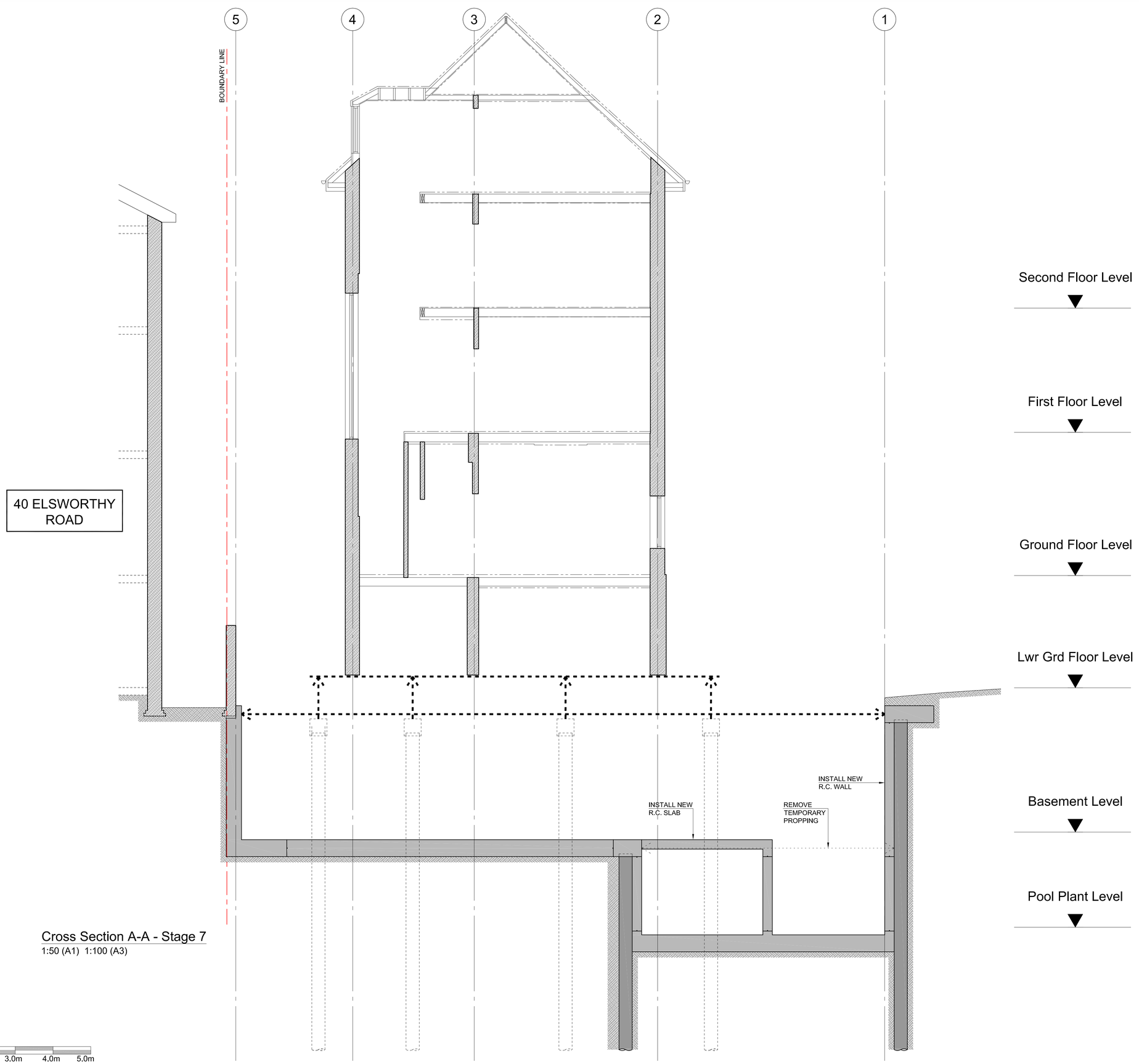

Cross Section A-A - Stage 7

1:50 (A1) 1:100 (A3)

0m 1.0m 2.0m 3.0m 4.0m 5.0m

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Rev.	Date	Amendment	Drawn	Chkd
P1	17.07.18	PRELIMINARY ISSUE	SMR	P.G

