APPENDIX C

Recent Trial Pitting Information

Symmetrys Limited
Consulting Structural Engineers

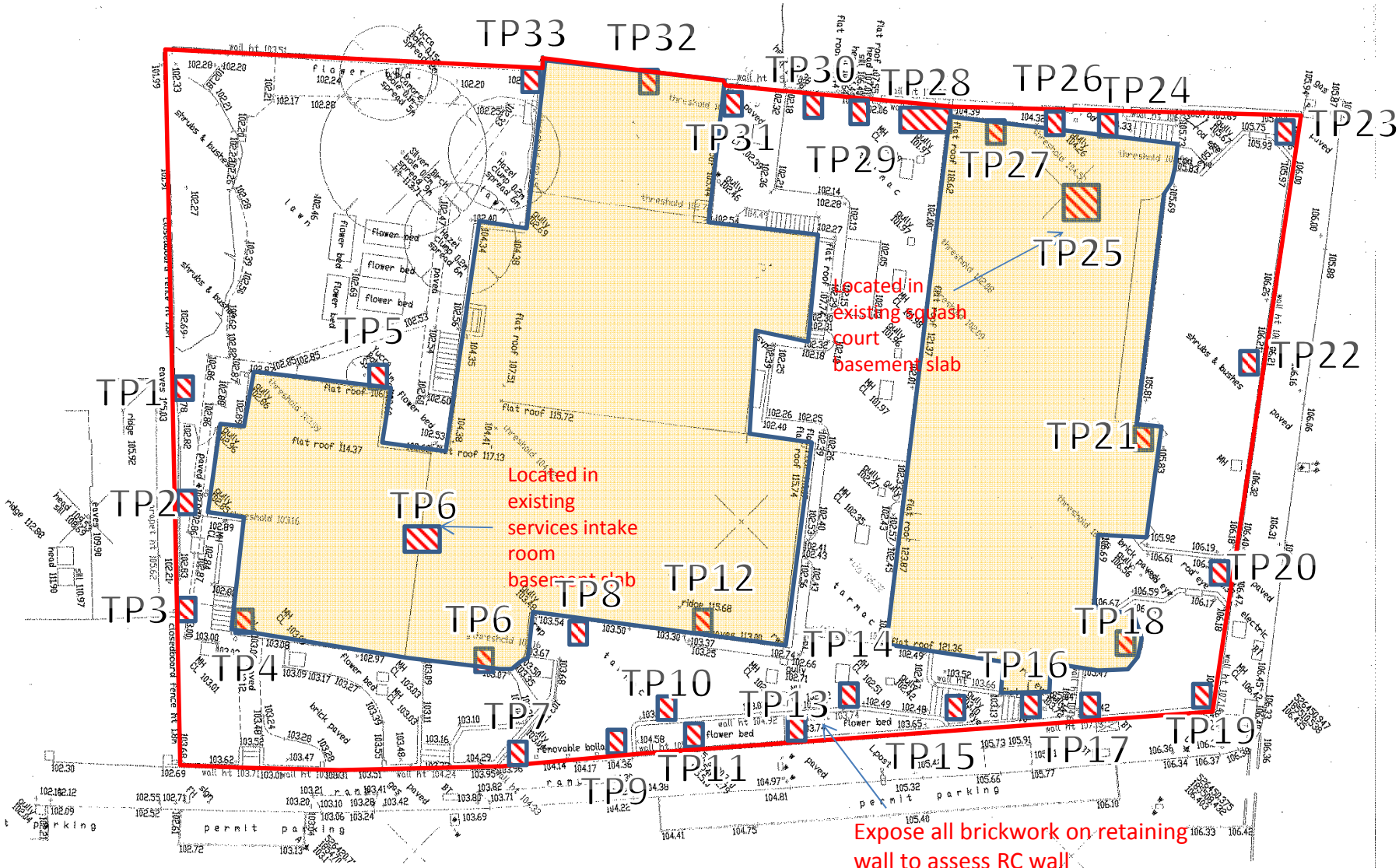
FITZJOHNS AVENUE, LONDON NW3

TRIAL PIT PROGESS LOG **Sept 15** **Rev 1**

For trial pit location, see plan overleaf. Pits numbered in red are those prioritised by Vinci. Pits described below as delayed by demolition of Prince Arthur road block could have been carried out prior to commencement of demolition.

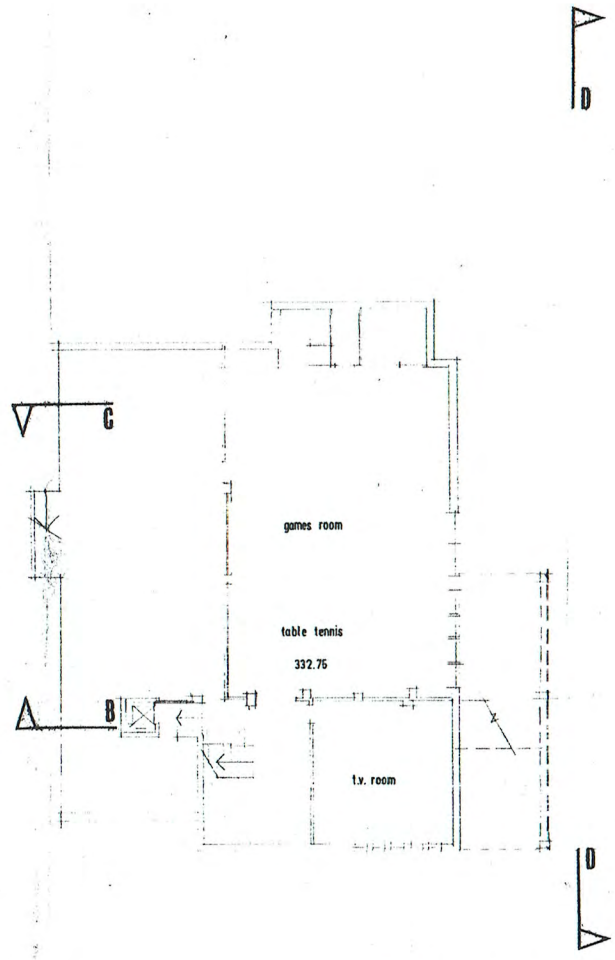
TRIAL PIT	STATUS	REASON FOR STATUS	COMMENT
1	Not started	Scaffold obstruction then demolition of PAR block	Demolition of PAR block due for completion early w/c 5th Oct
2	Complete	Results issued	
3	Not started	To be completed at fence post	Exposure of top of fence post footing requested by SYM 28.9.15
4	Not started	Demolition of PAR block	Demolition of PAR block due for completion early w/c 5th Oct
5	Not started	Scaffold obstruction then demolition of PAR block	Demolition of PAR block due for completion early w/c 5th Oct
6 (perimeter)	Incomplete	Demolition of PAR block	Existing footing exposed at lower level than expected. SYM request in email 22.09.15 to remove entire slab in room for safe further excavation. To be completed following demolition of PAR block.
6 (Internal)	Not started	Demolition of PAR block	Demolition of PAR block due for completion early w/c 5th Oct
7	Not started	Site access	
8	Not started	Scaffold obstruction then demolition of PAR block	Demolition of PAR block due for completion early w/c 5th Oct
9	Not started	Site access	
10	Not started	Site access	
11	Complete	Results issued	
12	Not started	Adjacent live substation	
13 & 14	Completed	Results issued	Combined following removal of planter
15	Not started	Scaffold obstruction	Squibb requested to obtain price for scaffold amendment for approval
16	Not started	Scaffold obstruction	Squibb requested in email 22.09.15 to obtain price for scaffold amendment

			for approval
17	Not started	Scaffold obstruction	Squibb requested in email 22.09.15 to obtain price for scaffold amendment for approval
18	Not started		
19	Incomplete	Concrete slab below ground level requires breaking out.	Breaking out requested by SYM 29.09.15 to be completed w/e 2.10.15
20	Complete	Results issued	
21	Not started		
22	Complete	Results issued	
23	Complete	Results issued	
24	Not started	No scaffold obstruction	Scaffolding not started on this elevation pending party wall approvals.
25	Incomplete (internal version complete and results issued)	Carried out w/c 28.9.15 in location superseded by SYM email 22.09.15. RC slab 400mm thick.	SYM request 29.09.15 pit to be excavated as shown in email 22.9.15. Work to start 30.09.15
26	Incomplete	Ground level slab removed and some excavation completed. SYM request 21.9.15 and email 22.09.15 to shore sides then excavate and break through foundation slab.	No further works carried out in this area.
27	Incomplete	Coring through RC wall and slab completed. Coring results issued.	Progress halted as TP26 and TP28 easier to progress.
28	Complete	Results issued	
29	Complete	Results issued.	
30	Complete	Results issued.	
31	Complete	Results issued.	
32	Not started		To be completed w/c 5th Oct following demolition of PAR block
33	Not started		To be completed w/c 5th Oct following demolition of PAR block
34	Not started	Scaffold obstruction then demolition of PAR block	Demolition of PAR block due for completion early w/c 5th Oct


TP33
TP32
TP30
TP28
TP26
TP24
TP23
TP31
TP29
TP27
TP25
TP5
TP1
TP22
TP21
TP2
TP6
TP20
TP12
TP8
TP3
TP6
TP18
TP14
TP4
TP16
TP10
TP13
TP7
TP19
TP15
TP17
TP11
TP9
Located in existing egress court basement slab
Located in existing services intake room basement slab
Expose all brickwork on retaining wall to assess RC wall construction to all locations

this drawing is not to be scaled.
all dimensions to be checked on site.

22567 (R1)
(1)



TP25
AT BASE OF COLUMN

LONDON BOROUGH OF CAMDEN
TOWN AND COUNTRY PLANNING ACTS
26 OCT 1976
PLANS APPROVED
ON BEHALF OF THE COUNCIL

LONDON BOROUGH OF CAMDEN
TOWN AND COUNTRY PLANNING ACTS
26 OCT 1976
RECOMMENDATION AGREED
ON BEHALF OF THE COUNCIL

E6/26/5/22567 (R1)

PLAN level -1

332.75 FT. 333.00 FT.
101.156 M 101.232 M

-1

GERALD SHENSTONE AND PARTNERS ARCHITECTS

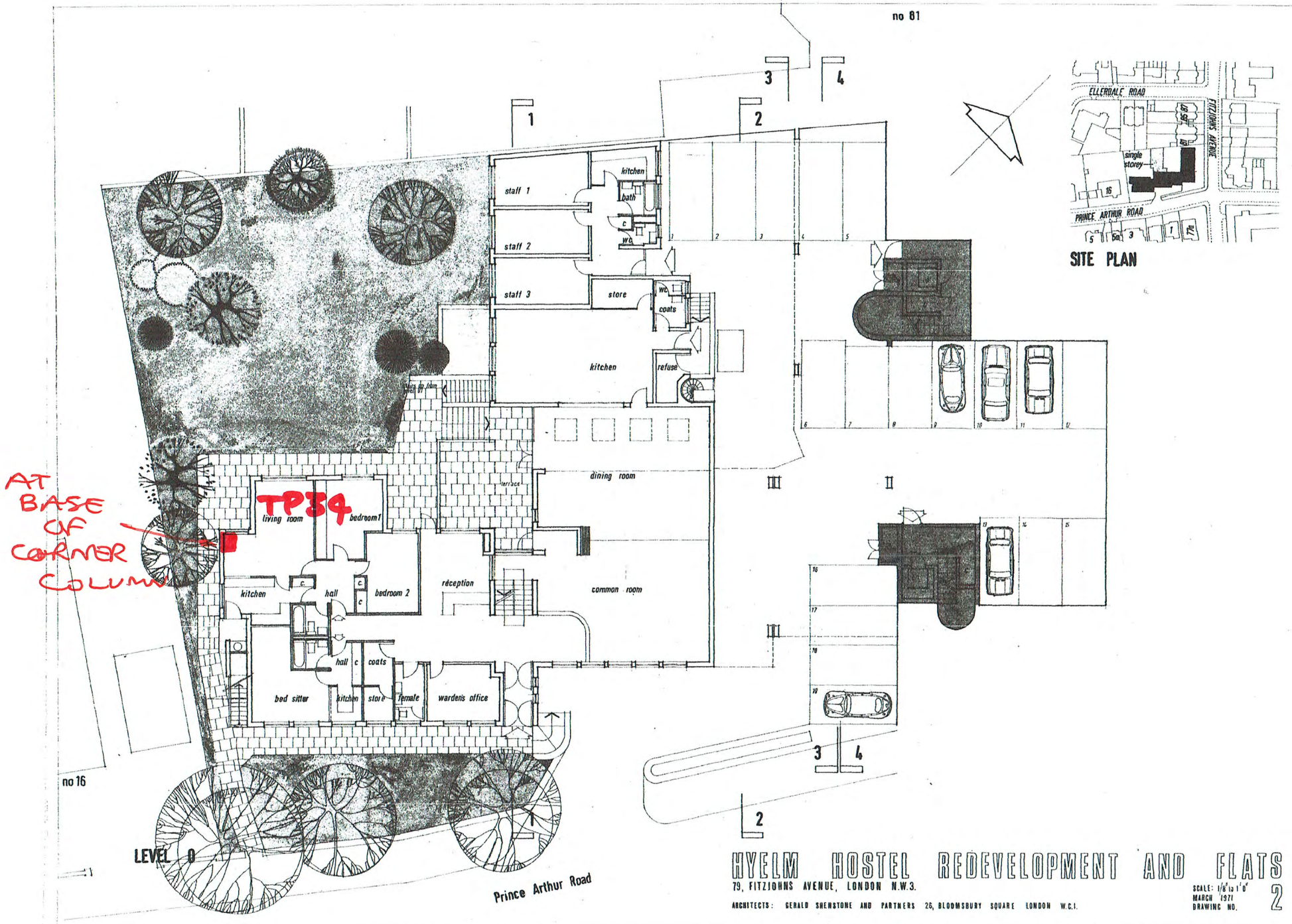
28 BLOOMSBURY SQUARE WC1A 2PN
01 636 8696

HYELM HOSTEL PHASE 2
179 Fitzjohns Avenue NW3

PLAN LEVEL -1

project	5004
scale	1:100
date	SEP 1976
drawn	A.S.K

1A



HYELM HOSTEL REDEVELOPMENT AND FLATS

79, FITZJOHNS AVENUE, LONDON N.W.3.

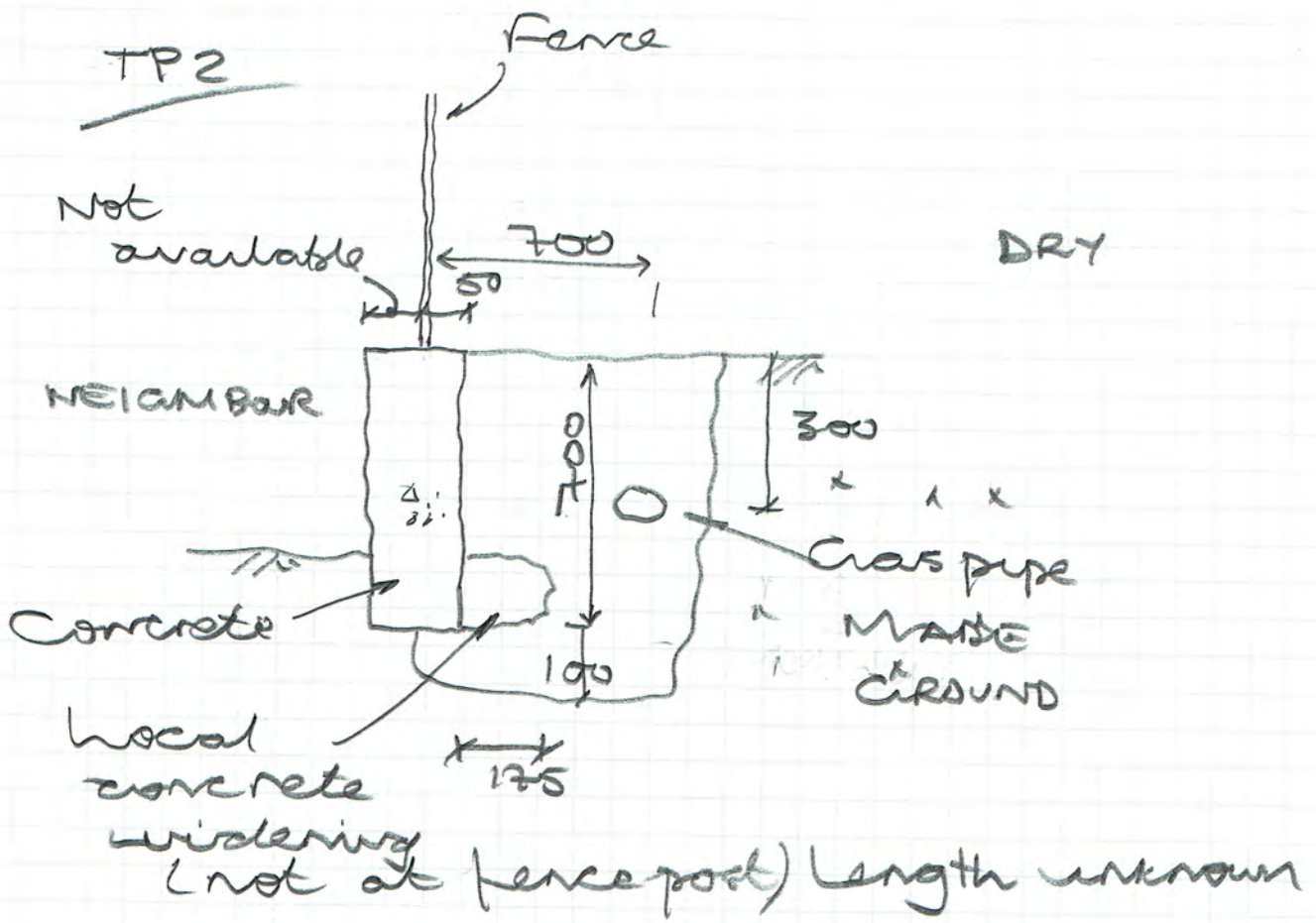
ARCHITECTS: GERALD SHENSTONE AND PARTNERS 26, BLOOMSBURY SQUARE LONDON W.C.1.

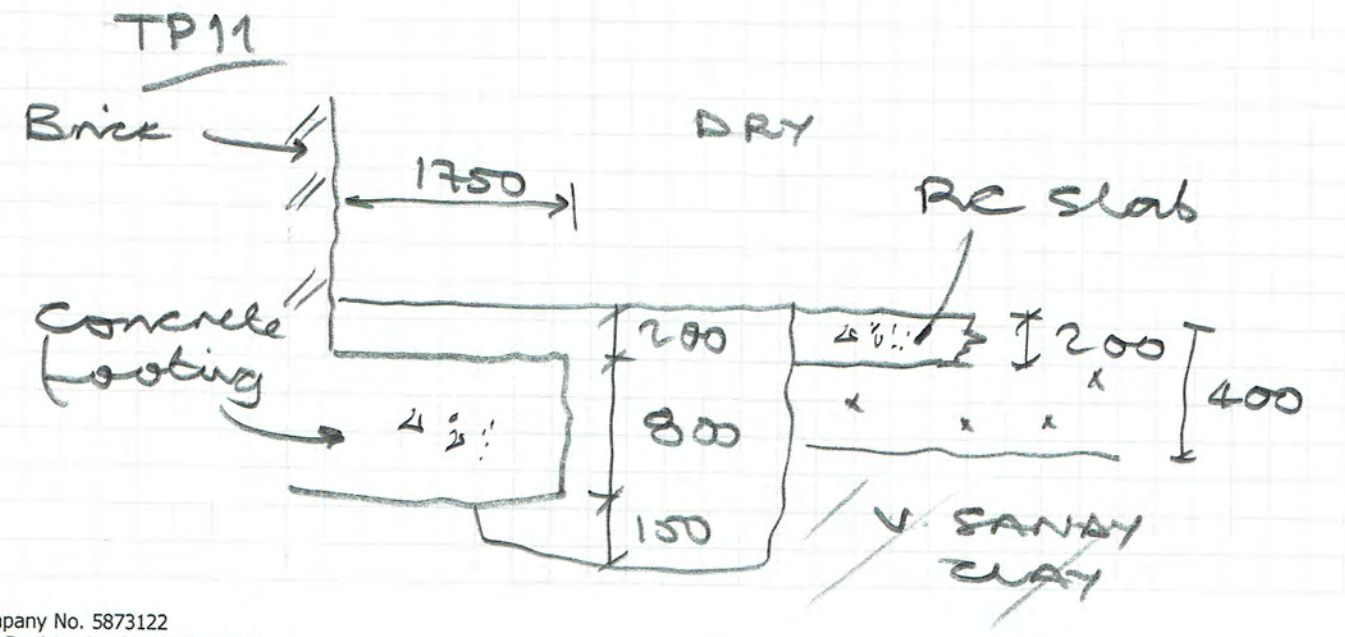
SCALE: 1/8" to 1'0"
MARCH 1971
DRAWING NO. 2

Symmetrys Limited
Consulting Structural Engineers

W: www.symmetrys.com
E: info@symmetrys.com

		Job No.	Sheet No.	Revision
		2014052		
Job Title	79 Fitzjohns Avenue, London NW3	Date	Made By	Checked By
Section	TRIAL PIT RESULTS	SEPT 15	RT	



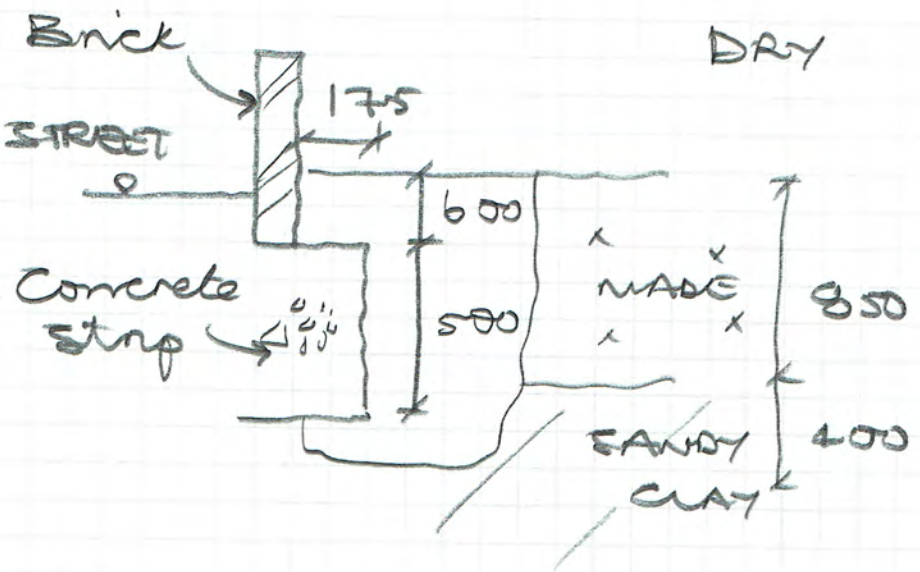


Symmetrys Limited
Consulting Structural Engineers

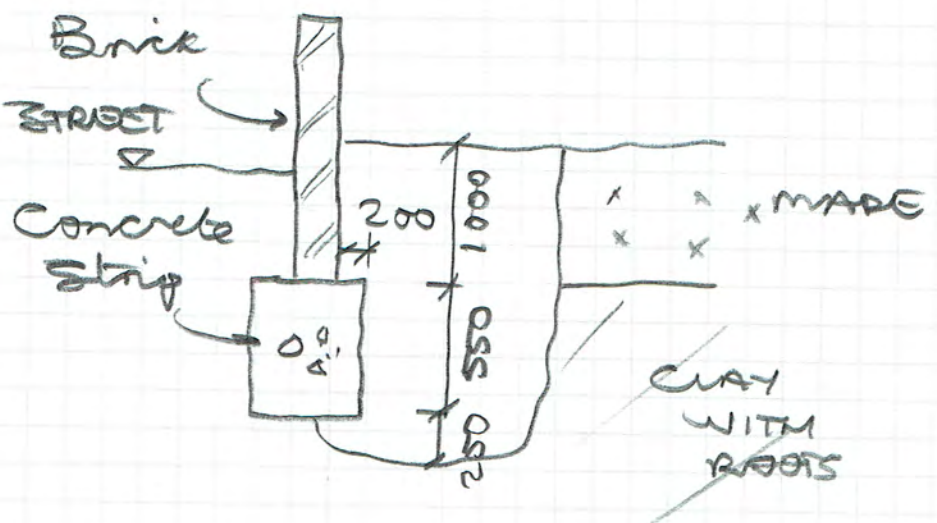
W: www.symmetrys.com
E: info@symmetrys.com

		Job No.	Sheet No.	Revision
		2014052		
Job Title	79 Fitzjohns Avenue, London NW3	Date	Made By	Checked By
Section	TRIAL PIT RESULTS	SEPT 15	RT	

TP 20



TP22

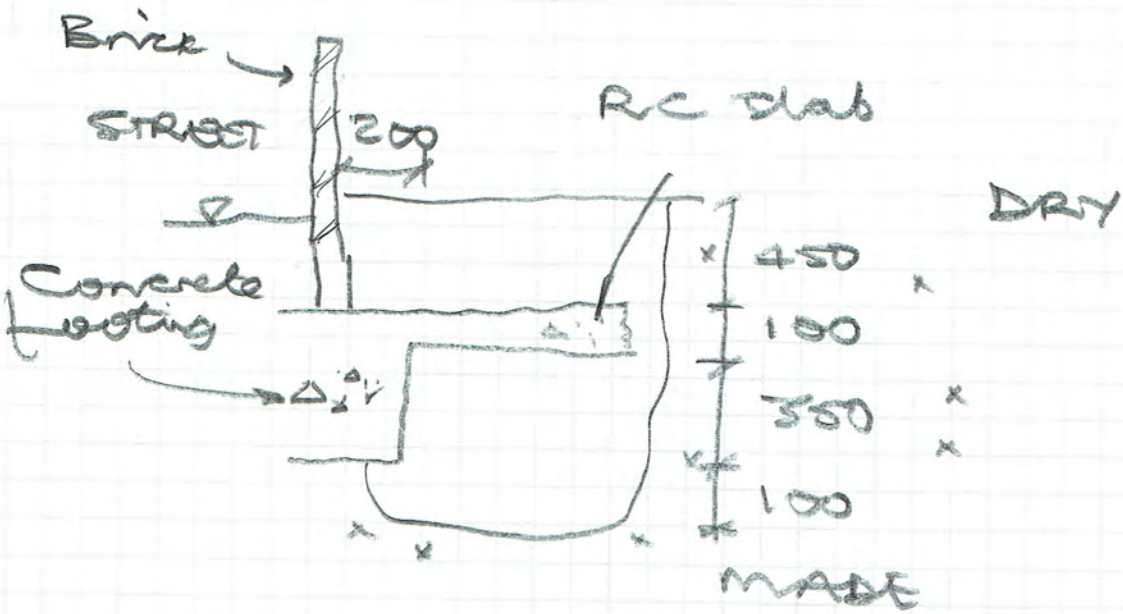


Symmetrys Limited
Consulting Structural Engineers

W: www.symmetrys.com
E: info@symmetrys.com

		Job No.	Sheet No.	Revision
		2014052		
Job Title	79 Fitzjohns Avenue, London NW3	Date	Made By	Checked By
Section	TRIAL PIT RESULTS	SEPT 15	RT	

TP 23



TP 25 (Original position)

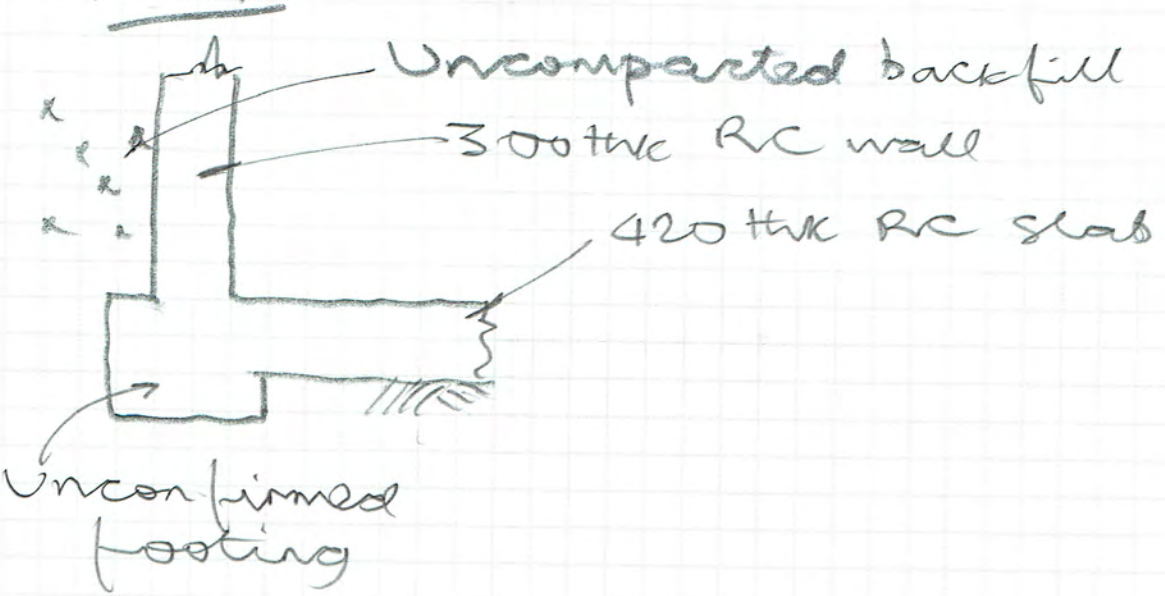
400 thk RC slab, mesh top

Symmetrys Limited
Consulting Structural Engineers

W: www.symmetrys.com
E: info@symmetrys.com

		Job No.	Sheet No.	Revision
		2014052		
Job Title	79 Fitzjohns Avenue, London NW3	Date	Made By	Checked By
Section	TRIAL PIT RESULTS	SEPT 15	RT	

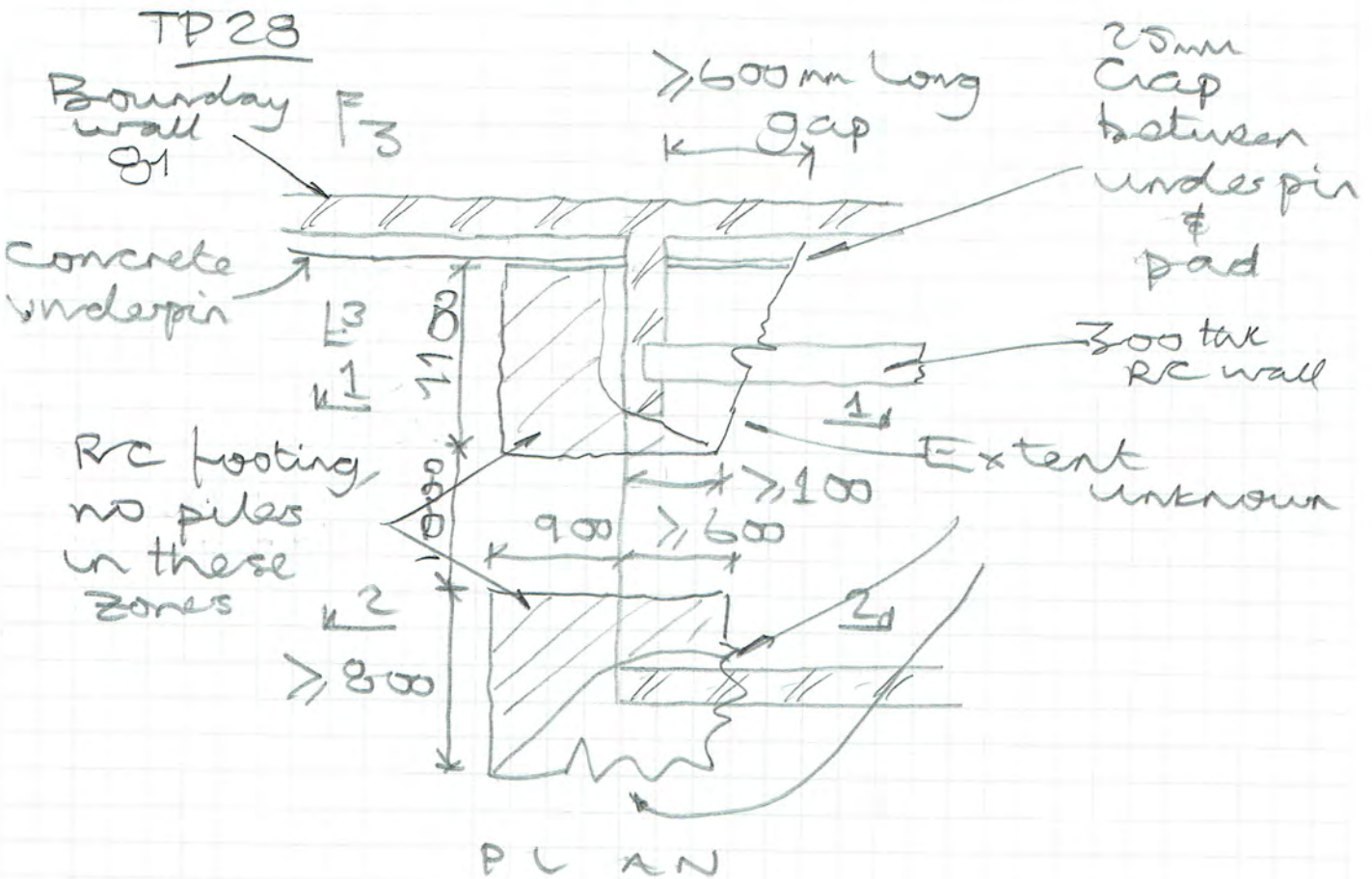
TP 27

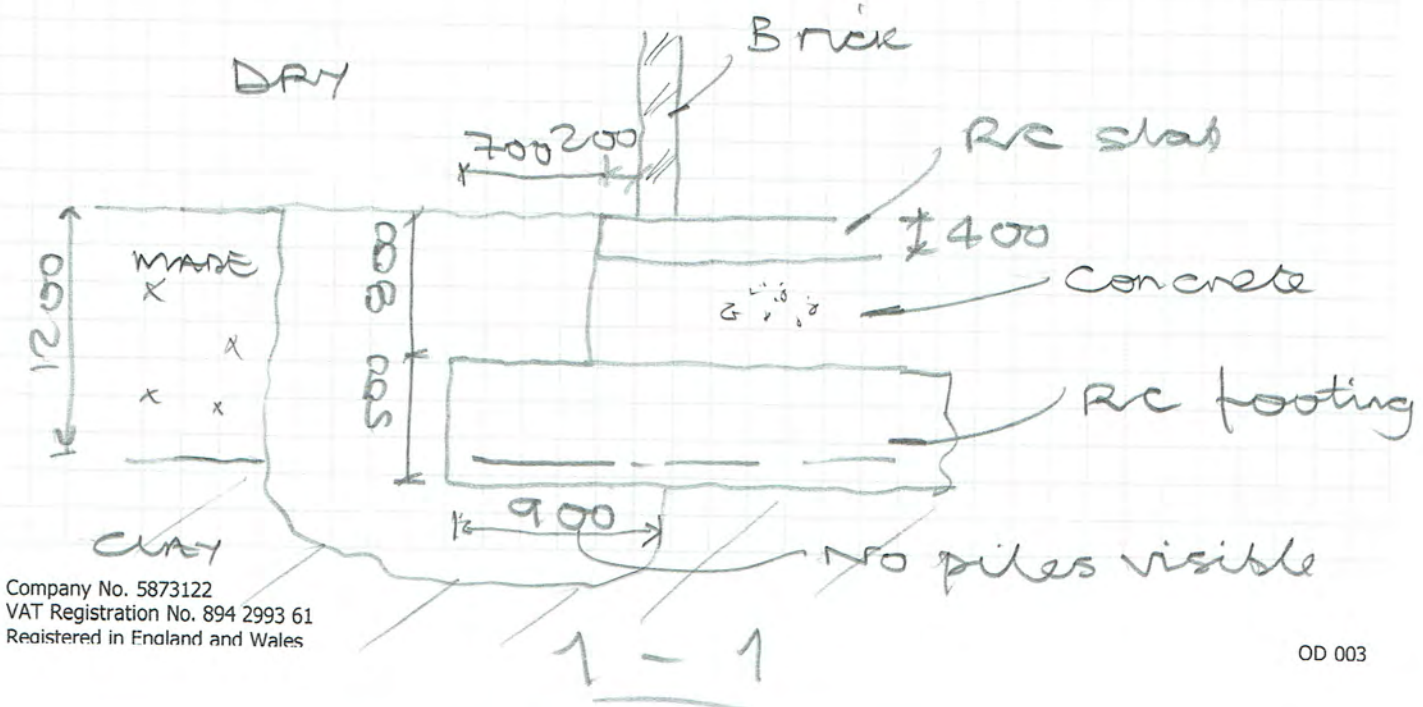


Symmetrys Limited
Consulting Structural Engineers

W: www.symmetrys.com
E: info@symmetrys.com

		Job No.	Sheet No.	Revision
		2014052		
Job Title	79 Fitzjohns Avenue, London NW3	Date	Made By	Checked By
Section	TRIAL PIT RESULTS	SEPT 15	RT	



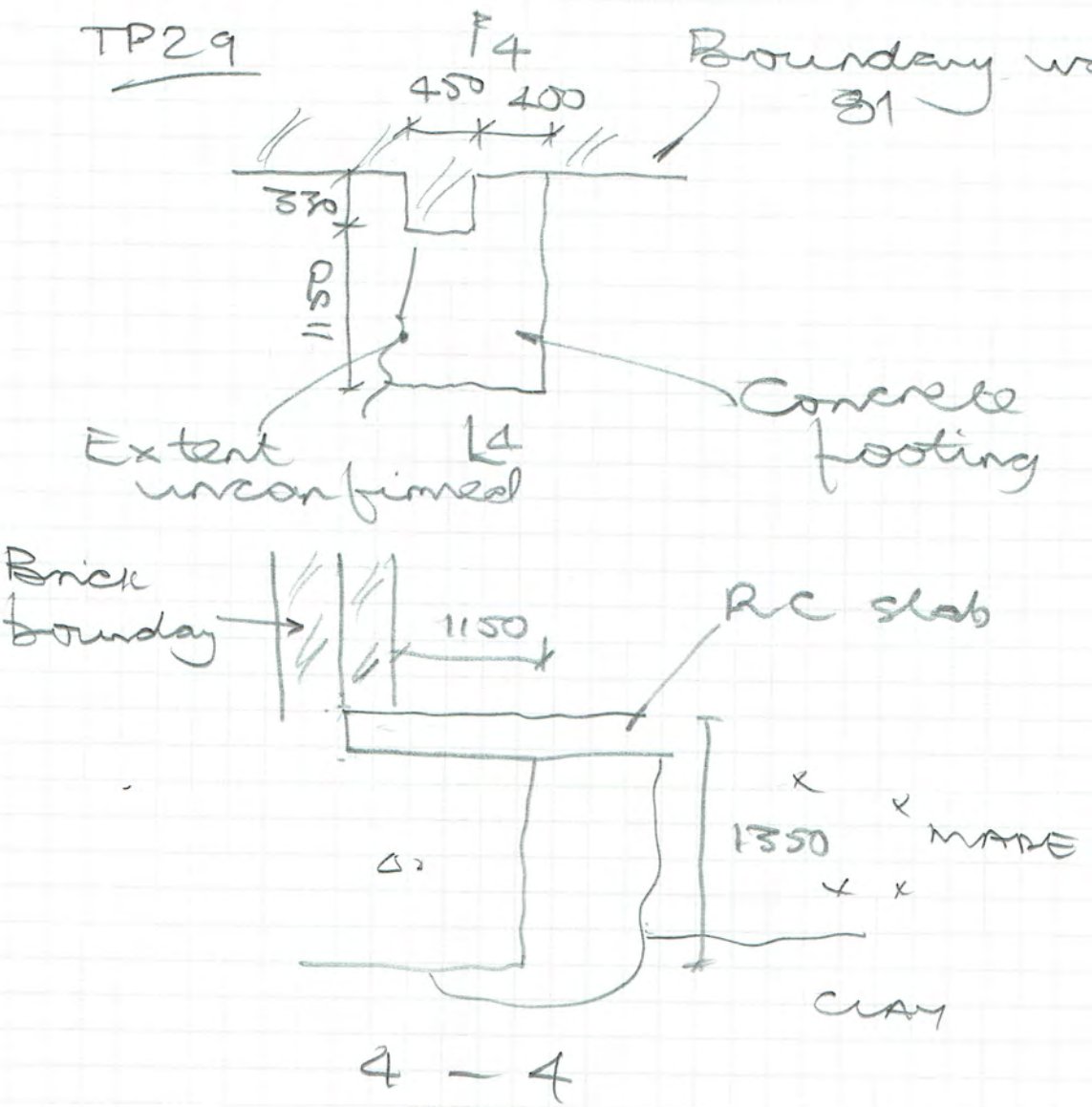


Company No. 5873122
VAT Registration No. 894 2993 61
Registered in England and Wales

