	42.50m	355.64	289.00	289.00	106627
23	-5.00	Total>	178.19	45.00m	371.09	287.28	287.28	109465

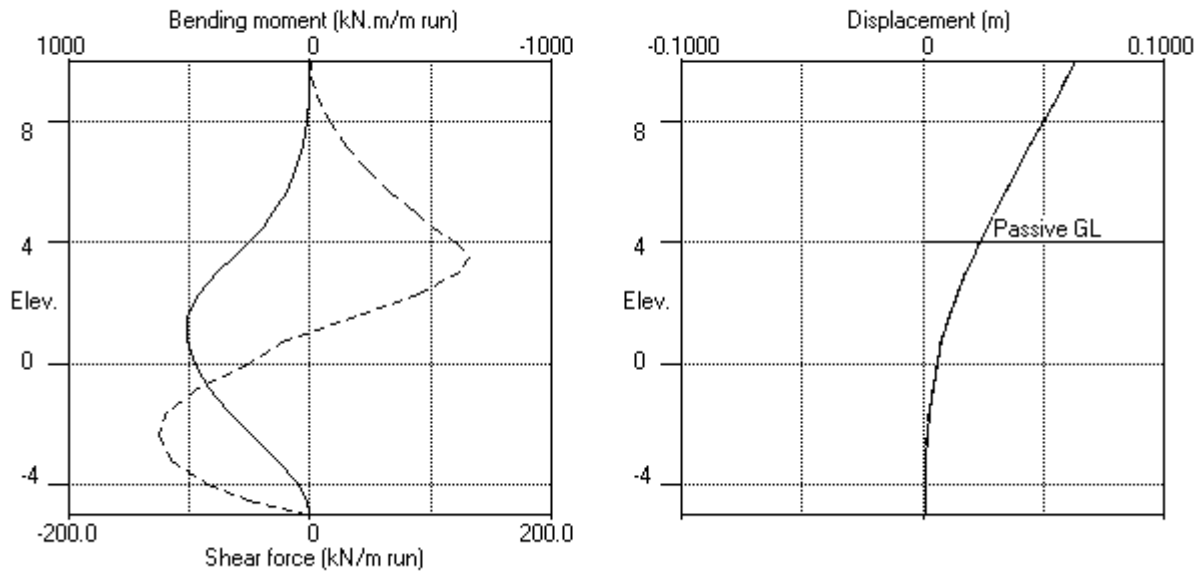
Note: 89.30a Soil pressure at active limit
 266.76p Soil pressure at passive limit

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

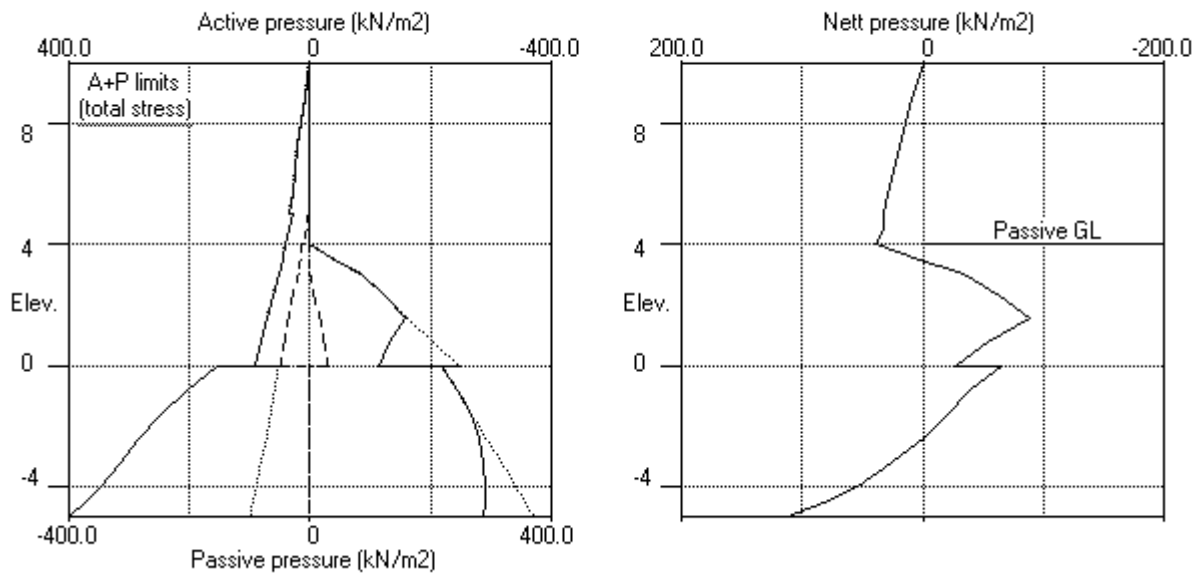
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