Drawing Status: PRELIMINARY

Form

Job Title

42 ELSWORTHY ROAD
LONDON
NW3 3DL

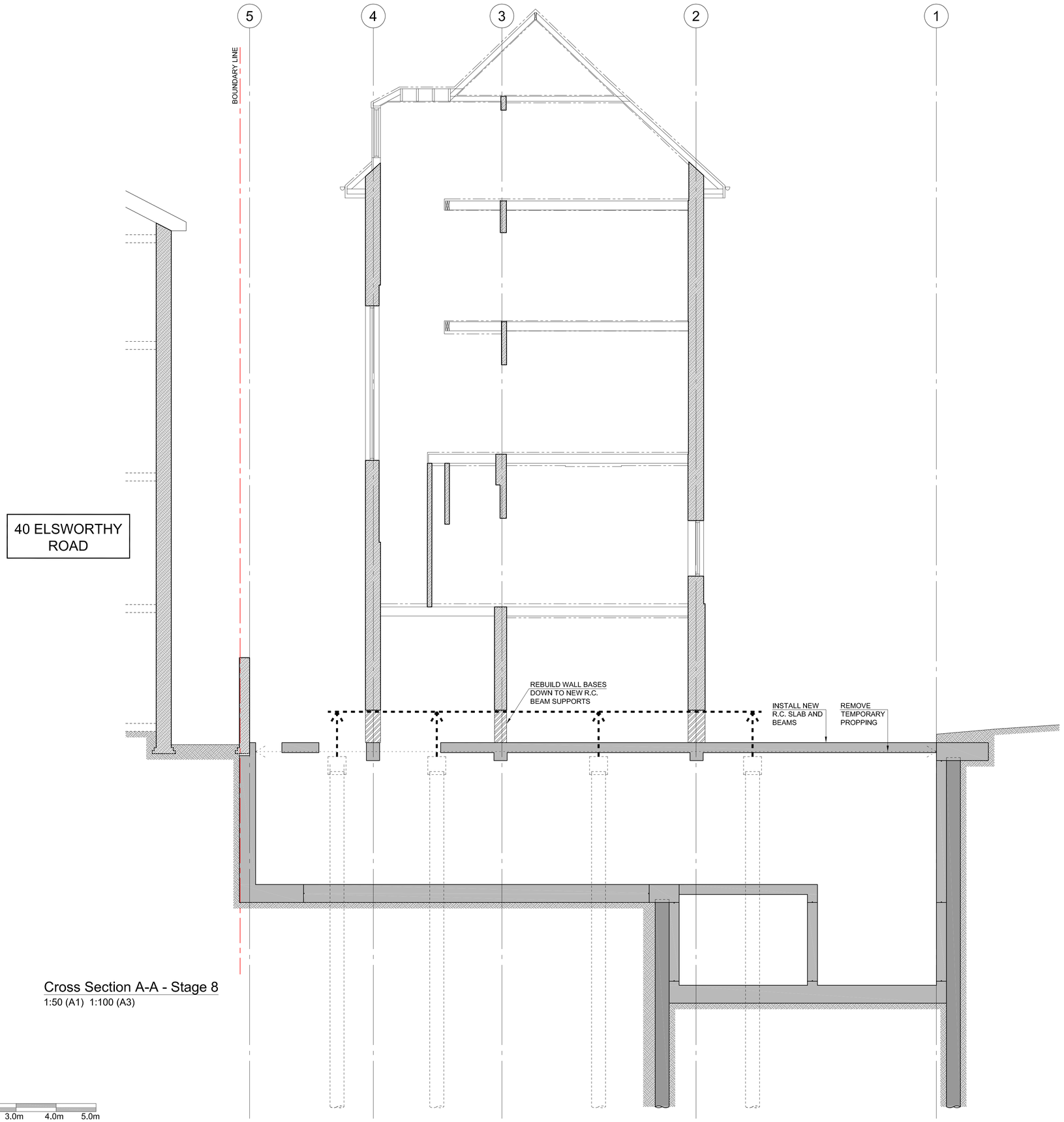
Drawing Title

OUTLINE CONSTRUCTION SEQUENCE - CROSS SECTION A-A STAGE 7

Form Structural Design Ltd 77 St John Street London EC1M 4NN
T:020 7253 2893 E:studio@form-sd.com W:www.form-sd.com

Date	Scale	Drawn	Checked
June 18	1:50 (A1)	SMR	PG

Job No.	Drawing No.	Revision
172843	A(30)07	P1



Cross Section A-A - Stage 8

1:50 (A1) 1:100 (A3)

0m 1.0m 2.0m 3.0m 4.0m 5.0m

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June 18	1:50 (A1)	SMR	PG

Job No.	Drawing No.	Revision
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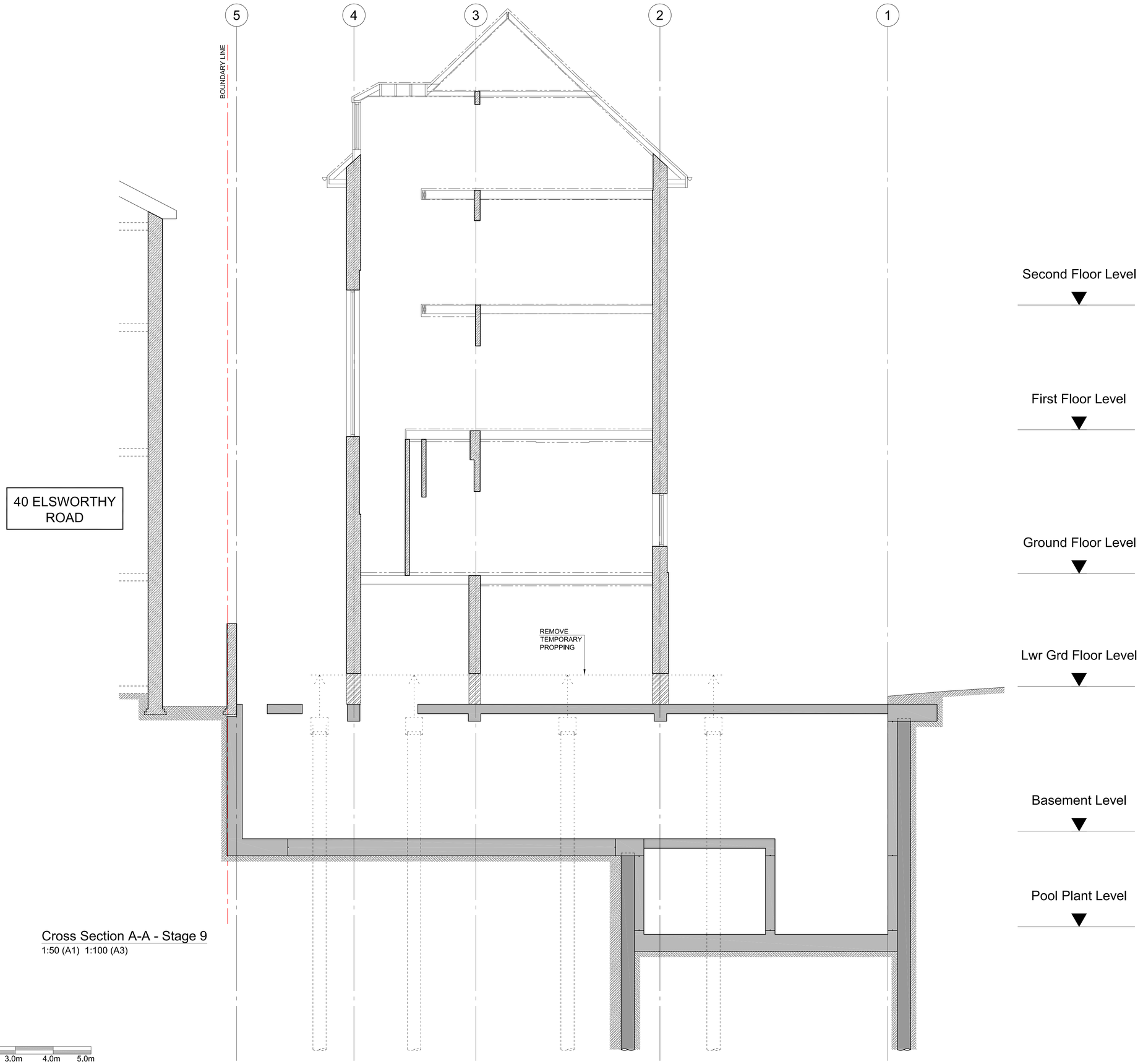

Cross Section A-A - Stage 9

1:50 (A1) 1:100 (A3)

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Drawing Title
OUTLINE CONSTRUCTION SEQUENCE - CROSS SECTION A-A STAGE 9