Symmetrys Limited
Consulting Structural Engineers

W: www.symmetrys.com
E: info@symmetrys.com

		Job No.	Sheet No.	Revision
		2014052		
Job Title	79 Fitzjohns Avenue, London NW3	Date	Made By	Checked By
Section	TRIAL PIT RESULTS	SEPT 15	RT	

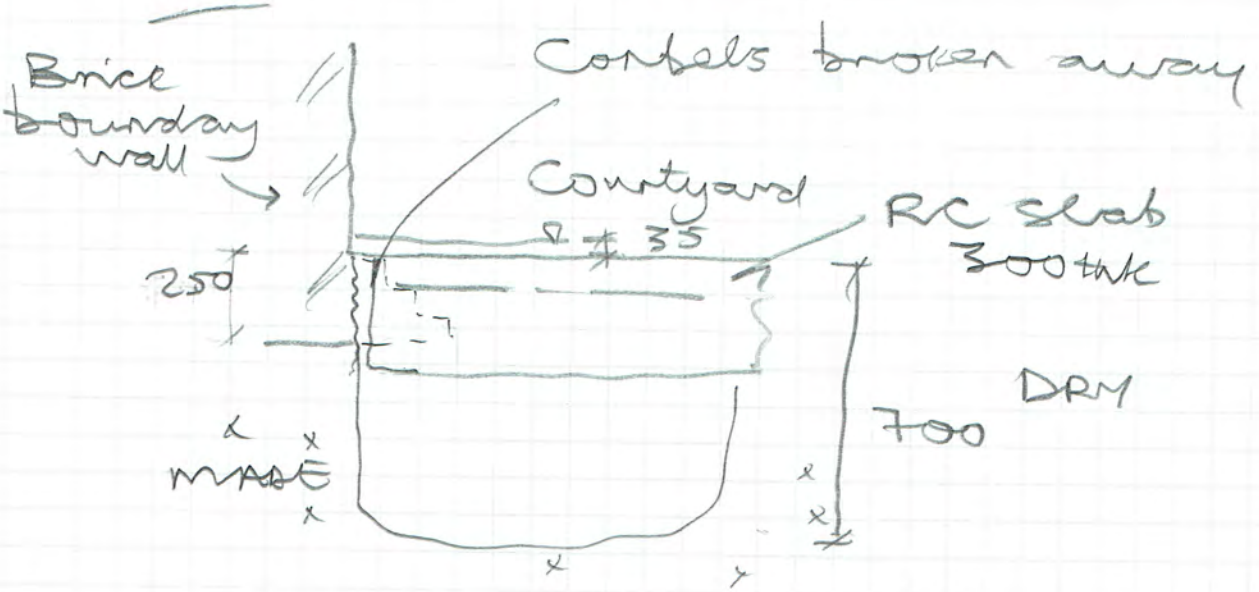


Symmetrys Limited
Consulting Structural Engineers

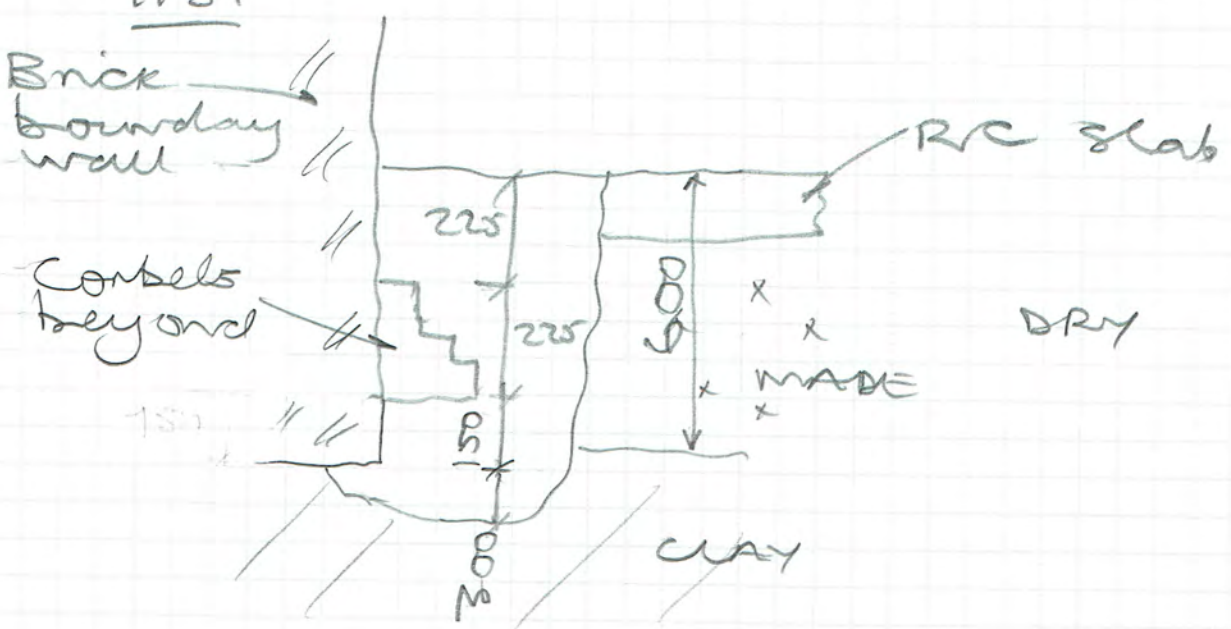
W: www.symmetrys.com
E: info@symmetrys.com

		Job No.	Sheet No.	Revision
		2014052		
Job Title	79 Fitzjohns Avenue, London NW3	Date	Made By	Checked By
Section	TRIAL PIT RESULTS	SEPT 15	RT	

TP30



TP31



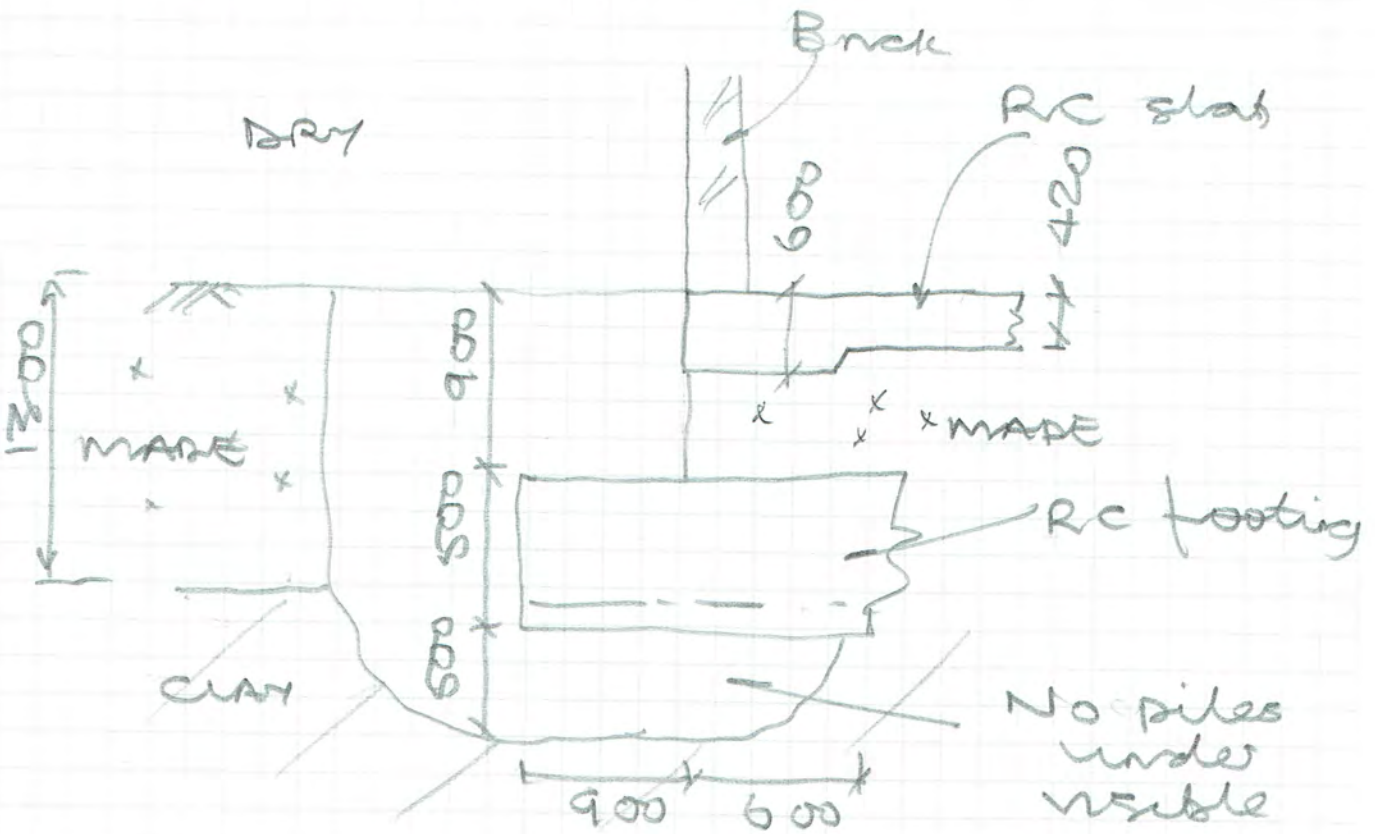
Symmetrys Limited
Consulting Structural Engineers

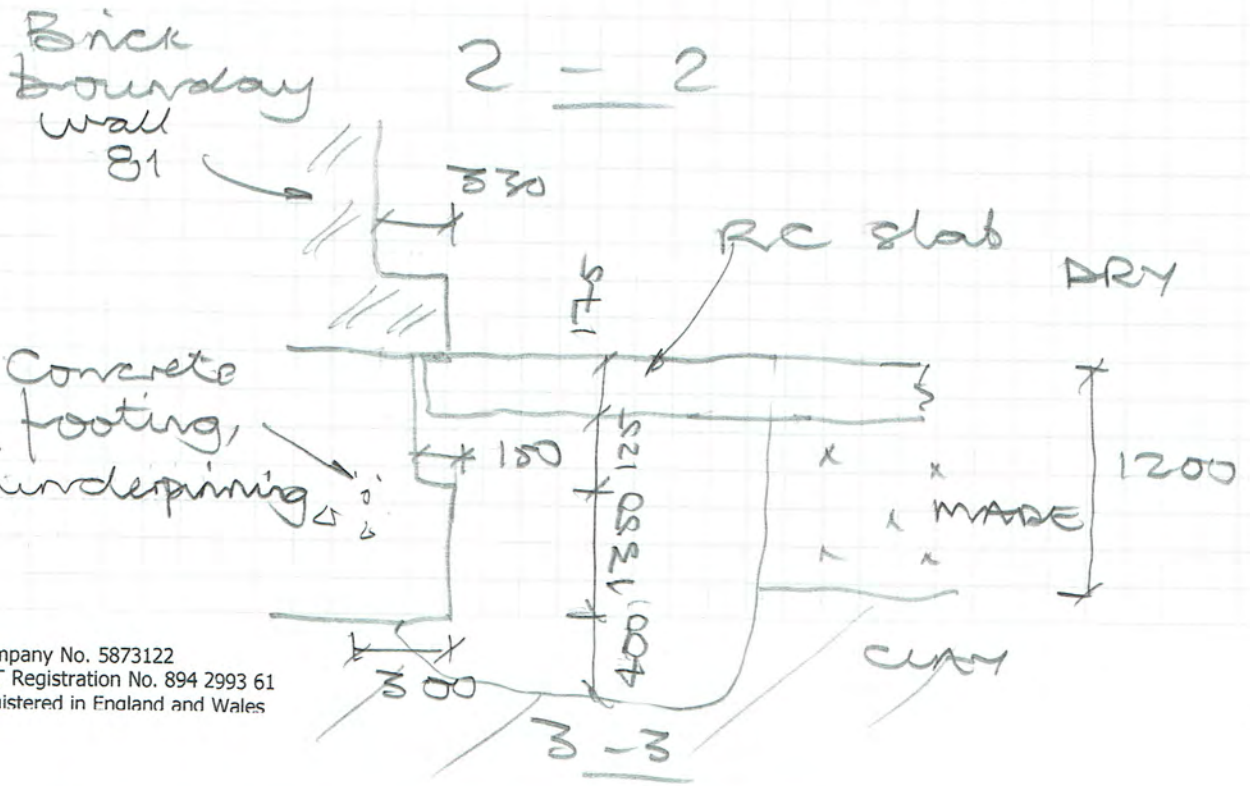
W: www.symmetrys.com
E: info@symmetrys.com

Job No.	Sheet No.	Revision
2014052		

Job Title	79 Fitzjohns Avenue, London NW3	Date	Made By	Checked By
Section	TRIAL PIT RESULTS	SEPT 15	RT	

TP28 continued:

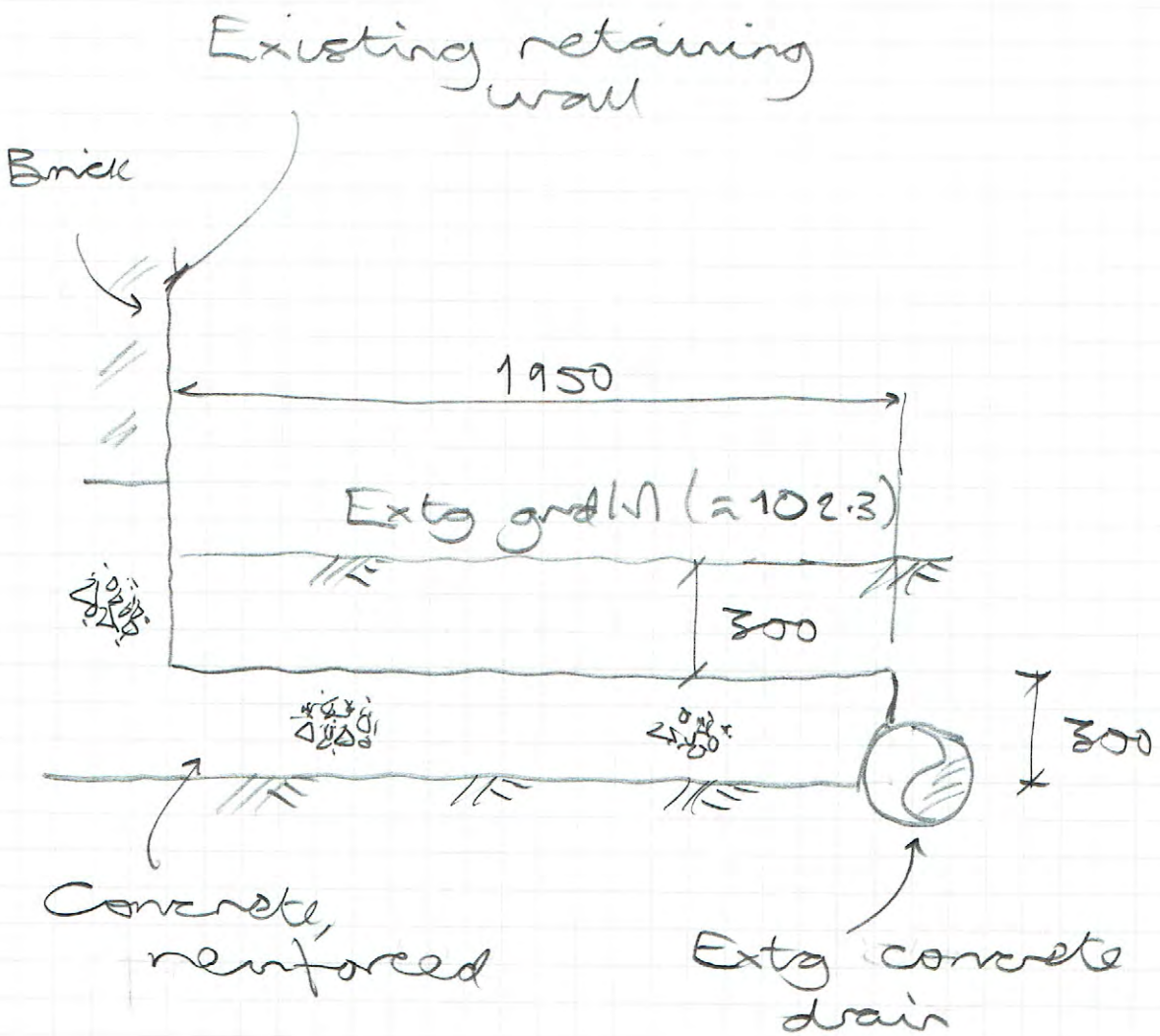




Symmetrys Limited
Consulting Structural Engineers

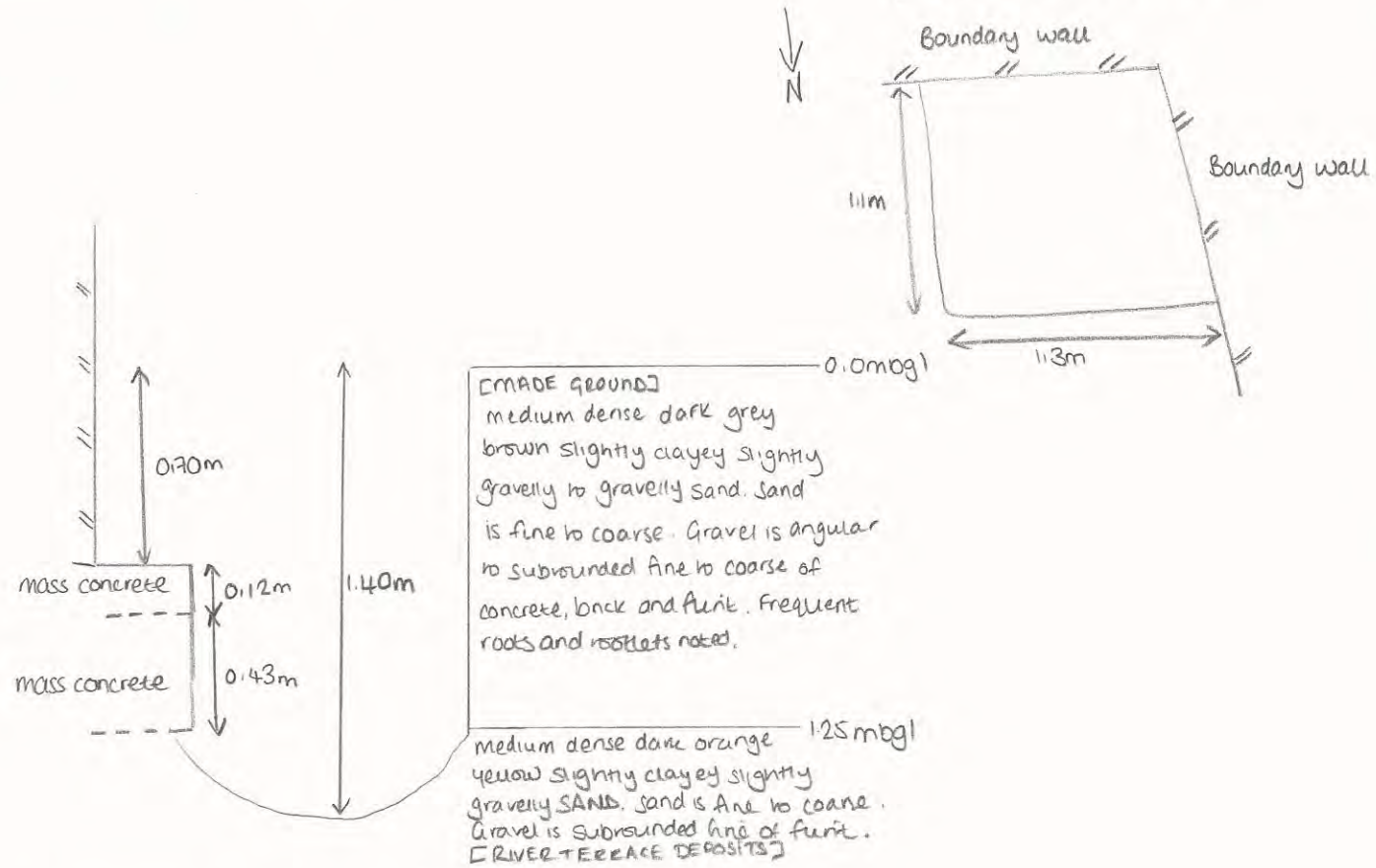
W: www.symmetrys.com
E: info@symmetrys.com

		Job No.	Sheet No.	Revision
		2014052		
Job Title	79 Fitzjohns Avenue, London NW3	Date	Made By	Checked By
Section	TRIAL PIT 100 - PRINCE ARTHUR ROAD GL 10-11	Nov 14	RT	



79 FITZJOHN'S AVENUE CGL 109008. 20 OCTOBER 2015

TP19



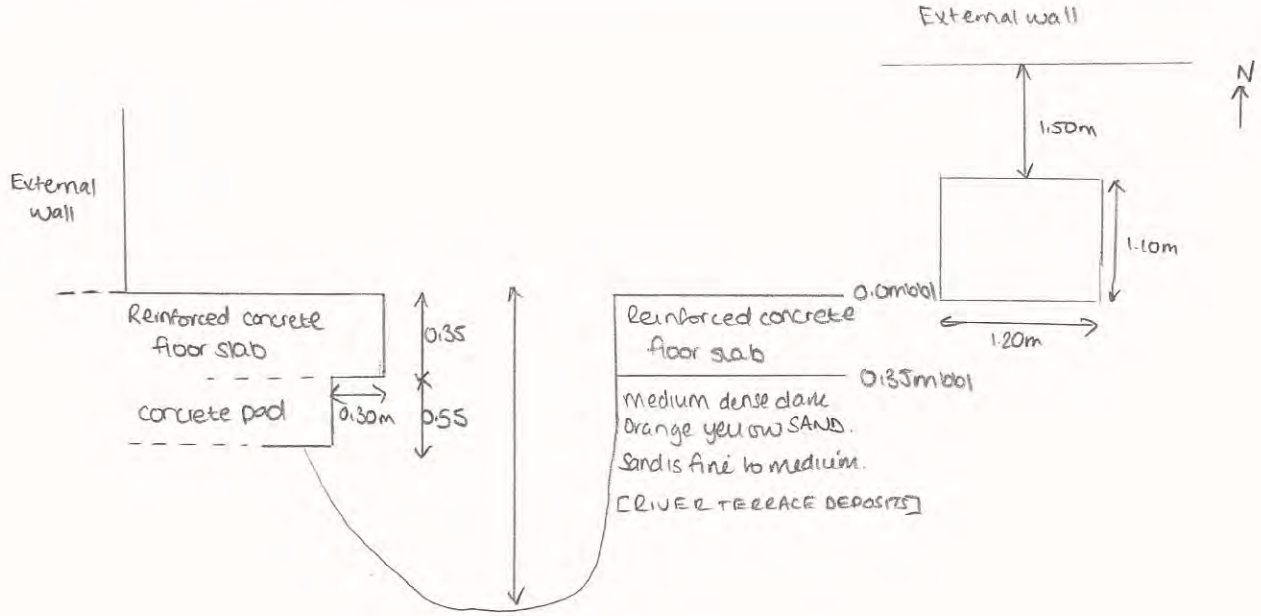
Notes: Environmental samples at 1.0mbgl and 1.4mbgl.

No groundwater encountered

Mass concrete slab between 0.82m and 1.25mbgl extended across excavation - broken through to determine thickness

---

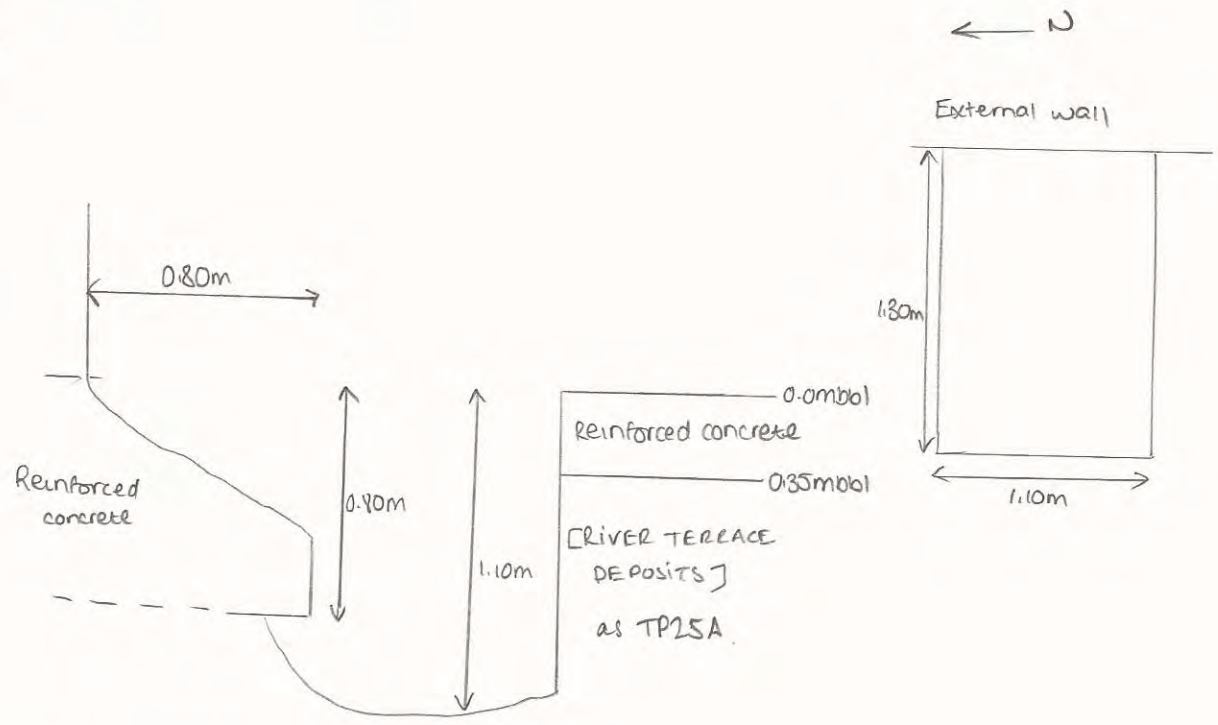
TP25A.



Notes: No groundwater encountered.

(TP25B over page)

TP25B



Notes: No groundwater encountered.

APPENDIX D

WALLAP Analyses Output

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	102.10	1 Granular Made Ground	1 Granular Made Ground
2	101.00	2 Firm Clay	2 Firm Clay
3	99.40	3 Sand	3 Sand
4	98.20	4 Stiff Clay	4 Stiff Clay

SOIL PROPERTIES

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	20.00a	30000	0.470	OC	0.262	5.284	
		21.00b			(0.300)	(0.000)	(0.000)	
4	Stiff Clay	19.00	75000	1.000	OC	1.000	1.000	75.00u
					(0.490)	(2.389)	(2.390)	
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	
6	Stiff Clay - Drained	19.00	60000	0.817	OC	0.353	3.413	1.000d
					(0.200)	(1.388)	(5.175)	
7	Fill	20.00	60000	0.500	OC	0.189	8.378	
					(0.300)	(0.000)	(0.000)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Stiff Clay	0.00	0.500	0.00	0.00	0.500	0.00
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
6	Stiff Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
7	Fill	40.00	0.434	0.00	40.00	0.434	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

WALL PROPERTIES

Type of structure = Soldier Pile Wall
Soldier Pile width = 0.60 m
Soldier Pile spacing = 2.50 m
Passive mobilisation factor = 3.00 m
Elevation of toe of wall = 96.50
Maximum finite element length = 0.40 m
Youngs modulus of wall E = 2.2250E+07 kN/m2
Moment of inertia of wall I = 2.4290E-03 m4/m run
E.I = 54045 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclination (degs)	Pre-stress /strut kN	Tension allowed
1	103.00	1.00	0.015000	2.100E+08	5.00	0.00	0	Yes

SURCHARGE LOADS

Surcharge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	102.10	0.00(A)	10.00	10.00	10.00	=	N/A	1.00 -

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

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 102.10
2	Change EI of wall to 14700 kN.m2/m run From elevation 103.00 to 98.70 Yield moment not defined Reset wall displacements to zero at this stage
3	Excavate to elevation 102.10 on PASSIVE side Toe of berm at elevation 99.15 Width of top of berm = 1.00 Width of toe of berm = 7.07
4	Install strut or anchor no.1 at elevation 103.00
5	Excavate to elevation 98.00 on PASSIVE side
6	Fill to elevation 98.70 on PASSIVE side with soil type 3
7	Change properties of soil type 2 to soil type 5 No analysis at this stage Ko pressures will not be reset
8	Change properties of soil type 4 to soil type 6 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) = 6.600 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 9.50 m

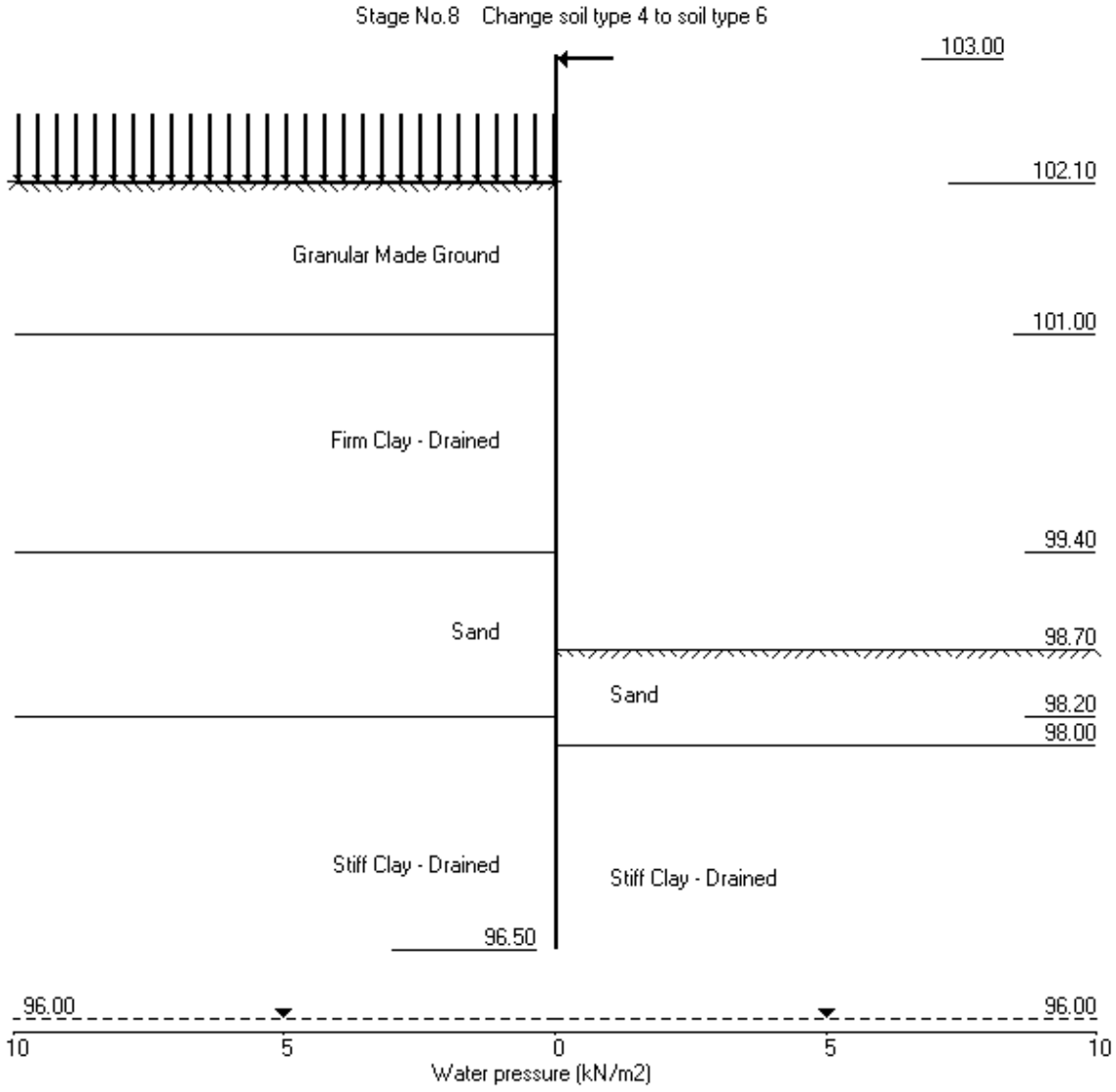
Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 102.10	No	No	No
2	Change EI of wall to 14700kN.m2/m run	No	No	No
3	Excav. to elev. 102.10 on PASSIVE side	No	No	No
4	Install strut no.1 at elev. 103.00	No	No	No
5	Excav. to elev. 98.00 on PASSIVE side	No	No	No
6	Fill to elev. 98.70 on PASSIVE side	No	No	No
7	Change soil type 2 to soil type 5	No	No	No
8	Change soil type 4 to soil type 6	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m


Stage No.8 Change soil type 4 to soil type 6
103.00
102.10
Granular Made Ground
101.00
Firm Clay - Drained
99.40
Sand
98.70
Sand
98.20
98.00
Stiff Clay - Drained
Stiff Clay - Drained
96.50
96.00
96.00
10
5
0
5
10
Water pressure (kN/m2)

Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: Serviceability Limit State

All loads and soil strengths are unfactored

STABILITY ANALYSIS of Soldier Pile Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 96.50 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	102.10	102.10	Cant.	Conditions not suitable for FoS calc.			
2	102.10	102.10		No analysis at this stage			
3	102.10	102.10	Cant.	Conditions not suitable for FoS calc.			
4	102.10	102.10		No analysis at this stage			
5	102.10	98.00	103.00	2.727	n/a	97.73	0.27
6	102.10	98.70	103.00	3.125	n/a	97.91	0.79
7	102.10	98.70		No analysis at this stage			
8	102.10	98.70	103.00	1.346	n/a	97.43	1.27

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Soldier Pile Wall

Analysis options

Soldier Pile width = 0.60m; spacing = 2.50m
Passive mobilisation factor = 3.000
Length of wall perpendicular to section = 9.50m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached

Rigid boundaries: Active side 20.00 from wall
Passive side 15.00 from wall

Limit State: Serviceability Limit State

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

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement		Bending moment Calculated		Bending moment Factored		Shear force Calculated		Shear force Factored	
		max.	min.	max.	min.	max.	min.	max.	min.	max.	min.
		m	m	kN.m/m		kN.m/m		kN/m	kN/m	kN/m	kN/m
1	103.00	0.000	0.000	0	0	0	0	0	-18	0	-24
2	102.78	0.001	0.000	0	-4	0	-5	0	-18	0	-24
3	102.55	0.002	0.000	0	-8	0	-11	0	-18	0	-24
4	102.33	0.003	0.000	0	-12	0	-16	0	-18	0	-24
5	102.10	0.004	0.000	0	-16	0	-21	0	-18	0	-24
6	101.85	0.005	0.000	0	-20	0	-27	1	-16	2	-22
7	101.60	0.006	0.000	1	-24	1	-32	2	-15	3	-20
8	101.30	0.007	0.000	2	-28	2	-38	4	-13	5	-18
9	101.00	0.008	0.000	3	-32	4	-43	5	-11	6	-15
10	100.70	0.009	0.000	4	-35	5	-47	5	-7	6	-10
11	100.40	0.009	0.000	5	-36	6	-49	1	-3	2	-5
12	100.00	0.009	0.000	4	-37	6	-49	4	-1	6	-2
13	99.70	0.009	0.000	4	-35	5	-47	8	-2	11	-3
14	99.40	0.009	0.000	3	-32	4	-43	14	-2	19	-3
15	99.15	0.008	-0.000	3	-28	3	-37	18	-2	24	-3
16	98.93	0.008	-0.000	2	-23	3	-31	22	-2	29	-3
17	98.70	0.007	-0.000	2	-18	2	-24	26	-2	35	-2
18	98.45	0.006	-0.000	4	-11	5	-15	29	-1	39	-2
19	98.20	0.005	-0.000	11	-4	15	-6	34	-1	45	-2
20	98.00	0.005	-0.000	18	0	25	0	38	-1	51	-1
21	97.60	0.004	-0.000	29	0	40	0	9	-5	13	-7
22	97.20	0.002	-0.000	19	0	26	0	0	-30	0	-40
23	96.85	0.001	-0.000	7	0	10	0	0	-29	0	-39
24	96.50	0.000	-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 Calculated max.	elev.	min.	elev.	Bending moment Factored max.	min.	Shear force Calculated max.	elev.	min.	elev.	Shear force Factored max.	min.
	kN.m/m		kN.m/m		kN.m/m		kN/m		kN/m		kN/m	kN/m
1	4	100.40	-0	102.78	5	-0	5	101.00	-2	99.40	6	-3
2	No calculation at this stage											
3	5	100.40	-0	102.10	6	-0	5	100.70	-2	99.40	6	-3
4	No calculation at this stage											
5	29	97.60	-20	100.40	39	-27	37	98.00	-29	97.20	50	-39
6	29	97.60	-20	100.40	40	-27	38	98.00	-30	97.20	51	-40
7	No calculation at this stage											
8	11	97.60	-37	100.00	15	-49	28	98.45	-18	103.00	37	-24

Summary of results (continued)

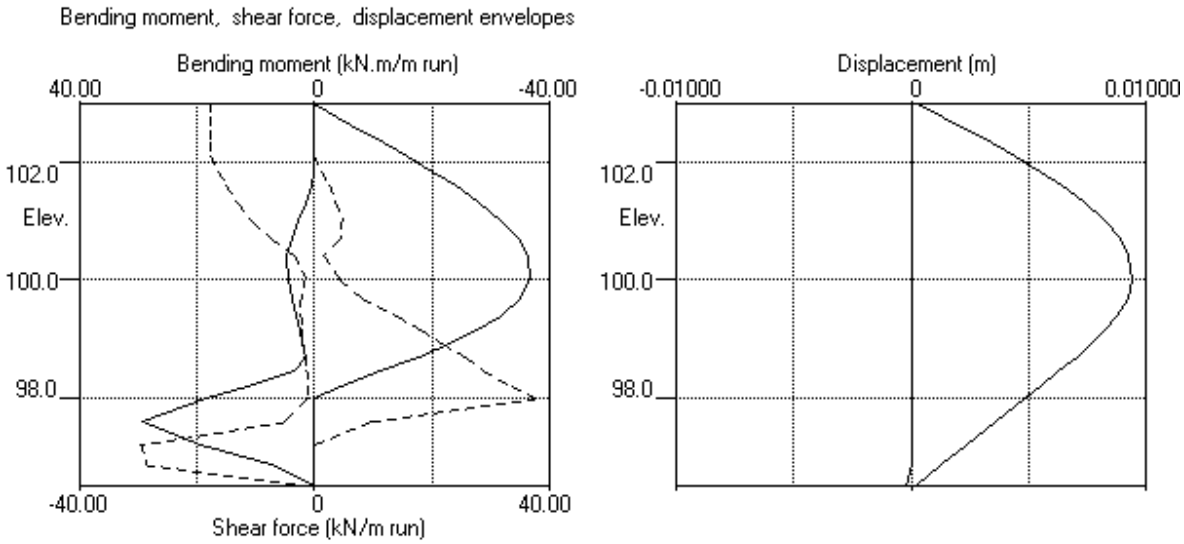
Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.001	103.00	0.000	103.00	Apply surcharge no.1 at elev. 102.10
2	Wall displacements reset to zero				Change EI of wall to 14700kN.m2/m run
3	0.000	103.00	-0.000	98.70	Excav. to elev. 102.10 on PASSIVE side
4	No calculation at this stage				Install strut no.1 at elev. 103.00
5	0.005	100.40	-0.000	96.50	Excav. to elev. 98.00 on PASSIVE side
6	0.005	100.40	-0.000	96.50	Fill to elev. 98.70 on PASSIVE side
7	No calculation at this stage				Change soil type 2 to soil type 5
8	0.009	100.00	0.000	103.00	Change soil type 4 to soil type 6

Strut forces at each stage (horizontal components)

Stage no.	----- Strut no. 1 ----- at elev. 103.00 --Calculated-- kN per m run	kN per strut	Factored kN per strut
5	11	11	15
6	11	11	15
8	18	18	24

Units: kN,m


Bending moment, shear force, displacement envelopes
Bending moment (kN.m/m run)
40.00
0
-40.00
102.0
Elev.
100.0
98.0
-40.00
0
40.00
Shear force (kN/m run)
Displacement (m)
-0.01000
0
0.01000
102.0
Elev.
100.0
98.0