Units: kN,m

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

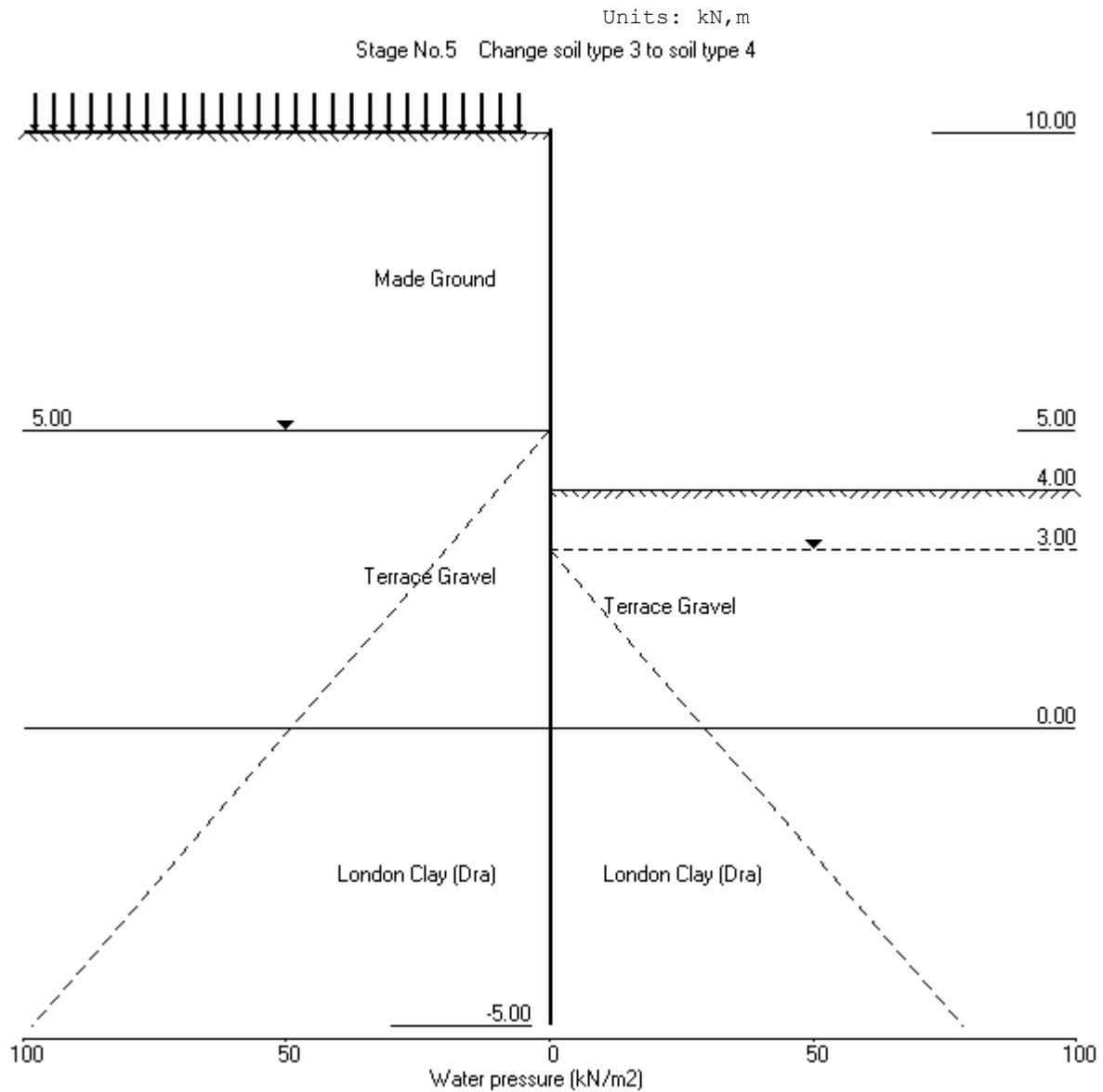


Stage No.4 Apply water pressure profile no.2 (Worst Cred.)



APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :



APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	0.072	7.31E-03	0.0	-0.0	
2	9.40	4.59	0.068	7.31E-03	1.4	0.5	
3	8.80	9.33	0.064	7.31E-03	5.6	2.4	
4	8.00	14.77	0.058	7.30E-03	15.2	10.4	
5	7.20	19.80	0.052	7.27E-03	29.0	27.8	
6	6.40	24.68	0.046	7.20E-03	46.8	57.8	
7	5.70	28.88	0.041	7.10E-03	65.6	97.0	
8	5.00	33.05	0.036	6.93E-03	87.2	150.3	
		27.18	0.036	6.93E-03	87.2	150.3	
9	4.50	33.42	0.033	6.75E-03	102.4	197.5	
10	4.00	39.65	0.029	6.53E-03	120.7	253.1	
11	3.50	2.87	0.026	6.25E-03	131.3	316.8	
12	3.00	-33.93	0.023	5.90E-03	123.5	385.7	
13	2.30	-62.94	0.019	5.31E-03	89.6	459.4	
14	1.60	-92.09	0.016	4.64E-03	35.4	508.1	
15	0.80	-82.84	0.012	3.84E-03	-34.6	507.2	
16	0.00	-53.21	0.010	3.08E-03	-89.0	454.9	
		-40.84	0.010	3.08E-03	-89.0	454.9	
17	-0.80	-14.69	0.007	2.42E-03	-111.3	376.3	
18	-1.60	4.21	0.006	1.90E-03	-115.4	280.6	
19	-2.40	16.84	0.004	1.53E-03	-107.0	190.3	
20	-3.20	24.84	0.003	1.29E-03	-90.4	107.6	
21	-4.00	36.35	0.002	1.17E-03	-65.9	40.8	
22	-4.50	63.11	0.002	1.15E-03	-41.0	12.6	
23	-5.00	100.94	0.001	1.14E-03	0.0	-0.0	

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	1064
2	9.40	0.00	13.38	4.59	47.91	4.59	4.59a	1064
3	8.80	0.00	27.19	9.33	97.37	9.33	9.33a	1064
4	8.00	0.00	43.02	14.77	154.04	14.77	14.77a	1064
5	7.20	0.00	57.69	19.80	206.57	19.80	19.80a	1064
6	6.40	0.00	71.90	24.68	257.45	24.68	24.68a	1064
7	5.70	0.00	84.14	28.88	301.29	28.88	28.88a	1064
8	5.00	0.00	96.28	33.05	344.74	33.05	33.05a	1064
		0.00	96.28	27.18	459.95	27.18	27.18a	5321
9	4.50	4.90	101.00	28.51	482.50	28.51	33.42a	5321
10	4.00	9.81	105.70	29.84	504.92	29.84	39.65a	5321
11	3.50	14.71	110.37	31.16	527.23	31.16	45.87a	5321
12	3.00	19.61	115.02	32.47	549.45	32.47	52.08a	5321
13	2.30	26.48	121.50	34.30	580.43	34.30	60.78a	5321
14	1.60	33.34	127.96	36.12	611.29	36.12	69.47a	5321
15	0.80	41.19	135.31	38.20	646.42	38.20	79.39a	5321
16	0.00	49.03	142.65	40.27	681.44	40.27	89.30a	5321
		49.03	142.65	56.77	346.03	73.19	122.23	7694
17	-0.80	56.88	150.76	60.79	363.83	117.76	174.64	8124
18	-1.60	64.72	158.85	64.79	381.60	155.25	219.97	8555
19	-2.40	72.57	166.93	68.79	399.34	186.65	259.22	8986
20	-3.20	80.41	174.99	72.79	417.04	213.62	294.04	9417
21	-4.00	88.26	183.05	76.78	434.72	244.31	332.57	9848
22	-4.50	93.16	188.07	79.27	445.76	270.16	363.32	10117
23	-5.00	98.07	193.10	81.75	456.80	296.32	394.39	10386

Node no.	Y coord	----- PASSIVE 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
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	6738
11	3.50	0.00	9.00	2.54	43.00	43.00	43.00p	6738
12	3.00	0.00	18.01	5.08	86.02	86.02	86.02p	6738
13	2.30	6.86	24.46	6.91	116.86	116.86	123.72p	6738
14	1.60	13.73	30.95	8.74	147.83	147.83	161.56p	6738
15	0.80	21.57	38.40	10.84	183.44	140.65	162.23	6738
16	0.00	29.42	45.91	12.96	219.34	113.09	142.51	6738
		29.42	45.91	8.87	133.65	133.65	163.07p	9831
17	-0.80	37.26	54.30	13.02	152.06	152.06	189.33p	10381
18	-1.60	45.11	62.77	17.21	170.65	170.65	215.76p	10932
19	-2.40	52.96	71.32	21.45	189.43	189.43	242.38p	11482
20	-3.20	60.80	79.96	25.73	208.40	208.40	269.20p	12033

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
 Secant Piled Wall | Date: 6-06-2015
 900mm dia. @ 1250mm c/c | 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	Soil stiffness coeff.
		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	12583
22	-4.50	73.55	94.20	32.78	239.66	226.66	300.21	12927
23	-5.00	78.45	99.74	35.52	251.82	214.99	293.44	13271