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Date	Scale	Drawn	Checked
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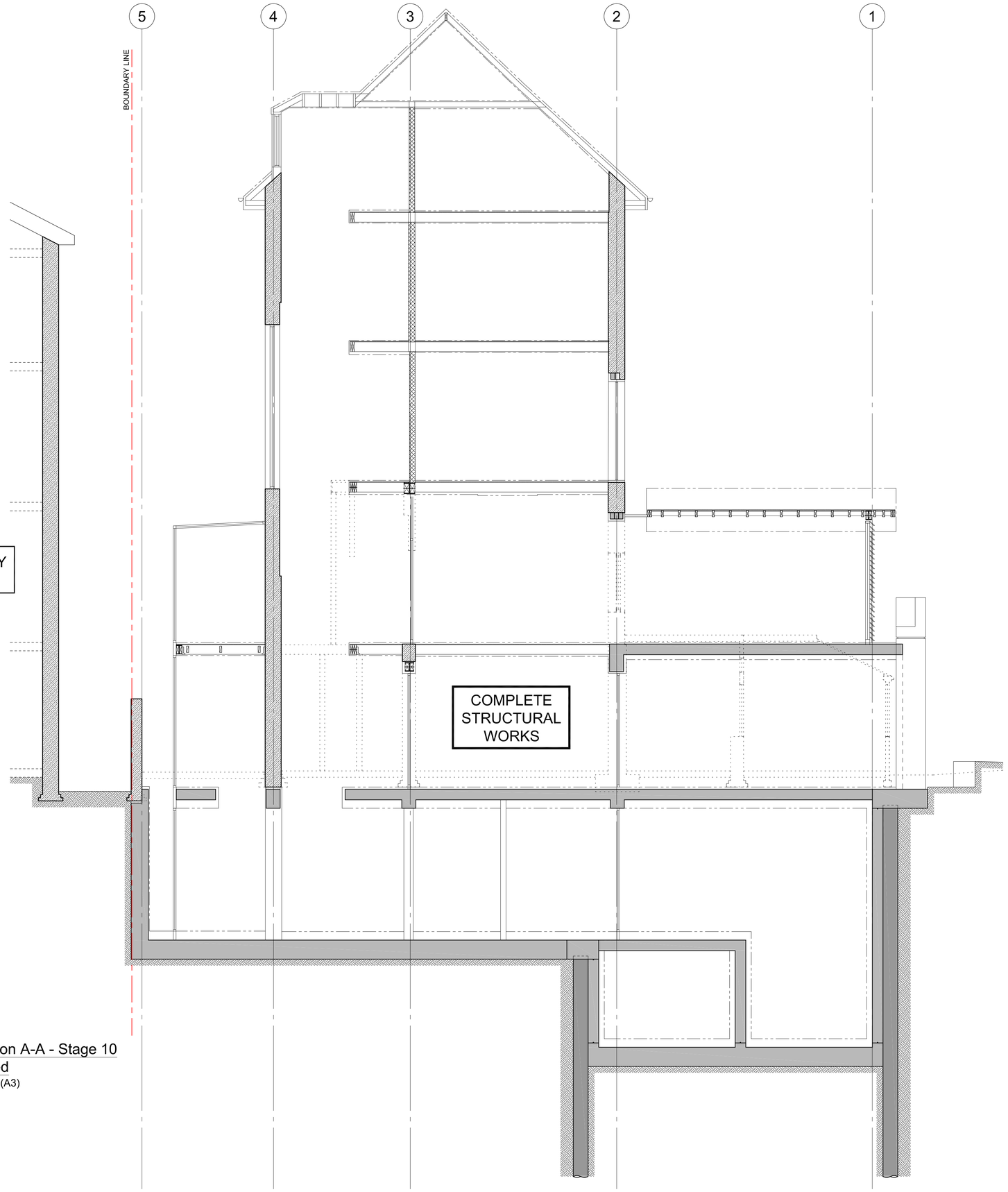
Job No.	Drawing No.	Revision
172843	A(30)09	P1



Cross Section A-A - Stage 10
As Proposed
1:50 (A1) 1:100 (A3)

Notes

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Job Title
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LONDON
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Drawing Title
OUTLINE CONSTRUCTION SEQUENCE - CROSS SECTION A-A
STAGE 10 - AS PROPOSED

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June 18	1:50 (A1)	SMR	PG

Job No.	Drawing No.	Revision
172843	A(30)10	P1

APPENDIX B

Plaxis 3D analysis

1. INTRODUCTION

1.1 Underpinning

The method of underpinning existing foundations has become almost routine in London over the past 8 to 10 years, with the rapid proliferation of basement developments within the city. The method consists of sequentially excavating the soils beneath a foundation to the new basement level and casting a new deeper concrete foundation beneath the existing footing to enable loads to be transferred to depth. Once all of the underpins are constructed, the basement may be excavated.

The method is shown graphically in Plate 1 below, this is Figure 20 from Arup's Geological, Hydrogeological, and Hydrological Study of Camden[1].

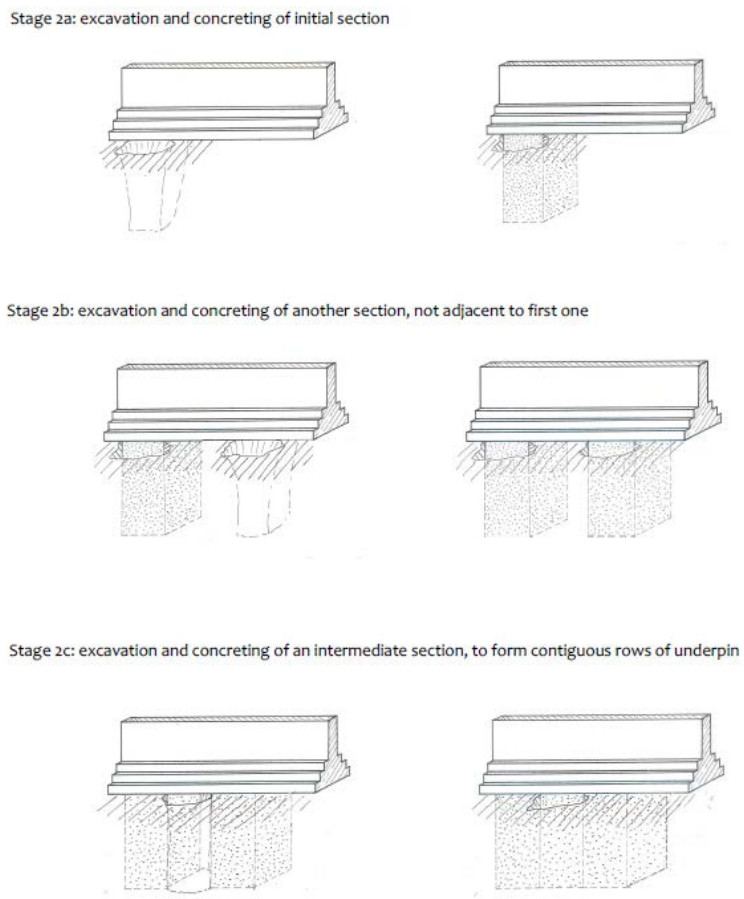


Plate 1: Underpinning (Arup Figure 20)

[1] Arup Ltd, 2010, London Borough of Camden, Camden geological, hydrogeological, and hydrological study, guidance for subterranean development.