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	102.10	1 Granular Made Ground	1 Granular Made Ground
2	101.00	2 Firm Clay	2 Firm Clay
3	99.40	3 Sand	3 Sand
4	98.20	4 Stiff Clay	4 Stiff Clay

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	20.00a	30000	0.470	OC	0.262	5.284	
		21.00b			(0.300)	(0.000)	(0.000)	
4	Stiff Clay	19.00	75000	1.000	OC	1.000	1.000	75.00u
					(0.490)	(2.389)	(2.390)	
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	
6	Stiff Clay - Drained	19.00	60000	0.817	OC	0.353	3.413	1.000d
					(0.200)	(1.388)	(5.175)	
7	Fill	20.00	60000	0.500	OC	0.189	8.378	
					(0.300)	(0.000)	(0.000)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Stiff Clay	0.00	0.500	0.00	0.00	0.500	0.00
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
6	Stiff Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
7	Fill	40.00	0.434	0.00	40.00	0.434	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

WALL PROPERTIES

Type of structure = Soldier Pile Wall
Soldier Pile width = 0.60 m
Soldier Pile spacing = 2.50 m
Passive mobilisation factor = 3.00 m
Elevation of toe of wall = 96.50
Maximum finite element length = 0.40 m
Youngs modulus of wall E = 2.2250E+07 kN/m2
Moment of inertia of wall I = 2.4290E-03 m4/m run
E.I = 54045 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	103.00	1.00	0.015000	2.100E+08	5.00	0.00	0	Yes

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	102.10	0.00(A)	10.00	10.00	10.00	=	N/A	1.00 -

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

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 102.10
2	Change EI of wall to 14700 kN.m2/m run From elevation 103.00 to 98.70 Yield moment not defined Reset wall displacements to zero at this stage
3	Excavate to elevation 102.10 on PASSIVE side Toe of berm at elevation 99.15 Width of top of berm = 1.00 Width of toe of berm = 7.07
4	Install strut or anchor no.1 at elevation 103.00
5	Excavate to elevation 98.00 on PASSIVE side
6	Fill to elevation 98.70 on PASSIVE side with soil type 3
7	Change properties of soil type 2 to soil type 5 No analysis at this stage Ko pressures will not be reset
8	Change properties of soil type 4 to soil type 6 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 = 2.000
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) = 6.600 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 9.50 m

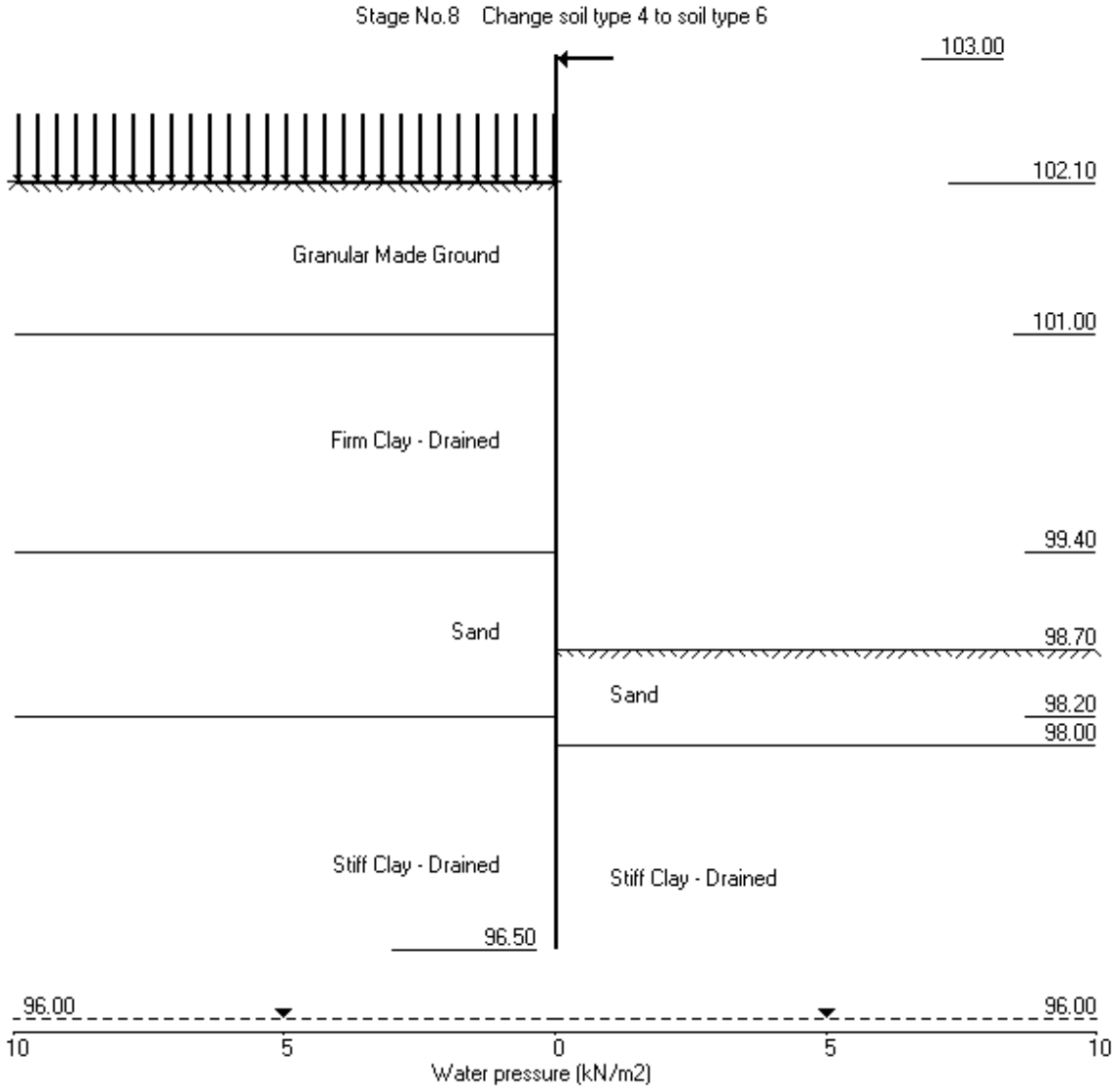
Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 102.10	No	No	No
2	Change EI of wall to 14700kN.m2/m run	No	No	No
3	Excav. to elev. 102.10 on PASSIVE side	No	No	No
4	Install strut no.1 at elev. 103.00	No	No	No
5	Excav. to elev. 98.00 on PASSIVE side	No	No	No
6	Fill to elev. 98.70 on PASSIVE side	No	No	No
7	Change soil type 2 to soil type 5	No	No	No
8	Change soil type 4 to soil type 6	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m


Stage No.8 Change soil type 4 to soil type 6
103.00
102.10
Granular Made Ground
101.00
Firm Clay - Drained
99.40
Sand
98.70
Sand
98.20
98.00
Stiff Clay - Drained
Stiff Clay - Drained
96.50
96.00
96.00
10
5
0
5
10
Water pressure (kN/m2)

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 = 2.000
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 Soldier Pile Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 96.50: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000: Toe elev.	Wall Penetration
1	102.10	102.10	Cant.	Conditions not suitable for FoS calc.			
2	102.10	102.10		No analysis at this stage			
3	102.10	102.10	Cant.	Conditions not suitable for FoS calc.			
4	102.10	102.10		No analysis at this stage			
5	102.10	98.00	103.00	1.977	n/a	97.54	0.46
6	102.10	98.70	103.00	2.270	n/a	97.75	0.95
7	102.10	98.70		No analysis at this stage			
8	102.10	98.70	103.00	1.076	n/a	96.76	1.94

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Soldier Pile Wall

Analysis options

Soldier Pile width = 0.60m; spacing = 2.50m
Passive mobilisation factor = 3.000
Length of wall perpendicular to section = 9.50m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached

Rigid boundaries: Active side 20.00 from wall
Passive side 15.00 from wall

Limit State: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	103.00	0.001	0.000	0.0	0.0	0.0	-26.8
2	102.78	0.003	0.000	0.0	-6.0	0.0	-26.8
3	102.55	0.005	0.000	0.0	-12.1	0.0	-26.8
4	102.33	0.006	0.000	0.0	-18.1	0.0	-26.8
5	102.10	0.008	0.000	0.0	-24.1	0.0	-26.8
6	101.85	0.010	0.000	0.2	-30.7	1.3	-25.5
7	101.60	0.012	0.000	0.6	-36.8	2.4	-24.0
8	101.30	0.014	0.000	1.6	-43.7	3.7	-21.7
9	101.00	0.015	0.000	2.9	-49.8	5.0	-18.8
10	100.70	0.017	0.000	4.0	-54.9	4.7	-14.6
11	100.40	0.017	0.000	4.8	-58.6	2.7	-9.8
12	100.00	0.018	0.000	5.3	-61.2	0.7	-2.3
13	99.70	0.018	0.000	5.3	-60.9	4.1	-1.5
14	99.40	0.018	0.000	5.0	-58.7	11.2	-1.8
15	99.15	0.017	0.000	4.6	-55.3	16.2	-1.8
16	98.93	0.016	0.000	4.3	-51.1	21.1	-1.7
17	98.70	0.015	0.000	3.9	-45.8	26.3	-1.8
18	98.45	0.014	0.000	3.4	-38.6	30.1	-1.8
19	98.20	0.013	0.000	3.0	-31.1	35.4	-1.7
20	98.00	0.012	0.000	2.6	-25.2	39.4	-2.0
21	97.60	0.010	0.000	12.3	-13.1	24.5	-2.2
22	97.20	0.008	-0.000	12.8	-3.3	15.5	-13.6
23	96.85	0.006	-0.000	5.3	-0.1	5.2	-18.3
24	96.50	0.004	-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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	4.4	100.40	-0.0	102.78	5.0	101.00	-1.8	99.40
2	No calculation at this stage							
3	5.3	100.00	-0.0	102.10	4.7	100.70	-2.2	97.60
4	No calculation at this stage							
5	12.6	97.20	-32.8	100.00	39.0	98.00	-18.0	96.85
6	12.8	97.20	-33.4	100.00	39.4	98.00	-18.3	96.85
7	No calculation at this stage							
8	0.0	103.00	-61.2	100.00	30.1	98.45	-26.8	103.00

Summary of results (continued)

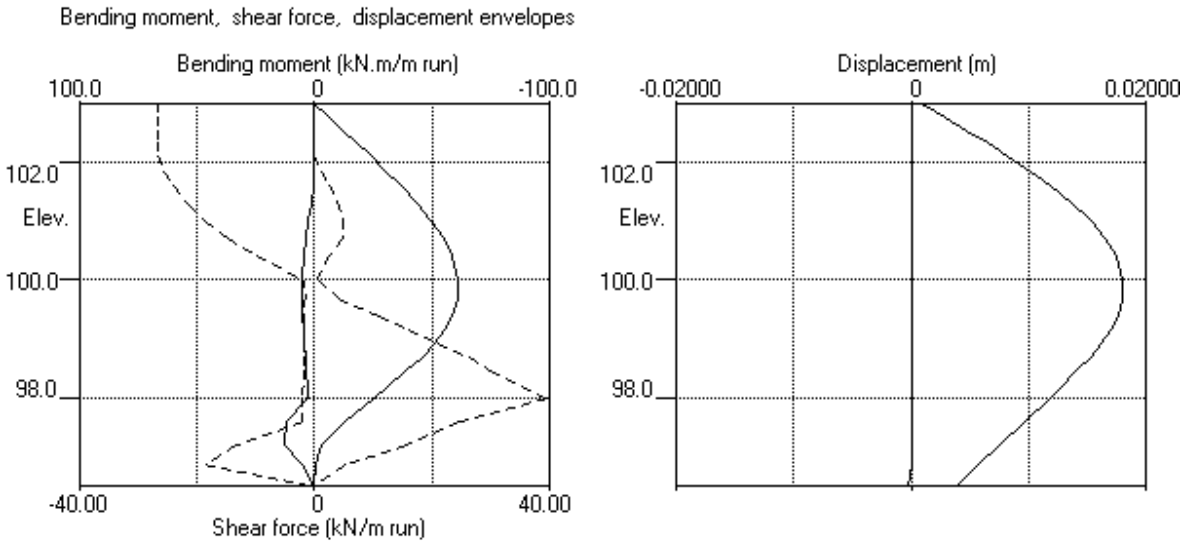
Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.001	103.00	0.000	103.00	Apply surcharge no.1 at elev. 102.10
2	Wall displacements reset to zero				Change EI of wall to 14700kN.m2/m run
3	0.001	103.00	-0.000	96.50	Excav. to elev. 102.10 on PASSIVE side
4	No calculation at this stage				Install strut no.1 at elev. 103.00
5	0.009	100.00	-0.000	96.50	Excav. to elev. 98.00 on PASSIVE side
6	0.009	100.00	-0.000	96.50	Fill to elev. 98.70 on PASSIVE side
7	No calculation at this stage				Change soil type 2 to soil type 5
8	0.018	100.00	0.000	103.00	Change soil type 4 to soil type 6

Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 1 --- at elev. 103.00 kN/m run	kN/strut
5	16.21	16.21
6	16.41	16.41
8	26.83	26.83

Units: kN,m


Bending moment, shear force, displacement envelopes
Bending moment (kN.m/m run)
100.0
0
-100.0
102.0
Elev.
100.0
98.0
-40.00
0
40.00
Shear force (kN/m run)
Displacement (m)
-0.02000
0
0.02000
102.0
Elev.
100.0
98.0

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	104.40	1 Granular Made Ground	1 Granular Made Ground
2	101.00	2 Firm Clay	2 Firm Clay
3	99.40	3 Sand	3 Sand
4	98.20	4 Stiff Clay	4 Stiff Clay

SOIL PROPERTIES

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	20.00a	30000	0.470	OC	0.262	5.284	
		21.00b			(0.300)	(0.000)	(0.000)	
4	Stiff Clay	19.00	75000	1.000	OC	1.000	1.000	75.00u
					(0.490)	(2.389)	(2.390)	
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	
6	Stiff Clay - Drained	19.00	60000	0.817	OC	0.353	3.413	1.000d
					(0.200)	(1.388)	(5.175)	
7	Fill	20.00	60000	0.500	OC	0.189	8.378	
					(0.300)	(0.000)	(0.000)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Stiff Clay	0.00	0.500	0.00	0.00	0.500	0.00
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
6	Stiff Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
7	Fill	40.00	0.434	0.00	40.00	0.434	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

WALL PROPERTIES

Type of structure = Soldier Pile Wall
Soldier Pile width = 0.60 m
Soldier Pile spacing = 2.50 m
Passive mobilisation factor = 3.00 m
Elevation of toe of wall = 96.50
Maximum finite element length = 0.40 m
Youngs modulus of wall E = 2.2250E+07 kN/m2
Moment of inertia of wall I = 2.4290E-03 m4/m run
E.I = 54045 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	Not defined							
2	Not defined							
3	103.00	3.00	0.017800	2.100E+08	7.50	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	102.25	0.50(A)	10.00	1.00	150.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Excavate to elevation 104.40 on ACTIVE side Toe of berm at elevation 102.25 Width of top of berm = 0.50 Width of toe of berm = 0.51
2	Apply surcharge no.1 at elevation 102.25
3	Change EI of wall to 14700 kN.m2/m run From elevation 104.40 to 102.00 Yield moment not defined Reset wall displacements to zero at this stage
4	Excavate to elevation 102.50 on PASSIVE side Toe of berm at elevation 100.63 Width of top of berm = 0.10 Width of toe of berm = 8.00
5	Install strut or anchor no.3 at elevation 103.00
6	Excavate to elevation 99.60 on PASSIVE side
7	Change properties of soil type 2 to soil type 5 No analysis at this stage Ko pressures will not be reset
8	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

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

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 7.200 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 20.00 m

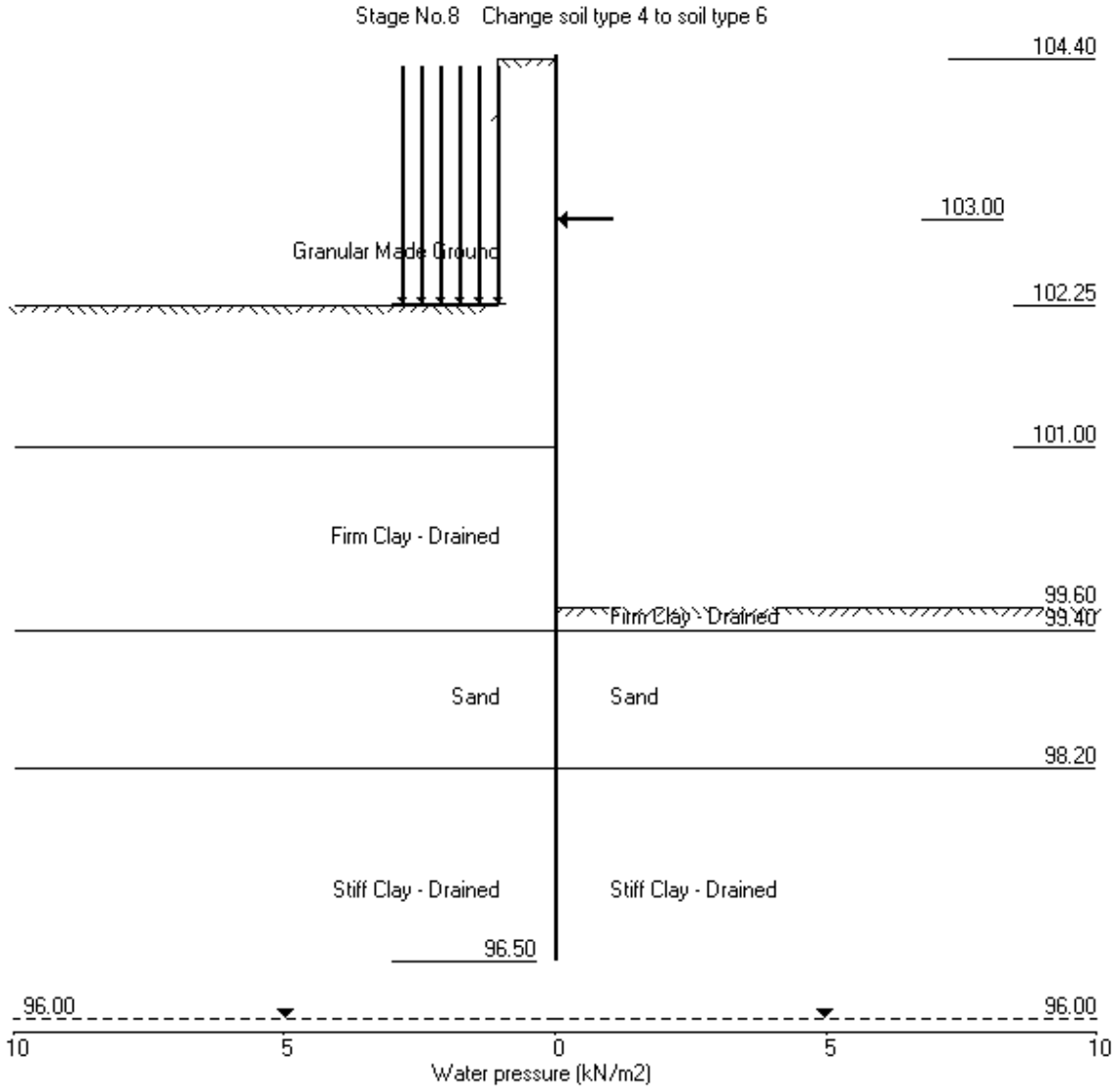
Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Excav. to elev. 104.40 on ACTIVE side	No	No	No
2	Apply surcharge no.1 at elev. 102.25	No	No	No
3	Change EI of wall to 14700kN.m2/m run	No	No	No
4	Excav. to elev. 102.50 on PASSIVE side	No	No	No
5	Install strut no.3 at elev. 103.00	No	No	No
6	Excav. to elev. 99.60 on PASSIVE side	No	No	No
7	Change soil type 2 to soil type 5	No	No	No
8	Change soil type 4 to soil type 6	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m


Stage No.8 Change soil type 4 to soil type 6
104.40
103.00
Granular Made Ground
102.25
101.00
Firm Clay - Drained
99.60
Firm Clay - Drained
99.40
Sand
Sand
98.20
Stiff Clay - Drained
Stiff Clay - Drained
96.50
96.00
96.00
10
5
0
5
10
Water pressure (kN/m2)

Units: kN,m

Summary of results

STABILITY ANALYSIS of Soldier Pile Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 96.50 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	104.40	104.40		Wall tending to move from right to left			
2	104.40	104.40	Cant.	Conditions not suitable for FoS calc.			
3	104.40	104.40		No analysis at this stage			
4	104.40	102.50	Cant.	2.241	97.20	101.32	1.18
5	104.40	102.50		No analysis at this stage			
6	104.40	99.60	103.00	1.932	n/a	98.54	1.06
7	104.40	99.60		No analysis at this stage			
8	104.40	99.60	103.00	1.310	n/a	97.81	1.79

Note: To obtain a Factor of Safety for the case of wall failing from right to left you should reverse the data (Ctrl+K) and re-analyse.

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Soldier Pile Wall

Analysis options

Soldier Pile width = 0.60m; spacing = 2.50m
Passive mobilisation factor = 3.000
Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached

Rigid boundaries: Active side 20.00 from wall
Passive side 15.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	104.40	0.007	0.000	0.0	-0.0	0.0	0.0
2	104.00	0.006	0.000	0.0	-0.1	0.0	-0.5
3	103.60	0.005	0.000	0.0	-0.6	0.0	-2.2
4	103.30	0.005	0.000	0.0	-1.6	0.0	-4.2
5	103.00	0.004	0.000	0.0	-3.2	0.0	-52.3
6	102.75	0.005	0.000	0.0	-13.1	0.0	-52.3
7	102.50	0.006	0.000	0.1	-26.1	1.2	-51.1
8	102.25	0.006	0.000	0.6	-38.5	2.5	-48.5
9	102.00	0.006	0.000	1.3	-50.1	2.5	-45.3
10	101.60	0.007	0.000	2.9	-66.4	3.9	-37.6
11	101.30	0.007	0.000	4.6	-76.5	7.5	-29.1
12	101.00	0.007	0.000	7.6	-83.5	12.9	-19.2
13	100.63	0.007	0.000	9.7	-88.0	8.2	-2.5
14	100.31	0.007	0.000	9.1	-86.7	14.3	-3.4
15	100.00	0.007	0.000	7.5	-79.7	27.2	-5.7
16	99.60	0.006	0.000	4.8	-65.4	46.7	-6.0
17	99.40	0.006	0.000	3.6	-55.2	55.4	-5.4
18	99.10	0.005	0.000	2.2	-38.2	56.7	-3.5
19	98.80	0.005	0.000	1.6	-21.5	50.5	-1.5
20	98.50	0.004	0.000	8.0	-7.4	39.0	0.0
21	98.20	0.004	0.000	13.3	-1.7	26.7	0.0
22	97.90	0.003	0.000	15.5	-0.5	15.6	0.0
23	97.60	0.002	0.000	13.7	-0.0	4.2	-9.7
24	97.20	0.002	0.000	9.6	0.0	0.2	-14.6
25	96.85	0.001	0.000	4.4	0.0	0.0	-13.6
26	96.50	0.000	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.2	97.20	-14.7	101.00	6.4	100.00	-9.7	102.50
2	1.2	97.60	-23.4	101.00	9.3	98.20	-14.0	102.00
3	No calculation at this stage							
4	9.7	100.63	-0.1	103.00	12.9	101.00	-6.0	99.60
5	No calculation at this stage							
6	15.5	97.90	-42.6	101.00	36.6	99.60	-31.9	102.75
7	No calculation at this stage							
8	11.1	97.60	-88.0	100.63	56.7	99.10	-52.3	102.75

Summary of results (continued)

Maximum and minimum displacement at each stage

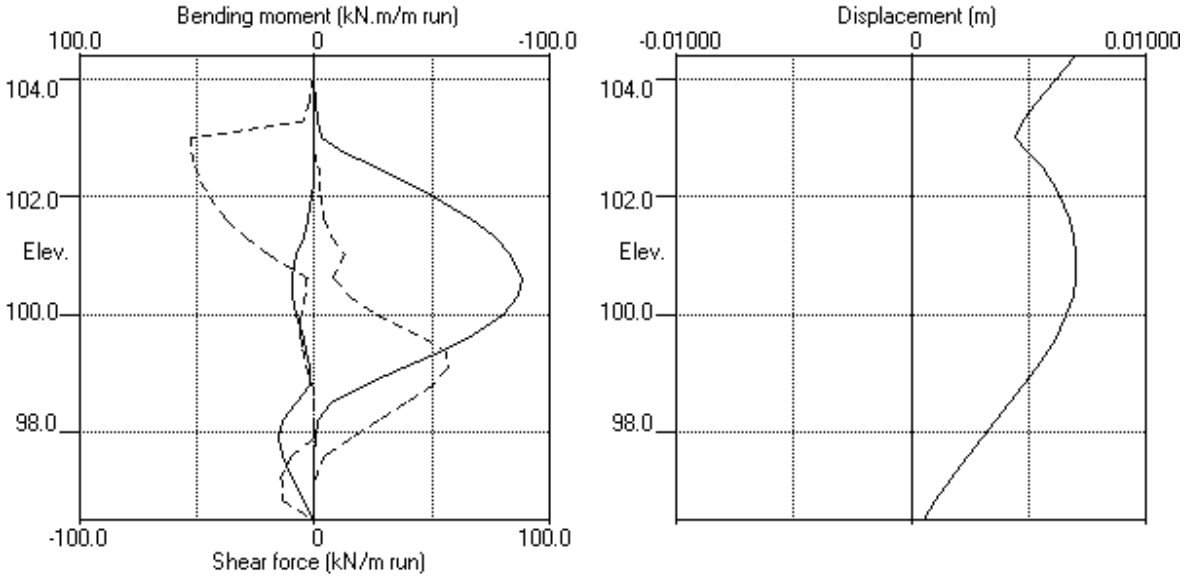
Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	98.80	-0.003	104.40	Excav. to elev. 104.40 on ACTIVE side
2	0.001	100.00	-0.001	104.40	Apply surcharge no.1 at elev. 102.25
3	Wall displacements reset to zero				Change EI of wall to 14700kN.m2/m run
4	0.007	104.40	0.000	104.40	Excav. to elev. 102.50 on PASSIVE side
5	No calculation at this stage				Install strut no.3 at elev. 103.00
6	0.004	102.25	0.000	104.40	Excav. to elev. 99.60 on PASSIVE side
7	No calculation at this stage				Change soil type 2 to soil type 5
8	0.007	101.00	0.000	104.40	Change soil type 4 to soil type 6

Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 3 --- at elev. 103.00 kN/m run	kN/strut
6	31.87	95.62
8	52.31	156.93

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	104.40	1 Granular Made Ground	1 Granular Made Ground
2	101.00	2 Firm Clay	2 Firm Clay
3	99.40	3 Sand	3 Sand
4	98.20	4 Stiff Clay	4 Stiff Clay

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	20.00a	30000	0.470	OC	0.262	5.284	
		21.00b			(0.300)	(0.000)	(0.000)	
4	Stiff Clay	19.00	75000	1.000	OC	1.000	1.000	75.00u
					(0.490)	(2.389)	(2.390)	
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	
6	Stiff Clay - Drained	19.00	60000	0.817	OC	0.353	3.413	1.000d
					(0.200)	(1.388)	(5.175)	
7	Fill	20.00	60000	0.500	OC	0.189	8.378	
					(0.300)	(0.000)	(0.000)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Stiff Clay	0.00	0.500	0.00	0.00	0.500	0.00
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
6	Stiff Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
7	Fill	40.00	0.434	0.00	40.00	0.434	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

WALL PROPERTIES

Type of structure = Soldier Pile Wall
Soldier Pile width = 0.60 m
Soldier Pile spacing = 2.50 m
Passive mobilisation factor = 3.00 m
Elevation of toe of wall = 96.50
Maximum finite element length = 0.40 m
Youngs modulus of wall E = 2.2250E+07 kN/m2
Moment of inertia of wall I = 2.4290E-03 m4/m run
E.I = 54045 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	Not defined							
2	Not defined							
3	103.00	3.00	0.017800	2.100E+08	7.50	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	102.25	0.50(A)	10.00	1.00	150.00	=	N/A	1.00 -

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

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Excavate to elevation 104.40 on ACTIVE side Toe of berm at elevation 102.25 Width of top of berm = 0.50 Width of toe of berm = 0.51
2	Apply surcharge no.1 at elevation 102.25
3	Change EI of wall to 14700 kN.m2/m run From elevation 104.40 to 102.00 Yield moment not defined Reset wall displacements to zero at this stage
4	Excavate to elevation 102.50 on PASSIVE side Toe of berm at elevation 100.63 Width of top of berm = 0.10 Width of toe of berm = 8.00
5	Install strut or anchor no.3 at elevation 103.00
6	Excavate to elevation 99.60 on PASSIVE side
7	Change properties of soil type 2 to soil type 5 No analysis at this stage Ko pressures will not be reset
8	Change properties of soil type 4 to soil type 6 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 = 2.000
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) = 7.200 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 20.00 m

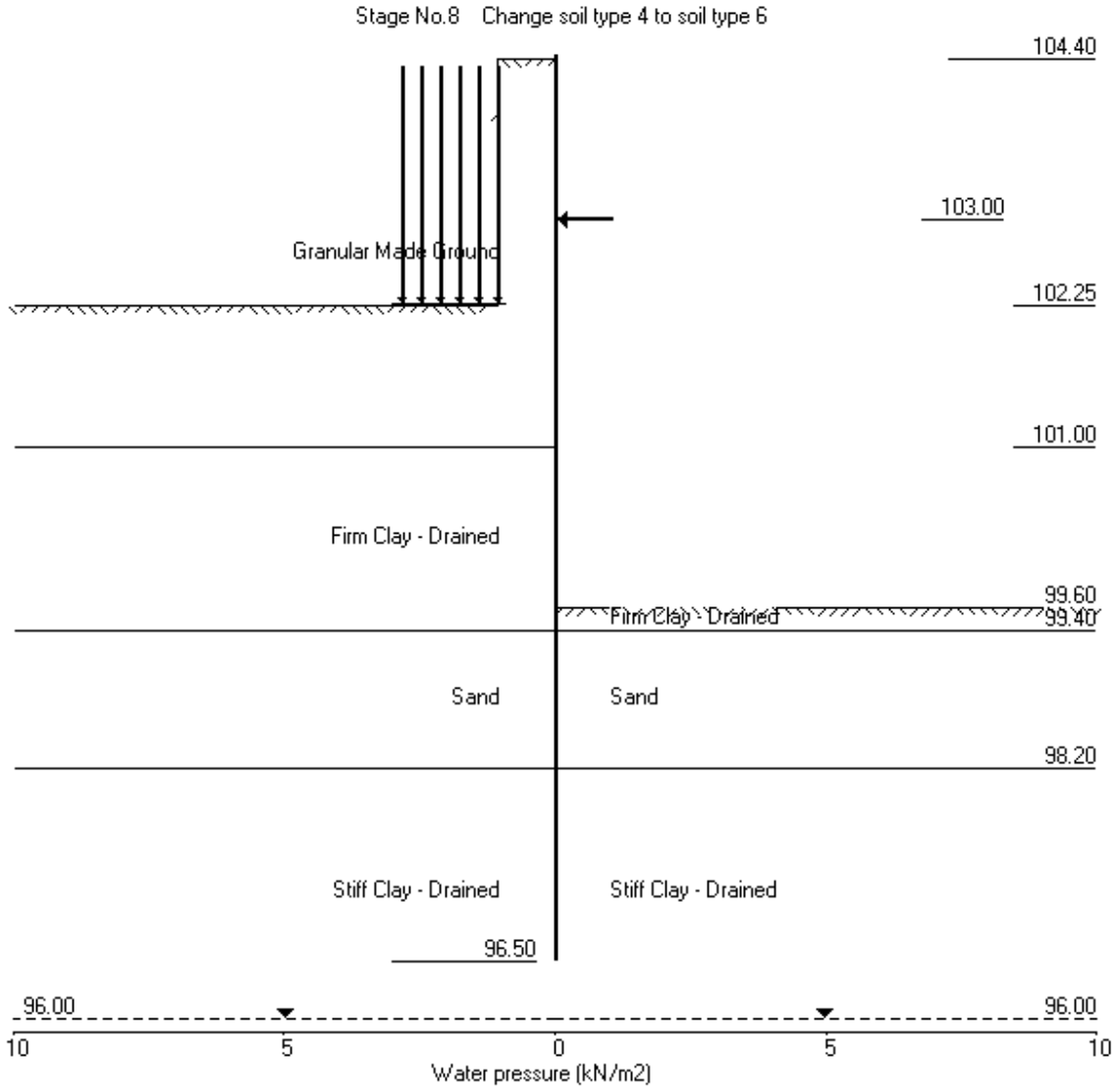
Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Excav. to elev. 104.40 on ACTIVE side	No	No	No
2	Apply surcharge no.1 at elev. 102.25	No	No	No
3	Change EI of wall to 14700kN.m2/m run	No	No	No
4	Excav. to elev. 102.50 on PASSIVE side	No	No	No
5	Install strut no.3 at elev. 103.00	No	No	No
6	Excav. to elev. 99.60 on PASSIVE side	No	No	No
7	Change soil type 2 to soil type 5	No	No	No
8	Change soil type 4 to soil type 6	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m


Stage No.8 Change soil type 4 to soil type 6
104.40
103.00
Granular Made Ground
102.25
101.00
Firm Clay - Drained
99.60
Firm Clay - Drained
99.40
Sand
Sand
98.20
Stiff Clay - Drained
Stiff Clay - Drained
96.50
96.00
96.00
10
5
0
5
10
Water pressure (kN/m2)

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 = 2.000
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 Soldier Pile Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 96.50 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetration
1	104.40	104.40		Wall tending to move from right to left			
2	104.40	104.40	Cant.	Conditions not suitable for FoS calc.			
3	104.40	104.40		No analysis at this stage			
4	104.40	102.50	Cant.	1.711	97.20	100.69	1.81
5	104.40	102.50		No analysis at this stage			
6	104.40	99.60	103.00	1.416	n/a	97.91	1.69
7	104.40	99.60		No analysis at this stage			
8	104.40	99.60	103.00	1.052	n/a	96.76	2.84

Note: To obtain a Factor of Safety for the case of wall failing from right to left you should reverse the data (Ctrl+K) and re-analyse.

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Soldier Pile Wall

Analysis options

Soldier Pile width = 0.60m; spacing = 2.50m
Passive mobilisation factor = 3.000
Length of wall perpendicular to section = 20.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached

Rigid boundaries: Active side 20.00 from wall
Passive side 15.00 from wall

Limit State: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	104.40	0.011	0.000	0.0	-0.0	0.0	0.0
2	104.00	0.010	0.000	0.0	-0.1	0.0	-0.7
3	103.60	0.009	0.000	0.0	-0.7	0.0	-2.7
4	103.30	0.008	0.000	0.1	-1.8	0.0	-5.1
5	103.00	0.008	0.000	0.0	-3.9	0.0	-76.3
6	102.75	0.009	0.000	0.0	-19.1	0.0	-76.3
7	102.50	0.010	0.000	0.0	-38.2	0.0	-76.3
8	102.25	0.011	0.000	0.3	-56.8	1.9	-73.1
9	102.00	0.012	0.000	0.9	-74.6	2.8	-69.2
10	101.60	0.013	0.000	2.5	-100.4	5.2	-59.5
11	101.30	0.014	0.000	4.8	-116.6	9.1	-48.9
12	101.00	0.014	0.000	8.4	-129.4	14.6	-36.6
13	100.63	0.014	0.000	12.6	-138.5	4.5	-16.3
14	100.31	0.015	0.000	13.0	-141.0	13.6	-0.5
15	100.00	0.015	0.000	12.3	-137.9	26.8	-3.3
16	99.60	0.014	0.000	10.1	-123.9	43.2	-6.4
17	99.40	0.014	0.000	8.7	-114.6	54.3	-7.1
18	99.10	0.013	0.000	6.8	-97.1	61.1	-5.5
19	98.80	0.013	0.000	5.3	-78.6	61.8	-3.7
20	98.50	0.012	0.000	4.5	-60.2	57.4	-1.6
21	98.20	0.011	0.000	4.3	-44.4	47.7	0.0
22	97.90	0.010	0.000	4.1	-31.0	42.7	-1.7
23	97.60	0.009	0.000	6.8	-19.4	35.5	-3.0
24	97.20	0.007	0.000	6.3	-6.3	21.8	-7.9
25	96.85	0.006	0.000	2.5	-1.6	9.5	-8.9
26	96.50	0.005	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.0	104.40	-21.3	100.63	7.9	99.60	-12.1	102.50
2	0.2	96.85	-30.3	101.00	12.3	98.20	-17.2	102.00
3	No calculation at this stage							
4	13.0	100.31	-0.0	102.75	14.6	101.00	-7.1	99.40
5	No calculation at this stage							
6	6.8	97.60	-79.2	100.63	40.4	99.60	-50.7	102.50
7	No calculation at this stage							
8	0.1	103.30	-141.0	100.31	61.8	98.80	-76.3	102.50

Summary of results (continued)

Maximum and minimum displacement at each stage

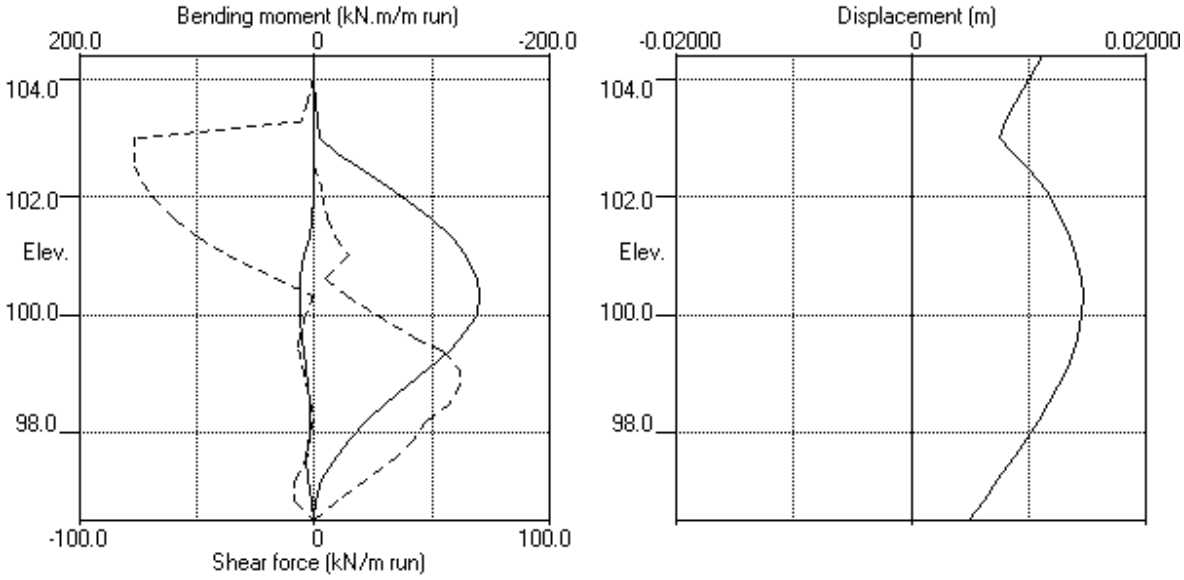
Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	98.20	-0.004	104.40	Excav. to elev. 104.40 on ACTIVE side
2	0.003	100.00	-0.001	104.40	Apply surcharge no.1 at elev. 102.25
3	Wall displacements reset to zero				Change EI of wall to 14700kN.m2/m run
4	0.011	104.40	0.000	104.40	Excav. to elev. 102.50 on PASSIVE side
5	No calculation at this stage				Install strut no.3 at elev. 103.00
6	0.009	101.60	0.000	104.40	Excav. to elev. 99.60 on PASSIVE side
7	No calculation at this stage				Change soil type 2 to soil type 5
8	0.015	100.31	0.000	104.40	Change soil type 4 to soil type 6

Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 3 --- at elev. 103.00 kN/m run	kN/strut
6	50.71	152.12
8	76.34	229.01

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	105.20	1 Granular Made Ground	1 Granular Made Ground
2	104.20	2 Firm Clay	2 Firm Clay
3	100.20	3 Sand	3 Sand
4	99.00	4 Stiff Clay	4 Stiff Clay