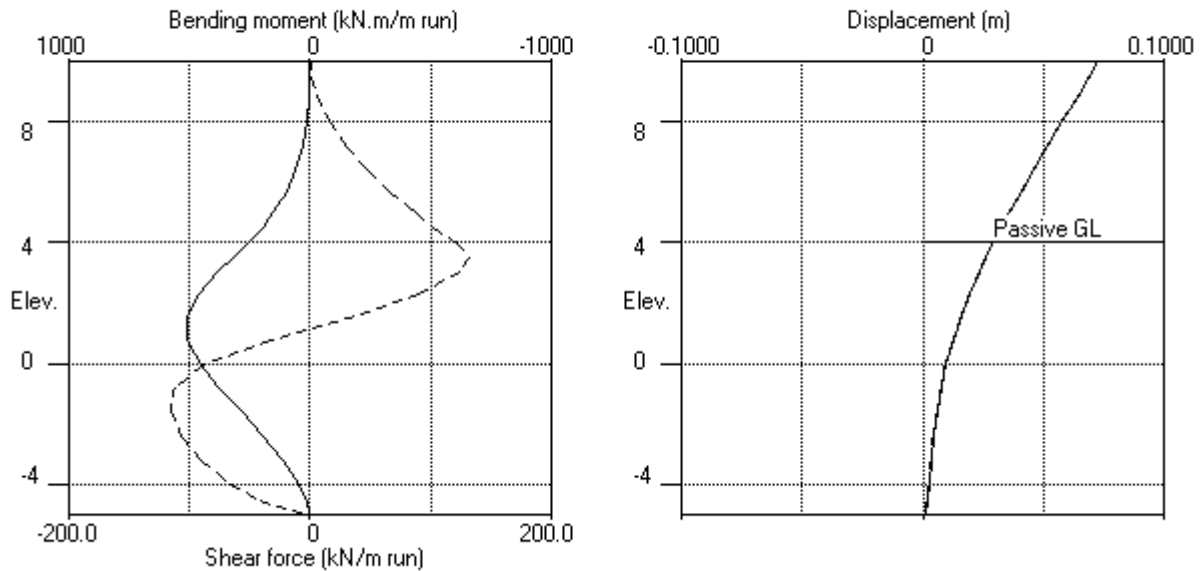
Note: 89.30a Soil pressure at active limit
 296.22p Soil pressure at passive limit

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

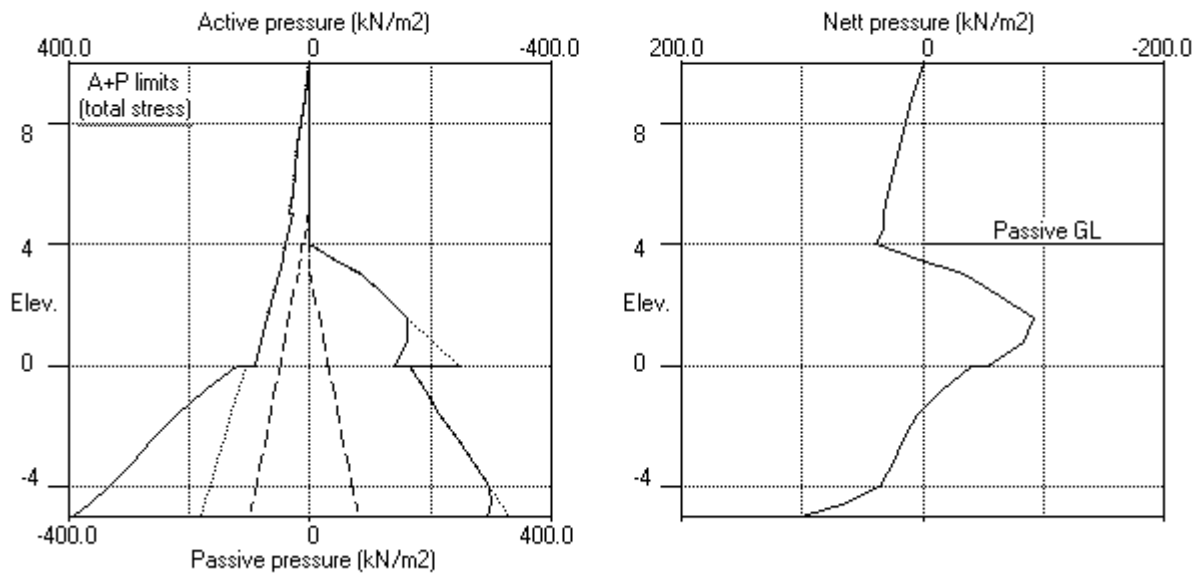
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

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: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

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Program: WALLAP Version 6.05 Revision A45.B58.R49      | Job No. 1503
          Licensed from GEOSOLVE                      | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall                                     | Date: 6-06-2015
900mm dia. @ 1250mm 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: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm 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	0.072	0.000	0.0	-0.0	0.0	0.0
2	9.40	0.068	0.000	0.5	0.0	1.4	-0.6
3	8.80	0.064	0.000	2.4	-0.5	5.6	-1.1
4	8.00	0.058	0.000	10.4	-1.3	15.2	-0.8
5	7.20	0.052	0.000	27.8	-1.6	29.0	0.0
6	6.40	0.046	0.000	57.8	-0.7	46.8	0.0
7	5.70	0.041	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	0.033	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	385.7	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	508.4	0.0	36.7	-28.2
15	0.80	0.012	0.000	509.4	0.0	0.0	-53.7
16	0.00	0.010	0.000	478.2	0.0	0.0	-89.0
17	-0.80	0.007	0.000	421.7	0.0	0.0	-111.3
18	-1.60	0.006	0.000	332.3	0.0	0.0	-117.8
19	-2.40	0.004	0.000	233.4	0.0	0.0	-125.9
20	-3.20	0.003	0.000	132.8	0.0	0.0	-115.3
21	-4.00	0.002	0.000	48.8	0.0	0.0	-83.1
22	-4.50	0.002	0.000	14.0	0.0	0.0	-48.8
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	9.0	3.00	-1.6	7.20	5.7	5.00	-1.5	0.80
2	361.6	2.30	0.0	10.00	106.2	4.00	-78.7	-0.80
3	463.8	1.60	-0.0	-5.00	123.1	3.50	-107.2	-1.60
4	509.4	0.80	-0.0	10.00	131.3	3.50	-125.9	-2.40
5	508.1	1.60	-0.0	10.00	131.3	3.50	-115.4	-1.60

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Run ID. SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2 | Sheet No.
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

Summary of results (continued)