The connection between the existing foundation and the top of the underpin is typically formed using a dry pack concrete, rammed home to create a solid connection.

1.2 Ground movements caused by underpinning

In the majority London situations, party wall foundations are directly underpinned, giving rise to a potential settlement of the foundation as the dry pack settles, and as the loads are transferred to soils at depth that have previously not supported foundation loads. In these conditions it is relatively straightforward to asses settlement, and to calculate a corresponding building damage category for the affected neighbouring structure.

In the case of Elsworthy Road, there is no party wall foundation and the underpin wall is to be constructed some 1.7m in front of the neighbouring foundation. Therefore, the effect of dry-pack compression and load transfer to depth is not a consideration in generating ground movements. What is a consideration, however, is elastic movements within the London Clay as the excavation proceeds. As each excavation face is opened, there is a relaxation of stresses at the face of the clay which will lead to lateral and horizontal movements. The amount of movement is dependent on the stiffness of the clay and on the at-rest (K_0) earth pressures (the ratio of horizontal to vertical stress within the undisturbed soil).

At rest (K_0) earth pressures within the London Clay vary with depth from up to 2.5 to 3.5 at shallow depth, reducing to approximately 1.0 at depth – recorded as 30m approximately in detailed investigations[2]. This is thought to have been caused by historical overburden pressures on the London Clay causing significant over-consolidation of the soils. The implications are that horizontal stresses are some 2 to 3 times higher than vertical stresses at the ground surface and that therefore horizontal relaxation of stresses could potentially give rise to lateral movements of the surrounding ground; and with it, neighbouring foundations.

[2] Hight. W et al. (2007), Characteristics of the London Clay from the Terminal 5 site at Heathrow Airport; Geotechniqure, 57, No. 1, 3-18.

2. PLAXIS 3D ANALYSIS

2.1 Introduction

CGL has carried out a simplified PLAXIS 3D analysis exercise to investigate the potential for ground movements arising from the installation of underpin foundations in front of the boundary wall (No. 40 Elsworthy Road) for the proposed basement. PLAXIS 3D is three dimensional finite element analysis software specifically designed for geotechnical analysis and soil structure interaction.

2.2 Parameters

For the purpose of this investigation the London Clay is assumed to be a linear elastic material. Whilst not strictly representative of the London Clay, it is considered that the use of this model provides a conservative estimate of ground movements as it does not allow for small strain stiffness of the clay and non-linearity of movement profiles. The assumption of linear elastic behaviour would be expected to overestimate displacements at distance from the underpinned wall[3].

Parameters have been derived from the main body of the report and are summarised below. Drained parameters have been assumed throughout to provide additional conservatism to the assessment.

Table D1: Geotechnical Parameters

Stratum	*Design Level (mOD)*	*Bulk Unit Weight, γ_b (kN/m^3)*	*Drained Young's Modulus, E' (MPa)*	*Poisson's ratio*
Made Ground (cohesive)	47.0	18	19.5[e]	0.2
Weathered London Clay/ London Clay Formation	45.6	20	31.5 + 3.15z[a,e]	0.2
Concrete	n/a	25	2.8e4	0.15

2.3 Construction sequence

The construction sequence modelled is summarised below:

1. Phase 1 – existing condition, ground level at 47mOD, neighbouring foundation assumed at 46.5mOD and set back 1.7m from line of underpinning. Surcharge taken to be 200kPa.

[3] Jardine, R.J., Potts, A.B., Fourie, A.B., and Burland, J.B., Studies of the influence of non-linear stress-strain characteristics in soil-structure interaction (1986), Geotechnique, 36, No. 3, 377-396.

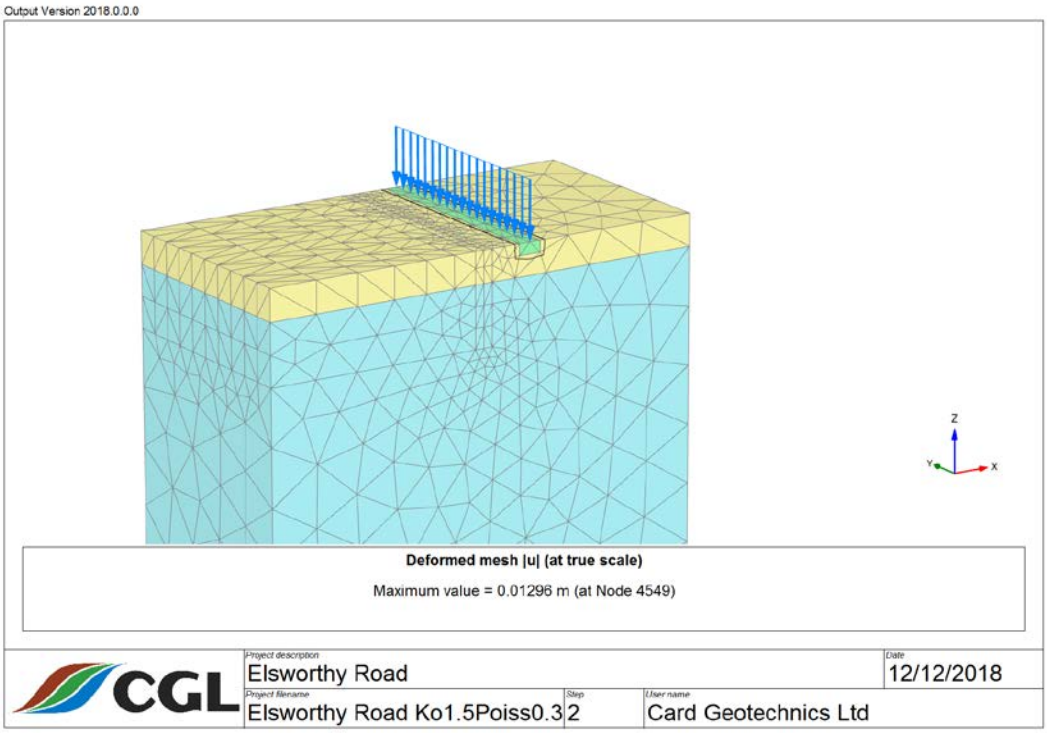


Plate 2: Underpinning (Arup Figure 20)

2. Phase 2 – Excavate first stage underpins, assume 1m wide underpin parallel to foundation (as shown on Form SD drawings).