SOIL PROPERTIES

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	20.00a	30000	0.470	OC	0.262	5.284	
		21.00b			(0.300)	(0.000)	(0.000)	
4	Stiff Clay	19.00	75000	1.000	OC	1.000	1.000	75.00u
					(0.490)	(2.389)	(2.390)	
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	
6	Stiff Clay - Drained	19.00	60000	0.817	OC	0.353	3.413	1.000d
					(0.200)	(1.388)	(5.175)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Stiff Clay	0.00	0.500	0.00	0.00	0.500	0.00
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
6	Stiff Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 98.00
Maximum finite element length = 0.40 m
Youngs modulus of wall E = 2.1000E+08 kN/m2
Moment of inertia of wall I = 3.5950E-04 m4/m run
(Arcelor PU18-1) E.I = 75495 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	Not defined							
2	104.20	1.00	0.017800	2.100E+08	7.50	0.00	0	No
3	103.00	1.00	0.017800	2.100E+08	7.50	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	105.20	0.00(A)	10.00	10.00	30.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 105.20
2	Excavate to elevation 103.20 on PASSIVE side
3	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
4	Change properties of soil type 5 to soil type 2 No analysis at this stage Ko pressures will not be reset
5	Change properties of soil type 6 to soil type 4 No analysis at this stage Ko pressures will not be reset
6	Install strut or anchor no.3 at elevation 103.00
7	Excavate to elevation 102.00 on PASSIVE side
8	Excavate to elevation 100.20 on PASSIVE side
9	Change properties of soil type 2 to soil type 5 No analysis at this stage Ko pressures will not be reset
10	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

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

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 7.200 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 10.00 m

Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

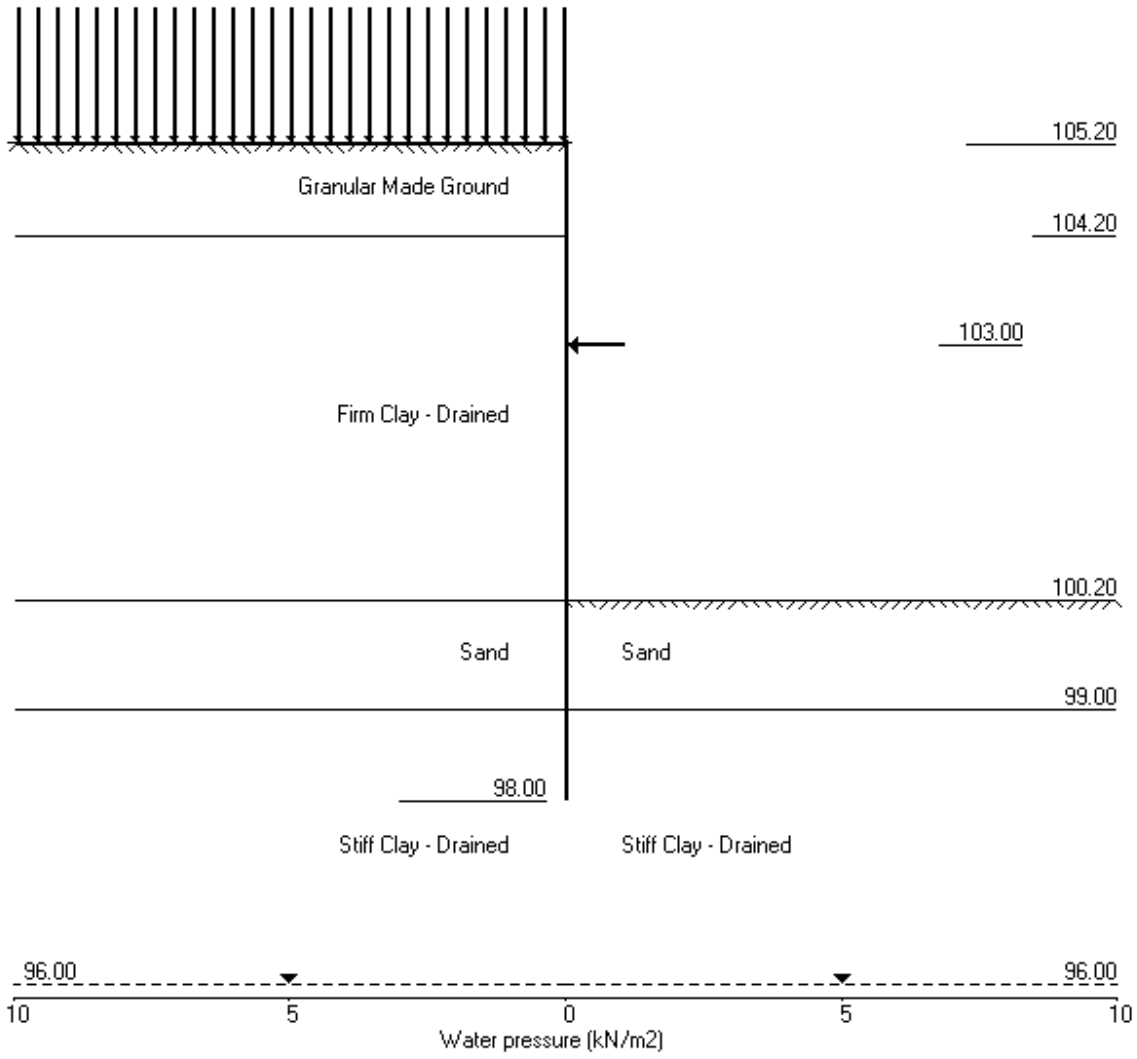
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 105.20	No	No	No
2	Excav. to elev. 103.20 on PASSIVE side	No	No	No
3	Change soil type 4 to soil type 6	No	No	No
4	Change soil type 5 to soil type 2	No	No	No
5	Change soil type 6 to soil type 4	No	No	No
6	Install strut no.3 at elev. 103.00	No	No	No
7	Excav. to elev. 102.00 on PASSIVE side	No	No	No
8	Excav. to elev. 100.20 on PASSIVE side	No	No	No
9	Change soil type 2 to soil type 5	No	No	No
10	Change soil type 4 to soil type 6	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.10 Change soil type 4 to soil type 6



Units: kN,m

Summary of results

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

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 98.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	105.20	105.20	Cant.	Conditions not suitable for FoS calc.			
2	105.20	103.20	Cant.	3.166	98.52	102.14	1.06
3	105.20	103.20	Cant.	3.165	98.47	102.14	1.06
4	105.20	103.20		No analysis at this stage			
5	105.20	103.20	Cant.	3.166	98.52	102.14	1.06
6	105.20	103.20		No analysis at this stage			
7	105.20	102.00	103.00	Conditions not suitable for FoS calc.			
8	105.20	100.20	103.00	2.168	n/a	99.29	0.91
9	105.20	100.20		No analysis at this stage			
10	105.20	100.20	103.00	1.301	n/a	99.09	1.11

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 10.00m
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 15.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	105.20	0.004	0.000	0.0	-0.0	0.0	0.0
2	104.80	0.003	0.000	1.4	0.0	6.8	0.0
3	104.50	0.003	0.000	4.3	0.0	12.6	0.0
4	104.20	0.003	0.000	9.0	0.0	18.9	0.0
5	103.90	0.002	0.000	16.5	0.0	30.1	0.0
6	103.60	0.002	0.000	27.0	0.0	38.3	0.0
7	103.20	0.002	0.000	44.2	0.0	47.3	-2.4
8	103.00	0.002	0.000	54.3	0.0	52.0	-73.5
9	102.70	0.002	0.000	34.0	0.0	0.3	-66.0
10	102.40	0.002	0.000	32.5	0.0	0.0	-57.9
11	102.00	0.002	0.000	27.4	-6.5	0.0	-46.4
12	101.60	0.002	0.000	20.8	-22.6	0.0	-34.6
13	101.20	0.002	0.000	14.3	-33.5	0.0	-22.0
14	100.80	0.003	0.000	8.6	-38.8	0.0	-12.3
15	100.50	0.003	0.000	5.3	-38.9	6.3	-9.5
16	100.20	0.002	0.000	2.9	-35.0	20.2	-6.3
17	99.90	0.002	0.000	1.3	-28.0	24.6	-4.5
18	99.60	0.002	0.000	0.2	-20.4	23.3	-2.7
19	99.30	0.002	0.000	0.0	-13.8	22.0	-0.7
20	99.00	0.002	0.000	0.0	-7.6	21.9	0.0
21	98.70	0.002	0.000	0.0	-2.7	12.8	0.0
22	98.40	0.002	0.000	0.0	-0.3	5.1	0.0
23	98.00	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	11.4	103.60	-0.9	99.60	13.8	104.20	-5.4	102.40
2	34.0	102.70	-0.3	99.30	24.6	103.20	-16.3	101.60
3	34.0	102.70	-0.3	99.30	24.6	103.20	-16.3	101.60
4	No calculation at this stage							
5	34.0	102.70	-0.3	99.30	24.6	103.20	-16.3	101.60
6	No calculation at this stage							
7	38.4	103.00	-3.1	99.60	31.3	103.00	-37.0	103.00
8	52.7	103.00	-37.6	100.50	46.7	103.00	-64.4	103.00
9	No calculation at this stage							
10	54.3	103.00	-38.9	100.50	52.0	103.00	-73.5	103.00

Summary of results (continued)

Maximum and minimum displacement at each stage

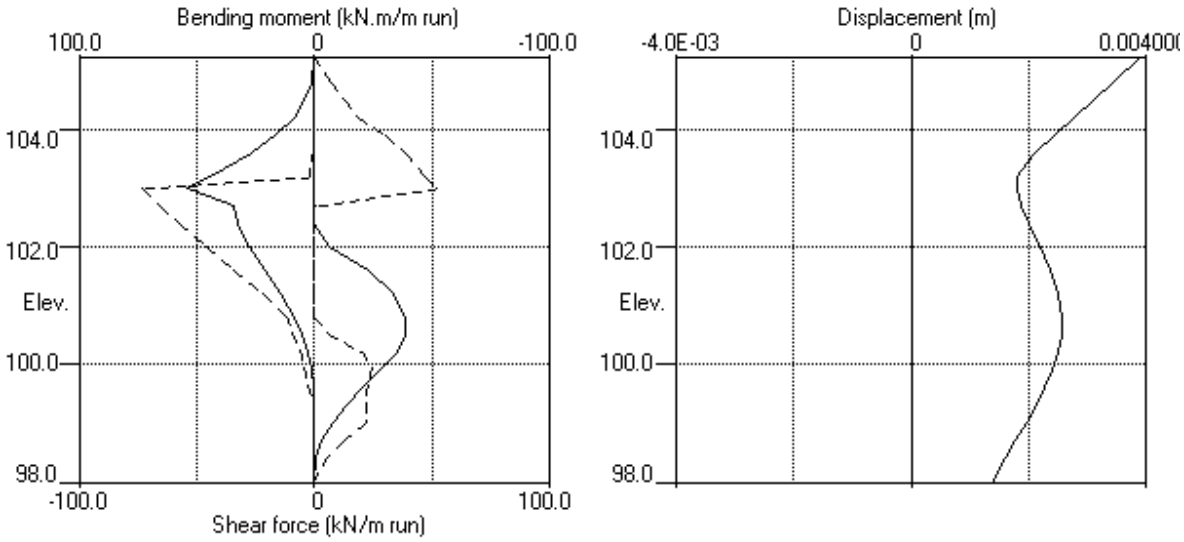
Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.001	105.20	0.000	105.20	Apply surcharge no.1 at elev. 105.20
2	0.004	105.20	0.000	105.20	Excav. to elev. 103.20 on PASSIVE side
3	0.004	105.20	0.000	105.20	Change soil type 4 to soil type 6
4	No calculation at this stage				Change soil type 5 to soil type 2
5	0.004	105.20	0.000	105.20	Change soil type 6 to soil type 4
6	No calculation at this stage				Install strut no.3 at elev. 103.00
7	0.003	105.20	0.000	105.20	Excav. to elev. 102.00 on PASSIVE side
8	0.002	100.80	0.000	105.20	Excav. to elev. 100.20 on PASSIVE side
9	No calculation at this stage				Change soil type 2 to soil type 5
10	0.003	100.80	0.000	105.20	Change soil type 4 to soil type 6

Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 3 --- at elev. 103.00 kN/m run	kN/strut
7	68.30	68.30
8	111.06	111.06
10	125.49	125.49

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	105.20	1 Granular Made Ground	1 Granular Made Ground
2	104.20	2 Firm Clay	2 Firm Clay
3	100.20	3 Sand	3 Sand
4	99.00	4 Stiff Clay	4 Stiff Clay

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	20.00a	30000	0.470	OC	0.262	5.284	
		21.00b			(0.300)	(0.000)	(0.000)	
4	Stiff Clay	19.00	75000	1.000	OC	1.000	1.000	75.00u
					(0.490)	(2.389)	(2.390)	
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	
6	Stiff Clay - Drained	19.00	60000	0.817	OC	0.353	3.413	1.000d
					(0.200)	(1.388)	(5.175)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Stiff Clay	0.00	0.500	0.00	0.00	0.500	0.00
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
6	Stiff Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 98.00
Maximum finite element length = 0.40 m
Youngs modulus of wall E = 2.1000E+08 kN/m2
Moment of inertia of wall I = 3.5950E-04 m4/m run
(Arcelor PU18-1) E.I = 75495 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	Not defined							
2	104.20	1.00	0.017800	2.100E+08	7.50	0.00	0	No
3	103.00	1.00	0.017800	2.100E+08	7.50	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	105.20	0.00(A)	10.00	10.00	30.00	=	N/A	1.00 P/U

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 105.20
2	Excavate to elevation 103.20 on PASSIVE side
3	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset
4	Change properties of soil type 5 to soil type 2 No analysis at this stage Ko pressures will not be reset
5	Change properties of soil type 6 to soil type 4 Ko pressures will not be reset
6	Install strut or anchor no.3 at elevation 103.00
7	Excavate to elevation 102.00 on PASSIVE side
8	Excavate to elevation 100.20 on PASSIVE side
9	Change properties of soil type 2 to soil type 5 No analysis at this stage Ko pressures will not be reset
10	Change properties of soil type 4 to soil type 6 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 = 2.000
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) = 7.200 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 10.00 m

Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

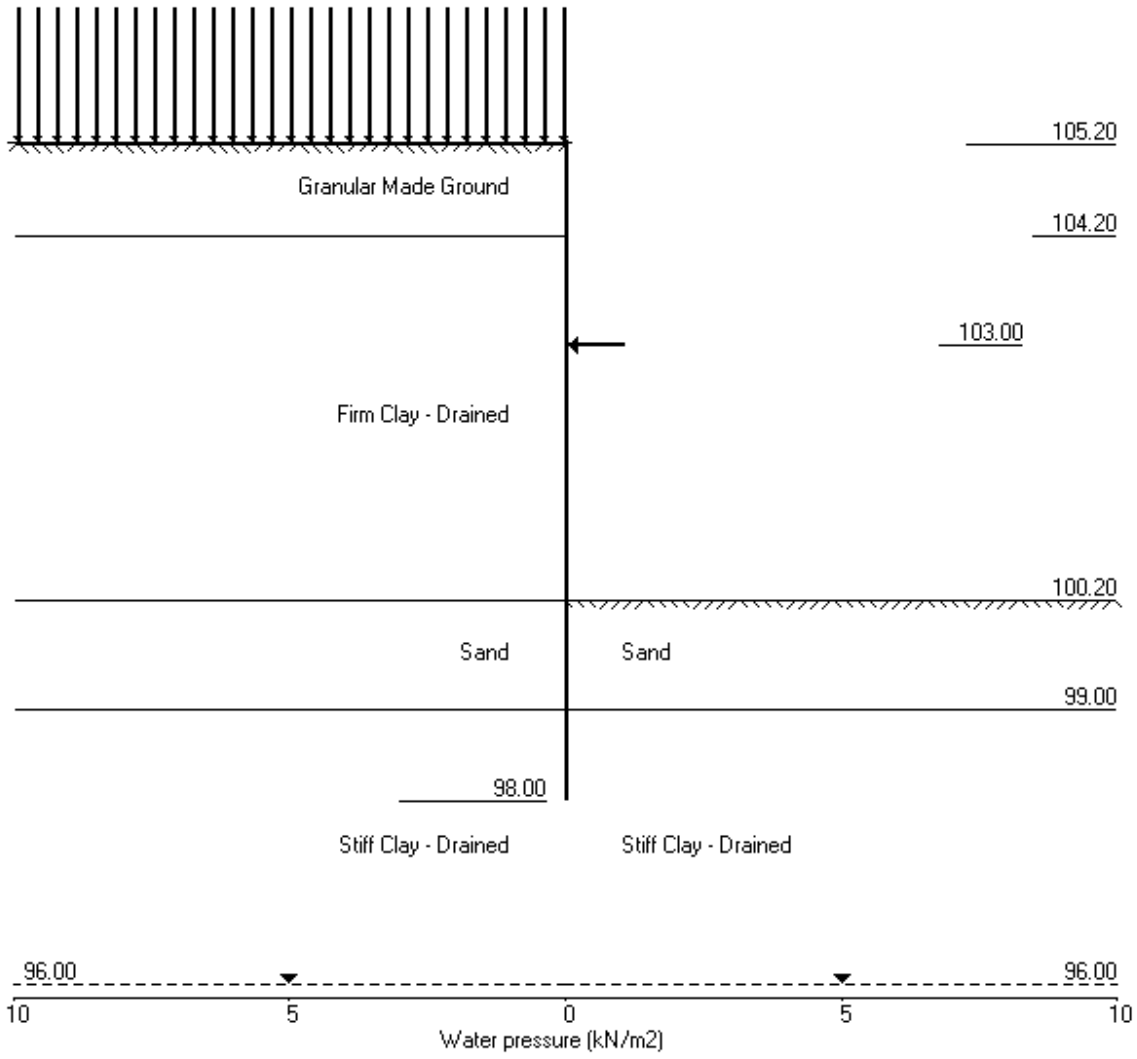
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 105.20	No	No	No
2	Excav. to elev. 103.20 on PASSIVE side	No	No	No
3	Change soil type 4 to soil type 6	No	No	No
4	Change soil type 5 to soil type 2	No	No	No
5	Change soil type 6 to soil type 4	No	No	No
6	Install strut no.3 at elev. 103.00	No	No	No
7	Excav. to elev. 102.00 on PASSIVE side	No	No	No
8	Excav. to elev. 100.20 on PASSIVE side	No	No	No
9	Change soil type 2 to soil type 5	No	No	No
10	Change soil type 4 to soil type 6	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.10 Change soil type 4 to soil type 6



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 = 2.000
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

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 98.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetration
1	105.20	105.20	Cant.	5.355	98.79	104.67	0.53
2	105.20	103.20	Cant.	2.295	98.56	101.82	1.38
3	105.20	103.20	Cant.	2.299	98.50	101.82	1.38
4	105.20	103.20		No analysis at this stage			
5	105.20	103.20	Cant.	2.295	98.56	101.82	1.38
6	105.20	103.20		No analysis at this stage			
7	105.20	102.00	103.00	Conditions not suitable for FoS calc.			
8	105.20	100.20	103.00	1.582	n/a	98.95	1.25
9	105.20	100.20		No analysis at this stage			
10	105.20	100.20	103.00	1.040	n/a	98.21	1.99

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 10.00m
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 15.00 from wall

Limit State: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	105.20	0.007	0.000	0.0	-0.0	0.0	0.0
2	104.80	0.006	0.000	1.4	0.0	7.0	0.0
3	104.50	0.006	0.000	4.4	0.0	13.2	0.0
4	104.20	0.005	0.000	9.4	0.0	19.9	0.0
5	103.90	0.005	0.000	17.5	0.0	32.6	0.0
6	103.60	0.004	0.000	28.9	0.0	42.1	0.0
7	103.20	0.004	0.000	48.2	0.0	53.0	-0.5
8	103.00	0.004	0.000	59.6	0.0	58.7	-89.2
9	102.70	0.004	0.000	36.8	0.0	4.9	-80.1
10	102.40	0.004	0.000	36.8	0.0	0.0	-70.4
11	102.00	0.005	0.000	33.7	-14.1	0.0	-56.4
12	101.60	0.005	0.000	28.4	-33.7	0.0	-41.3
13	101.20	0.006	0.000	22.4	-47.0	0.0	-26.6
14	100.80	0.006	0.000	16.4	-53.7	0.0	-14.0
15	100.50	0.006	0.000	12.4	-54.0	5.9	-12.2
16	100.20	0.006	0.000	9.0	-50.1	20.1	-9.8
17	99.90	0.006	0.000	6.3	-42.7	28.4	-8.1
18	99.60	0.006	0.000	4.2	-33.5	30.4	-6.2
19	99.30	0.006	0.000	2.6	-24.5	30.9	-4.2
20	99.00	0.006	0.000	1.6	-16.0	32.2	-2.1
21	98.70	0.005	0.000	1.0	-8.4	22.6	-2.0
22	98.40	0.005	0.000	0.4	-2.7	14.4	-1.5
23	98.00	0.005	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	12.9	103.20	-0.2	99.30	14.1	104.20	-5.2	102.00
2	36.8	102.40	-0.0	105.20	25.3	103.20	-15.0	101.20
3	36.8	102.40	-0.0	105.20	25.3	103.20	-15.0	101.20
4	No calculation at this stage							
5	36.8	102.40	-0.0	105.20	25.3	103.20	-15.0	101.20
6	No calculation at this stage							
7	40.4	103.00	-2.2	99.60	33.4	103.00	-37.2	103.00
8	54.8	103.00	-50.4	100.50	49.1	103.00	-73.6	103.00
9	No calculation at this stage							
10	59.6	103.00	-54.0	100.50	58.7	103.00	-89.2	103.00

Summary of results (continued)

Maximum and minimum displacement at each stage

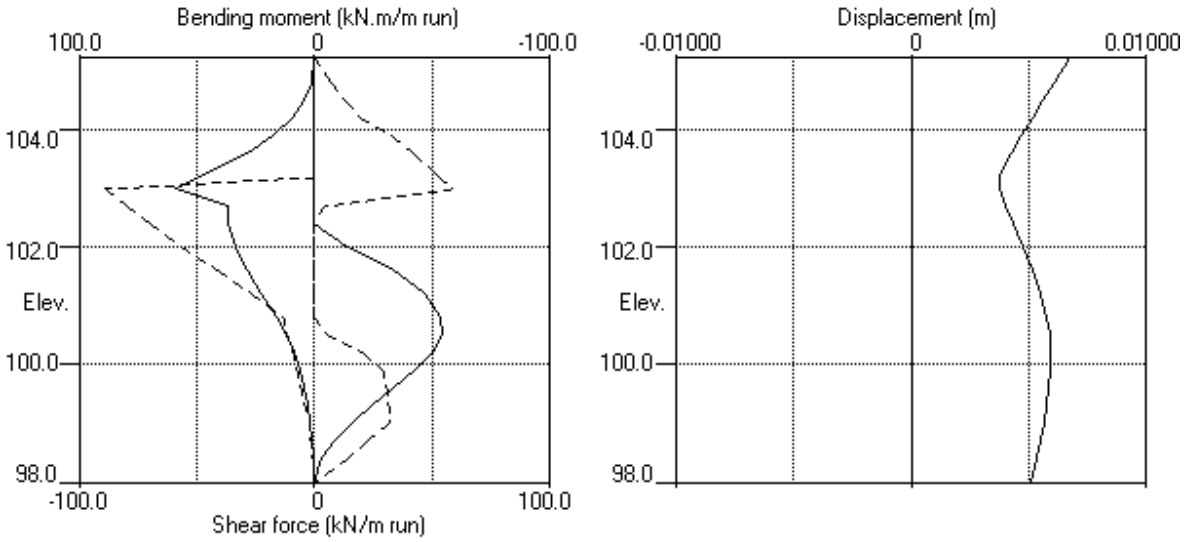
Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.002	105.20	0.000	105.20	Apply surcharge no.1 at elev. 105.20
2	0.007	105.20	0.000	105.20	Excav. to elev. 103.20 on PASSIVE side
3	0.007	105.20	0.000	105.20	Change soil type 4 to soil type 6
4	No calculation at this stage				Change soil type 5 to soil type 2
5	0.007	105.20	0.000	105.20	Change soil type 6 to soil type 4
6	No calculation at this stage				Install strut no.3 at elev. 103.00
7	0.006	105.20	0.000	105.20	Excav. to elev. 102.00 on PASSIVE side
8	0.005	100.50	0.000	105.20	Excav. to elev. 100.20 on PASSIVE side
9	No calculation at this stage				Change soil type 2 to soil type 5
10	0.006	100.20	0.000	105.20	Change soil type 4 to soil type 6

Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 3 --- at elev. 103.00 kN/m run	kN/strut
7	70.60	70.60
8	122.64	122.64
10	147.95	147.95

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	106.20	1 Granular Made Ground	1 Granular Made Ground
2	105.20	2 Firm Clay	2 Firm Clay
3	101.20	3 Sand	3 Sand
4	100.00	4 Stiff Clay	4 Stiff Clay

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	20.00a	30000	0.470	OC	0.262	5.284	
		21.00b			(0.300)	(0.000)	(0.000)	
4	Stiff Clay	19.00	75000	1.000	OC	1.000	1.000	75.00u
					(0.490)	(2.389)	(2.390)	
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	
6	Stiff Clay - Drained	19.00	60000	0.817	OC	0.353	3.413	1.000d
					(0.200)	(1.388)	(5.175)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Stiff Clay	0.00	0.500	0.00	0.00	0.500	0.00
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
6	Stiff Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 97.40
Maximum finite element length = 0.50 m
Youngs modulus of wall E = 2.1000E+08 kN/m2
Moment of inertia of wall I = 3.9650E-04 m4/m run
(Arcelor PU18) E.I = 83265 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	100.50	1.00	0.250000	3.000E+07	7.50	0.00	0	Yes
2	105.20	1.00	0.017800	2.100E+08	7.50	0.00	0	No
3	103.00	1.00	0.017800	2.100E+08	7.50	0.00	0	No
4	106.00	1.00	0.250000	3.000E+07	7.50	0.00	0	Yes

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	106.20	1.00(A)	30.00	10.00	10.00	=	N/A	1.00 -
2	106.20	1.00(A)	30.00	2.50	20.00	=	N/A	1.00 -

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

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 106.20
2	Excavate to elevation 104.20 on PASSIVE side Toe of berm at elevation 101.00 Width of top of berm = 1.50 Width of toe of berm = 4.00
3	Fill to elevation 104.33 on PASSIVE side with soil type 2
4	Excavate to elevation 102.60 on PASSIVE side
5	Install strut or anchor no.3 at elevation 103.00
6	Apply surcharge no.2 at elevation 106.20
7	Excavate to elevation 100.20 on PASSIVE side
8	Install strut or anchor no.4 at elevation 106.00
9	Change properties of soil type 4 to soil type 6 Ko pressures will be reset
10	Change properties of soil type 2 to soil type 5 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 = 2.000
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) = 10.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 30.00 m

Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

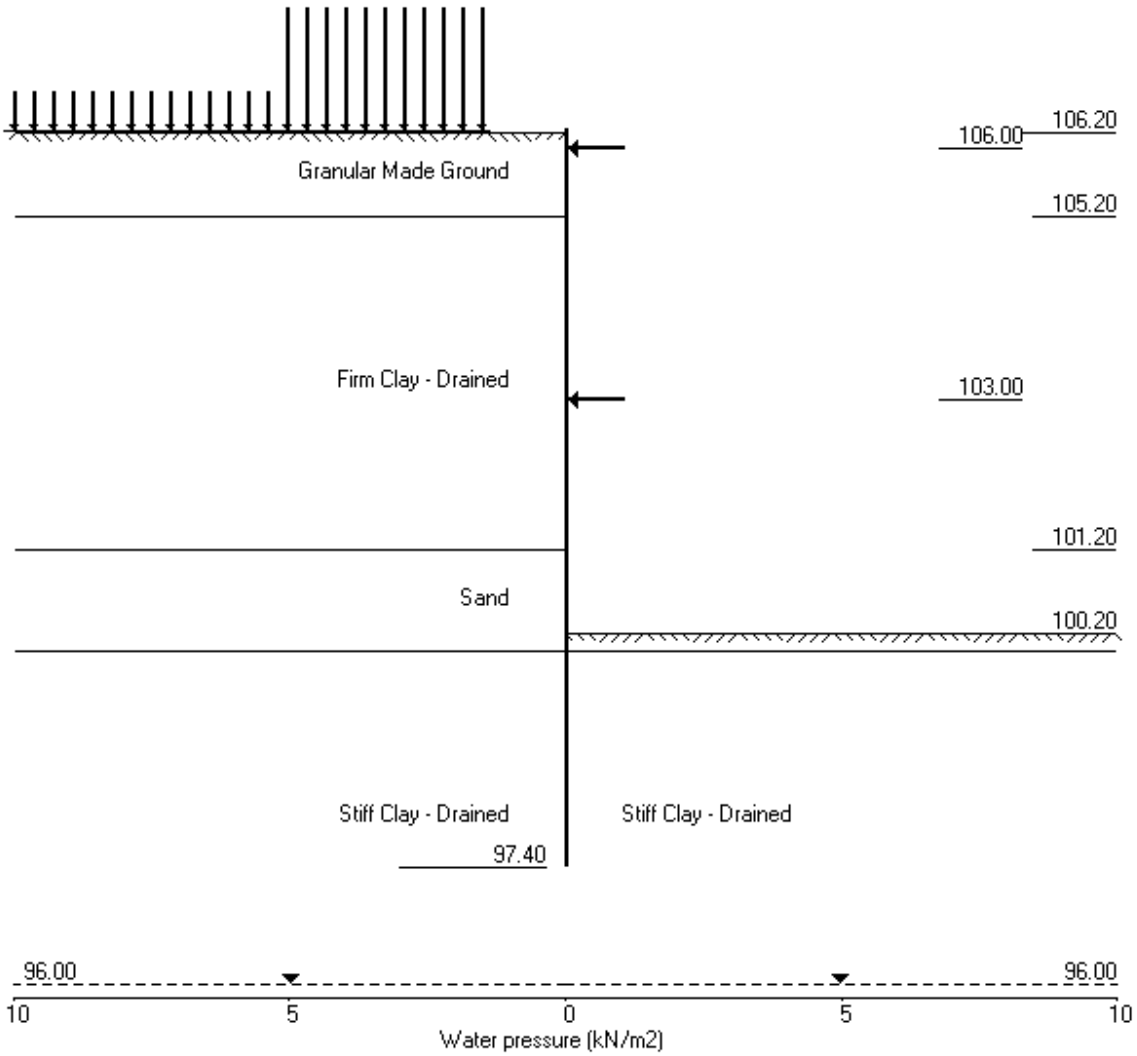
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 106.20	No	No	No
2	Excav. to elev. 104.20 on PASSIVE side	No	No	No
3	Fill to elev. 104.33 on PASSIVE side	No	No	No
4	Excav. to elev. 102.60 on PASSIVE side	No	No	No
5	Install strut no.3 at elev. 103.00	No	No	No
6	Apply surcharge no.2 at elev. 106.20	No	No	No
7	Excav. to elev. 100.20 on PASSIVE side	No	No	No
8	Install strut no.4 at elev. 106.00	No	No	No
9	Change soil type 4 to soil type 6	No	No	No
10	Change soil type 2 to soil type 5	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.10 Change soil type 2 to soil type 5



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 = 2.000
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

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 97.40 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	106.20	106.20	Cant.	Conditions not suitable for FoS calc.			
2	106.20	104.20	Cant.	1.600	98.07	99.51	4.69
3	106.20	104.33	Cant.	4.410	97.83	103.58	0.75
4	106.20	102.60	Cant.	2.087	97.93	100.87	1.73
5	106.20	102.60		No analysis at this stage			
6	106.20	102.60	103.00	Conditions not suitable for FoS calc.			
7	106.20	100.20	103.00	1.794	n/a	99.67	0.53
8	106.20	100.20		No analysis at this stage			

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

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m
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 15.00 from wall

Limit State: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	106.20	0.025	0.000	0.0	0.0	0.0	0.0
2	106.00	0.024	0.000	0.0	0.0	24.9	-0.0
3	105.60	0.023	0.000	10.2	0.0	26.5	0.0
4	105.20	0.021	0.000	21.4	0.0	30.2	0.0
5	104.77	0.019	0.000	37.7	-0.0	44.3	-0.5
6	104.33	0.017	0.000	60.2	-0.3	59.0	-0.8
7	104.20	0.017	0.000	68.2	-0.4	63.4	-0.9
8	103.85	0.015	0.000	92.5	-0.7	74.9	-0.9
9	103.50	0.014	0.000	120.7	-1.0	85.5	-0.9
10	103.00	0.012	0.000	167.5	-1.4	100.4	-125.0
11	102.60	0.012	0.000	120.2	-1.7	33.3	-111.9
12	102.30	0.012	0.000	91.9	-1.8	25.4	-101.2
13	102.00	0.011	0.000	67.1	-1.9	18.8	-89.8
14	101.60	0.011	0.000	64.2	-2.0	10.4	-73.6
15	101.20	0.011	0.000	66.7	-1.9	7.5	-60.6
16	101.00	0.011	0.000	67.1	-8.5	4.2	-53.4
17	100.60	0.011	0.000	66.6	-24.9	5.9	-38.4
18	100.20	0.011	0.000	64.0	-35.4	21.9	-22.3
19	100.00	0.011	0.000	62.4	-38.3	28.9	-15.4
20	99.50	0.011	0.000	52.3	-38.5	11.7	-25.9
21	99.00	0.010	0.000	36.6	-30.0	24.0	-32.2
22	98.50	0.010	0.000	20.1	-17.7	26.7	-29.8
23	98.00	0.009	0.000	6.7	-6.4	20.0	-20.2
24	97.70	0.009	0.000	1.9	-1.7	11.7	-11.2
25	97.40	0.009	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.1	105.20	-2.0	101.60	1.3	100.00	-0.9	103.85
2	47.0	100.60	-0.0	97.40	15.9	103.00	-22.9	99.00
3	47.5	100.60	-0.0	97.40	16.0	103.00	-23.0	99.00
4	67.1	101.00	-0.0	97.40	33.3	102.60	-32.2	99.00
5	No calculation at this stage							
6	65.7	101.20	-0.0	97.40	40.9	103.00	-31.0	99.00
7	80.8	103.00	-0.0	97.40	64.4	103.00	-55.8	103.00
8	No calculation at this stage							
9	156.0	103.00	-35.4	99.50	94.0	103.00	-98.6	103.00
10	167.5	103.00	-38.5	99.50	100.4	103.00	-125.0	103.00

Summary of results (continued)

Maximum and minimum displacement at each stage

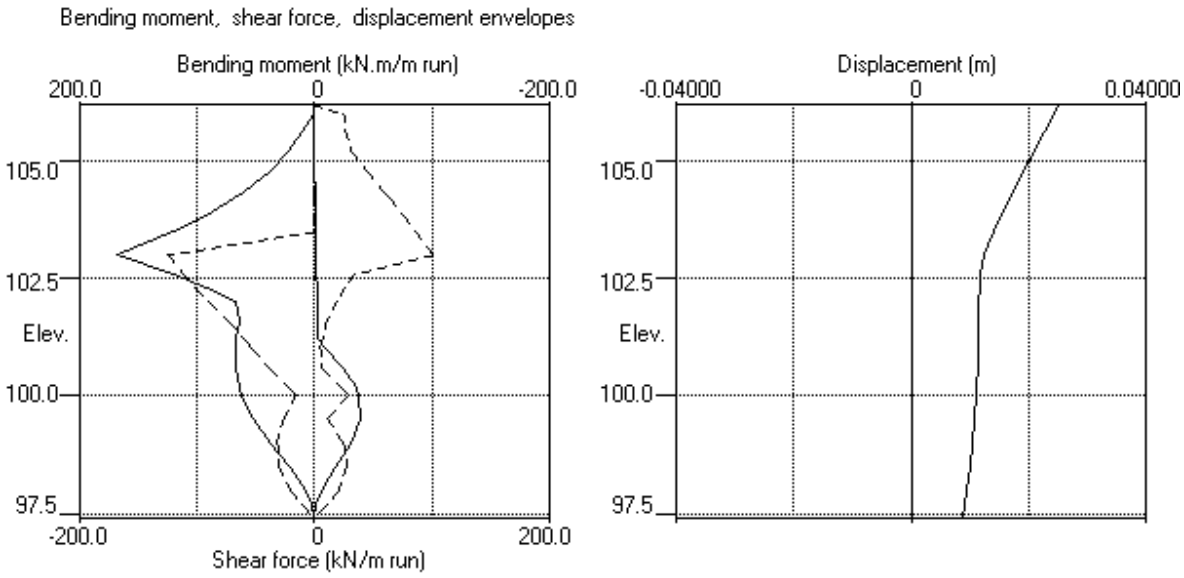
Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	101.20	0.000	106.20	Apply surcharge no.1 at elev. 106.20
2	0.017	106.20	0.000	106.20	Excav. to elev. 104.20 on PASSIVE side
3	0.017	106.20	0.000	106.20	Fill to elev. 104.33 on PASSIVE side
4	0.025	106.20	0.000	106.20	Excav. to elev. 102.60 on PASSIVE side
5	No calculation at this stage				Install strut no.3 at elev. 103.00
6	0.025	106.20	0.000	106.20	Apply surcharge no.2 at elev. 106.20
7	0.023	106.20	0.000	106.20	Excav. to elev. 100.20 on PASSIVE side
8	No calculation at this stage				Install strut no.4 at elev. 106.00
9	0.023	106.20	0.000	106.20	Change soil type 4 to soil type 6
10	0.023	106.20	0.000	106.20	Change soil type 2 to soil type 5

Summary of results (continued)

Strut forces at each stage (horizontal components)

Stage no.	Strut no. 3 at elev. 103.00		Strut no. 4 at elev. 106.00	
	kN/m run	kN/strut	kN/m run	kN/strut
6	29.96	29.96	---	---
7	120.22	120.22	---	---
9	192.63	192.63	-21.24	-21.24
10	225.37	225.37	-24.72	-24.72

Units: kN,m


Bending moment, shear force, displacement envelopes
Bending moment (kN.m/m run)
200.0
0
-200.0
105.0
102.5
Elev.
100.0
97.5
-200.0
0
200.0
Shear force (kN/m run)
Displacement (m)
-0.04000
0
0.04000
105.0
102.5
Elev.
100.0
97.5

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	106.20	1 Granular Made Ground	1 Granular Made Ground
2	105.20	2 Firm Clay	2 Firm Clay
3	101.20	3 Sand	3 Sand
4	100.00	4 Stiff Clay	4 Stiff Clay

SOIL PROPERTIES

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	20.00a	30000	0.470	OC	0.262	5.284	
		21.00b			(0.300)	(0.000)	(0.000)	
4	Stiff Clay	19.00	75000	1.000	OC	1.000	1.000	75.00u
					(0.490)	(2.389)	(2.390)	
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	
6	Stiff Clay - Drained	19.00	60000	0.817	OC	0.353	3.413	1.000d
					(0.200)	(1.388)	(5.175)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Stiff Clay	0.00	0.500	0.00	0.00	0.500	0.00
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
6	Stiff Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 97.40
Maximum finite element length = 0.50 m
Youngs modulus of wall E = 2.1000E+08 kN/m2
Moment of inertia of wall I = 3.9650E-04 m4/m run
(Arcelor PU18) E.I = 83265 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	100.50	1.00	0.250000	3.000E+07	7.50	0.00	0	Yes
2	105.20	1.00	0.017800	2.100E+08	7.50	0.00	0	No
3	103.00	1.00	0.017800	2.100E+08	7.50	0.00	0	No
4	106.00	1.00	0.250000	3.000E+07	7.50	0.00	0	Yes

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	106.20	1.00(A)	30.00	10.00	10.00	=	N/A	N/A
2	106.20	1.00(A)	30.00	2.50	20.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 106.20
2	Excavate to elevation 104.20 on PASSIVE side Toe of berm at elevation 101.00 Width of top of berm = 1.50 Width of toe of berm = 4.00
3	Fill to elevation 104.33 on PASSIVE side with soil type 2
4	Excavate to elevation 102.60 on PASSIVE side
5	Install strut or anchor no.3 at elevation 103.00
6	Apply surcharge no.2 at elevation 106.20
7	Excavate to elevation 100.20 on PASSIVE side
8	Install strut or anchor no.4 at elevation 106.00
9	Change properties of soil type 4 to soil type 6 Ko pressures will be reset
10	Change properties of soil type 2 to soil type 5 Ko pressures will not be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