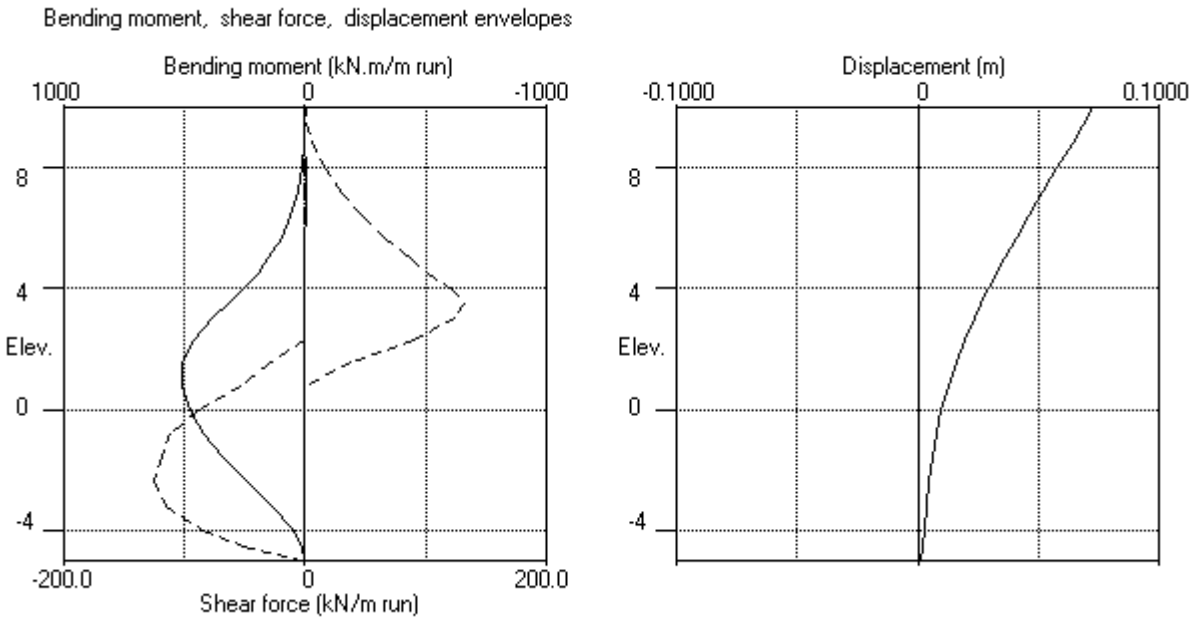
Maximum and minimum displacement at each stage

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	0.038	10.00	0.000	10.00	Excav. to elev. 4.50 on PASSIVE side	
3	0.053	10.00	0.000	10.00	Excav. to elev. 4.00 on PASSIVE side	
4	0.064	10.00	0.000	10.00	Apply water pressure profile no.2	
5	0.072	10.00	0.000	10.00	Change soil type 3 to soil type 4	

APPENDIX C-4. WALLAP run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2

Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. 1503
Licensed from GEOSOLVE | Made by : HGC
Data filename/Run ID: SPW_Dia900mm_1250mmCC_Toe-5mOD_Fmn+4_5mOD_LT_ULS2
Secant Piled Wall | Date: 6-06-2015
900mm dia. @ 1250mm c/c | Checked :