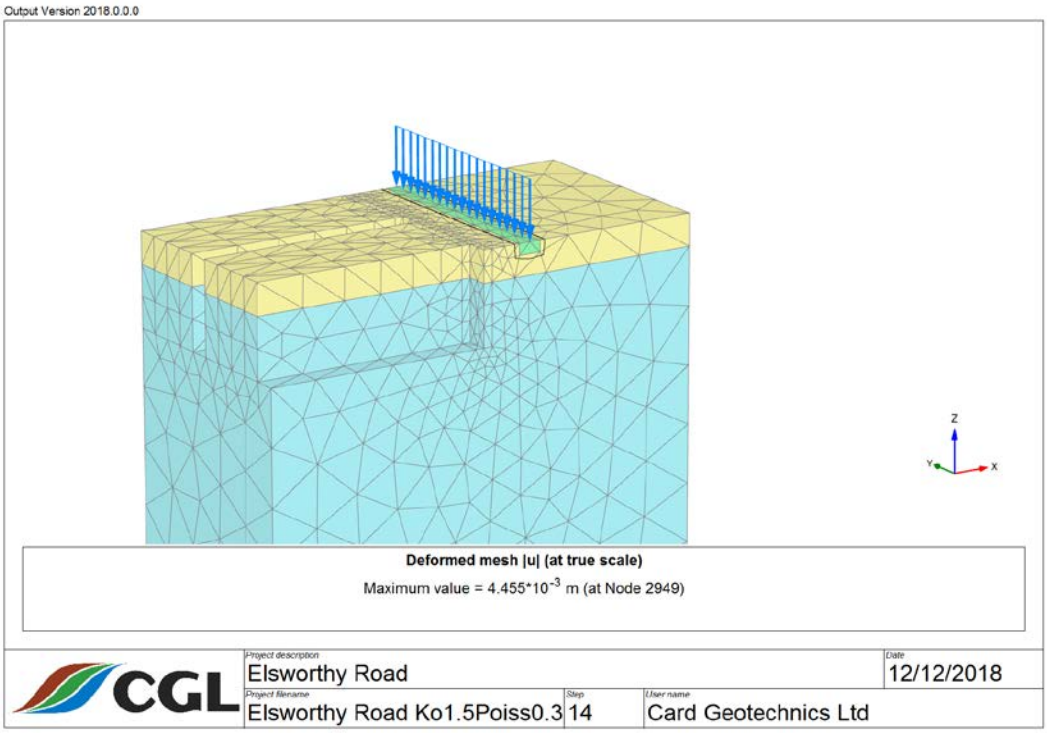


Plate 3: Phase 2 setup

3. Phase 3 – Excavate second stage underpins, concrete first stage – fixed x/y displacements on underpin top face to model propping.