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

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

Boundary conditions:
Length of wall (normal to plane of analysis) = 30.00 m

Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

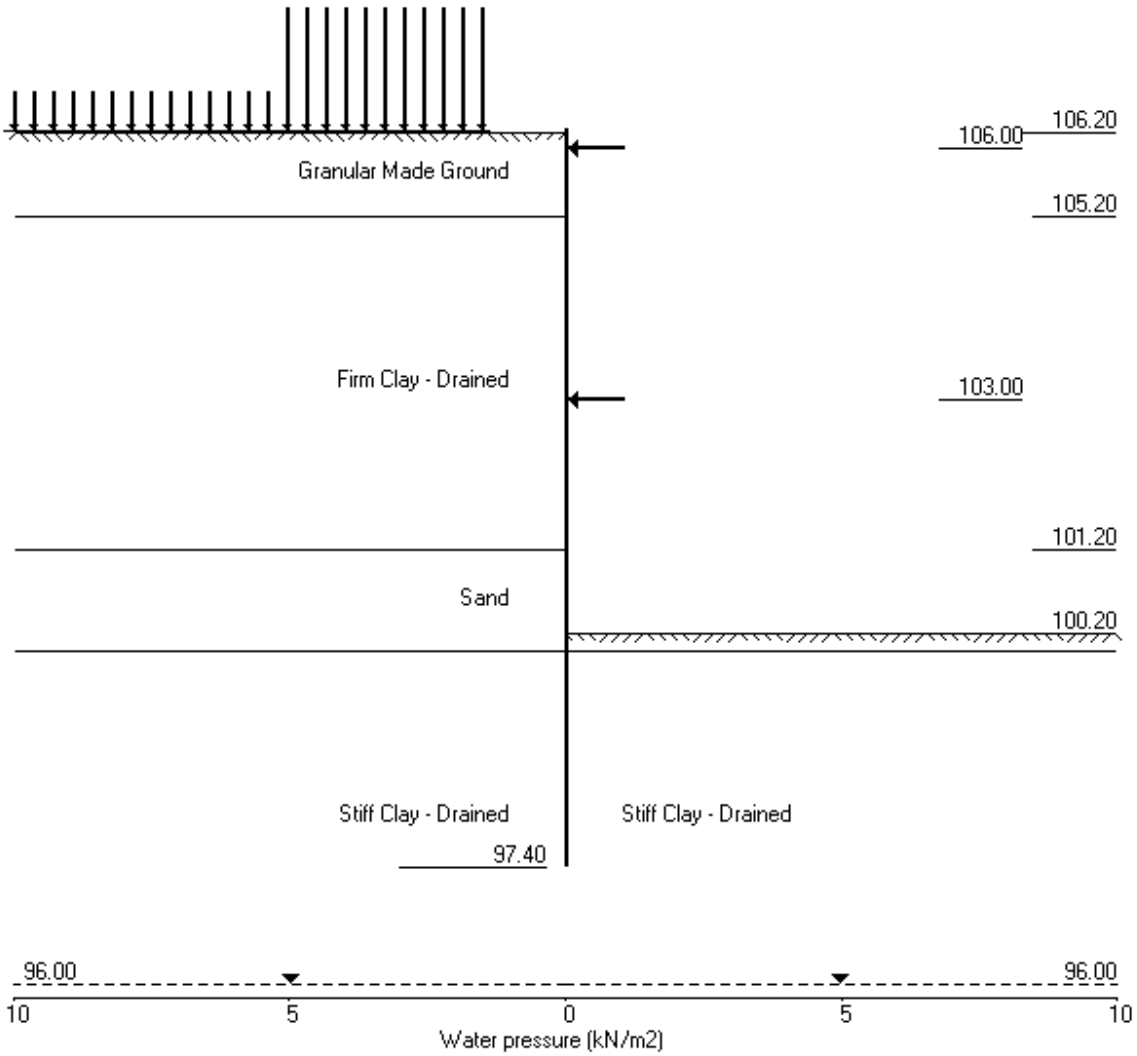
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 106.20	No	No	No
2	Excav. to elev. 104.20 on PASSIVE side	No	No	No
3	Fill to elev. 104.33 on PASSIVE side	No	No	No
4	Excav. to elev. 102.60 on PASSIVE side	No	No	No
5	Install strut no.3 at elev. 103.00	No	No	No
6	Apply surcharge no.2 at elev. 106.20	No	No	No
7	Excav. to elev. 100.20 on PASSIVE side	No	No	No
8	Install strut no.4 at elev. 106.00	No	No	No
9	Change soil type 4 to soil type 6	No	No	No
10	Change soil type 2 to soil type 5	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.10 Change soil type 2 to soil type 5



Units: kN,m

Summary of results

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

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 97.40 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	106.20	106.20	Cant.	Conditions not suitable for FoS calc.			
2	106.20	104.20	Cant.	2.123	98.14	100.56	3.64
3	106.20	104.33	Cant.	6.069	97.82	103.81	0.52
4	106.20	102.60	Cant.	2.852	97.93	101.12	1.48
5	106.20	102.60		No analysis at this stage			
6	106.20	102.60	103.00	Conditions not suitable for FoS calc.			
7	106.20	100.20	103.00	2.496	n/a	99.82	0.38
8	106.20	100.20		No analysis at this stage			

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

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m
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 15.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	106.20	0.013	0.000	0.0	-0.0	0.0	0.0
2	106.00	0.013	0.000	0.0	0.0	11.6	-0.0
3	105.60	0.012	0.000	4.9	0.0	12.9	0.0
4	105.20	0.011	0.000	10.6	0.0	16.0	0.0
5	104.77	0.009	0.000	20.5	0.0	28.5	-0.3
6	104.33	0.008	0.000	35.8	-0.2	41.4	-0.6
7	104.20	0.008	0.000	41.4	-0.2	45.4	-0.6
8	103.85	0.007	0.000	59.2	-0.5	55.8	-0.7
9	103.50	0.006	0.000	80.6	-0.7	65.3	-0.6
10	103.00	0.006	0.000	116.8	-0.9	78.1	-97.1
11	102.60	0.005	0.000	80.0	-1.1	32.6	-86.3
12	102.30	0.005	0.000	58.2	-1.2	21.0	-77.5
13	102.00	0.005	0.000	53.4	-1.3	10.4	-68.0
14	101.60	0.005	0.000	54.5	-1.3	0.0	-54.6
15	101.20	0.005	0.000	51.8	-9.3	0.2	-43.4
16	101.00	0.005	0.000	50.0	-16.7	0.3	-37.7
17	100.60	0.005	0.000	44.8	-28.4	3.7	-25.8
18	100.20	0.005	0.000	38.8	-34.8	16.9	-14.4
19	100.00	0.005	0.000	36.0	-36.3	22.1	-13.8
20	99.50	0.005	0.000	26.8	-34.0	16.1	-19.0
21	99.00	0.004	0.000	17.0	-23.9	25.2	-18.3
22	98.50	0.004	0.000	9.7	-12.1	22.7	-14.3
23	98.00	0.003	0.000	3.5	-2.7	11.7	-9.8
24	97.70	0.003	0.000	1.0	-0.5	4.8	-5.8
25	97.40	0.003	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.1	98.50	-1.3	101.60	1.1	100.00	-0.7	103.85
2	29.7	102.00	-0.0	106.20	13.9	103.50	-11.6	99.00
3	30.2	102.00	-0.0	106.20	14.0	103.50	-11.7	99.00
4	54.5	101.60	-0.0	106.20	32.6	102.60	-19.0	99.50
5	No calculation at this stage							
6	53.6	101.60	-0.0	106.20	35.9	103.00	-18.1	99.50
7	70.9	103.00	-0.0	106.20	57.0	103.00	-52.7	103.00
8	No calculation at this stage							
9	110.5	103.00	-33.6	100.00	74.2	103.00	-80.9	103.00
10	116.8	103.00	-36.3	100.00	78.1	103.00	-97.1	103.00

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	101.20	0.000	106.20	Apply surcharge no.1 at elev. 106.20
2	0.008	106.20	0.000	106.20	Excav. to elev. 104.20 on PASSIVE side
3	0.008	106.20	0.000	106.20	Fill to elev. 104.33 on PASSIVE side
4	0.013	106.20	0.000	106.20	Excav. to elev. 102.60 on PASSIVE side
5	No calculation at this stage				Install strut no.3 at elev. 103.00
6	0.013	106.20	0.000	106.20	Apply surcharge no.2 at elev. 106.20
7	0.012	106.20	0.000	106.20	Excav. to elev. 100.20 on PASSIVE side
8	No calculation at this stage				Install strut no.4 at elev. 106.00
9	0.012	106.20	0.000	106.20	Change soil type 4 to soil type 6
10	0.012	106.20	0.000	106.20	Change soil type 2 to soil type 5

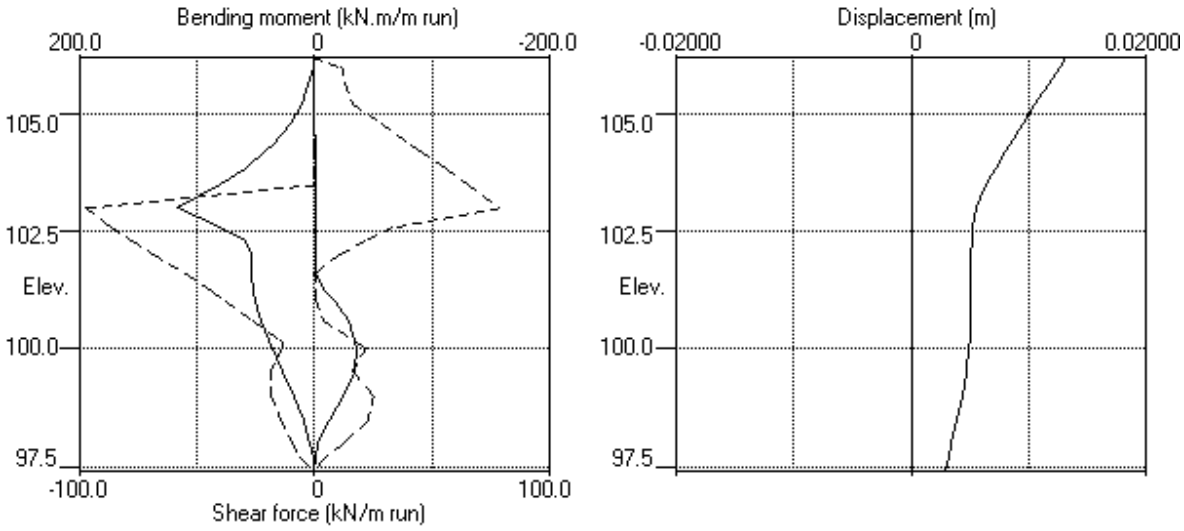
Summary of results (continued)

Strut forces at each stage (horizontal components)

Stage no.	Strut no. 3 at elev. 103.00		Strut no. 4 at elev. 106.00	
	kN/m run	kN/strut	kN/m run	kN/strut
6	21.75	21.75	---	---
7	109.70	109.70	---	---
9	155.05	155.05	-9.68	-9.68
10	175.26	175.26	-11.48	-11.48

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	105.50	1 Granular Made Ground	1 Granular Made Ground
2	104.00	2 Firm Clay	2 Firm Clay
3	102.00	3 Sand	3 Sand
4	100.00	4 Stiff Clay	4 Stiff Clay

SOIL PROPERTIES

Soil Properties File = SOIL PARAMS.dat

No.	Soil type Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	20.00a	30000	0.470	OC	0.262	5.284	
		21.00b			(0.300)	(0.000)	(0.000)	
4	Stiff Clay	19.00	75000	1.000	OC	1.000	1.000	75.00u
					(0.490)	(2.389)	(2.390)	
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	
6	Stiff Clay - Drained	19.00	60000	0.817	OC	0.353	3.413	1.000d
					(0.200)	(1.388)	(5.175)	
7	FIll	20.00	60000	0.500	OC	0.189	8.378	
					(0.300)	(0.000)	(0.000)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Stiff Clay	0.00	0.500	0.00	0.00	0.500	0.00
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
6	Stiff Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
7	FIll	40.00	0.434	0.00	40.00	0.434	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	96.00	96.00	0.0	1	96.00	96.00	0.0

WALL PROPERTIES

Type of structure = Soldier Pile Wall
Soldier Pile width = 0.60 m
Soldier Pile spacing = 2.50 m
Passive mobilisation factor = 3.00 m
Elevation of toe of wall = 96.00
Maximum finite element length = 0.50 m
Youngs modulus of wall E = 2.5200E+07 kN/m2
Moment of inertia of wall I = 2.2685E-03 m4/m run
E.I = 57166 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre-stress /strut kN	Tension allowed
1	Not defined							
2	103.00	1.00	0.017800	2.100E+08	7.50	0.00	0	No
3	104.70	1.00	0.017800	2.100E+08	7.50	0.00	0	No

HORIZONTAL and MOMENT LOADS/RESTRAINTS

Load no.	Elevation	Horizontal load kN/m run	Moment load kN.m/m run	Moment restraint kN.m/m/rad	Partial factor/ Category
1	105.00	-15.00	0	0	N/A

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	105.50	0.00(A)	30.00	15.00	10.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 105.50
2	Excavate to elevation 104.00 on PASSIVE side
3	Change EI of wall to 66300 kN.m2/m run From elevation 105.50 to 102.00 Yield moment not defined Reset wall displacements to zero at this stage
4	Install strut or anchor no.3 at elevation 104.70
5	Excavate to elevation 100.63 on PASSIVE side
6	Change properties of soil type 2 to soil type 5 No analysis at this stage Ko pressures will not be reset
7	Change properties of soil type 4 to soil type 6 Ko pressures will not be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

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

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 10.50 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 30.00 m

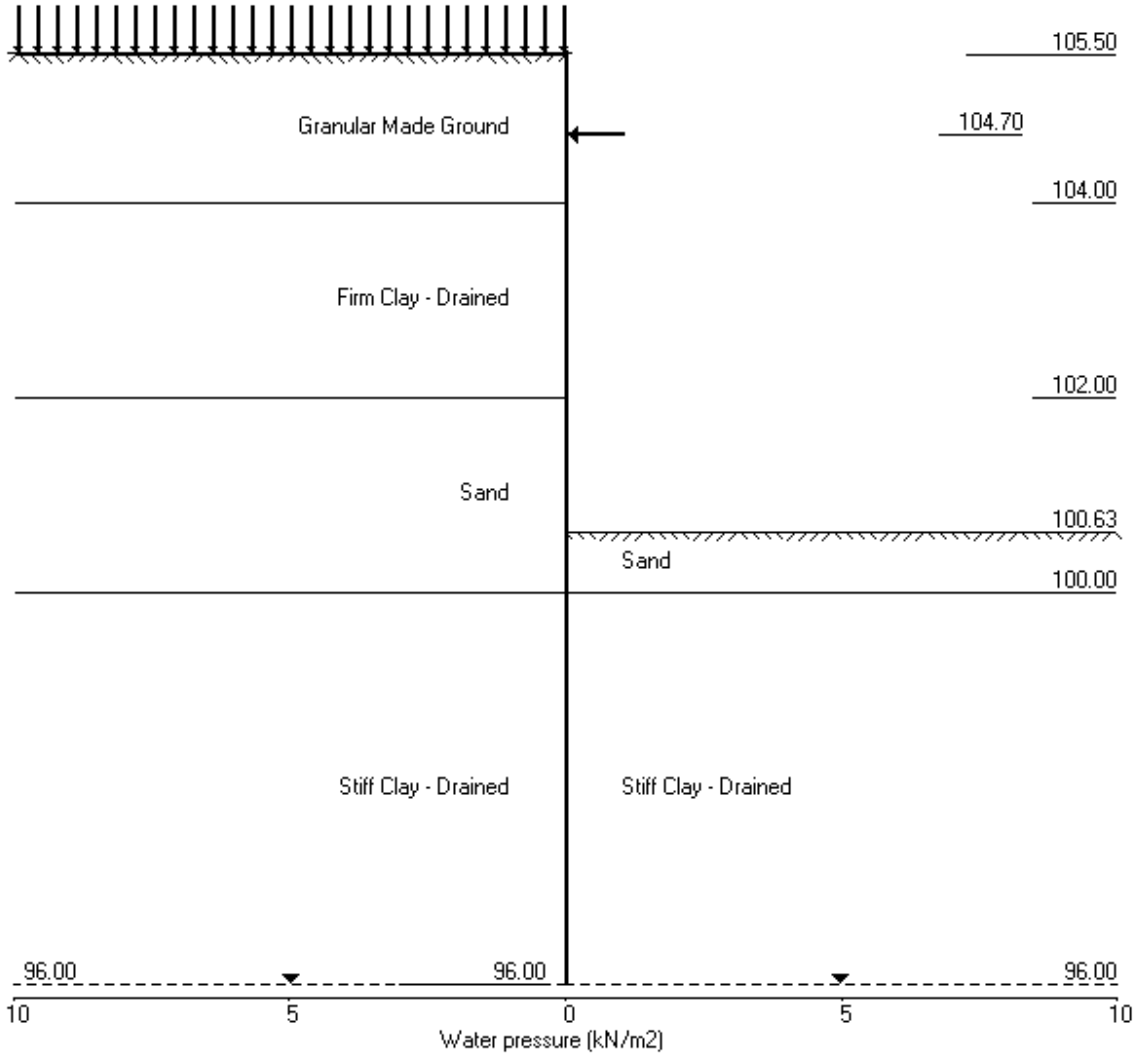
Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 105.50	No	No	No
2	Excav. to elev. 104.00 on PASSIVE side	No	No	No
3	Change EI of wall to 66300kN.m2/m run	No	No	No
4	Install strut no.3 at elev. 104.70	No	No	No
5	Excav. to elev. 100.63 on PASSIVE side	No	No	No
6	Change soil type 2 to soil type 5	No	No	No
7	Change soil type 4 to soil type 6	No	No	No
*	Summary output	Yes	-	Yes

Stage No.7 Change soil type 4 to soil type 6



Units: kN,m

Summary of results

STABILITY ANALYSIS of Soldier Pile Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 96.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	105.50	105.50	Cant.	Conditions not suitable for FoS calc.			
2	105.50	104.00	Cant.	5.523	96.83	103.25	0.75
3	105.50	104.00	Cant.	5.523	96.83	103.25	0.75
4	105.50	104.00		No analysis at this stage			
5	105.50	100.63	104.70	2.920	n/a	99.76	0.87
6	105.50	100.63		No analysis at this stage			
7	105.50	100.63	104.70	1.846	n/a	98.94	1.69

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Soldier Pile Wall

Analysis options

Soldier Pile width = 0.60m; spacing = 2.50m
Passive mobilisation factor = 3.000
Length of wall perpendicular to section = 30.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached

Rigid boundaries: Active side 20.00 from wall
Passive side 15.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	105.50	0.000	-0.002	0.0	0.0	0.0	0.0
2	105.10	0.000	-0.001	0.6	0.0	3.1	0.0
3	104.70	0.000	0.000	2.7	0.0	7.1	-42.6
4	104.35	0.001	0.000	5.1	-11.5	10.3	-38.7
5	104.00	0.002	0.000	9.6	-24.3	15.5	-34.3
6	103.50	0.003	0.000	14.7	-39.2	3.6	-26.9
7	103.00	0.004	0.000	14.0	-51.0	0.0	-18.0
8	102.50	0.004	0.000	10.9	-57.7	0.0	-7.6
9	102.00	0.004	0.000	7.4	-58.7	4.5	-6.6
10	101.50	0.004	0.000	4.3	-54.0	14.7	-5.3
11	101.06	0.004	0.000	2.4	-45.5	24.7	-3.7
12	100.63	0.004	0.000	1.1	-32.3	35.7	-2.0
13	100.31	0.004	0.000	0.6	-20.1	39.2	-0.7
14	100.00	0.003	0.000	8.2	-7.8	36.5	-0.1
15	99.50	0.003	0.000	19.1	0.0	28.3	-0.0
16	99.00	0.002	0.000	20.7	-0.0	17.8	-1.6
17	98.50	0.002	0.000	23.7	-0.0	4.4	-8.3
18	98.00	0.001	0.000	22.7	-0.0	0.0	-10.0
19	97.50	0.001	0.000	17.0	-0.0	0.0	-12.5
20	97.00	0.001	0.000	10.1	-0.0	0.0	-13.3
21	96.50	0.001	0.000	3.7	-0.0	0.0	-10.1
22	96.00	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	6.0	103.50	-0.0	98.50	5.7	104.00	-2.7	102.50
2	14.7	103.50	0.0	105.50	15.5	104.00	-6.6	102.50
3	14.7	103.50	0.0	105.50	15.5	104.00	-6.6	102.50
4	No calculation at this stage							
5	20.7	99.00	-39.4	102.00	37.6	100.31	-30.9	104.70
6	No calculation at this stage							
7	23.7	98.50	-58.7	102.00	39.2	100.31	-42.6	104.70

Summary of results (continued)

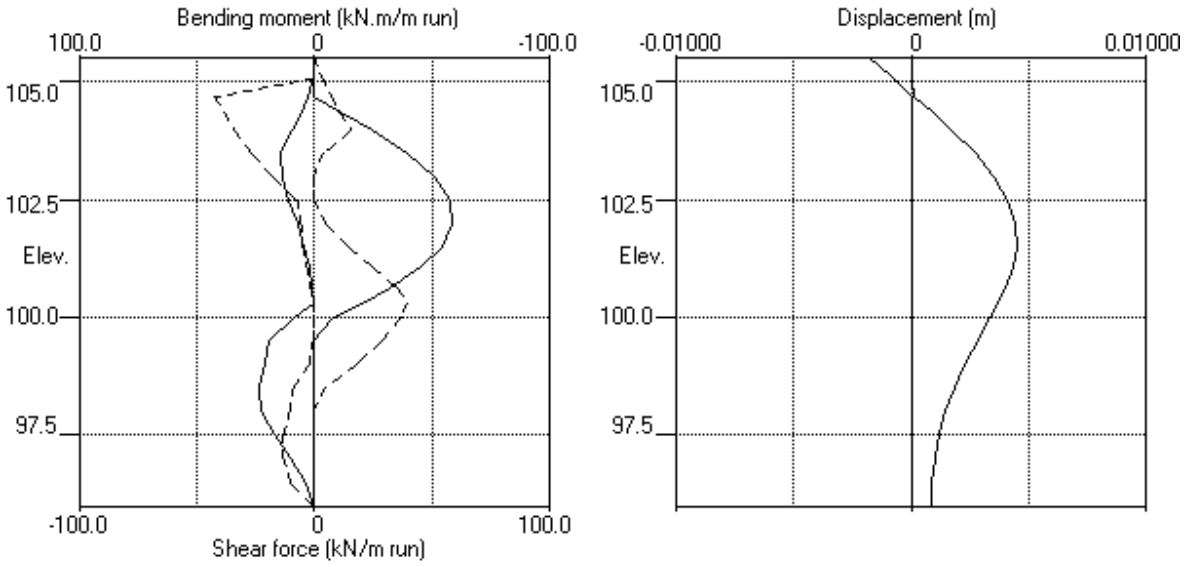
Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.001	105.50	0.000	105.50	Apply surcharge no.1 at elev. 105.50
2	0.002	105.50	0.000	105.50	Excav. to elev. 104.00 on PASSIVE side
3	0.000	105.50	0.000	105.50	Change EI of wall to 66300kN.m2/m run
4	No calculation at this stage				Install strut no.3 at elev. 104.70
5	0.003	102.00	-0.001	105.50	Excav. to elev. 100.63 on PASSIVE side
6	No calculation at this stage				Change soil type 2 to soil type 5
7	0.004	101.50	-0.002	105.50	Change soil type 4 to soil type 6

Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 3 --- at elev. 104.70 kN/m run	kN/strut
5	37.62	37.62
7	49.67	49.67

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	105.50	1 Granular Made Ground	1 Granular Made Ground
2	104.00	2 Firm Clay	2 Firm Clay
3	102.00	3 Sand	3 Sand
4	100.00	4 Stiff Clay	4 Stiff Clay

SOIL PROPERTIES (Unfactored SLS soil strengths)
Soil Properties File = SOIL PARAMS.dat

No.	Soil type Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	20.00a	30000	0.470	OC	0.262	5.284	
		21.00b			(0.300)	(0.000)	(0.000)	
4	Stiff Clay	19.00	75000	1.000	OC	1.000	1.000	75.00u
					(0.490)	(2.389)	(2.390)	
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	
6	Stiff Clay - Drained	19.00	60000	0.817	OC	0.353	3.413	1.000d
					(0.200)	(1.388)	(5.175)	
7	FIll	20.00	60000	0.500	OC	0.189	8.378	
					(0.300)	(0.000)	(0.000)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Stiff Clay	0.00	0.500	0.00	0.00	0.500	0.00
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
6	Stiff Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
7	FIll	40.00	0.434	0.00	40.00	0.434	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	96.00	96.00	0.0	1	96.00	96.00	0.0

WALL PROPERTIES

Type of structure = Soldier Pile Wall
Soldier Pile width = 0.60 m
Soldier Pile spacing = 2.50 m
Passive mobilisation factor = 3.00 m
Elevation of toe of wall = 96.00
Maximum finite element length = 0.50 m
Youngs modulus of wall E = 2.5200E+07 kN/m2
Moment of inertia of wall I = 2.2685E-03 m4/m run
E.I = 57166 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	Not defined							
2	103.00	1.00	0.017800	2.100E+08	7.50	0.00	0	No
3	104.70	1.00	0.017800	2.100E+08	7.50	0.00	0	No

HORIZONTAL and MOMENT LOADS/RESTRAINTS

Load no.	Elevation	Horizontal load kN/m run	Moment load kN.m/m run	Moment restraint kN.m/m/rad	Partial factor/ Category
1	105.00	-15.00	0	0	1.00 P/U

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	105.50	0.00(A)	30.00	15.00	10.00	=	N/A	1.00 -

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

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 105.50
2	Excavate to elevation 104.00 on PASSIVE side
3	Change EI of wall to 66300 kN.m2/m run From elevation 105.50 to 102.00 Yield moment not defined Reset wall displacements to zero at this stage
4	Install strut or anchor no.3 at elevation 104.70
5	Excavate to elevation 100.63 on PASSIVE side
6	Change properties of soil type 2 to soil type 5 No analysis at this stage Ko pressures will not be reset
7	Change properties of soil type 4 to soil type 6 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 = 2.000
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) = 10.50 m

Boundary conditions:
   Length of wall (normal to plane of analysis) = 30.00 m

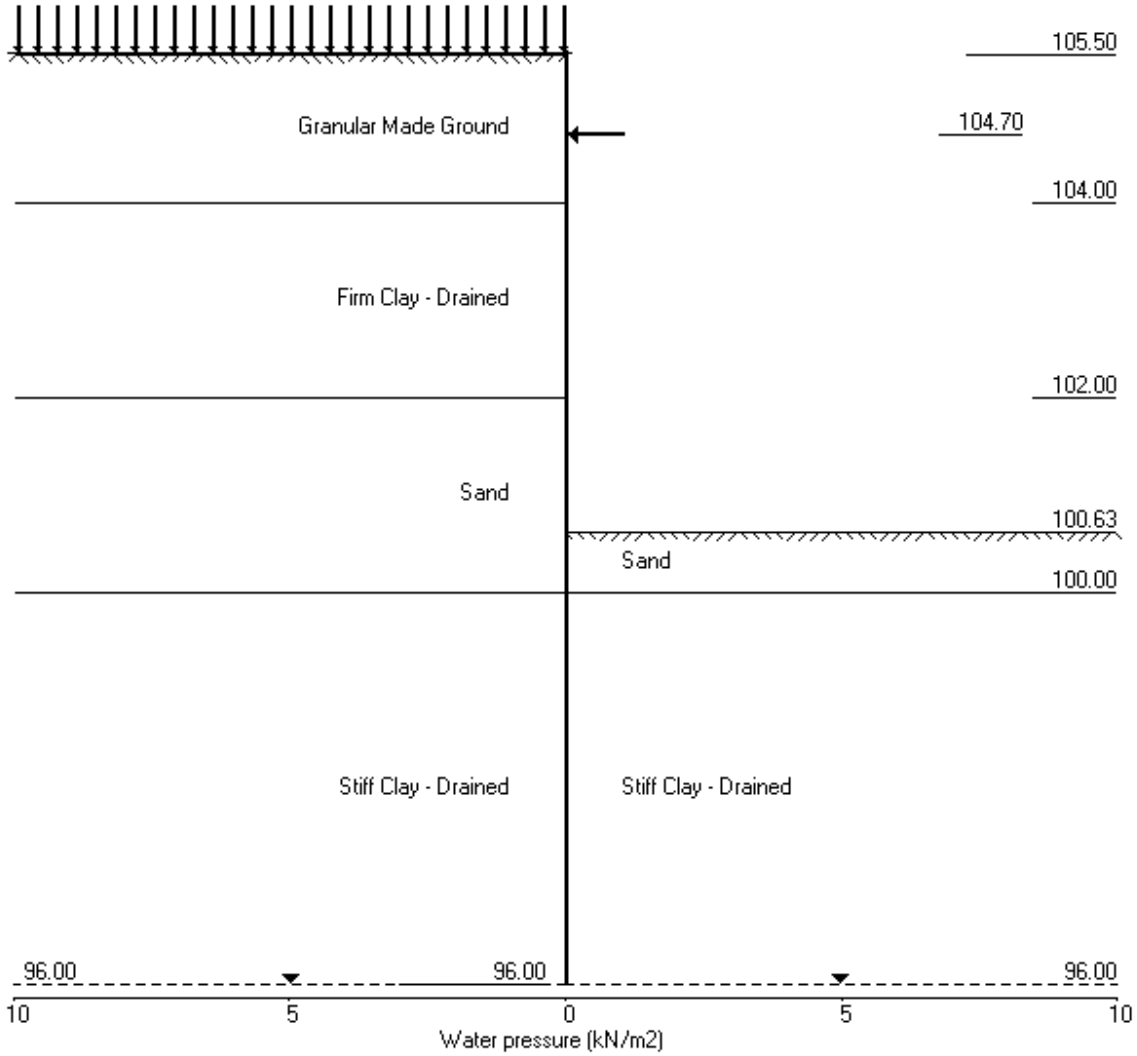
   Width of excavation on active side of wall = 15.00 m
   Width of excavation on passive side of wall = 15.00 m

   Distance to rigid boundary on active side = 20.00 m
   Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 105.50	No	No	No
2	Excav. to elev. 104.00 on PASSIVE side	No	No	No
3	Change EI of wall to 66300kN.m2/m run	No	No	No
4	Install strut no.3 at elev. 104.70	No	No	No
5	Excav. to elev. 100.63 on PASSIVE side	No	No	No
6	Change soil type 2 to soil type 5	No	No	No
7	Change soil type 4 to soil type 6	No	No	No
*	Summary output	Yes	-	Yes

Stage No.7 Change soil type 4 to soil type 6



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 = 2.000
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 Soldier Pile Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 96.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetration
1	105.50	105.50	Cant.	Conditions not suitable for FoS calc.			
2	105.50	104.00	Cant.	4.102	96.81	103.04	0.96
3	105.50	104.00	Cant.	4.102	96.81	103.04	0.96
4	105.50	104.00		No analysis at this stage			
5	105.50	100.63	104.70	2.106	n/a	99.48	1.14
6	105.50	100.63		No analysis at this stage			
7	105.50	100.63	104.70	1.477	n/a	98.09	2.54

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Soldier Pile Wall

Analysis options

Soldier Pile width = 0.60m; spacing = 2.50m
Passive mobilisation factor = 3.000
Length of wall perpendicular to section = 30.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached

Rigid boundaries: Active side 20.00 from wall
Passive side 15.00 from wall

Limit State: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	105.50	0.000	-0.003	0.0	0.0	0.0	0.0
2	105.10	0.000	-0.002	0.6	0.0	3.1	0.0
3	104.70	0.000	0.000	2.7	0.0	7.2	-59.6
4	104.35	0.002	0.000	5.3	-17.4	10.7	-55.4
5	104.00	0.003	0.000	10.0	-35.9	16.0	-50.7
6	103.50	0.005	0.000	15.7	-58.7	5.5	-41.9
7	103.00	0.007	0.000	16.3	-77.3	0.0	-31.1
8	102.50	0.008	0.000	14.3	-90.0	0.0	-18.4
9	102.00	0.009	0.000	11.1	-95.8	0.0	-6.5
10	101.50	0.010	0.000	8.0	-94.7	10.0	-5.6
11	101.06	0.010	0.000	5.8	-88.0	22.6	-4.3
12	100.63	0.010	0.000	4.2	-75.6	36.5	-2.8
13	100.31	0.009	0.000	3.6	-63.2	43.6	-1.5
14	100.00	0.009	0.000	3.3	-49.3	46.0	-0.6
15	99.50	0.008	0.000	10.6	-27.6	44.1	-1.0
16	99.00	0.007	0.000	17.8	-7.7	36.4	-1.3
17	98.50	0.006	0.000	18.5	0.0	24.3	-2.3
18	98.00	0.005	0.000	16.3	0.0	11.2	-7.9
19	97.50	0.004	0.000	18.6	0.0	0.0	-9.9
20	97.00	0.003	0.000	14.1	-0.0	0.0	-11.8
21	96.50	0.003	0.000	6.8	-0.0	0.0	-14.1
22	96.00	0.002	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	6.7	103.50	-0.0	97.00	6.1	104.00	-2.6	102.00
2	16.3	103.00	0.0	105.50	16.0	104.00	-6.5	102.00
3	16.3	103.00	0.0	105.50	16.0	104.00	-6.5	102.00
4	No calculation at this stage							
5	18.5	98.50	-54.6	102.00	46.0	100.00	-37.1	104.70
6	No calculation at this stage							
7	18.6	97.50	-95.8	102.00	44.1	99.50	-59.6	104.70

Summary of results (continued)

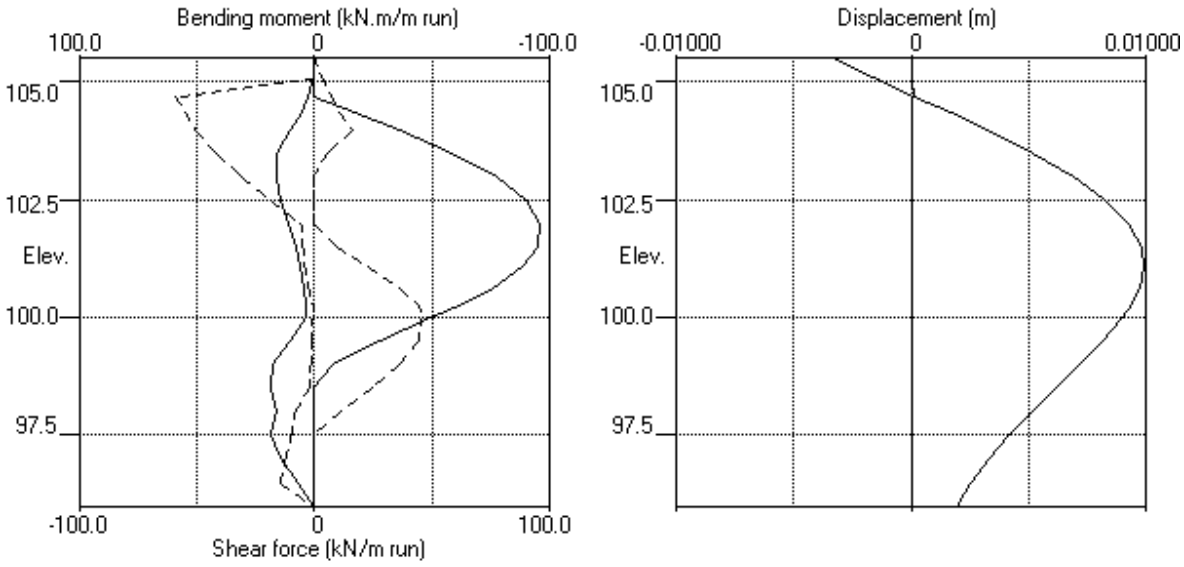
Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.001	105.50	0.000	105.50	Apply surcharge no.1 at elev. 105.50
2	0.004	105.50	0.000	105.50	Excav. to elev. 104.00 on PASSIVE side
3	0.000	105.50	0.000	105.50	Change EI of wall to 66300kN.m2/m run
4	No calculation at this stage				Install strut no.3 at elev. 104.70
5	0.005	101.50	-0.002	105.50	Excav. to elev. 100.63 on PASSIVE side
6	No calculation at this stage				Change soil type 2 to soil type 5
7	0.010	101.06	-0.003	105.50	Change soil type 4 to soil type 6

Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 3 --- at elev. 104.70 kN/m run	kN/strut
5	43.92	43.92
7	66.80	66.80

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	100.50	1 Granular Made Ground	1 Granular Made Ground
2	100.00	2 Firm Clay	2 Firm Clay
3	99.30	3 Sand	3 Sand
4	98.00	2 Firm Clay	2 Firm Clay
5	97.00	3 Sand	3 Sand

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	20.00a	30000	0.470	OC	0.262	5.284	
		21.00b			(0.300)	(0.000)	(0.000)	
4	Stiff Clay	19.00	75000	1.000	OC	1.000	1.000	75.00u
					(0.490)	(2.389)	(2.390)	
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	
6	Stiff Clay - Drained	19.00	60000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	

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

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Stiff Clay	0.00	0.500	0.00	0.00	0.500	0.00
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
6	Stiff Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	96.00	96.00	0.0	1	94.00	94.00	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 89.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 2.2000E+07 kN/m2
Moment of inertia of wall I = 0.010600 m4/m run
E.I = 233200 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin-ation (degs)	Pre-stress /strut kN	Tension allowed
1	100.50	1.00	0.100000	2.100E+07	7.50	0.00	0	No
2	99.50	1.00	0.100000	2.100E+07	7.50	0.00	0	No
3	94.60	1.00	0.100000	2.100E+07	7.50	0.00	0	No
4	98.50	1.00	0.017000	2.100E+08	7.50	0.00	0	No

HORIZONTAL and MOMENT LOADS/RESTRAINTS

Load no.	Elevation	Horizontal load kN/m run	Moment load kN.m/m run	Moment restraint kN.m/m/rad	Partial factor/ Category
1	100.50	150.0	0	0	N/A

SURCHARGE LOADS

Surch-arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge		Far edge	Equiv. soil type	Partial factor/ Category
1	Not defined								
2	Not defined								
3	100.50	3.00(A)	30.00	5.00	105.00	=		N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.3 at elevation 100.50
2	Apply load no.1 at elevation 100.50
3	Apply water pressure profile no.1
4	Excavate to elevation 100.00 on PASSIVE side
5	Install strut or anchor no.1 at elevation 100.50
6	Excavate to elevation 94.00 on PASSIVE side
7	Change properties of soil type 2 to soil type 5 Ko pressures will not be reset
8	Change EI of wall to 257800 kN.m2/m run From elevation 100.50 to 94.60 Yield moment not defined Allow wall to relax with new modulus value
9	Install strut or anchor no.3 at elevation 94.60

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

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

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 9.500 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 30.00 m

Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

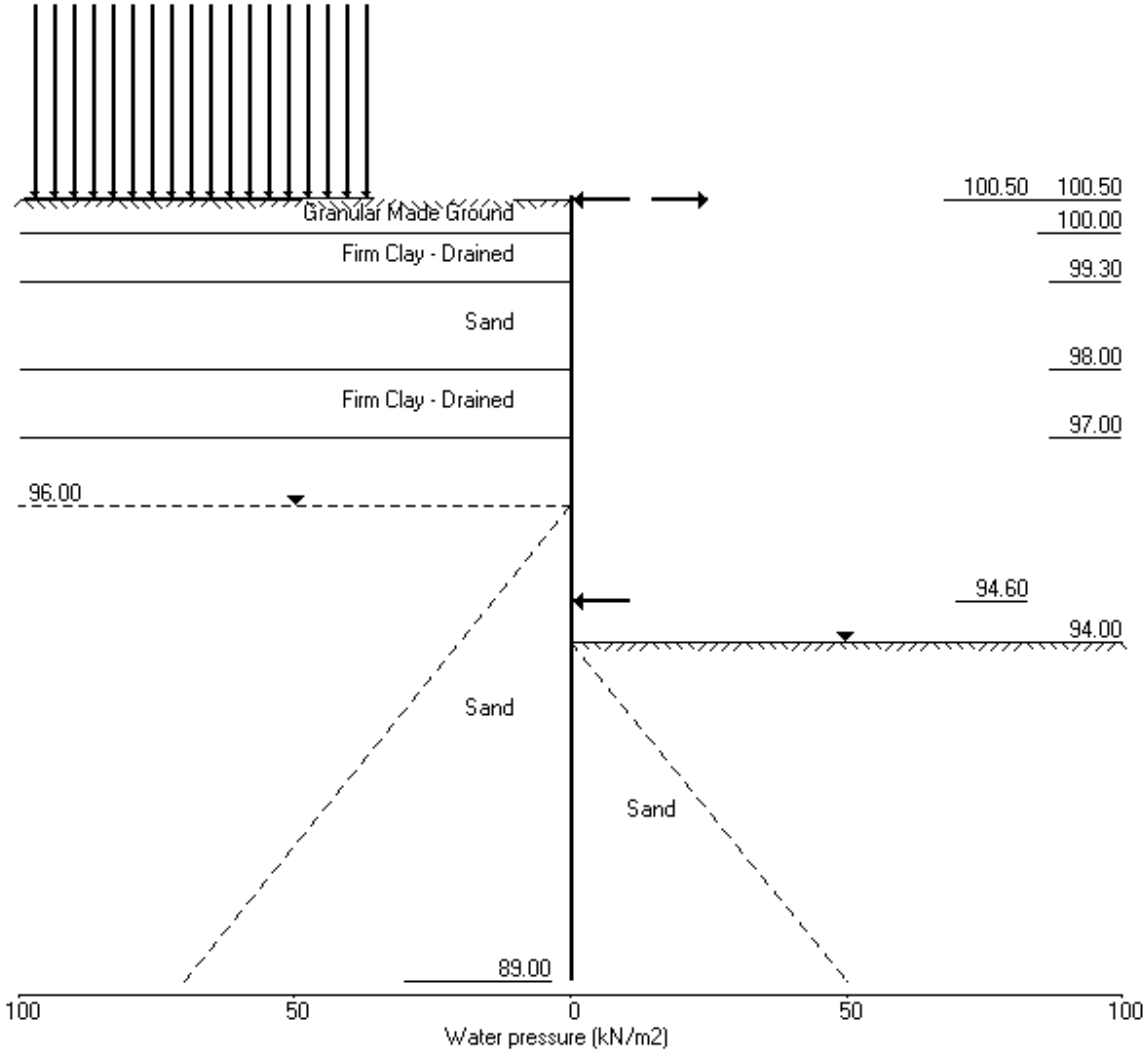
OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.3 at elev. 100.50	No	No	No
2	Apply load no.1 at elev. 100.50	No	No	No
3	Apply water pressure profile no.1	No	No	No
4	Excav. to elev. 100.00 on PASSIVE side	No	No	No
5	Install strut no.1 at elev. 100.50	No	No	No
6	Excav. to elev. 94.00 on PASSIVE side	No	No	No
7	Change soil type 2 to soil type 5	No	No	No
8	Change EI of wall to 257800kN.m2/m run	No	No	No
9	Install strut no.3 at elev. 94.60	No	No	No
*	Summary output	Yes	-	Yes

CARD GEOTECHNICS LIMITED | Sheet No.
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. CGL9008
Licensed from GEOSOLVE | Made by : ANK
Data filename/Run ID: CGL09008 SECTION 6-6 CPW02 - SLS |
79 Fitzjohn's Avenue | Date: 5-02-2016
Ground Movement Assessment CPW - Section 6-6 - SLS | Checked :

Units: kN,m

Stage No.9 Install strut no.3 at elev. 94.60



Units: kN,m

Summary of results

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

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 89.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	100.50	100.50	Cant.	Conditions not suitable for FoS calc.			
2	100.50	100.50	Cant.	4.904	90.52	96.81	3.69
3	100.50	100.50	Cant.	5.000	90.53	96.81	3.69
4	100.50	100.00	Cant.	4.072	90.45	96.61	3.39
5	100.50	100.00		No analysis at this stage			
6	100.50	94.00	100.50	1.359	n/a	91.08	2.92
7	100.50	94.00	100.50	1.351	n/a	91.05	2.95
8	100.50	94.00	100.50	1.351	n/a	91.05	2.95
9	100.50	94.00		More than one strut			

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m
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 15.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	100.50	0.008	-0.000	0.0	-0.0	150.0	-86.4
2	100.00	0.010	-0.000	75.4	-42.8	150.7	-85.7
3	99.65	0.011	0.000	120.2	-72.5	104.7	-84.2
4	99.30	0.013	0.000	148.7	-101.4	57.2	-81.7
5	98.98	0.014	0.000	164.2	-127.7	38.7	-79.3
6	98.65	0.015	0.000	173.9	-153.1	22.9	-76.2
7	98.33	0.016	0.000	179.0	-177.4	9.9	-72.3
8	98.00	0.017	0.000	180.4	-200.3	0.0	-67.6
9	97.50	0.018	0.000	170.9	-231.0	0.0	-55.9
10	97.00	0.019	0.000	146.7	-256.8	0.0	-52.3
11	96.50	0.020	0.000	120.1	-274.9	0.0	-53.0
12	96.00	0.020	0.000	93.9	-286.2	0.0	-51.2
13	95.40	0.020	0.000	64.5	-289.5	5.2	-46.3
14	95.00	0.020	0.000	46.9	-284.2	21.8	-41.5
15	94.60	0.019	0.000	31.5	-271.7	40.5	-35.8
16	94.00	0.018	0.000	14.2	-237.9	72.7	-26.2
17	93.50	0.017	0.000	5.4	-195.3	94.8	-18.3
18	93.00	0.016	0.000	0.0	-145.2	103.1	-11.5
19	92.40	0.014	0.000	0.0	-84.6	94.8	-5.0
20	91.80	0.012	0.000	0.0	-29.1	66.4	-1.2
21	91.20	0.011	0.000	0.0	-9.9	32.1	0.0
22	90.60	0.009	0.000	9.4	-7.1	7.4	0.0
23	90.00	0.007	0.000	8.0	-3.9	5.0	-6.7
24	89.50	0.005	0.000	3.6	-1.5	3.9	-8.8
25	89.00	0.004	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.1	99.65	-9.5	94.60	2.5	91.80	-3.8	97.00
2	165.9	98.33	-6.8	91.80	150.0	100.50	-49.7	97.00
3	170.4	98.33	-11.4	91.80	150.0	100.50	-50.4	97.00
4	180.4	98.00	-11.1	91.80	150.7	100.00	-53.0	96.50
5	No calculation at this stage							
6	8.3	90.60	-274.4	95.40	99.4	93.00	-78.1	100.50
7	9.4	90.60	-289.5	95.40	103.1	93.00	-86.4	100.50
8	9.4	90.60	-289.5	95.40	103.1	93.00	-86.4	100.50
9	9.4	90.60	-289.5	95.40	103.1	93.00	-86.4	100.50

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.001	89.00	-0.000	100.50	Apply surcharge no.3 at elev. 100.50
2	0.007	100.50	0.000	100.50	Apply load no.1 at elev. 100.50
3	0.007	100.50	0.000	100.50	Apply water pressure profile no.1
4	0.007	100.50	0.000	100.50	Excav. to elev. 100.00 on PASSIVE side
5	No calculation at this stage				Install strut no.1 at elev. 100.50
6	0.019	95.40	0.000	100.50	Excav. to elev. 94.00 on PASSIVE side
7	0.020	95.40	0.000	100.50	Change soil type 2 to soil type 5
8	0.020	95.40	0.000	100.50	Change EI of wall to 257800kN.m2/m run
9	0.020	95.40	0.000	100.50	Install strut no.3 at elev. 94.60

Summary of results (continued)

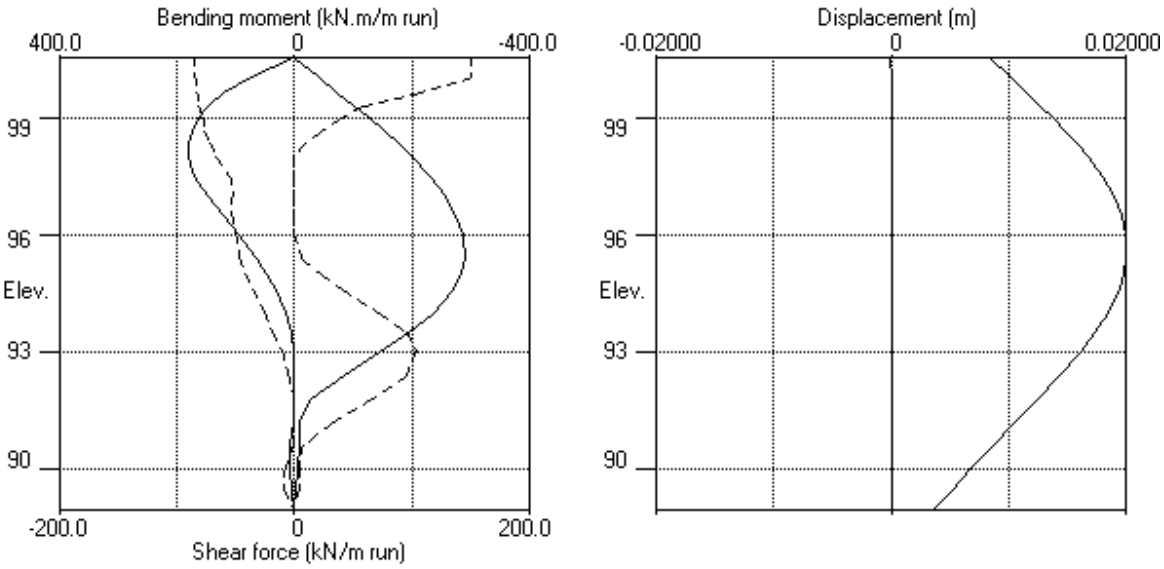
Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 100.50		Strut no. 3 at elev. 94.60	
	kN/m run	kN/strut	kN/m run	kN/strut
6	78.13	78.13*	---	---
7	86.39	86.39*	---	---
8	86.39	86.39*	---	---
9	86.39	86.39*	0.00	0.00

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

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	100.50	1 Granular Made Ground	1 Granular Made Ground
2	100.00	2 Firm Clay	2 Firm Clay
3	99.30	3 Sand	3 Sand
4	98.00	2 Firm Clay	2 Firm Clay
5	97.00	3 Sand	3 Sand

SOIL PROPERTIES (Unfactored SLS soil strengths)

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	20.00a	30000	0.470	OC	0.262	5.284	
		21.00b			(0.300)	(0.000)	(0.000)	
4	Stiff Clay	19.00	75000	1.000	OC	1.000	1.000	75.00u
					(0.490)	(2.389)	(2.390)	
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	
6	Stiff Clay - Drained	19.00	60000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	

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

Additional soil parameters associated with Ka and Kp

------- Soil type ------- No.	Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Stiff Clay	0.00	0.500	0.00	0.00	0.500	0.00
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00
6	Stiff Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	
1	1	96.00	96.00	0.0	1	94.00	94.00	0.0	MC+WC

WALL PROPERTIES

```
                        Type of structure = Fully Embedded Wall
                 Elevation of toe of wall = 89.00
            Maximum finite element length =  0.60 m
                 Youngs modulus of wall E = 2.2000E+07 kN/m2
              Moment of inertia of wall I = 0.010600 m4/m run
                                      E.I = 233200 kN.m2/m run
                   Yield Moment of wall = Not defined
```

STRUTS and ANCHORS

Strut/anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclination (degs)	Pre-stress /strut kN	Tension allowed
1	100.50	1.00	0.100000	2.100E+07	7.50	0.00	0	No
2	99.50	1.00	0.100000	2.100E+07	7.50	0.00	0	No
3	94.60	1.00	0.100000	2.100E+07	7.50	0.00	0	No
4	98.50	1.00	0.017000	2.100E+08	7.50	0.00	0	No

HORIZONTAL and MOMENT LOADS/RESTRAINTS

Load no.	Elevation	Horizontal load kN/m run	Moment load kN.m/m run	Moment restraint kN.m/m/rad	Partial factor/ Category
1	100.50	150.0	0	0	1.00 P/U

SURCHARGE LOADS

Surcharge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Surcharge kN/m2 Far edge	Equiv. soil type	Partial factor/ Category
1	Not defined							
2	Not defined							
3	100.50	3.00(A)	30.00	5.00	105.00	=	N/A	1.00 -

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

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.3 at elevation 100.50
2	Apply load no.1 at elevation 100.50
3	Apply water pressure profile no.1 (Worst Cred.)
4	Excavate to elevation 100.00 on PASSIVE side
5	Install strut or anchor no.1 at elevation 100.50
6	Excavate to elevation 94.00 on PASSIVE side
7	Change properties of soil type 2 to soil type 5 Ko pressures will not be reset
8	Change EI of wall to 257800 kN.m2/m run From elevation 100.50 to 94.60 Yield moment not defined Allow wall to relax with new modulus value
9	Install strut or anchor no.3 at elevation 94.60

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 = 2.000
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) = 9.500 m

Boundary conditions:
   Length of wall (normal to plane of analysis) = 30.00 m

   Width of excavation on active side of wall = 15.00 m
   Width of excavation on passive side of wall = 15.00 m

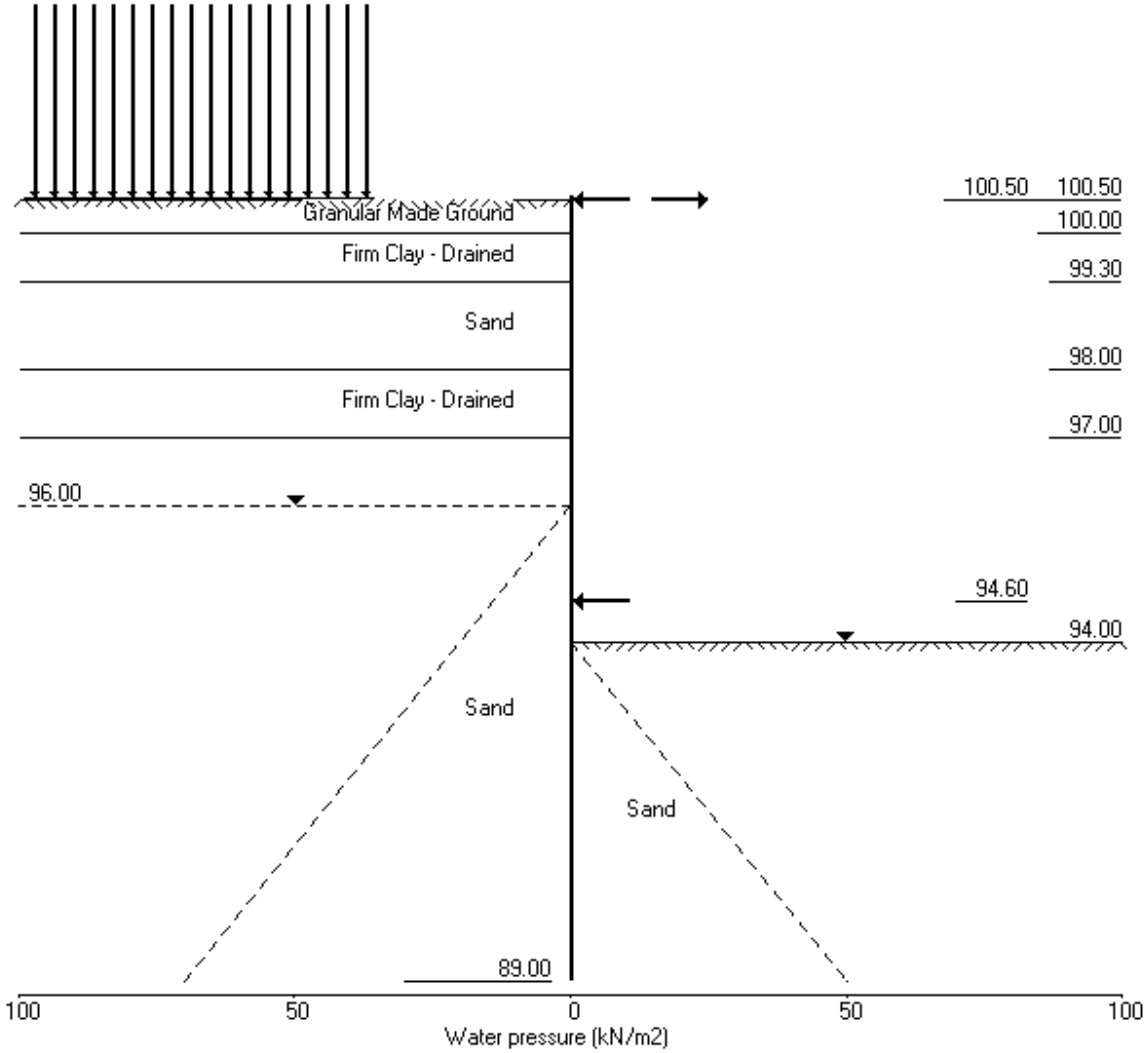
   Distance to rigid boundary on active side = 20.00 m
   Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.3 at elev. 100.50	No	No	No
2	Apply load no.1 at elev. 100.50	No	No	No
3	Apply water pressure profile no.1	No	No	No
4	Excav. to elev. 100.00 on PASSIVE side	No	No	No
5	Install strut no.1 at elev. 100.50	No	No	No
6	Excav. to elev. 94.00 on PASSIVE side	No	No	No
7	Change soil type 2 to soil type 5	No	No	No
8	Change EI of wall to 257800kN.m2/m run	No	No	No
9	Install strut no.3 at elev. 94.60	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.9 Install strut no.3 at elev. 94.60



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 = 2.000
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

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 89.00: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000: Toe elev.	Wall Penetration
1	100.50	100.50	Cant.	Conditions not suitable for FoS calc.			
2	100.50	100.50	Cant.	3.816	90.54	96.32	4.18
3	100.50	100.50	Cant.	3.895	90.55	96.32	4.18
4	100.50	100.00	Cant.	3.169	90.47	95.74	4.26
5	100.50	100.00		No analysis at this stage			
6	100.50	94.00	100.50	1.087	n/a	89.65	4.35
7	100.50	94.00	100.50	1.081	n/a	89.60	4.40
8	100.50	94.00	100.50	1.081	n/a	89.60	4.40
9	100.50	94.00		More than one strut			

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m
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 15.00 from wall

Limit State: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	100.50	0.015	-0.000	0.0	-0.0	150.0	-128.7
2	100.00	0.019	0.000	75.4	-64.0	150.8	-127.9
3	99.65	0.021	0.000	122.6	-108.4	118.0	-126.0
4	99.30	0.024	0.000	158.0	-151.9	83.7	-123.1
5	98.98	0.027	0.000	182.9	-191.4	69.2	-120.0
6	98.65	0.029	0.000	202.8	-230.0	54.2	-116.1
7	98.33	0.031	0.000	218.2	-267.0	41.4	-111.2
8	98.00	0.033	0.000	229.8	-302.3	30.8	-105.2
9	97.50	0.036	0.000	234.3	-350.4	0.0	-91.0
10	97.00	0.039	0.000	215.9	-393.0	0.0	-78.7
11	96.50	0.041	0.000	189.7	-426.0	0.0	-63.2
12	96.00	0.042	0.000	161.1	-451.0	0.0	-57.5
13	95.40	0.044	0.000	126.7	-468.1	0.0	-56.2
14	95.00	0.044	0.000	104.8	-470.1	5.1	-53.1
15	94.60	0.045	0.000	84.4	-463.7	27.6	-48.6
16	94.00	0.044	0.000	57.8	-435.9	65.6	-40.0
17	93.50	0.044	0.000	40.1	-395.4	95.0	-32.1
18	93.00	0.042	0.000	27.8	-342.4	115.0	-24.7
19	92.40	0.041	0.000	16.5	-269.0	126.8	-16.8
20	91.80	0.038	0.000	8.7	-192.7	125.0	-10.6
21	91.20	0.036	0.000	3.8	-121.5	109.4	-6.3
22	90.60	0.033	0.000	1.1	-57.7	79.8	-3.1
23	90.00	0.030	0.000	0.1	-20.7	45.4	-0.9
24	89.50	0.028	0.000	0.0	-4.7	20.7	-0.0
25	89.00	0.025	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.0	100.00	-13.7	94.60	3.6	91.80	-4.8	97.00
2	211.8	97.50	-0.1	89.50	150.0	100.50	-51.4	96.50
3	219.7	97.50	-1.2	90.60	150.0	100.50	-55.1	96.00
4	234.3	97.50	-0.7	90.00	150.8	100.00	-57.5	96.00
5	No calculation at this stage							
6	0.0	100.50	-445.5	95.00	122.0	92.40	-115.3	100.50
7	0.0	100.50	-470.1	95.00	126.8	92.40	-128.7	100.50
8	0.0	100.50	-470.1	95.00	126.8	92.40	-128.7	100.50
9	0.0	100.50	-470.1	95.00	126.8	92.40	-128.7	100.50

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.003	89.00	-0.000	100.50	Apply surcharge no.3 at elev. 100.50
2	0.012	100.50	0.000	100.50	Apply load no.1 at elev. 100.50
3	0.012	100.50	0.000	100.50	Apply water pressure profile no.1
4	0.014	100.50	0.000	100.50	Excav. to elev. 100.00 on PASSIVE side
5	No calculation at this stage				Install strut no.1 at elev. 100.50
6	0.043	94.60	0.000	100.50	Excav. to elev. 94.00 on PASSIVE side
7	0.045	94.60	0.000	100.50	Change soil type 2 to soil type 5
8	0.045	94.60	0.000	100.50	Change EI of wall to 257800kN.m2/m run
9	0.045	94.60	0.000	100.50	Install strut no.3 at elev. 94.60

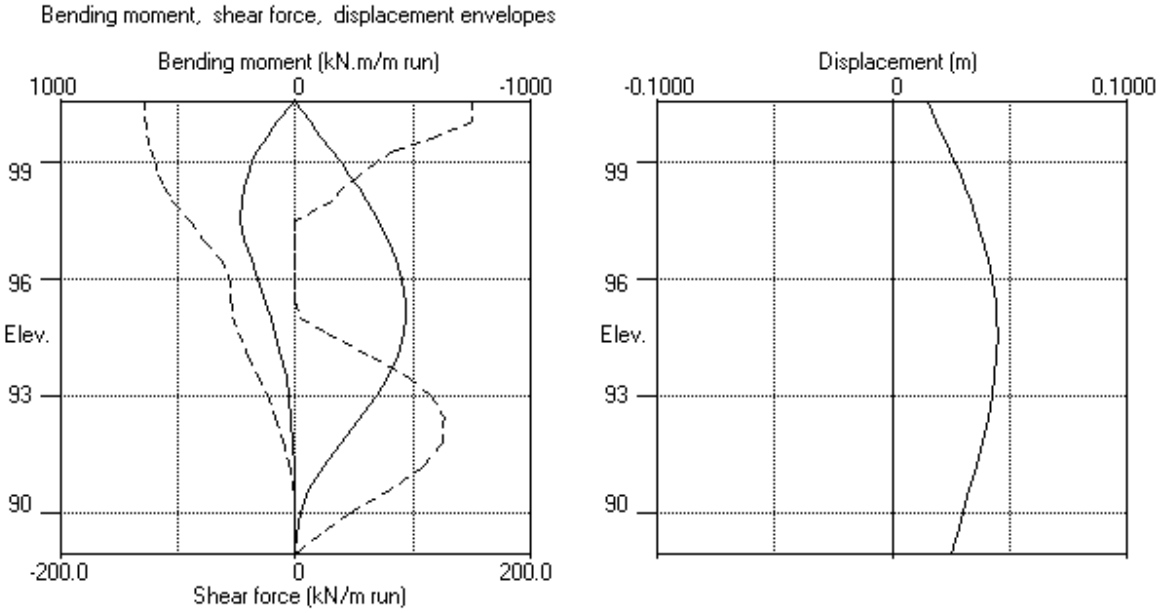
Summary of results (continued)

Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 100.50		Strut no. 3 at elev. 94.60	
	kN/m run	kN/strut	kN/m run	kN/strut
6	115.34	115.34*	---	---
7	128.75	128.75*	---	---
8	128.75	128.75*	---	---
9	128.75	128.75*	0.00	0.00

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

Units: kN,m


Bending moment, shear force, displacement envelopes
Bending moment (kN.m/m run)
1000
0
-1000
99
96
Elev.
93
90
-200.0
0
200.0
Shear force (kN/m run)
Displacement (m)
-0.1000
0
0.1000
99
96
Elev.
93
90

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	104.00	1 Granular Made Ground	1 Granular Made Ground
2	103.00	3 Sand	3 Sand
3	100.50	2 Firm Clay	2 Firm Clay
4	97.00	3 Sand	3 Sand

SOIL PROPERTIES

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	19.00a	20000	0.470	OC	0.262	5.284	
	(101.00)	21.00b	(3000)		(0.300)	(0.000)	(0.000)	
4	Not defined							
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Not defined						
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	96.00	96.00	0.0	1	96.00	96.00	0.0

WALL PROPERTIES

Type of structure = Soldier Pile Wall
Soldier Pile width = 0.60 m
Soldier Pile spacing = 2.50 m
Passive mobilisation factor = 3.00 m
Elevation of toe of wall = 98.00
Maximum finite element length = 0.30 m
Youngs modulus of wall E = 2.7000E+07 kN/m2
Moment of inertia of wall I = 2.5400E-03 m4/m run
E.I = 68580 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	103.00	1.00	0.017000	2.100E+08	3.00	0.00	0	Yes

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	104.00	0.00(A)	40.00	15.00	10.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 104.00
2	Change EI of wall to 48000 kN.m2/m run From elevation 104.00 to 100.00 Yield moment not defined Reset wall displacements to zero at this stage
3	Excavate to elevation 102.50 on PASSIVE side
4	Install strut or anchor no.1 at elevation 103.00
5	Excavate to elevation 99.60 on PASSIVE side
6	Fill to elevation 102.00 on PASSIVE side with soil type 3
7	Remove strut or anchor no.1 at elevation 103.00
8	Change properties of soil type 2 to soil type 5 Ko pressures will not be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

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

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 12.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 40.00 m

Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

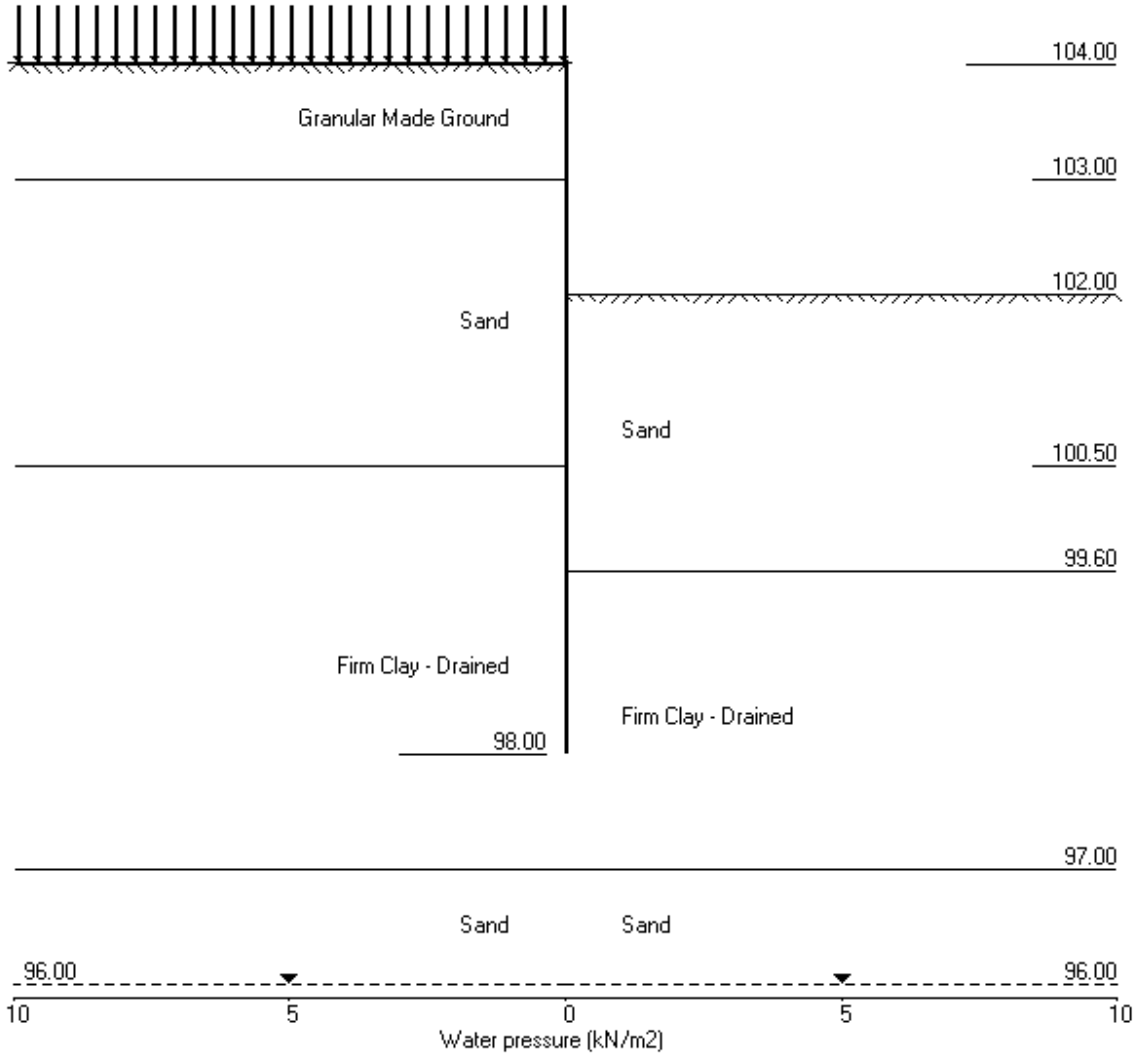
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 104.00	No	No	No
2	Change EI of wall to 48000kN.m2/m run	No	No	No
3	Excav. to elev. 102.50 on PASSIVE side	No	No	No
4	Install strut no.1 at elev. 103.00	No	No	No
5	Excav. to elev. 99.60 on PASSIVE side	No	No	No
6	Fill to elev. 102.00 on PASSIVE side	No	No	No
7	Remove strut no.1 at elev. 103.00	No	No	No
8	Change soil type 2 to soil type 5	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.8 Change soil type 2 to soil type 5



Units: kN,m

Summary of results

STABILITY ANALYSIS of Soldier Pile Wall according to Strength Factor method
Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 98.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	104.00	104.00	Cant.	Conditions not suitable for FoS calc.			
2	104.00	104.00		No analysis at this stage			
3	104.00	102.50	Cant.	2.383	98.76	101.07	1.43
4	104.00	102.50		No analysis at this stage			
5	104.00	99.60	103.00	2.141	n/a	99.26	0.34
6	104.00	102.00	103.00	4.404	n/a	101.61	0.39
7	104.00	102.00	Cant.	1.711	98.78	99.97	2.03
8	104.00	102.00	Cant.	1.641	98.51	100.07	1.93

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Soldier Pile Wall

Analysis options

Soldier Pile width = 0.60m; spacing = 2.50m
Passive mobilisation factor = 3.000
Length of wall perpendicular to section = 40.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached

Rigid boundaries: Active side 20.00 from wall
Passive side 15.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	104.00	0.013	0.000	0.0	0.0	0.0	0.0
2	103.75	0.012	0.000	0.2	0.0	1.6	0.0
3	103.50	0.011	0.000	0.8	0.0	3.5	0.0
4	103.25	0.011	0.000	2.0	0.0	5.7	0.0
5	103.00	0.010	0.000	3.8	0.0	8.0	-25.5
6	102.75	0.009	0.000	5.2	-2.4	9.0	-23.5
7	102.50	0.009	0.000	7.7	-8.0	11.3	-21.2
8	102.25	0.008	0.000	10.8	-12.8	12.5	-18.6
9	102.00	0.007	0.000	13.3	-17.1	15.4	-15.7
10	101.70	0.007	0.000	17.5	-21.3	15.5	-11.8
11	101.40	0.006	0.000	22.1	-24.1	10.8	-7.4
12	101.10	0.005	0.000	24.4	-25.6	5.8	-2.6
13	100.80	0.005	0.000	25.5	-25.7	2.7	-0.4
14	100.50	0.004	0.000	25.8	-24.1	8.3	-1.0
15	100.25	0.003	0.000	25.8	-21.5	12.8	-4.8
16	100.00	0.003	0.000	26.4	-17.3	18.8	-7.9
17	99.80	0.003	0.000	26.5	-13.3	24.7	-9.4
18	99.60	0.003	0.000	27.3	-8.1	32.0	-10.3
19	99.30	0.002	0.000	25.9	-1.6	15.8	-12.3
20	99.00	0.002	0.000	20.1	0.0	5.5	-23.1
21	98.70	0.002	0.000	12.3	0.0	0.0	-25.6
22	98.40	0.002	0.000	4.8	0.0	0.0	-20.1
23	98.20	0.001	0.000	1.4	0.0	0.0	-12.0
24	98.00	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	4.7	101.40	-0.0	98.00	3.8	103.00	-2.5	99.30
2	No calculation at this stage							
3	18.1	100.80	0.0	104.00	11.3	102.25	-10.4	99.30
4	No calculation at this stage							
5	3.8	103.00	-25.7	100.80	29.6	99.60	-25.5	103.00
6	3.7	103.00	-24.7	100.80	32.0	99.60	-25.3	103.00
7	27.3	99.60	-0.0	98.00	15.5	101.70	-25.5	98.70
8	26.8	99.60	-0.0	98.00	15.5	101.70	-25.6	98.70

Summary of results (continued)

Maximum and minimum displacement at each stage

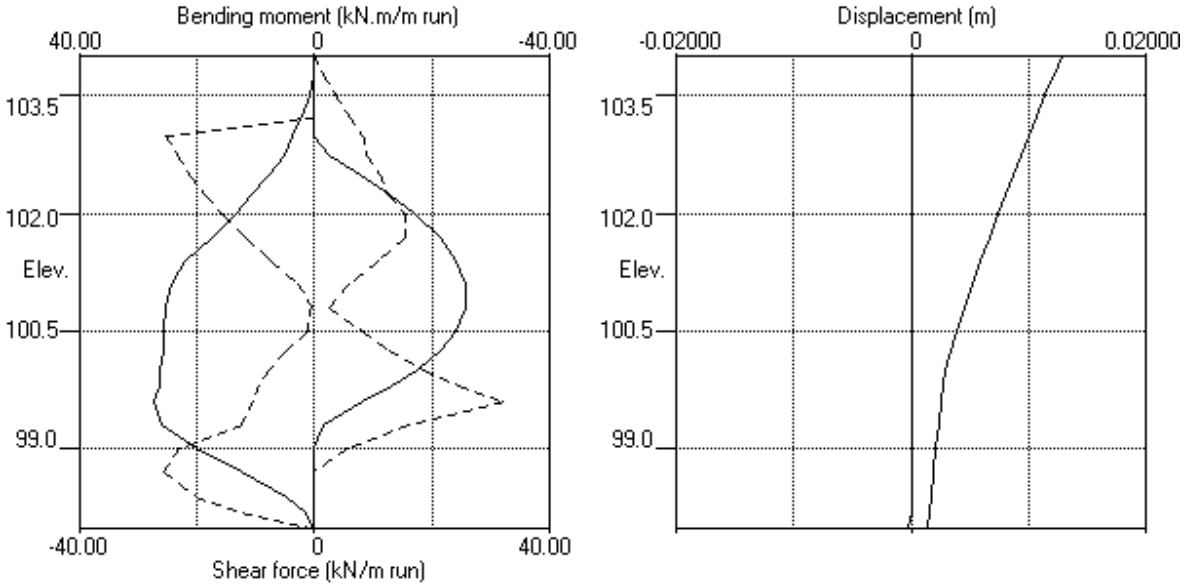
Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.001	104.00	0.000	104.00	Apply surcharge no.1 at elev. 104.00
2	Wall displacements reset to zero				Change EI of wall to 48000kN.m2/m run
3	0.003	104.00	0.000	104.00	Excav. to elev. 102.50 on PASSIVE side
4	No calculation at this stage				Install strut no.1 at elev. 103.00
5	0.003	101.10	0.000	104.00	Excav. to elev. 99.60 on PASSIVE side
6	0.003	101.70	0.000	104.00	Fill to elev. 102.00 on PASSIVE side
7	0.012	104.00	-0.000	98.00	Remove strut no.1 at elev. 103.00
8	0.013	104.00	-0.000	98.00	Change soil type 2 to soil type 5

Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 1 --- at elev. 103.00 kN/m run	kN/strut
5	33.55	33.55
6	33.20	33.20

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	104.00	1 Granular Made Ground	1 Granular Made Ground
2	103.00	3 Sand	3 Sand
3	100.50	2 Firm Clay	2 Firm Clay
4	97.00	3 Sand	3 Sand

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	19.00a	20000	0.470	OC	0.262	5.284	
	(101.00)	21.00b	(3000)		(0.300)	(0.000)	(0.000)	
4	Not defined							
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Not defined						
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	96.00	96.00	0.0	1	96.00	96.00	0.0

WALL PROPERTIES

Type of structure = Soldier Pile Wall
Soldier Pile width = 0.60 m
Soldier Pile spacing = 2.50 m
Passive mobilisation factor = 3.00 m
Elevation of toe of wall = 98.00
Maximum finite element length = 0.30 m
Youngs modulus of wall E = 2.7000E+07 kN/m2
Moment of inertia of wall I = 2.5400E-03 m4/m run
E.I = 68580 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	103.00	1.00	0.017000	2.100E+08	3.00	0.00	0	Yes

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge kN/m2 Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	104.00	0.00(A)	40.00	15.00	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 104.00
2	Change EI of wall to 48000 kN.m2/m run From elevation 104.00 to 100.00 Yield moment not defined Reset wall displacements to zero at this stage
3	Excavate to elevation 102.50 on PASSIVE side
4	Install strut or anchor no.1 at elevation 103.00
5	Excavate to elevation 99.60 on PASSIVE side
6	Fill to elevation 102.00 on PASSIVE side with soil type 3
7	Remove strut or anchor no.1 at elevation 103.00
8	Change properties of soil type 2 to soil type 5 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 = 2.000
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) = 12.00 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 40.00 m

Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

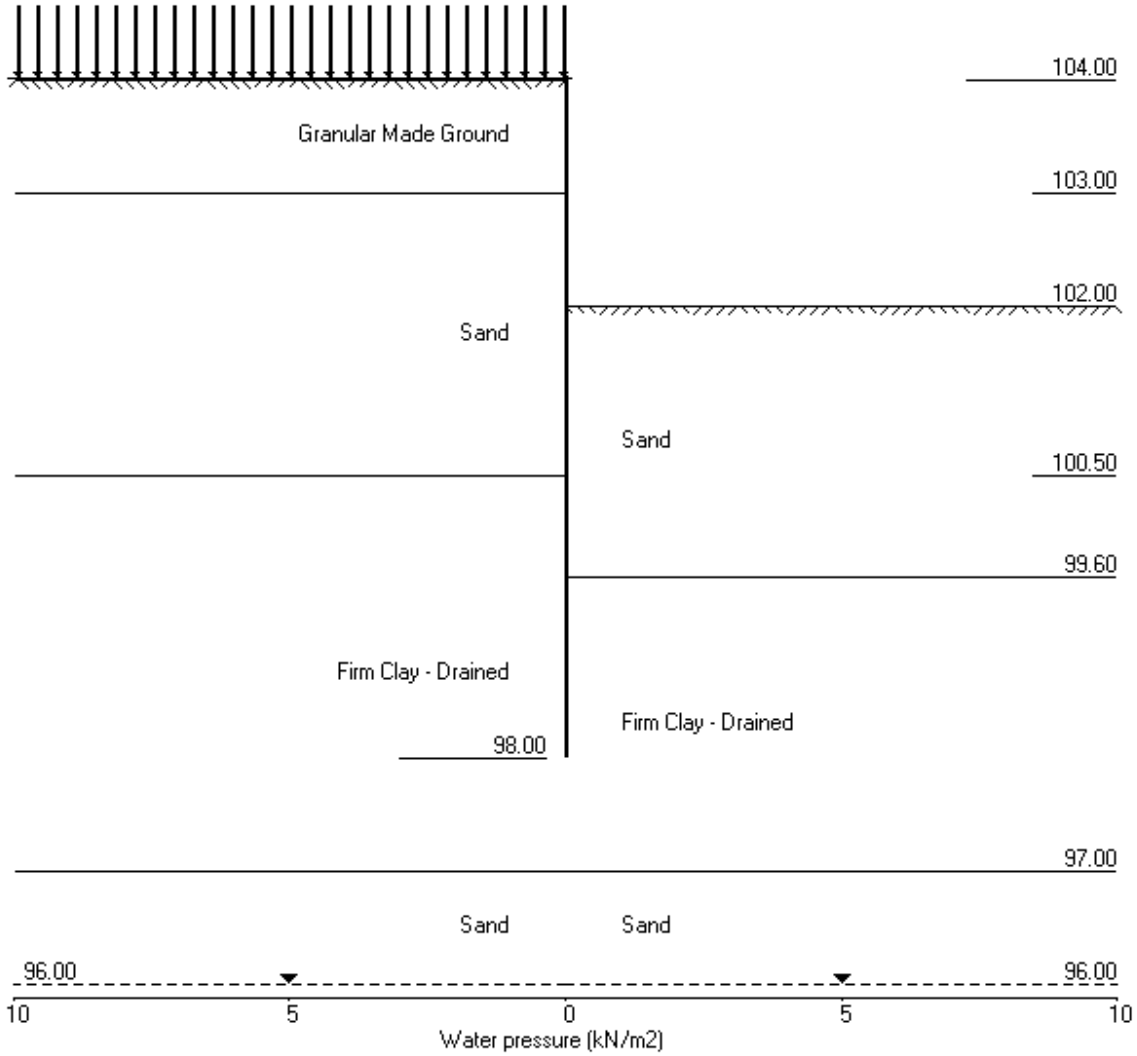
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 104.00	No	No	No
2	Change EI of wall to 48000kN.m2/m run	No	No	No
3	Excav. to elev. 102.50 on PASSIVE side	No	No	No
4	Install strut no.1 at elev. 103.00	No	No	No
5	Excav. to elev. 99.60 on PASSIVE side	No	No	No
6	Fill to elev. 102.00 on PASSIVE side	No	No	No
7	Remove strut no.1 at elev. 103.00	No	No	No
8	Change soil type 2 to soil type 5	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.8 Change soil type 2 to soil type 5