Units: kN,m



APPENDIX D

APPENDIX D Plaxis 2D FE Analysis of Secant Piled Wall

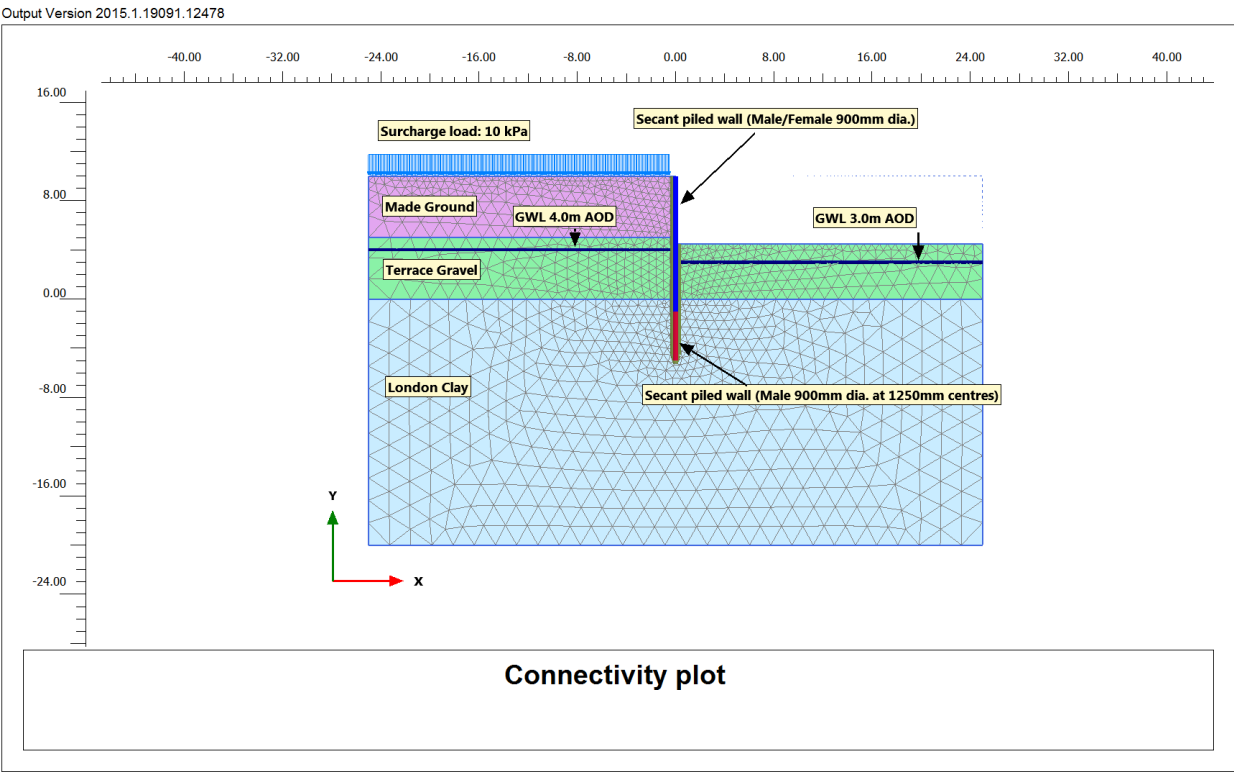


Figure D.1 Connectivity plot

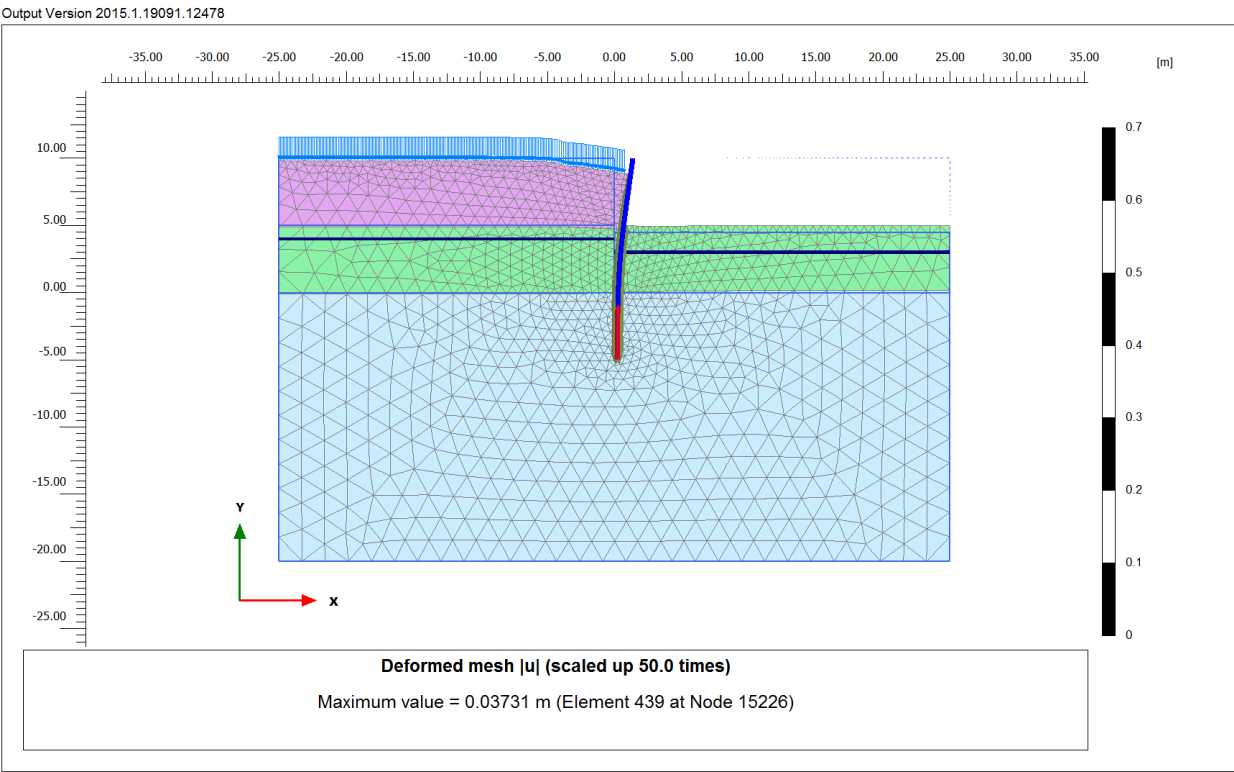


Figure D.2 Deformed mesh $|u|$

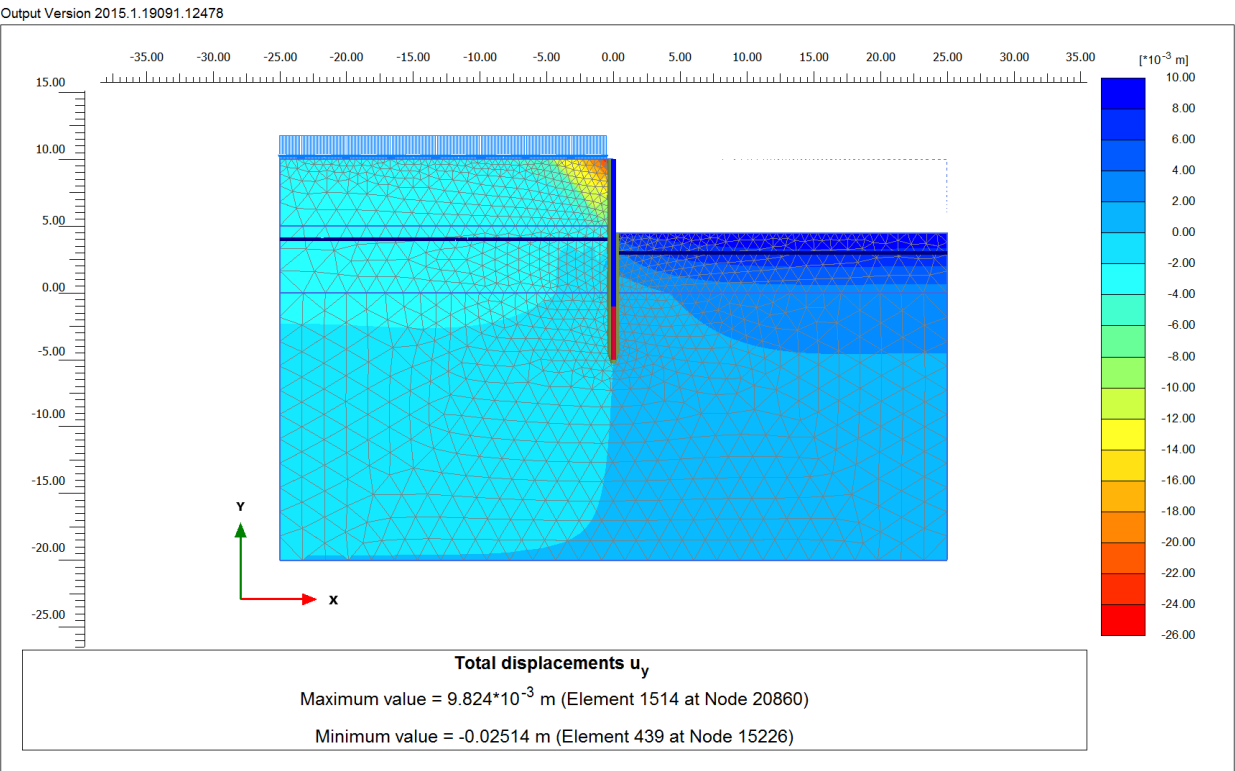


Figure D.3 Total vertical displacements