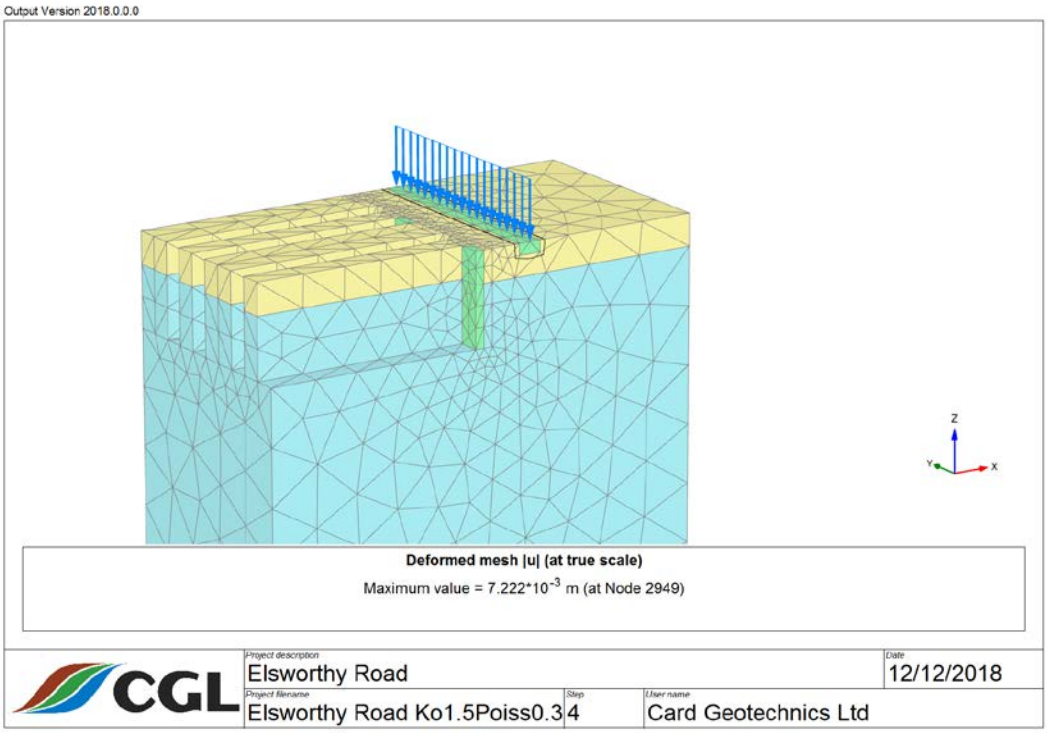


Plate 4: Phase 3 setup

4. Phase 4 – Excavate third stage underpins, concrete second stage.

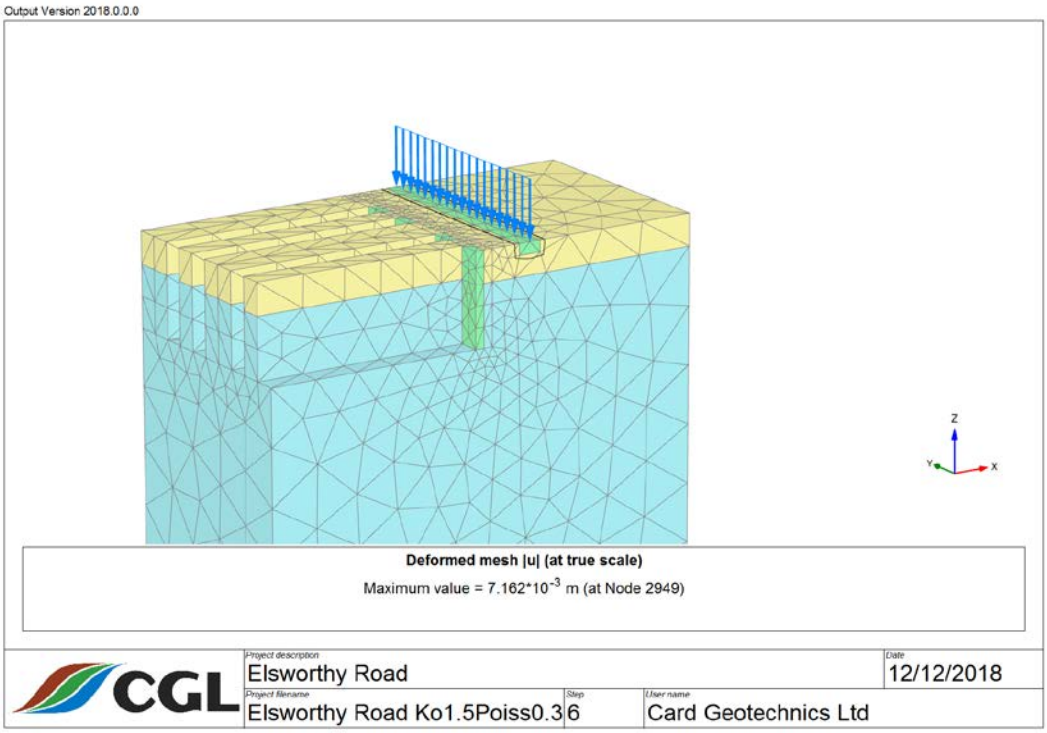


Plate 5: Phase 4 setup

5. Phase 5 – Excavate fourth stage underpins, concrete third stage

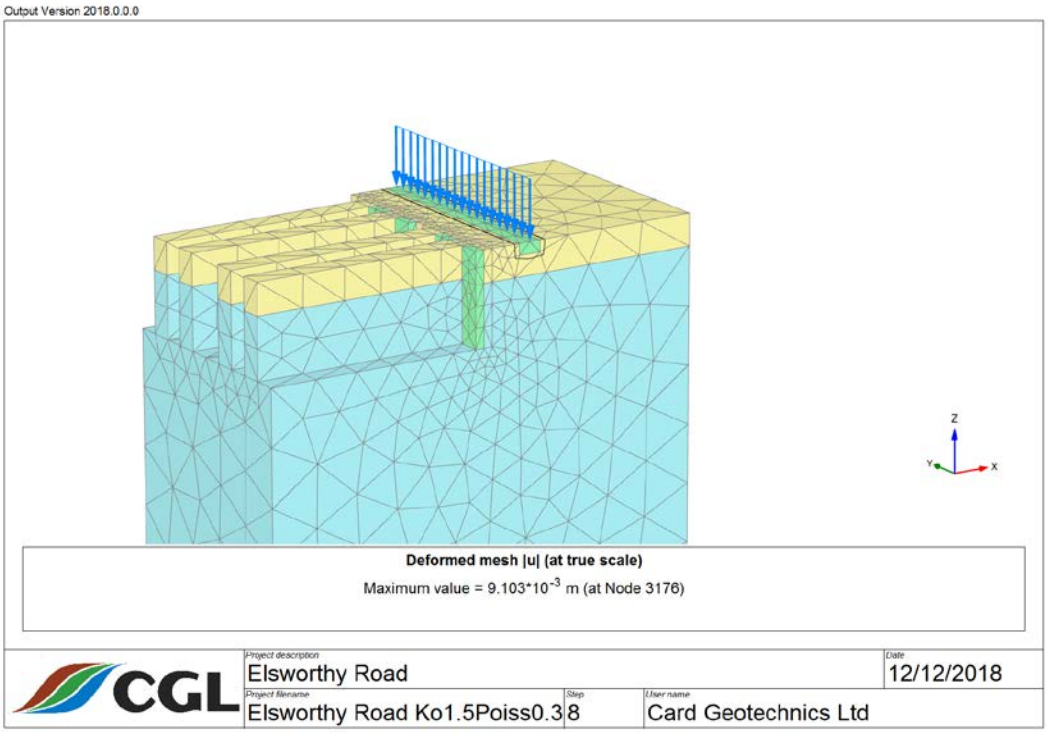


Plate 6: Phase 5 setup

6. Phase 6 – Excavate fifth stage underpins, concrete fourth stage

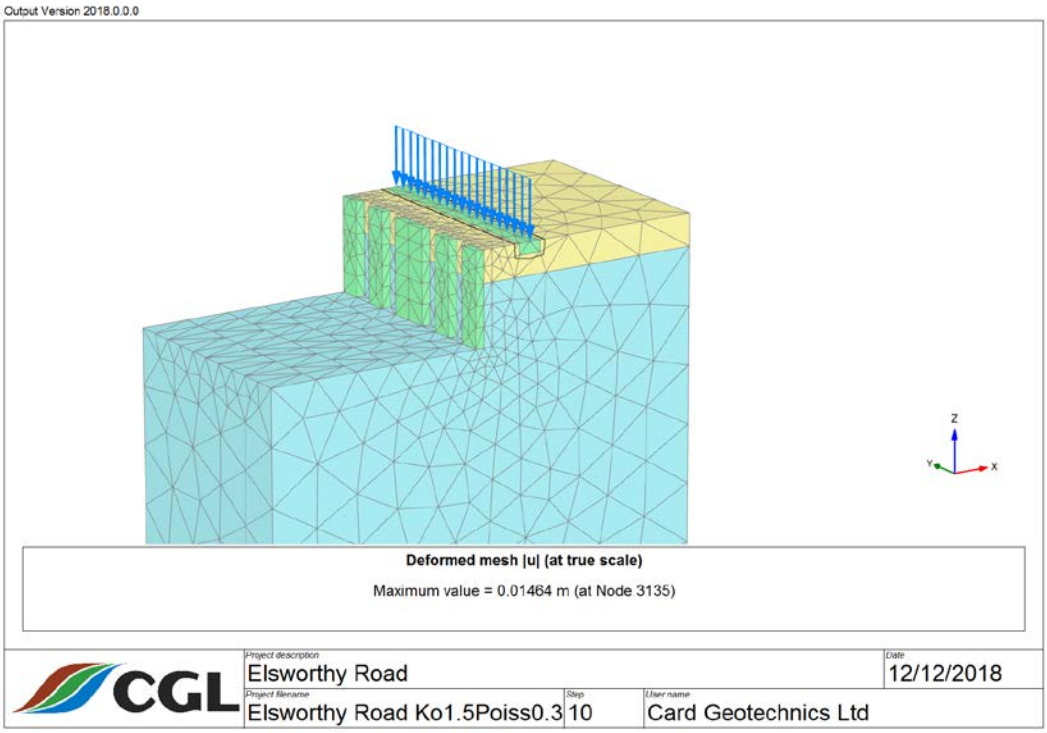


Plate 7: Phase 6 setup

7. Phase 7 – Final concreting

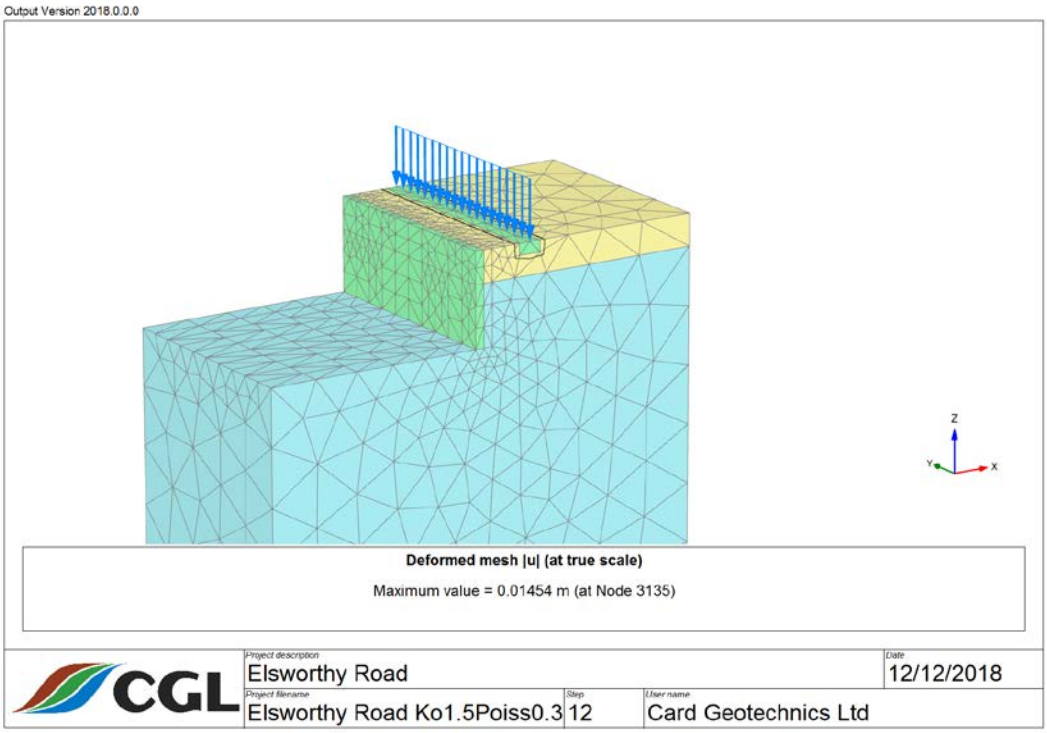


Plate 8: Phase 7 setup

The underpins are modelled as propped at ground surface at each stage using fixed displacement points in the horizontal (x/y) directions. This assumes a good standard of propping.

The existing foundation is modelled as a concrete volume supporting a line load.

2.4 Results

The impact of the underpinning on the adjacent foundation are summarised in the plates below, a series of sensitivity analyses were undertaken to assess the impact of ko on predicted movements. Negative movements in the x direction are towards the underpin wall, positive movements in the z direction are heave movements.

All results are taken from Phase 7, once all underpinning is completed.