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 = 2.000
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 Soldier Pile Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 98.00: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000: Toe elev.	Wall Penetration
1	104.00	104.00	Cant.	6.523	98.72	103.72	0.28
2	104.00	104.00		No analysis at this stage			
3	104.00	102.50	Cant.	1.736	98.73	100.27	2.23
4	104.00	102.50		No analysis at this stage			
5	104.00	99.60	103.00	1.495	n/a	99.03	0.57
6	104.00	102.00	103.00	3.061	n/a	101.35	0.65
7	104.00	102.00	Cant.	1.299	98.77	99.03	2.97
8	104.00	102.00	Cant.	1.263	98.50	99.16	2.84

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Soldier Pile Wall

Analysis options

Soldier Pile width = 0.60m; spacing = 2.50m
Passive mobilisation factor = 3.000
Length of wall perpendicular to section = 40.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached

Rigid boundaries: Active side 20.00 from wall
Passive side 15.00 from wall

Limit State: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	104.00	0.034	0.000	0.0	-0.0	0.0	0.0
2	103.75	0.032	0.000	0.2	0.0	1.9	0.0
3	103.50	0.030	0.000	1.0	0.0	4.1	0.0
4	103.25	0.029	0.000	2.3	0.0	6.6	0.0
5	103.00	0.027	0.000	4.3	0.0	9.3	-34.5
6	102.75	0.026	0.000	6.4	-3.9	11.2	-31.8
7	102.50	0.024	0.000	9.5	-11.5	14.3	-28.6
8	102.25	0.022	0.000	13.4	-18.2	17.5	-25.1
9	102.00	0.021	0.000	17.9	-23.8	21.4	-21.1
10	101.70	0.019	0.000	24.8	-29.4	23.6	-15.9
11	101.40	0.017	0.000	31.5	-33.4	20.9	-10.1
12	101.10	0.015	0.000	37.5	-35.5	15.7	-3.7
13	100.80	0.013	0.000	41.3	-35.6	10.8	0.0
14	100.50	0.012	0.000	43.9	-33.5	10.7	-0.2
15	100.25	0.010	0.000	45.2	-30.4	15.3	-4.7
16	100.00	0.009	0.000	46.0	-25.7	20.2	-11.0
17	99.80	0.008	0.000	46.0	-21.2	25.1	-14.6
18	99.60	0.007	0.000	45.9	-15.6	31.3	-16.9
19	99.30	0.006	0.000	41.9	-8.0	20.6	-22.5
20	99.00	0.005	0.000	32.5	-3.4	11.7	-37.3
21	98.70	0.004	0.000	19.8	-1.1	4.8	-42.4
22	98.40	0.004	0.000	8.0	0.0	0.6	-34.3
23	98.20	0.003	0.000	2.1	0.0	0.0	-20.8
24	98.00	0.003	-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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	7.6	100.80	-0.0	104.00	5.2	103.00	-4.4	99.30
2	No calculation at this stage							
3	30.3	100.50	-0.0	104.00	15.8	102.25	-18.5	99.30
4	No calculation at this stage							
5	4.3	103.00	-35.6	100.80	31.3	99.60	-34.5	103.00
6	4.2	103.00	-32.7	100.80	30.1	99.60	-33.3	103.00
7	46.0	100.00	-0.0	104.00	23.6	101.70	-42.4	98.70
8	42.2	99.60	-0.0	104.00	23.6	101.70	-41.1	98.70

Summary of results (continued)

Maximum and minimum displacement at each stage

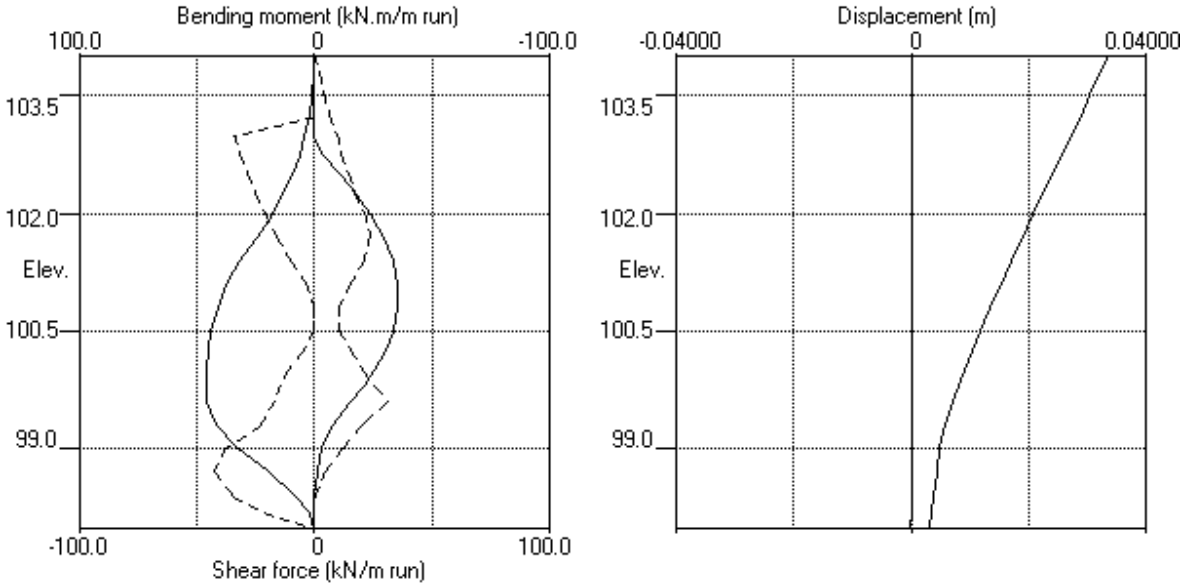
Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.003	104.00	0.000	104.00	Apply surcharge no.1 at elev. 104.00
2	Wall displacements reset to zero				Change EI of wall to 48000kN.m2/m run
3	0.008	104.00	0.000	104.00	Excav. to elev. 102.50 on PASSIVE side
4	No calculation at this stage				Install strut no.1 at elev. 103.00
5	0.007	101.40	0.000	104.00	Excav. to elev. 99.60 on PASSIVE side
6	0.006	102.00	0.000	104.00	Fill to elev. 102.00 on PASSIVE side
7	0.029	104.00	-0.000	98.00	Remove strut no.1 at elev. 103.00
8	0.034	104.00	-0.000	98.00	Change soil type 2 to soil type 5

Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 1 --- at elev. 103.00 kN/m run	kN/strut
5	43.85	43.85
6	42.40	42.40

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Soil types Passive side
1	102.20	1 Granular Made Ground	1 Granular Made Ground
2	101.00	3 Sand	3 Sand
3	98.00	2 Firm Clay	2 Firm Clay

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC Nu	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	19.00a	20000	0.470	OC	0.262	5.284	
	(101.00)	21.00b	(3000)		(0.300)	(0.000)	(0.000)	
4	Not defined							
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	parameters for Ka: Soil friction angle	Wall adhesion coeff.	Back-fill angle	parameters for Kp: Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Not defined						
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	96.00	96.00	0.0	1	96.00	96.00	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 98.00
Maximum finite element length = 0.25 m
Youngs modulus of wall E = 2.1000E+08 kN/m2
Moment of inertia of wall I = 2.1600E-04 m4/m run
(Arcelor PU12) E.I = 45360 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	101.70	1.00	0.100000	2.100E+08	3.00	0.00	0	No
2	101.30	1.00	0.300000	2.700E+07	3.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	102.20	1.20(A)	20.00	15.00	30.00	=	N/A	1.00 -

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

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 102.20
2	Excavate to elevation 101.20 on PASSIVE side
3	Install strut or anchor no.1 at elevation 101.70
4	Excavate to elevation 99.60 on PASSIVE side
5	Fill to elevation 100.80 on PASSIVE side with soil type 3
6	Install strut or anchor no.2 at elevation 101.30
7	Change EI of wall to 74988 kN.m2/m run From elevation 100.60 to 98.00 Yield moment not defined Allow wall to relax with new modulus value
8	Remove strut or anchor no.1 at elevation 101.70

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 = 2.000
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) = 4.500 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 30.00 m

Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

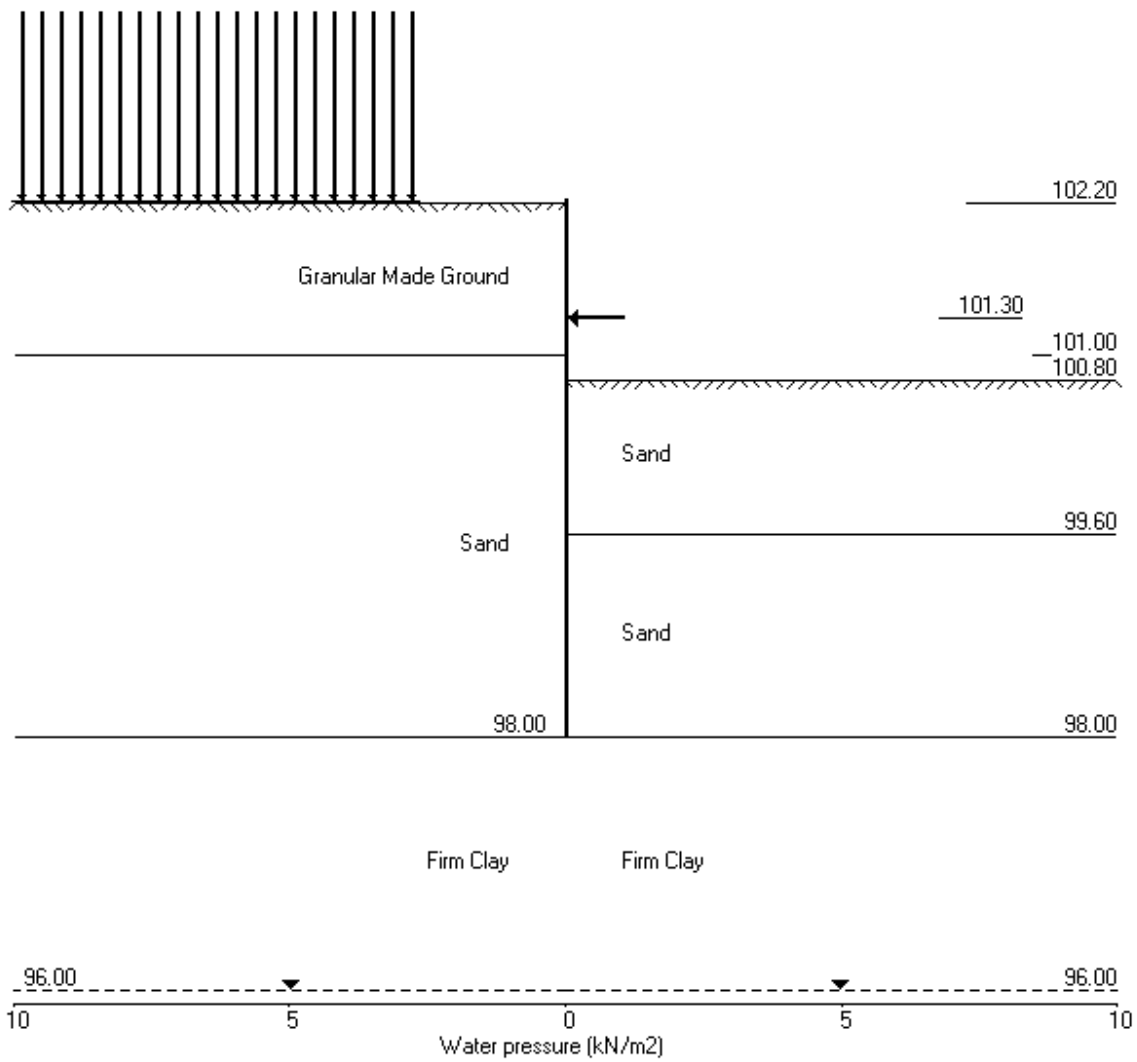
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 102.20	No	No	No
2	Excav. to elev. 101.20 on PASSIVE side	Yes	No	No
3	Install strut no.1 at elev. 101.70	No	No	No
4	Excav. to elev. 99.60 on PASSIVE side	Yes	No	No
5	Fill to elev. 100.80 on PASSIVE side	Yes	No	No
6	Install strut no.2 at elev. 101.30	No	No	No
7	Change EI of wall to 74988kN.m2/m run	No	No	No
8	Remove strut no.1 at elev. 101.70	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.8 Remove strut no.1 at elev. 101.70



Units: kN,m

Stage No. 2 Excavate to elevation 101.20 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 98.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
2	102.20	101.20	Cant.	2.238	98.27	100.21	0.99

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m

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 15.00 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	EI of wall kN.m2/m
1	102.20	0.00	0.003	6.55E-04	0.0	-0.0		45360
2	102.07	0.81	0.003	6.55E-04	0.1	0.0		45360
3	101.95	1.64	0.003	6.55E-04	0.2	0.0		45360
4	101.82	2.53	0.003	6.55E-04	0.5	0.1		45360
5	101.70	3.49	0.003	6.55E-04	0.8	0.1		45360
6	101.50	5.38	0.003	6.54E-04	1.7	0.4		45360
7	101.30	7.52	0.003	6.51E-04	3.0	0.9		45360
8	101.20	8.66	0.002	6.48E-04	3.8	1.2		45360
9	101.00	4.44	0.002	6.41E-04	5.1	2.1		45360
		-4.47	0.002	6.41E-04	5.1	2.1		
10	100.80	-6.31	0.002	6.29E-04	4.1	3.1		45360
11	100.60	-5.87	0.002	6.14E-04	2.8	3.8		45360
12	100.46	-5.57	0.002	6.02E-04	2.0	4.2		45360
13	100.32	-5.27	0.002	5.89E-04	1.3	4.4		45360
14	100.08	-4.78	0.002	5.65E-04	0.1	4.5		45360
15	99.84	-4.33	0.002	5.41E-04	-1.0	4.4		45360
16	99.60	-3.90	0.002	5.19E-04	-2.0	4.1		45360
17	99.36	-2.82	0.001	4.99E-04	-2.8	3.5		45360
18	99.12	-1.12	0.001	4.82E-04	-3.3	2.8		45360
19	98.88	0.59	0.001	4.70E-04	-3.3	1.9		45360
20	98.64	2.31	0.001	4.62E-04	-3.0	1.2		45360
21	98.40	4.07	0.001	4.57E-04	-2.2	0.5		45360
22	98.20	5.57	0.001	4.56E-04	-1.3	0.1		45360
23	98.00	7.12	0.001	4.56E-04	0.0	0.0		---

(continued)

Stage No.2 Excavate to elevation 101.20 on PASSIVE side

Units: kN,m

Stage No. 4 Excavate to elevation 99.60 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 98.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
4	102.20	99.60	101.70	1.330	n/a	98.61	0.99

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m

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 15.00 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	EI of wall kN.m2/m
1	102.20	0.00	0.003	-6.27E-04	0.0	-0.0		45360
2	102.07	1.08	0.003	-6.27E-04	0.1	0.0		45360
3	101.95	2.01	0.003	-6.27E-04	0.3	0.0		45360
4	101.82	2.80	0.003	-6.28E-04	0.6	0.1		45360
5	101.70	3.49	0.003	-6.28E-04	1.0	0.2	17.2	45360
		3.49	0.003	-6.28E-04	-16.2	0.2		
6	101.50	5.18	0.003	-6.22E-04	-15.3	-3.0		45360
7	101.30	7.01	0.003	-6.02E-04	-14.1	-5.9		45360
8	101.20	7.95	0.003	-5.88E-04	-13.4	-7.3		45360
9	101.00	9.85	0.003	-5.50E-04	-11.6	-9.8		45360
		8.95	0.003	-5.50E-04	-11.6	-9.8		
10	100.80	10.72	0.003	-5.02E-04	-9.6	-11.8		45360
11	100.60	12.47	0.003	-4.46E-04	-7.3	-13.5		45360
12	100.46	13.68	0.004	-4.03E-04	-5.5	-14.4		45360
13	100.32	14.87	0.004	-3.58E-04	-3.5	-15.1		45360
14	100.08	16.86	0.004	-2.77E-04	0.3	-15.5		45360
15	99.84	18.79	0.004	-1.97E-04	4.6	-14.9		45360
16	99.60	20.67	0.004	-1.22E-04	9.4	-13.2		45360
17	99.36	5.52	0.004	-6.01E-05	12.5	-10.5		45360
18	99.12	-8.50	0.004	-1.31E-05	12.1	-7.3		45360
19	98.88	-9.52	0.004	1.83E-05	10.0	-4.6		45360
20	98.64	-10.51	0.004	3.71E-05	7.6	-2.5		45360
21	98.40	-11.50	0.004	4.64E-05	4.9	-1.0		45360
22	98.20	-12.33	0.004	4.92E-05	2.6	-0.3		45360
23	98.00	-13.17	0.004	4.98E-05	0.0	0.0		---

At elev. 101.70 Strut force = 17.2 kN/strut = 17.2 kN/m run

(continued)

Stage No.4 Excavate to elevation 99.60 on PASSIVE side

Units: kN,m

Stage No. 5 Fill to elevation 100.80 on PASSIVE side with soil type 3

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

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 98.00 Factor of Safety	Moment equilib. at elev.	Toe FoS = 1.000 Toe elev.	Wall Penetr -ation
5	102.20	100.80	101.70	2.904	n/a	100.31	0.49

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 30.00m
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 15.00 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	EI of wall kN.m2/m
1	102.20	0.00	0.003	-3.42E-04	0.0	-0.0		45360
2	102.07	1.02	0.003	-3.42E-04	0.1	0.0		45360
3	101.95	1.93	0.003	-3.42E-04	0.2	0.0		45360
4	101.82	2.74	0.003	-3.42E-04	0.5	0.1		45360
5	101.70	3.49	0.003	-3.42E-04	0.9	0.2	16.2	45360
		3.49	0.003	-3.42E-04	-15.3	0.2		
6	101.50	5.23	0.003	-3.36E-04	-14.4	-2.8		45360
7	101.30	7.14	0.003	-3.18E-04	-13.2	-5.6		45360
8	101.20	8.13	0.003	-3.04E-04	-12.4	-6.9		45360
9	101.00	10.14	0.003	-2.69E-04	-10.6	-9.2		45360
		9.96	0.003	-2.69E-04	-10.6	-9.2		
10	100.80	12.06	0.003	-2.24E-04	-8.4	-11.0		45360
11	100.60	12.89	0.003	-1.73E-04	-5.9	-12.4		45360
12	100.46	13.46	0.003	-1.33E-04	-4.1	-13.1		45360
13	100.32	14.01	0.003	-9.25E-05	-2.1	-13.6		45360
14	100.08	14.93	0.003	-2.04E-05	1.3	-13.7		45360
15	99.84	15.80	0.003	4.99E-05	5.0	-12.9		45360
16	99.60	16.62	0.003	1.13E-04	8.9	-11.3		45360
17	99.36	3.66	0.003	1.67E-04	11.3	-8.8		45360
18	99.12	-9.43	0.003	2.05E-04	10.6	-5.9		45360
19	98.88	-9.50	0.003	2.31E-04	8.4	-3.6		45360
20	98.64	-9.54	0.003	2.45E-04	6.1	-1.9		45360
21	98.40	-9.54	0.003	2.53E-04	3.8	-0.7		45360
22	98.20	-9.52	0.003	2.55E-04	1.9	-0.2		45360
23	98.00	-9.48	0.003	2.55E-04	0.0	0.0		---

At elev. 101.70 Strut force = 16.2 kN/strut = 16.2 kN/m run

(continued)

Stage No.5 Fill to elevation 100.80 on PASSIVE side with soil type 3

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 = 2.000
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

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 98.00: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000: Toe elev.	Wall Penetration
1	102.20	102.20	Cant.	Conditions not suitable for FoS calc.			
2	102.20	101.20	Cant.	2.238	98.27	100.21	0.99
3	102.20	101.20		No analysis at this stage			
4	102.20	99.60	101.70	1.330	n/a	98.61	0.99
5	102.20	100.80	101.70	2.904	n/a	100.31	0.49
6	102.20	100.80		No analysis at this stage			
7	102.20	100.80		More than one strut			
8	102.20	100.80	101.30	3.027	n/a	100.45	0.35

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m
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 15.00 from wall

Limit State: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	102.20	0.003	0.000	0.0	-0.0	0.0	0.0
2	102.07	0.003	0.000	0.0	0.0	0.1	-0.0
3	101.95	0.003	0.000	0.0	-0.0	0.3	-0.0
4	101.82	0.003	0.000	0.1	-0.0	0.6	-0.0
5	101.70	0.003	0.000	0.2	-0.0	1.0	-16.2
6	101.50	0.003	0.000	0.4	-3.0	1.8	-15.3
7	101.30	0.003	0.000	0.9	-5.9	3.0	-16.0
8	101.20	0.003	0.000	1.2	-7.3	3.8	-15.3
9	101.00	0.003	0.000	2.1	-9.8	5.1	-13.4
10	100.80	0.003	0.000	3.1	-11.8	4.1	-11.2
11	100.60	0.003	0.000	3.8	-13.5	2.8	-8.6
12	100.46	0.004	0.000	4.2	-14.4	2.0	-6.8
13	100.32	0.004	0.000	4.4	-15.1	1.3	-4.8
14	100.08	0.004	0.000	4.5	-15.5	1.3	-1.2
15	99.84	0.004	0.000	4.4	-14.9	5.0	-1.0
16	99.60	0.004	0.000	4.1	-13.2	9.4	-2.0
17	99.36	0.004	0.000	3.5	-10.5	12.5	-2.8
18	99.12	0.004	0.000	2.8	-7.3	12.1	-3.3
19	98.88	0.004	0.000	1.9	-4.6	10.0	-3.3
20	98.64	0.004	0.000	1.2	-2.5	7.6	-3.0
21	98.40	0.004	0.000	0.5	-1.0	4.9	-2.2
22	98.20	0.004	0.000	0.1	-0.3	2.6	-1.3
23	98.00	0.004	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.2	100.60	-0.1	99.12	0.5	101.00	-0.2	100.08
2	4.5	100.08	-0.0	102.20	5.1	101.00	-3.3	98.88
3	No calculation at this stage							
4	0.2	101.70	-15.5	100.08	12.5	99.36	-16.2	101.70
5	0.2	101.70	-13.7	100.08	11.3	99.36	-15.3	101.70
6	No calculation at this stage							
7	0.2	101.70	-13.7	100.08	11.3	99.36	-15.3	101.70
8	0.9	101.30	-10.5	100.08	9.3	99.36	-16.0	101.30

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.001	98.00	0.000	102.20	Apply surcharge no.1 at elev. 102.20
2	0.003	102.20	0.000	102.20	Excav. to elev. 101.20 on PASSIVE side
3	No calculation at this stage				Install strut no.1 at elev. 101.70
4	0.004	99.12	0.000	102.20	Excav. to elev. 99.60 on PASSIVE side
5	0.003	100.08	0.000	102.20	Fill to elev. 100.80 on PASSIVE side
6	No calculation at this stage				Install strut no.2 at elev. 101.30
7	0.003	100.08	0.000	102.20	Change EI of wall to 74988kN.m2/m run
8	0.003	100.08	0.000	102.20	Remove strut no.1 at elev. 101.70

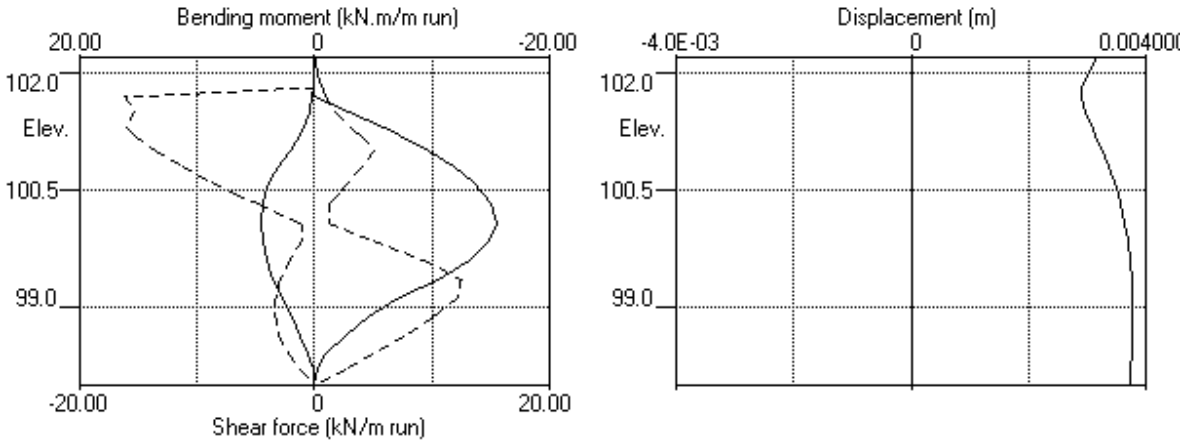
Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 101.70 kN/m run	Strut no. 1 at elev. 101.70 kN/strut	Strut no. 2 at elev. 101.30 kN/m run	Strut no. 2 at elev. 101.30 kN/strut
4	17.15	17.15	---	---
5	16.23	16.23	---	---
7	16.23	16.23	0.00	0.00
8	---	---	19.02	19.02

CARD GEOTECHNICS LIMITED | Sheet No.
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. CGL9008
Licensed from GEOSOLVE | Made by : ANK
Data filename/Run ID: CGL09008 SECTION 9-9 ShPW 002_ULS2 |
79 Fitzjohn's Avenue | Date:20-01-2016
Ground Movement Assessment - Section 9-9 - SLS (AZ24-700) | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	102.20	1 Granular Made Ground	1 Granular Made Ground
2	101.00	3 Sand	3 Sand
3	98.00	2 Firm Clay	2 Firm Clay

SOIL PROPERTIES

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC Nu	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	19.00a	20000	0.470	OC	0.262	5.284	
	(101.00)	21.00b	(3000)		(0.300)	(0.000)	(0.000)	
4	Not defined							
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	parameters for Ka: Soil friction angle	Wall adhesion coeff.	Back-fill angle	parameters for Kp: Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Not defined						
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	96.00	96.00	0.0	1	96.00	96.00	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 98.00
Maximum finite element length = 0.25 m
Youngs modulus of wall E = 2.1000E+08 kN/m2
Moment of inertia of wall I = 2.1600E-04 m4/m run
(Arcelor PU12) E.I = 45360 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	101.70	1.00	0.100000	2.100E+08	3.00	0.00	0	No
2	101.30	1.00	0.300000	2.700E+07	3.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	102.20	1.20(A)	20.00	15.00	30.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 102.20
2	Excavate to elevation 101.20 on PASSIVE side
3	Install strut or anchor no.1 at elevation 101.70
4	Excavate to elevation 99.60 on PASSIVE side
5	Fill to elevation 100.80 on PASSIVE side with soil type 3
6	Install strut or anchor no.2 at elevation 101.30
7	Change EI of wall to 74988 kN.m2/m run From elevation 100.60 to 98.00 Yield moment not defined Allow wall to relax with new modulus value
8	Remove strut or anchor no.1 at elevation 101.70

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

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

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 4.500 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 30.00 m

Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

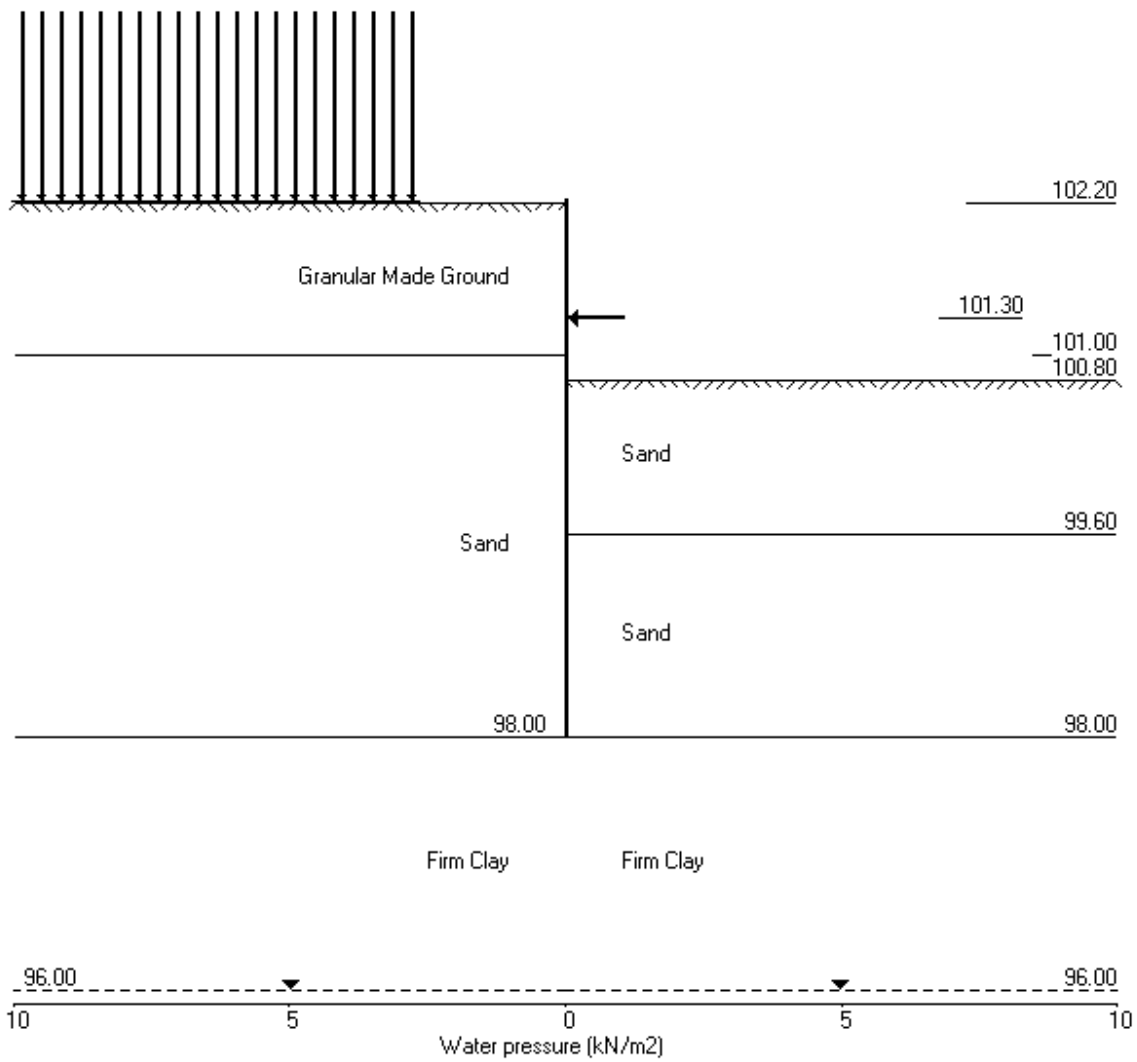
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 102.20	No	No	No
2	Excav. to elev. 101.20 on PASSIVE side	Yes	No	No
3	Install strut no.1 at elev. 101.70	No	No	No
4	Excav. to elev. 99.60 on PASSIVE side	Yes	No	No
5	Fill to elev. 100.80 on PASSIVE side	Yes	No	No
6	Install strut no.2 at elev. 101.30	No	No	No
7	Change EI of wall to 74988kN.m2/m run	No	No	No
8	Remove strut no.1 at elev. 101.70	No	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.8 Remove strut no.1 at elev. 101.70



Units: kN,m

Stage No. 2 Excavate to elevation 101.20 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 98.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
2	102.20	101.20	Cant.	2.799	98.27	100.49	0.71

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m

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 15.00 from wall

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	102.20	0.00	0.001	3.09E-04	0.0	-0.0		45360
2	102.07	0.78	0.001	3.09E-04	0.0	0.0		45360
3	101.95	1.64	0.001	3.09E-04	0.2	0.0		45360
4	101.82	2.59	0.001	3.09E-04	0.5	0.1		45360
5	101.70	3.66	0.001	3.08E-04	0.9	0.1		45360
6	101.50	5.62	0.001	3.07E-04	1.8	0.4		45360
7	101.30	7.83	0.001	3.04E-04	3.1	0.9		45360
8	101.20	9.00	0.001	3.02E-04	4.0	1.2		45360
9	101.00	4.93	0.001	2.94E-04	5.4	2.2		45360
		-6.85	0.001	2.94E-04	5.4	2.2		
10	100.80	-6.78	0.001	2.83E-04	4.0	3.1		45360
11	100.60	-6.72	0.001	2.67E-04	2.7	3.8		45360
12	100.46	-6.69	0.001	2.55E-04	1.7	4.1		45360
13	100.32	-6.68	0.001	2.42E-04	0.8	4.3		45360
14	100.08	-5.14	0.001	2.19E-04	-0.6	4.3		45360
15	99.84	-3.66	0.001	1.97E-04	-1.7	4.0		45360
16	99.60	-2.30	0.001	1.77E-04	-2.4	3.5		45360
17	99.36	-1.04	0.001	1.60E-04	-2.8	2.9		45360
18	99.12	0.12	0.001	1.47E-04	-2.9	2.2		45360
19	98.88	1.22	0.001	1.37E-04	-2.8	1.5		45360
20	98.64	2.27	0.001	1.31E-04	-2.3	0.9		45360
21	98.40	3.31	0.001	1.28E-04	-1.7	0.4		45360
22	98.20	4.19	0.000	1.27E-04	-0.9	0.1		45360
23	98.00	5.08	0.000	1.26E-04	-0.0	0.0		---

(continued)

Stage No.2 Excavate to elevation 101.20 on PASSIVE side

Units: kN,m

Stage No. 4 Excavate to elevation 99.60 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 98.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
4	102.20	99.60	101.70	1.664	n/a	98.95	0.65

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m

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 15.00 from wall

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	102.20	0.00	0.001	-2.83E-04	0.0	-0.0		45360
2	102.07	1.04	0.001	-2.83E-04	0.1	0.0		45360
3	101.95	1.98	0.001	-2.83E-04	0.3	0.0		45360
4	101.82	2.84	0.001	-2.83E-04	0.6	0.1		45360
5	101.70	3.66	0.001	-2.84E-04	1.0	0.2	14.0	45360
		3.66	0.001	-2.84E-04	-13.0	0.2		
6	101.50	5.45	0.001	-2.79E-04	-12.1	-2.3		45360
7	101.30	7.40	0.001	-2.64E-04	-10.8	-4.6		45360
8	101.20	8.40	0.001	-2.52E-04	-10.0	-5.7		45360
9	101.00	10.44	0.001	-2.23E-04	-8.1	-7.5		45360
		7.07	0.001	-2.23E-04	-8.1	-7.5		
10	100.80	8.47	0.001	-1.87E-04	-6.6	-9.0		45360
11	100.60	9.86	0.001	-1.45E-04	-4.7	-10.1		45360
12	100.46	10.81	0.002	-1.13E-04	-3.3	-10.7		45360
13	100.32	11.75	0.002	-7.97E-05	-1.7	-11.0		45360
14	100.08	13.32	0.002	-2.14E-05	1.3	-11.0		45360
15	99.84	14.85	0.002	3.51E-05	4.7	-10.3		45360
16	99.60	16.34	0.002	8.56E-05	8.4	-8.8		45360
17	99.36	-6.31	0.001	1.26E-04	9.6	-6.5		45360
18	99.12	-7.36	0.001	1.54E-04	8.0	-4.3		45360
19	98.88	-7.96	0.001	1.73E-04	6.1	-2.6		45360
20	98.64	-7.76	0.001	1.83E-04	4.2	-1.3		45360
21	98.40	-6.94	0.001	1.87E-04	2.5	-0.5		45360
22	98.20	-6.22	0.001	1.89E-04	1.2	-0.1		45360
23	98.00	-5.45	0.001	1.89E-04	0.0	0.0		---

At elev. 101.70 Strut force = 14.0 kN/strut = 14.0 kN/m run

(continued)

Stage No.4 Excavate to elevation 99.60 on PASSIVE side

Units: kN,m

Stage No. 5 Fill to elevation 100.80 on PASSIVE side with soil type 3

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

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 98.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
5	102.20	100.80	101.70	3.629	n/a	100.48	0.32

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 30.00m
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 15.00 from wall

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	102.20	0.00	0.001	-1.39E-04	0.0	-0.0		45360
2	102.07	0.98	0.001	-1.39E-04	0.1	0.0		45360
3	101.95	1.89	0.001	-1.39E-04	0.2	0.0		45360
4	101.82	2.78	0.001	-1.40E-04	0.5	0.1		45360
5	101.70	3.66	0.001	-1.40E-04	0.9	0.2	13.5	45360
		3.66	0.001	-1.40E-04	-12.6	0.2		
6	101.50	5.50	0.001	-1.35E-04	-11.6	-2.3		45360
7	101.30	7.52	0.001	-1.20E-04	-10.3	-4.5		45360
8	101.20	8.57	0.001	-1.10E-04	-9.5	-5.5		45360
9	101.00	10.73	0.001	-8.22E-05	-7.6	-7.2		45360
		8.07	0.001	-8.22E-05	-7.6	-7.2		
10	100.80	9.80	0.001	-4.76E-05	-5.8	-8.5		45360
11	100.60	10.52	0.001	-7.97E-06	-3.8	-9.5		45360
12	100.46	11.02	0.001	2.19E-05	-2.3	-9.9		45360
13	100.32	11.50	0.001	5.28E-05	-0.7	-10.1		45360
14	100.08	12.31	0.001	1.05E-04	2.2	-9.9		45360
15	99.84	13.04	0.001	1.56E-04	5.2	-9.1		45360
16	99.60	13.44	0.001	1.99E-04	8.4	-7.5		45360
17	99.36	-8.34	0.001	2.33E-04	9.0	-5.3		45360
18	99.12	-8.52	0.001	2.55E-04	7.0	-3.3		45360
19	98.88	-8.25	0.001	2.69E-04	5.0	-1.8		45360
20	98.64	-7.17	0.001	2.76E-04	3.1	-0.8		45360
21	98.40	-5.47	0.001	2.79E-04	1.6	-0.3		45360
22	98.20	-3.98	0.001	2.79E-04	0.6	-0.0		45360
23	98.00	-2.44	0.001	2.80E-04	0.0	-0.0		---

At elev. 101.70 Strut force = 13.5 kN/strut = 13.5 kN/m run

(continued)

Stage No.5 Fill to elevation 100.80 on PASSIVE side with soil type 3

Units: kN,m

Summary of results

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

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 98.00: Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000	Wall Penetration
1	102.20	102.20	Cant.	Conditions not suitable for FoS calc.			
2	102.20	101.20	Cant.	2.799	98.27	100.49	0.71
3	102.20	101.20		No analysis at this stage			
4	102.20	99.60	101.70	1.664	n/a	98.95	0.65
5	102.20	100.80	101.70	3.629	n/a	100.48	0.32
6	102.20	100.80		No analysis at this stage			
7	102.20	100.80		More than one strut			
8	102.20	100.80	101.30	3.781	n/a	100.59	0.21