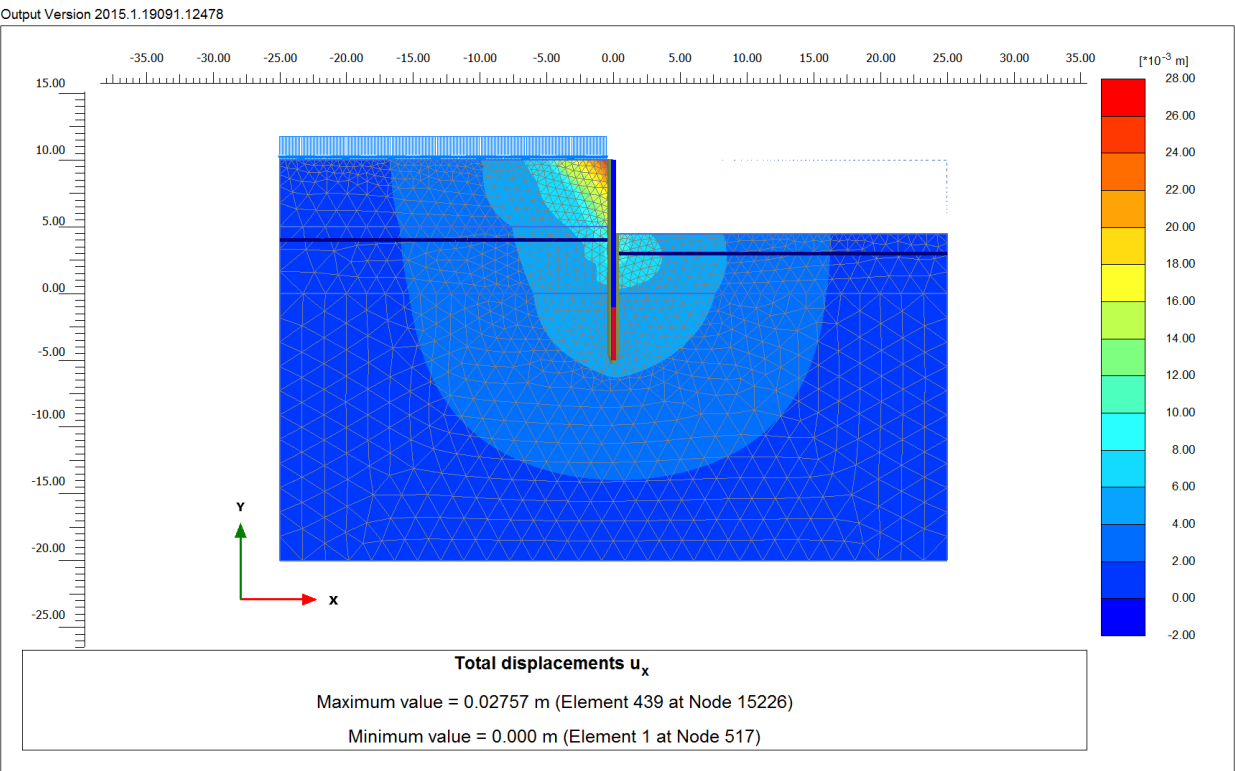


Figure D.4 Total horizontal displacements

APPENDIX D Plaxis 2D FE Analysis of Secant Piled Wall

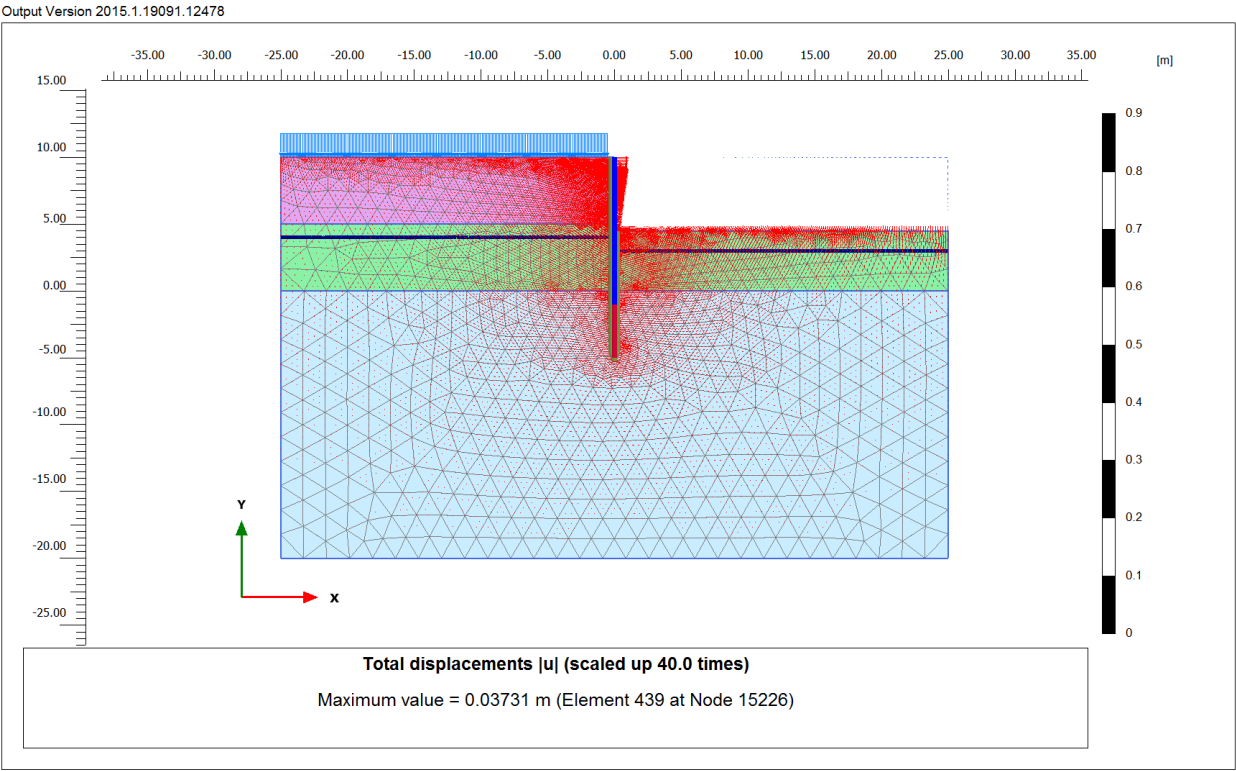


Figure D.5 Vector of total displacements

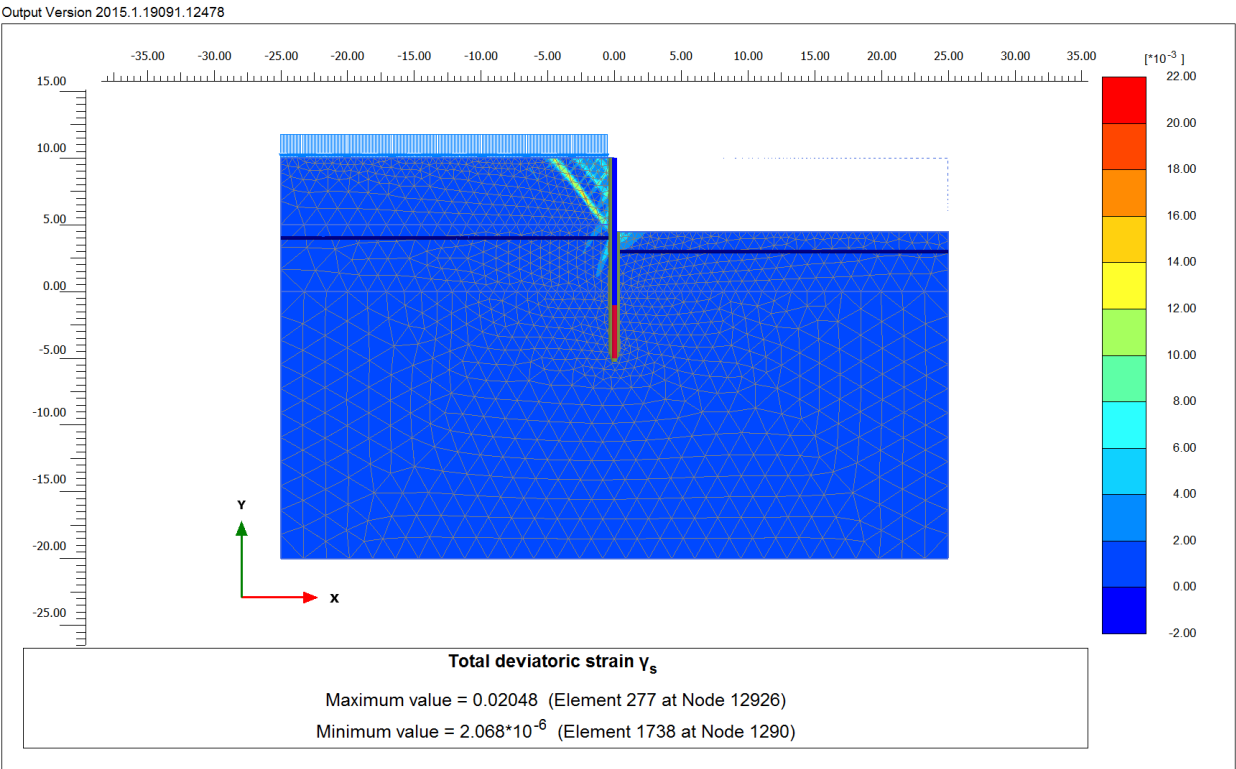


Figure D.6 Total shear strain, γ_s