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m
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 15.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	102.20	0.001	0.000	0.0	-0.0	0.0	0.0
2	102.07	0.001	0.000	0.0	0.0	0.1	-0.0
3	101.95	0.001	0.000	0.0	-0.0	0.3	-0.0
4	101.82	0.001	0.000	0.1	-0.0	0.6	-0.0
5	101.70	0.001	0.000	0.2	-0.0	1.0	-13.0
6	101.50	0.001	0.000	0.4	-2.3	1.8	-12.1
7	101.30	0.001	0.000	0.9	-4.6	3.1	-12.8
8	101.20	0.001	0.000	1.2	-5.7	4.0	-12.0
9	101.00	0.001	0.000	2.2	-7.5	5.4	-10.1
10	100.80	0.001	0.000	3.1	-9.0	4.0	-8.3
11	100.60	0.001	0.000	3.8	-10.1	2.7	-6.2
12	100.46	0.002	0.000	4.1	-10.7	1.7	-4.6
13	100.32	0.002	0.000	4.3	-11.0	0.8	-3.0
14	100.08	0.002	0.000	4.3	-11.0	2.2	-0.6
15	99.84	0.002	0.000	4.0	-10.3	5.2	-1.7
16	99.60	0.002	0.000	3.5	-8.8	8.4	-2.4
17	99.36	0.001	0.000	2.9	-6.5	9.6	-2.8
18	99.12	0.001	0.000	2.2	-4.3	8.0	-2.9
19	98.88	0.001	0.000	1.5	-2.6	6.1	-2.8
20	98.64	0.001	0.000	0.9	-1.3	4.2	-2.3
21	98.40	0.001	0.000	0.4	-0.5	2.5	-1.7
22	98.20	0.001	0.000	0.1	-0.1	1.2	-0.9
23	98.00	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 maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	0.2	100.60	-0.1	99.12	0.5	101.00	-0.2	100.08
2	4.3	100.08	-0.0	102.20	5.4	101.00	-2.9	99.12
3	No calculation at this stage							
4	0.2	101.70	-11.0	100.08	9.6	99.36	-13.0	101.70
5	0.2	101.70	-10.1	100.32	9.0	99.36	-12.6	101.70
6	No calculation at this stage							
7	0.2	101.70	-10.1	100.32	9.0	99.36	-12.6	101.70
8	0.9	101.30	-7.5	100.08	7.4	99.36	-12.8	101.30

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	minimum m	elev.	Stage description
1	0.000	98.00	0.000	102.20	Apply surcharge no.1 at elev. 102.20
2	0.001	102.20	0.000	102.20	Excav. to elev. 101.20 on PASSIVE side
3	No calculation at this stage				Install strut no.1 at elev. 101.70
4	0.002	100.08	0.000	102.20	Excav. to elev. 99.60 on PASSIVE side
5	0.001	100.60	0.000	102.20	Fill to elev. 100.80 on PASSIVE side
6	No calculation at this stage				Install strut no.2 at elev. 101.30
7	0.001	100.60	0.000	102.20	Change EI of wall to 74988kN.m2/m run
8	0.001	100.80	0.000	102.20	Remove strut no.1 at elev. 101.70

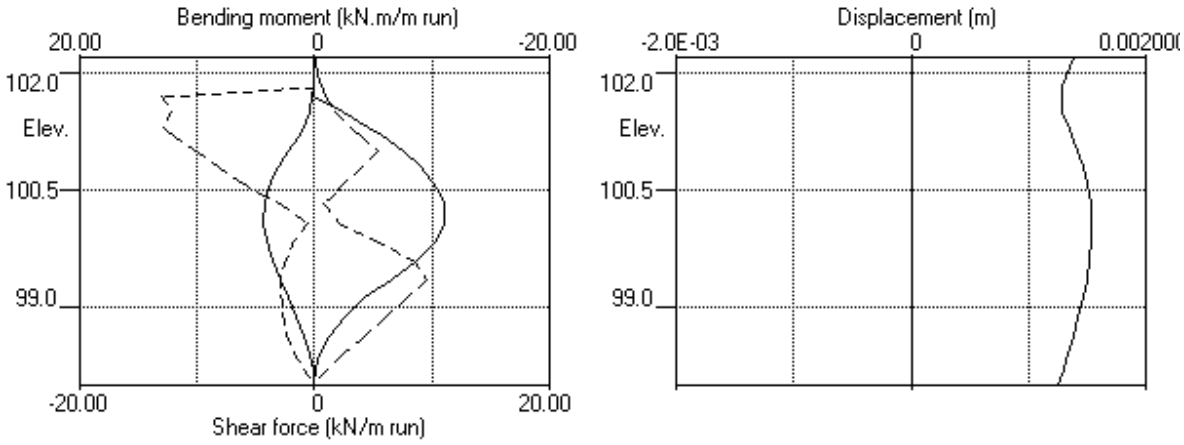
Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 101.70 kN/m run	Strut no. 1 at elev. 101.70 kN/strut	Strut no. 2 at elev. 101.30 kN/m run	Strut no. 2 at elev. 101.30 kN/strut
4	13.97	13.97	---	---
5	13.49	13.49	---	---
7	13.49	13.49	0.00	0.00
8	---	---	15.90	15.90

CARD GEOTECHNICS LIMITED | Sheet No.
Program: WALLAP Version 6.05 Revision A45.B58.R49 | Job No. CGL9008
Licensed from GEOSOLVE | Made by : ANK
Data filename/Run ID: CGL09008 SECTION 9-9 ShPW 002 |
79 Fitzjohn's Avenue | Date: 5-01-2016
Ground Movement Assessment - Section 9-9 - SLS (AZ24-700) | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	102.50	1 Granular Made Ground	1 Granular Made Ground
2	101.00	3 Sand	3 Sand
3	98.00	2 Firm Clay	2 Firm Clay

SOIL PROPERTIES

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	19.00a	20000	0.470	OC	0.262	5.284	
	(101.00)	21.00b	(3000)		(0.300)	(0.000)	(0.000)	
4	Not defined							
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Not defined						
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	96.00	96.00	0.0	1	96.00	96.00	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 96.00
Maximum finite element length = 0.40 m
Youngs modulus of wall E = 2.1000E+08 kN/m2
Moment of inertia of wall I = 2.1600E-04 m4/m run
(Arcelor PU12) E.I = 45360 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	101.70	1.00	0.100000	2.100E+08	3.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge Near edge kN/m2	Surcharge Far edge kN/m2	Equiv. soil type	Partial factor/ Category
1	102.50	0.00(A)	20.00	15.00	5.00	=	N/A	N/A

Note: A = Active side, P = Passive side

CONSTRUCTION STAGES

Construction stage no.	Stage description
1	Apply surcharge no.1 at elevation 102.50
2	Excavate to elevation 101.20 on PASSIVE side
3	Excavate to elevation 99.70 on PASSIVE side
4	Change properties of soil type 2 to soil type 5 Ko pressures will not be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

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

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 4.500 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 30.00 m

Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

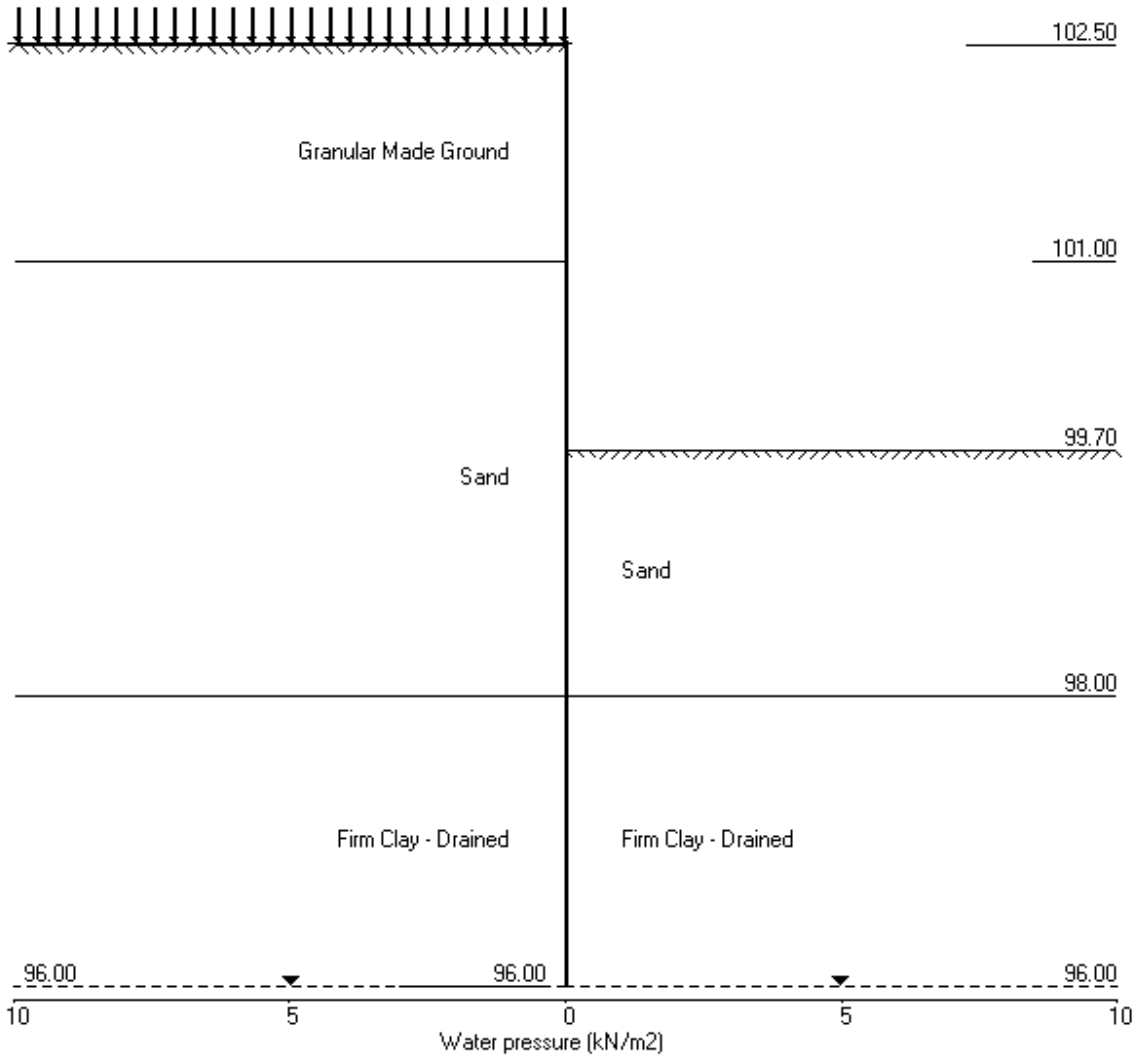
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 102.50	No	No	No
2	Excav. to elev. 101.20 on PASSIVE side	Yes	No	No
3	Excav. to elev. 99.70 on PASSIVE side	Yes	No	No
4	Change soil type 2 to soil type 5	Yes	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.4 Change soil type 2 to soil type 5



Units: kN,m

Stage No. 2 Excavate to elevation 101.20 on PASSIVE side

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

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 96.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
2	102.50	101.20	Cant.	3.520	96.72	100.21	0.99

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 30.00m
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 15.00 from wall

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	102.50	2.41	0.002	6.60E-04	0.0	-0.0	
2	102.25	3.69	0.002	6.60E-04	0.8	0.1	
3	102.00	4.95	0.002	6.59E-04	1.8	0.4	
4	101.60	7.41	0.002	6.49E-04	4.3	1.7	
5	101.20	10.40	0.001	6.24E-04	7.9	4.1	
6	101.00	3.92	0.001	6.02E-04	9.3	5.9	
		-9.84	0.001	6.02E-04	9.3	5.9	
7	100.70	-9.46	0.001	5.55E-04	6.4	8.2	
8	100.40	-9.10	0.001	4.96E-04	3.6	9.7	
9	100.05	-8.07	0.001	4.19E-04	0.6	10.5	
10	99.70	-5.27	0.001	3.39E-04	-1.7	10.2	
11	99.45	-3.56	0.001	2.84E-04	-2.8	9.6	
12	99.20	-2.10	0.000	2.33E-04	-3.5	8.8	
13	98.80	-0.32	0.000	1.62E-04	-4.0	7.2	
14	98.40	0.84	0.000	1.05E-04	-3.9	5.6	
15	98.00	1.46	0.000	6.29E-05	-3.4	4.1	
		-0.25	0.000	6.29E-05	-3.4	4.1	
16	97.60	1.32	0.000	3.27E-05	-3.2	2.7	
17	97.20	2.02	0.000	1.39E-05	-2.6	1.5	
18	96.80	2.21	0.000	4.13E-06	-1.7	0.7	
19	96.40	2.16	0.000	4.25E-07	-0.8	0.2	
20	96.00	2.03	0.000	-3.04E-07	0.0	0.0	

Units: kN,m

Stage No. 3 Excavate to elevation 99.70 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 96.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
3	102.50	99.70	Cant.	1.502	96.71	97.50	2.20

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m

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 15.00 from wall

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	102.50	1.57	0.011	2.63E-03	0.0	0.0	
2	102.25	2.71	0.010	2.63E-03	0.5	0.1	
3	102.00	3.99	0.010	2.63E-03	1.4	0.3	
4	101.60	6.05	0.008	2.63E-03	3.4	1.3	
5	101.20	8.10	0.007	2.61E-03	6.2	3.2	
6	101.00	9.12	0.007	2.59E-03	7.9	4.6	
		8.37	0.007	2.59E-03	7.9	4.6	
7	100.70	9.86	0.006	2.55E-03	10.7	7.4	
8	100.40	11.34	0.005	2.49E-03	13.8	11.0	
9	100.05	13.08	0.005	2.38E-03	18.1	16.7	
10	99.70	14.81	0.004	2.23E-03	23.0	23.8	
11	99.45	-9.05	0.003	2.08E-03	23.7	29.8	
12	99.20	-32.91	0.003	1.90E-03	18.5	35.1	
13	98.80	-31.06	0.002	1.56E-03	5.7	40.8	
14	98.40	-22.42	0.001	1.21E-03	-5.0	40.5	
15	98.00	-12.60	0.001	8.68E-04	-12.0	37.0	
		-40.06	0.001	8.68E-04	-12.0	37.0	
16	97.60	-12.81	0.001	5.77E-04	-22.6	29.0	
17	97.20	4.81	0.001	3.65E-04	-24.2	19.0	
18	96.80	16.02	0.000	2.39E-04	-20.0	9.7	
19	96.40	23.82	0.000	1.84E-04	-12.1	2.9	
20	96.00	36.49	0.000	1.71E-04	0.0	0.0	

Units: kN,m

Stage No. 4 Change properties of soil type 2 to soil type 5
Ko pressures will not be reset

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

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 96.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
4	102.50	99.70	Cant.	1.427	96.41	97.63	2.07

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 30.00m
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 15.00 from wall

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	102.50	1.57	0.011	2.63E-03	0.0	0.0	
2	102.25	2.71	0.010	2.63E-03	0.5	0.1	
3	102.00	3.99	0.010	2.63E-03	1.4	0.3	
4	101.60	6.05	0.008	2.63E-03	3.4	1.3	
5	101.20	8.10	0.007	2.61E-03	6.2	3.2	
6	101.00	9.12	0.007	2.59E-03	7.9	4.6	
		8.37	0.007	2.59E-03	7.9	4.6	
7	100.70	9.86	0.006	2.55E-03	10.7	7.4	
8	100.40	11.34	0.005	2.49E-03	13.8	11.0	
9	100.05	13.08	0.005	2.38E-03	18.1	16.7	
10	99.70	14.81	0.004	2.23E-03	23.0	23.8	
11	99.45	-9.05	0.003	2.08E-03	23.7	29.8	
12	99.20	-32.91	0.003	1.90E-03	18.5	35.1	
13	98.80	-31.06	0.002	1.56E-03	5.7	40.8	
14	98.40	-22.42	0.001	1.21E-03	-5.0	40.5	
15	98.00	-12.60	0.001	8.68E-04	-12.0	37.0	
		-40.06	0.001	8.68E-04	-12.0	37.0	
16	97.60	-12.81	0.001	5.77E-04	-22.6	29.0	
17	97.20	4.81	0.001	3.65E-04	-24.2	19.0	
18	96.80	16.02	0.000	2.39E-04	-20.0	9.7	
19	96.40	23.82	0.000	1.84E-04	-12.1	2.9	
20	96.00	36.49	0.000	1.71E-04	0.0	0.0	

(continued)

Stage No.4 Change properties of soil type 2 to soil type 5
Ko pressures will not be reset

Units: kN,m

Summary of results

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

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 96.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	102.50	102.50	Cant.	Conditions not suitable for FoS calc.			
2	102.50	101.20	Cant.	3.520	96.72	100.21	0.99
3	102.50	99.70	Cant.	1.502	96.71	97.50	2.20
4	102.50	99.70	Cant.	1.427	96.41	97.63	2.07

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m
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 15.00 from wall

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	102.50	0.011	0.000	0.0	-0.0	0.0	0.0
2	102.25	0.010	0.000	0.1	0.0	0.8	0.0
3	102.00	0.010	0.000	0.4	0.0	1.8	0.0
4	101.60	0.008	0.000	1.7	0.0	4.3	0.0
5	101.20	0.007	0.000	4.1	0.0	7.9	0.0
6	101.00	0.007	0.000	5.9	0.0	9.3	0.0
7	100.70	0.006	0.000	8.2	0.0	10.7	0.0
8	100.40	0.005	0.000	11.0	0.0	13.8	0.0
9	100.05	0.005	0.000	16.7	0.0	18.1	-0.3
10	99.70	0.004	0.000	23.8	0.0	23.0	-1.7
11	99.45	0.003	0.000	29.8	0.0	23.7	-2.8
12	99.20	0.003	0.000	35.1	0.0	18.5	-3.5
13	98.80	0.002	0.000	40.8	0.0	5.7	-4.0
14	98.40	0.001	0.000	40.5	0.0	0.0	-5.0
15	98.00	0.001	0.000	37.0	0.0	0.0	-12.0
16	97.60	0.001	0.000	29.0	0.0	0.0	-22.6
17	97.20	0.001	0.000	19.0	0.0	0.0	-24.2
18	96.80	0.000	0.000	9.7	0.0	0.0	-20.0
19	96.40	0.000	0.000	2.9	0.0	0.0	-12.1
20	96.00	0.000	0.000	0.0	0.0	0.0	0.0

Maximum and minimum bending moment and shear force at each stage

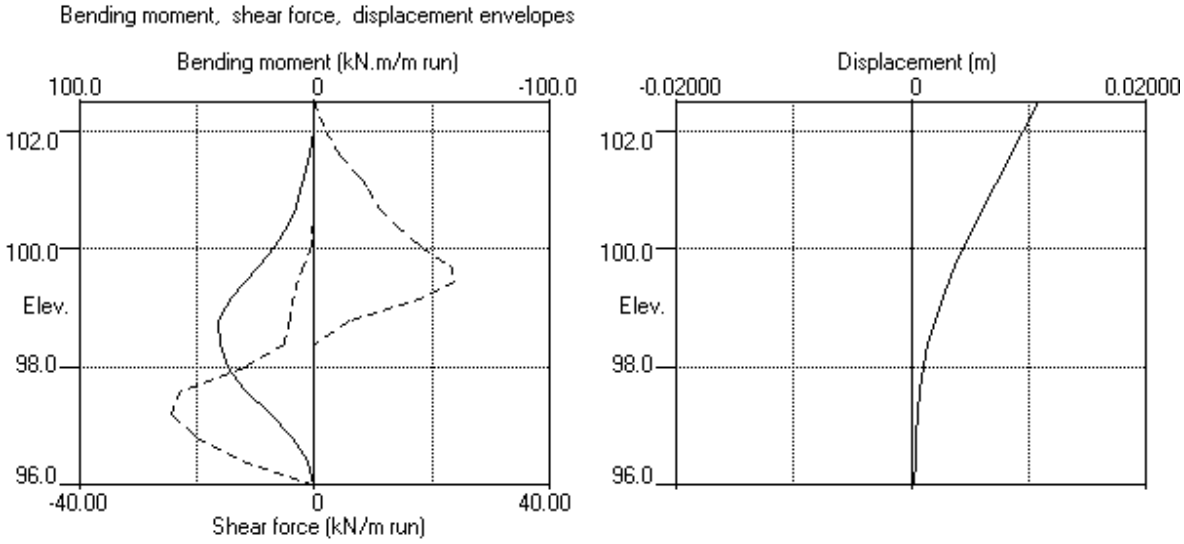
Stage no.	Bending moment maximum kN.m/m	Bending moment elev.	Bending moment minimum kN.m/m	Bending moment elev.	Shear force maximum kN/m	Shear force elev.	Shear force minimum kN/m	Shear force elev.
1	2.6	100.40	-0.0	102.50	2.0	101.00	-1.0	98.80
2	10.5	100.05	-0.0	102.50	9.3	101.00	-4.0	98.80
3	40.8	98.80	0.0	102.50	23.7	99.45	-24.2	97.20
4	40.8	98.80	0.0	102.50	23.7	99.45	-24.2	97.20

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	Displacement elev.	Displacement minimum m	Displacement elev.	Stage description
1	0.000	102.50	0.000	102.50	Apply surcharge no.1 at elev. 102.50
2	0.002	102.50	0.000	102.50	Excav. to elev. 101.20 on PASSIVE side
3	0.011	102.50	0.000	102.50	Excav. to elev. 99.70 on PASSIVE side
4	0.011	102.50	0.000	102.50	Change soil type 2 to soil type 5

Summary of results (continued)

Units: kN,m


Bending moment, shear force, displacement envelopes
Bending moment (kN.m/m run)
100.0
0
-100.0
102.0
100.0
Elev.
98.0
96.0
-40.00
0
40.00
Shear force (kN/m run)
Displacement (m)
-0.02000
0
0.02000
102.0
100.0
Elev.
98.0
96.0

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Soil types Passive side
1	102.50	1 Granular Made Ground	1 Granular Made Ground
2	101.00	3 Sand	3 Sand
3	98.00	2 Firm Clay	2 Firm Clay

SOIL PROPERTIES (Unfactored SLS soil strengths)

No.	Soil type -- Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC Nu	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Granular	18.00a	0	0.531	NC	0.285	4.633	
	Made Ground	20.00b	(5000)		(0.250)	(0.000)	(0.000)	
2	Firm Clay	18.00	55000	1.000	OC	1.000	1.000	55.00u
					(0.490)	(2.389)	(2.390)	
3	Sand	19.00a	20000	0.470	OC	0.262	5.284	
	(101.00)	21.00b	(3000)		(0.300)	(0.000)	(0.000)	
4	Not defined							
5	Firm Clay - Drained	18.00	44000	0.817	OC	0.353	3.413	0.0d
					(0.200)	(1.388)	(5.175)	

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

Additional soil parameters associated with Ka and Kp

No.	Soil type Description	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Granular Made Ground	30.00	0.631	0.00	30.00	0.631	0.00
2	Firm Clay	0.00	0.500	0.00	0.00	0.500	0.00
3	Sand	32.00	0.625	0.00	32.00	0.625	0.00
4	Not defined						
5	Firm Clay - Drained	25.00	0.642	0.00	25.00	0.642	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	96.00	96.00

Automatic water pressure balancing at toe of wall : No

Water press. profile no.	Active side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2	Passive side Point no.	Elev. m	Piezo elev. m	Water press. kN/m2
1	1	96.00	96.00	0.0	1	96.00	96.00	0.0

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 96.00
Maximum finite element length = 0.40 m
Youngs modulus of wall E = 2.1000E+08 kN/m2
Moment of inertia of wall I = 2.1600E-04 m4/m run
(Arcelor PU12) E.I = 45360 kN.m2/m run
Yield Moment of wall = Not defined

STRUTS and ANCHORS

Strut/ anchor no.	Elev.	Strut spacing m	X-section area of strut sq.m	Youngs modulus kN/m2	Free length m	Inclin -ation (degs)	Pre- stress /strut kN	Tension allowed
1	101.70	1.00	0.100000	2.100E+08	3.00	0.00	0	No

SURCHARGE LOADS

Surch -arge no.	Elev.	Distance from wall	Length parallel to wall	Width perpend. to wall	Surcharge ----- kN/m2 ----- Near edge	Far edge	Equiv. soil type	Partial factor/ Category
1	102.50	0.00(A)	20.00	15.00	5.00	=	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 102.50
2	Excavate to elevation 101.20 on PASSIVE side
3	Excavate to elevation 99.70 on PASSIVE side
4	Change properties of soil type 2 to soil type 5 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 = 2.000
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) = 4.500 m

Boundary conditions:
Length of wall (normal to plane of analysis) = 30.00 m

Width of excavation on active side of wall = 15.00 m
Width of excavation on passive side of wall = 15.00 m

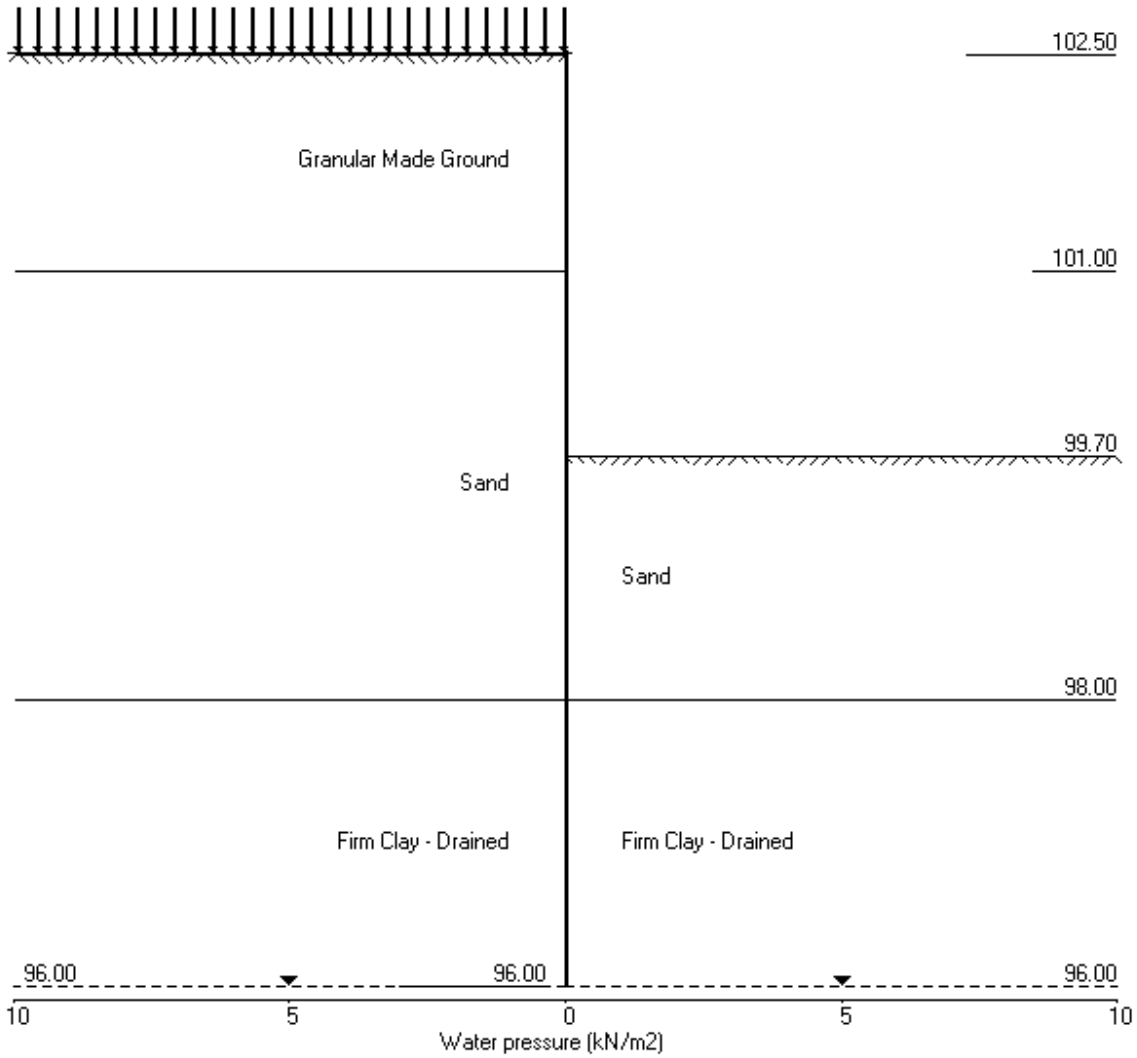
Distance to rigid boundary on active side = 20.00 m
Distance to rigid boundary on passive side = 15.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement, Bending mom., Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 102.50	No	No	No
2	Excav. to elev. 101.20 on PASSIVE side	Yes	No	No
3	Excav. to elev. 99.70 on PASSIVE side	Yes	No	No
4	Change soil type 2 to soil type 5	Yes	No	No
*	Summary output	Yes	-	Yes

Units: kN,m

Stage No.4 Change soil type 2 to soil type 5



Units: kN,m

Stage No. 2 Excavate to elevation 101.20 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	Overall FoS for toe elev. = 96.00 Factor of Safety	Moment equilib. at elev.	Toe FoS = 1.000 Toe elev.	Wall Penetr -ation
2	102.50	101.20	Cant.	2.660	96.71	99.75	1.45

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m

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 15.00 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	102.50	3.21	0.005	1.19E-03	0.0	-0.0	
2	102.25	4.50	0.004	1.19E-03	1.0	0.1	
3	102.00	5.72	0.004	1.19E-03	2.2	0.5	
4	101.60	8.09	0.004	1.18E-03	5.0	1.9	
5	101.20	10.83	0.003	1.15E-03	8.8	4.8	
6	101.00	4.01	0.003	1.12E-03	10.3	6.7	
		-2.33	0.003	1.12E-03	10.3	6.7	
7	100.70	-7.98	0.003	1.07E-03	8.7	9.8	
8	100.40	-7.56	0.002	9.99E-04	6.4	12.0	
9	100.05	-7.06	0.002	9.00E-04	3.8	13.8	
10	99.70	-6.62	0.002	7.90E-04	1.4	14.6	
11	99.45	-6.36	0.002	7.09E-04	-0.2	14.8	
12	99.20	-5.90	0.001	6.28E-04	-1.7	14.6	
13	98.80	-3.60	0.001	5.04E-04	-3.6	13.5	
14	98.40	-1.72	0.001	3.93E-04	-4.7	11.7	
15	98.00	-0.26	0.001	2.99E-04	-5.1	9.7	
		-5.22	0.001	2.99E-04	-5.1	9.7	
16	97.60	-1.15	0.001	2.24E-04	-6.3	7.3	
17	97.20	1.89	0.001	1.71E-04	-6.2	4.6	
18	96.80	4.24	0.001	1.41E-04	-5.0	2.3	
19	96.40	6.25	0.001	1.28E-04	-2.9	0.7	
20	96.00	8.12	0.000	1.25E-04	0.0	0.0	

(continued)

Stage No.2 Excavate to elevation 101.20 on PASSIVE side

Units: kN,m

Stage No. 3 Excavate to elevation 99.70 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	Overall FoS for toe elev. = 96.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
3	102.50	99.70	Cant.	1.158	96.71	96.58	3.12

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m

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 15.00 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	102.50	2.32	0.025	5.35E-03	0.0	-0.0	
2	102.25	3.92	0.023	5.35E-03	0.8	0.1	
3	102.00	5.52	0.022	5.35E-03	2.0	0.5	
4	101.60	8.09	0.020	5.34E-03	4.7	1.7	
5	101.20	10.65	0.018	5.31E-03	8.4	4.4	
6	101.00	11.94	0.017	5.29E-03	10.7	6.3	
		11.08	0.017	5.29E-03	10.7	6.3	
7	100.70	12.97	0.015	5.23E-03	14.3	10.2	
8	100.40	14.85	0.014	5.15E-03	18.5	15.1	
9	100.05	17.05	0.012	5.00E-03	24.1	22.5	
10	99.70	19.24	0.010	4.79E-03	30.4	32.0	
11	99.45	3.11	0.009	4.59E-03	33.2	40.0	
12	99.20	-13.03	0.008	4.35E-03	32.0	48.3	
13	98.80	-38.86	0.006	3.88E-03	21.6	59.3	
14	98.40	-29.59	0.005	3.33E-03	7.9	66.0	
15	98.00	-20.44	0.003	2.74E-03	-2.1	66.7	
		-90.87	0.003	2.74E-03	-2.1	66.7	
16	97.60	-48.07	0.002	2.19E-03	-29.9	58.6	
17	97.20	-14.07	0.002	1.74E-03	-42.3	42.8	
18	96.80	13.40	0.001	1.44E-03	-42.5	24.7	
19	96.40	44.52	0.000	1.30E-03	-30.9	8.8	
20	96.00	109.88	-0.000	1.26E-03	0.0	-0.0	

(continued)

Stage No.3 Excavate to elevation 99.70 on PASSIVE side

Units: kN,m

Stage No. 4 Change properties of soil type 2 to soil type 5
Ko pressures will not be reset

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

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 96.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
4	102.50	99.70	Cant.	1.122	96.41	96.69	3.01

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 30.00m
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 15.00 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	102.50	2.32	0.027	5.69E-03	0.0	-0.0	
2	102.25	3.92	0.025	5.69E-03	0.8	0.1	
3	102.00	5.52	0.024	5.68E-03	2.0	0.5	
4	101.60	8.09	0.022	5.68E-03	4.7	1.7	
5	101.20	10.65	0.019	5.65E-03	8.4	4.4	
6	101.00	11.94	0.018	5.62E-03	10.7	6.3	
		11.08	0.018	5.62E-03	10.7	6.3	
7	100.70	12.97	0.017	5.57E-03	14.3	10.2	
8	100.40	14.85	0.015	5.49E-03	18.5	15.1	
9	100.05	17.05	0.013	5.34E-03	24.1	22.5	
10	99.70	19.24	0.011	5.13E-03	30.4	32.0	
11	99.45	3.11	0.010	4.93E-03	33.2	40.0	
12	99.20	-13.03	0.009	4.69E-03	32.0	48.3	
13	98.80	-38.86	0.007	4.21E-03	21.6	59.3	
14	98.40	-35.27	0.005	3.66E-03	6.8	66.0	
15	98.00	-25.25	0.004	3.08E-03	-5.3	65.8	
		-46.92	0.004	3.08E-03	-5.3	65.8	
16	97.60	-55.63	0.003	2.53E-03	-25.9	58.6	
17	97.20	-20.19	0.002	2.08E-03	-41.0	43.9	
18	96.80	9.93	0.001	1.77E-03	-43.1	25.9	
19	96.40	43.61	0.001	1.62E-03	-32.4	9.5	
20	96.00	118.22	-0.000	1.57E-03	0.0	-0.0	

(continued)

Stage No.4 Change properties of soil type 2 to soil type 5
Ko pressures will not be reset

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 = 2.000
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

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	Overall FoS for toe elev. = 96.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation
1	102.50	102.50	Cant.	Conditions not suitable for FoS calc.			
2	102.50	101.20	Cant.	2.660	96.71	99.75	1.45
3	102.50	99.70	Cant.	1.158	96.71	96.58	3.12
4	102.50	99.70	Cant.	1.122	96.41	96.69	3.01

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 30.00m
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 15.00 from wall

Limit State: ULS DA1 Combination 2

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement maximum m	Displacement minimum m	Bending moment maximum kN.m/m	Bending moment minimum kN.m/m	Shear force maximum kN/m	Shear force minimum kN/m
1	102.50	0.027	0.000	0.0	-0.0	0.0	0.0
2	102.25	0.025	0.000	0.1	0.0	1.0	0.0
3	102.00	0.024	0.000	0.5	0.0	2.2	0.0
4	101.60	0.022	0.000	1.9	0.0	5.0	0.0
5	101.20	0.019	0.000	4.8	0.0	8.8	0.0
6	101.00	0.018	0.000	6.7	0.0	10.7	0.0
7	100.70	0.017	0.000	10.2	0.0	14.3	0.0
8	100.40	0.015	0.000	15.1	0.0	18.5	0.0
9	100.05	0.013	0.000	22.5	0.0	24.1	0.0
10	99.70	0.011	0.000	32.0	0.0	30.4	-0.5
11	99.45	0.010	0.000	40.0	0.0	33.2	-0.8
12	99.20	0.009	0.000	48.3	0.0	32.0	-1.7
13	98.80	0.007	0.000	59.3	0.0	21.6	-3.6
14	98.40	0.005	0.000	66.0	0.0	7.9	-4.7
15	98.00	0.004	0.000	66.7	0.0	0.0	-5.3
16	97.60	0.003	0.000	58.6	0.0	0.0	-29.9
17	97.20	0.002	0.000	43.9	0.0	0.0	-42.3
18	96.80	0.001	0.000	25.9	0.0	0.0	-43.1
19	96.40	0.001	0.000	9.5	0.0	0.0	-32.4
20	96.00	0.000	-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 maximum kN.m/m	elev.	Bending moment minimum kN.m/m	elev.	Shear force maximum kN/m	elev.	Shear force minimum kN/m	elev.
1	4.0	100.05	-0.0	96.00	3.0	101.00	-1.4	97.60
2	14.8	99.45	-0.0	102.50	10.3	101.00	-6.3	97.60
3	66.7	98.00	-0.0	102.50	33.2	99.45	-42.5	96.80
4	66.0	98.40	-0.0	102.50	33.2	99.45	-43.1	96.80

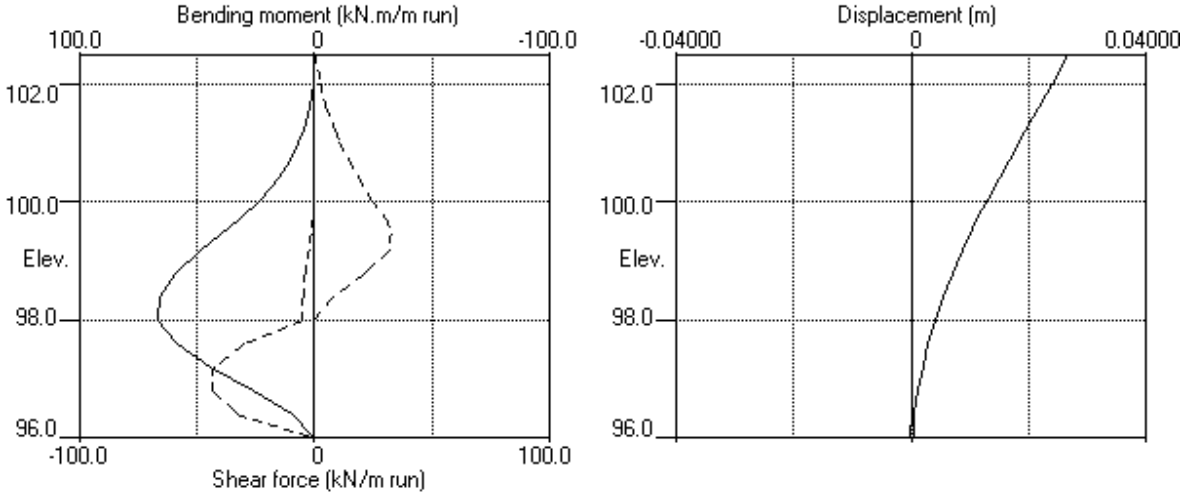
Maximum and minimum displacement at each stage

Stage no.	Displacement maximum m	elev.	Displacement minimum m	elev.	Stage description
1	0.001	102.50	0.000	102.50	Apply surcharge no.1 at elev. 102.50
2	0.005	102.50	0.000	102.50	Excav. to elev. 101.20 on PASSIVE side
3	0.025	102.50	-0.000	96.00	Excav. to elev. 99.70 on PASSIVE side
4	0.027	102.50	-0.000	96.00	Change soil type 2 to soil type 5

Summary of results (continued)

Units: kN,m

Bending moment, shear force, displacement envelopes



APPENDIX E

CGL Design Summary

Pile Walls

Section	Wall Type	Auger Diameter (mm)	Proposed Steel Section	Toe Level (mOD)	Top of Section (mOD)	Prop Level (mOD)	Prop Load - SLS (kN/m)	Max Prop Load - ULS (kN/m)	Max. Deflection (mm)
3	Sheet Piles	n/a	PU18-1	98	105.2	103	125.49	169.4	4
4	Sheet Piles	n/a	PU18-1	97.4	106.2	103	175.26	236.6	13
6	SecPW	600		90	100.5	98.5	86.39	128.75	20
7	SecPW	600		91	104	102.5	200.31	270.42	11
9	ShPW	N/A	PU12	96	102.2	101.7	15.9	21.47	2
10	ShPW	n/a	PU12	98	102.5	N/A	N/A	N/A	11

King Post Walls

Section	Wall Type	Auger Diameter (mm)	Steel Section	Toe Level (mOD)	Top of Section (mOD)	Prop Level (mOD)	Prop Load - SLS (kN/m)	Max Prop Load - ULS (kN/m)	Max. Deflection (mm)
1	King post at 2.5m spacing	600	254x254x107	96.5	104.4	103	133.52	180.25	6
2	King post at 2.5m spacing	600	254x254x107	96.5	104.4	103	133.52	180.25	6
5	Jacked King Post at 2.5m	600	305X305X283	96	105.5	104.7	49.67	67.05	4
8	King post at 2.5m spacing	600	305X305X283	98	104	103	33.55	45.23	13