APPENDIX D Plaxis 2D FE Analysis of Secant Piled Wall

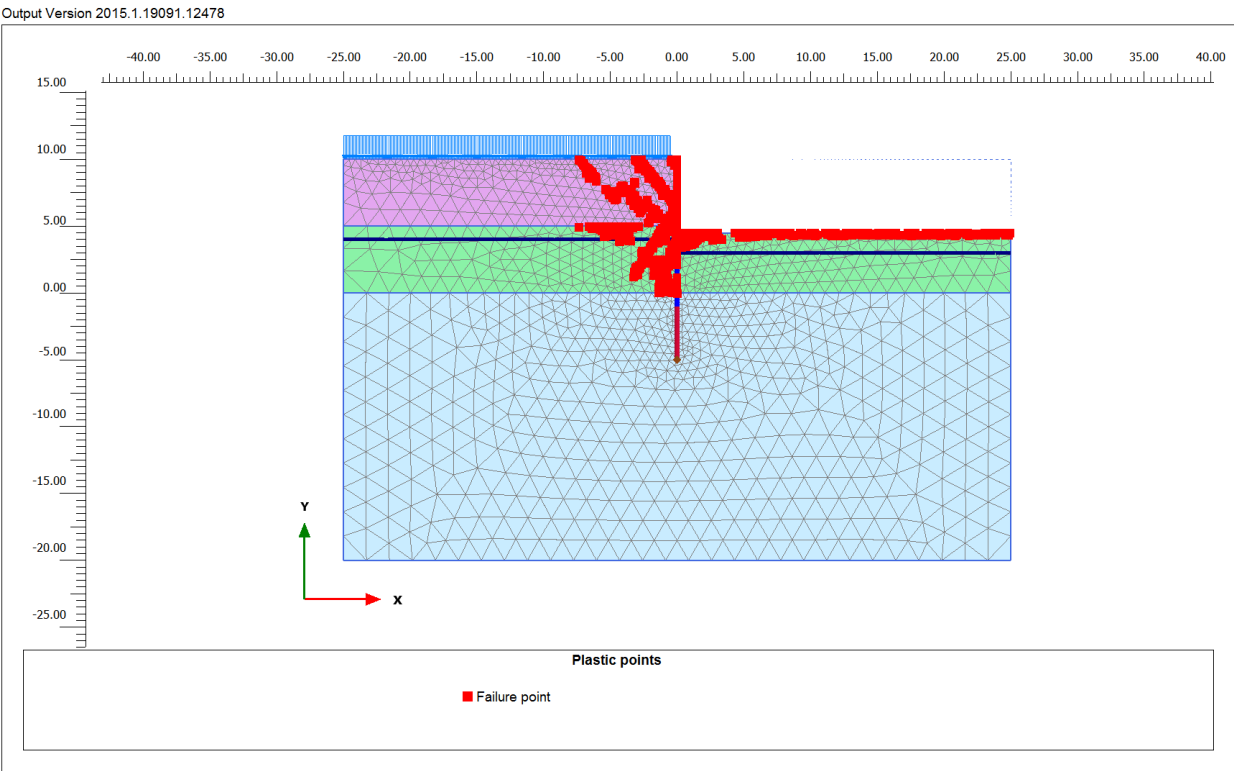


Figure D.7 Distribution of plastic points

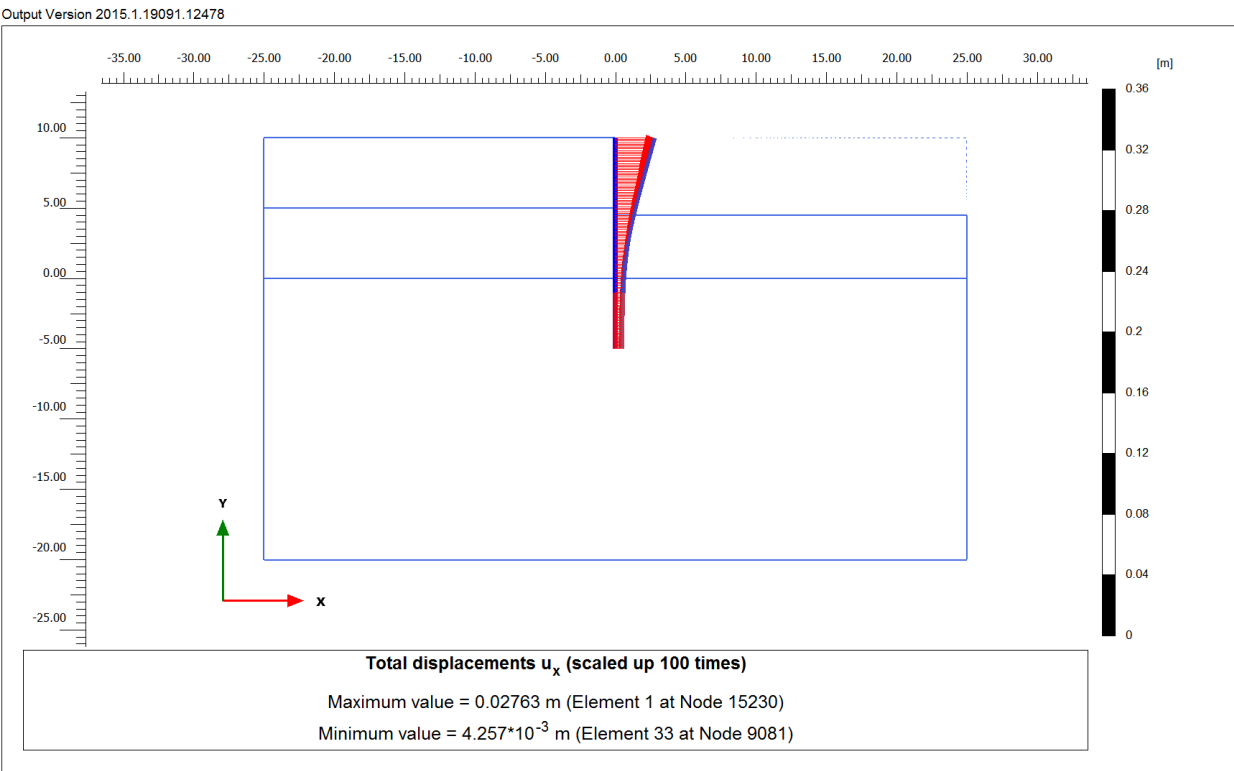


Figure D.8 Profile of horizontal wall displacements for Secant Piles (Hard/Firm 900mm dia.@ 1250mm centres)

APPENDIX D Plaxis 2D FE Analysis of Secant Piled Wall

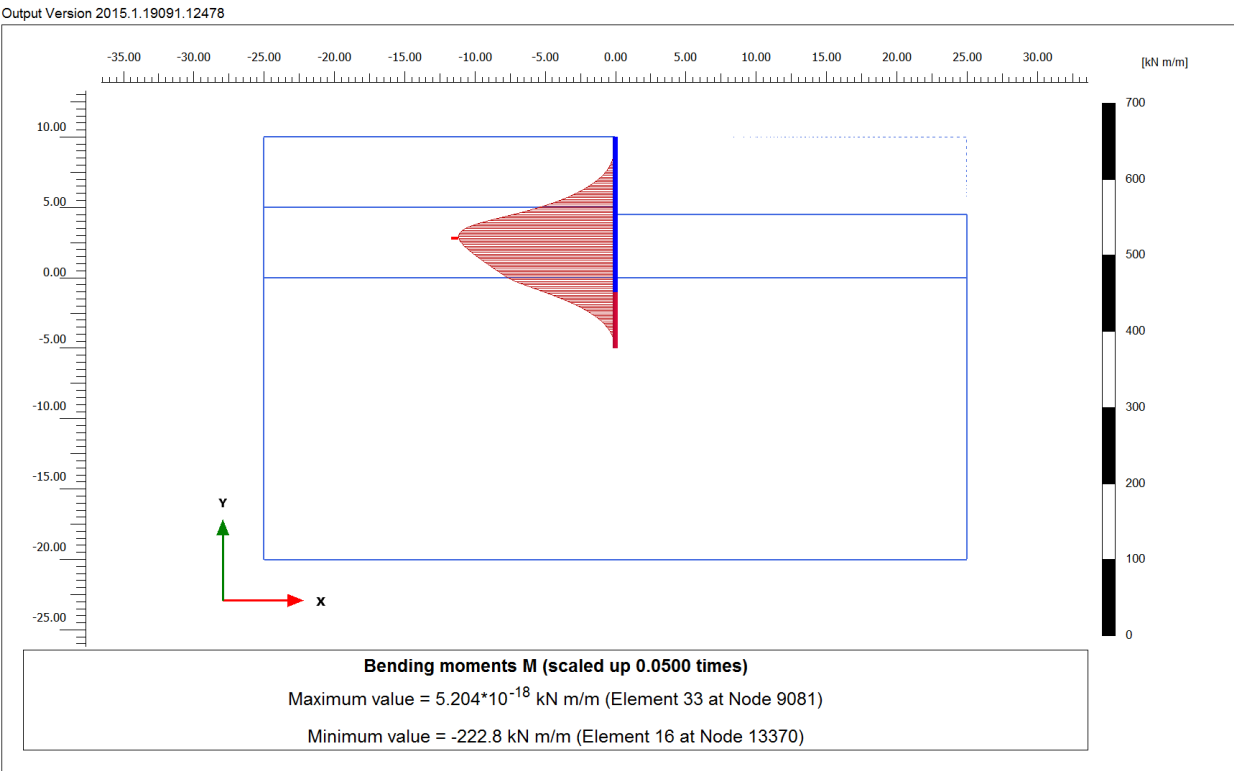


Figure D.9 Profile of wall bending moment for Secant Piles (Hard/Firm 900mm dia.@ 1250mm centres)

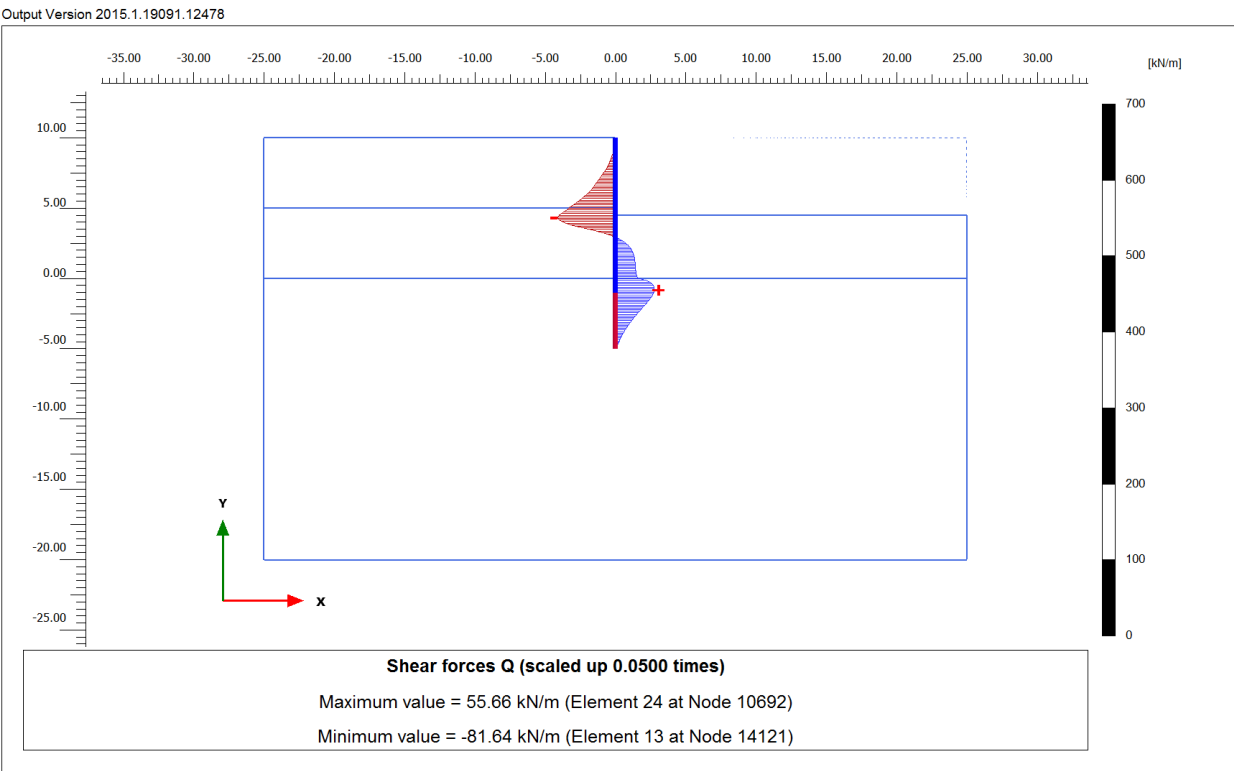


Figure D.10 Profile of wall shear force for Secant Piles (Hard/Firm 900mm dia.@ 1250mm centres)

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