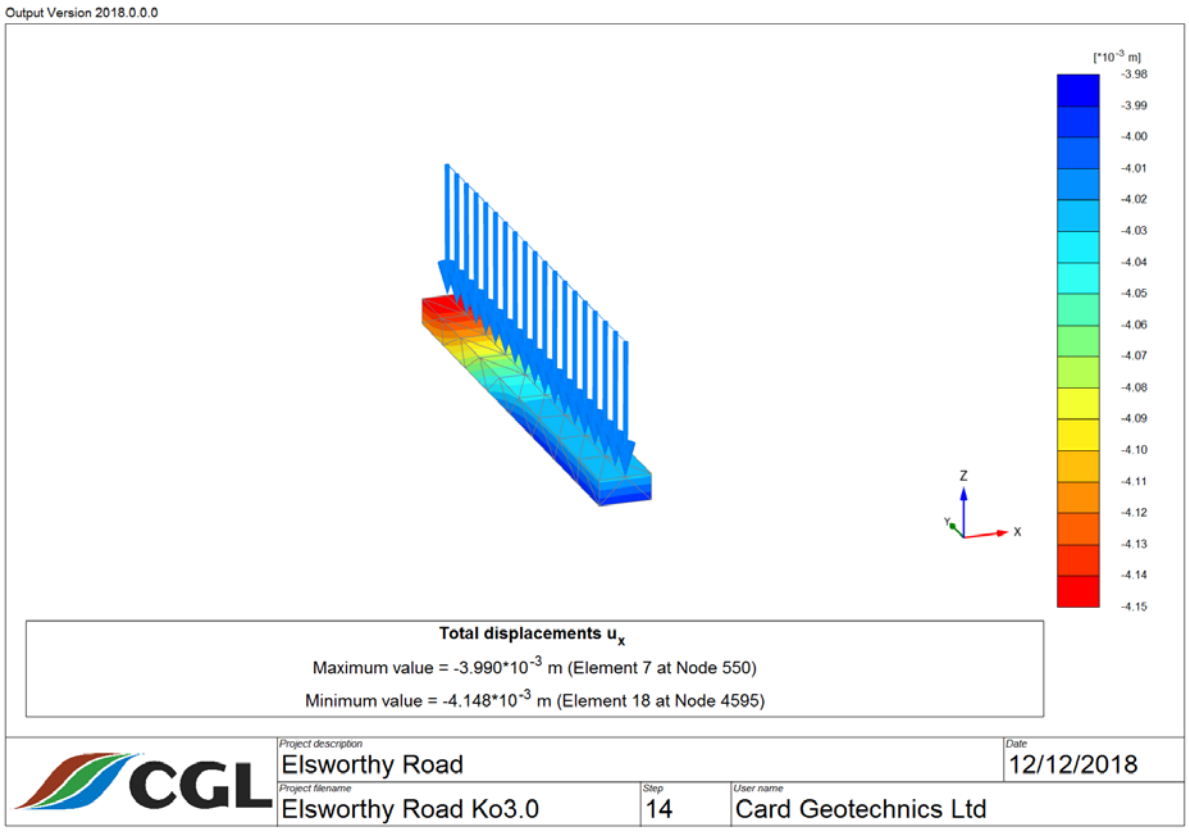


Plate 9: Ko = 3.0, horizontal movements

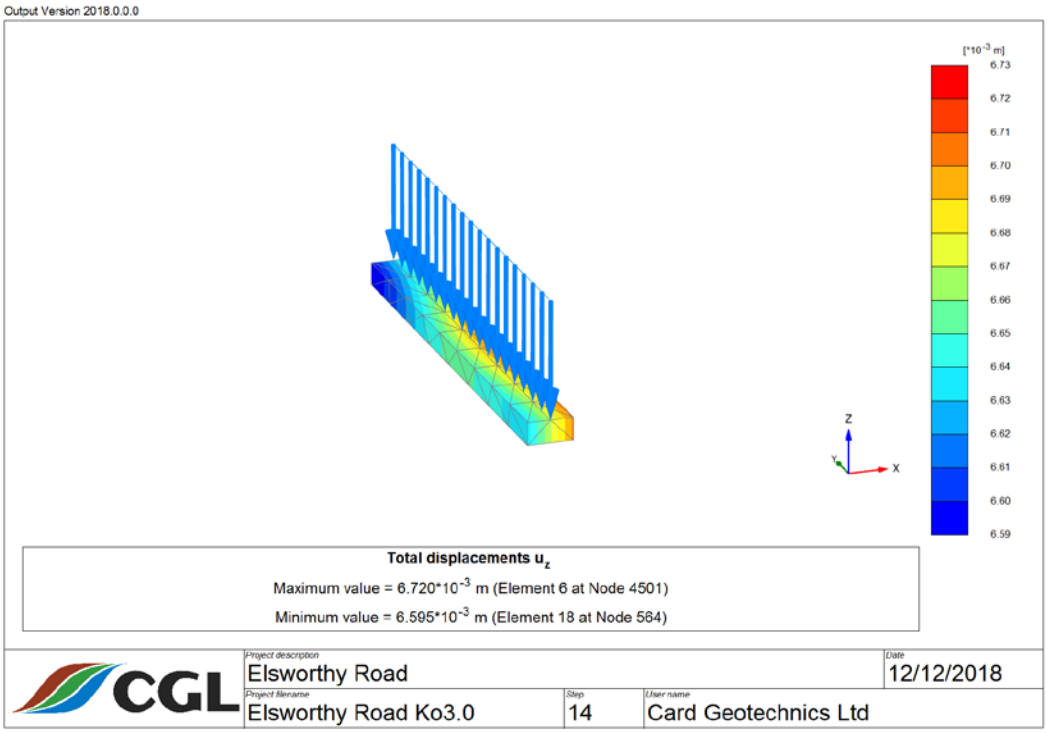


Plate 10: Ko = 3.0, vertical movements

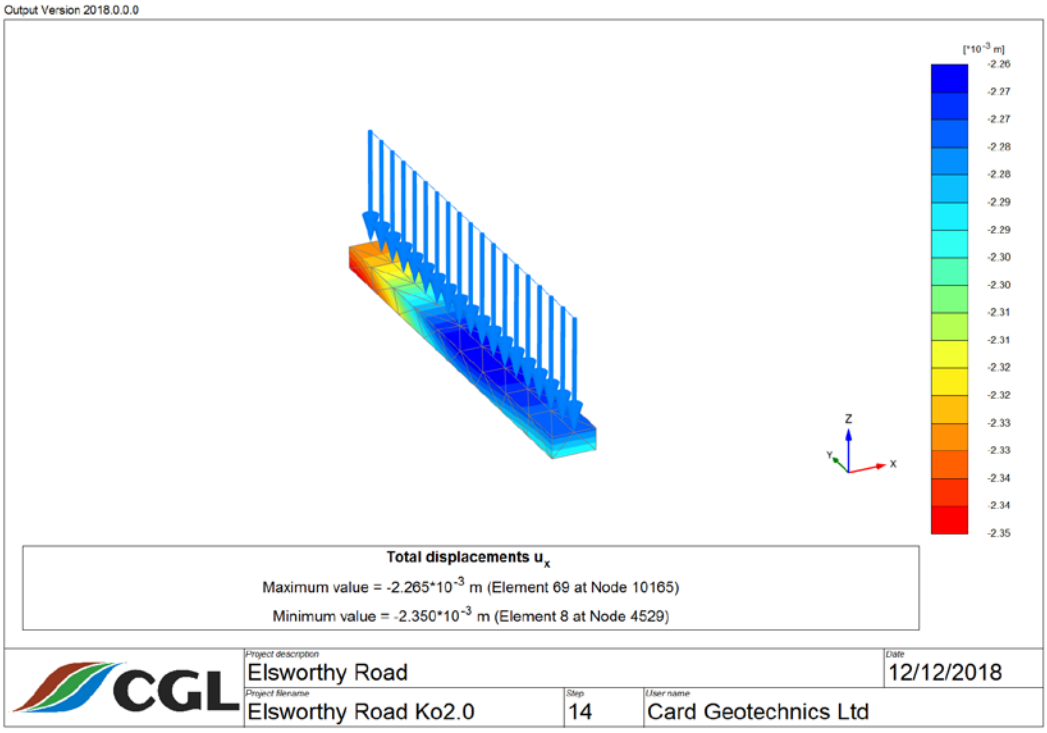


Plate 11: Ko = 2.0, horizontal movements

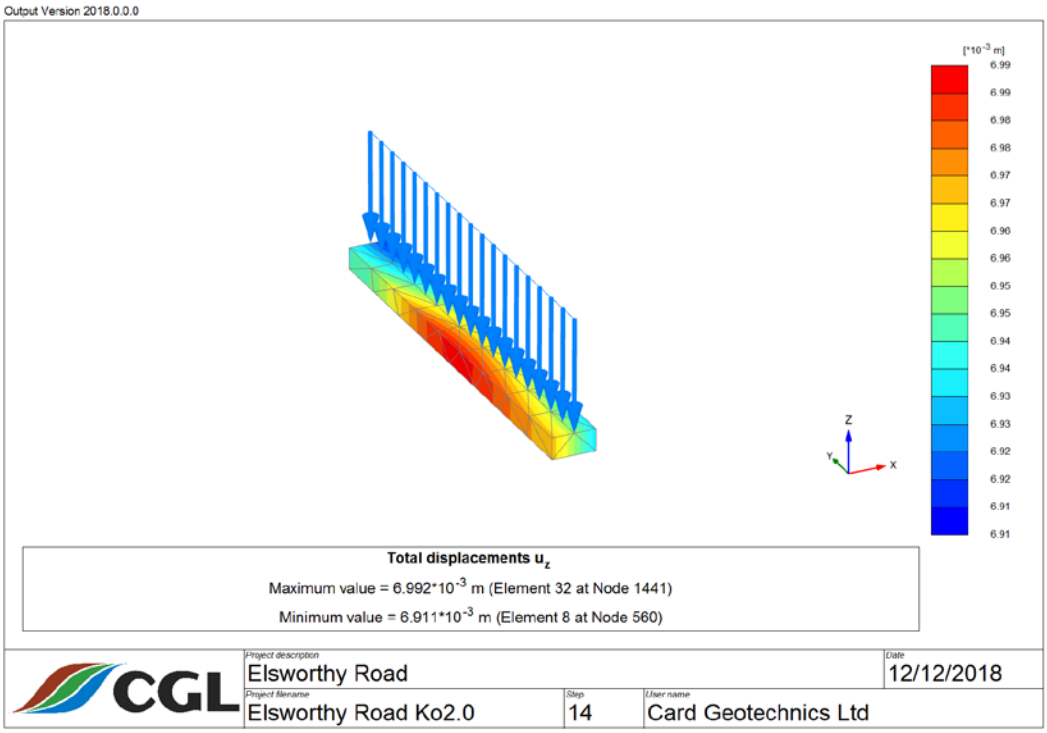


Plate 12: Ko 2.0, vertical displacements

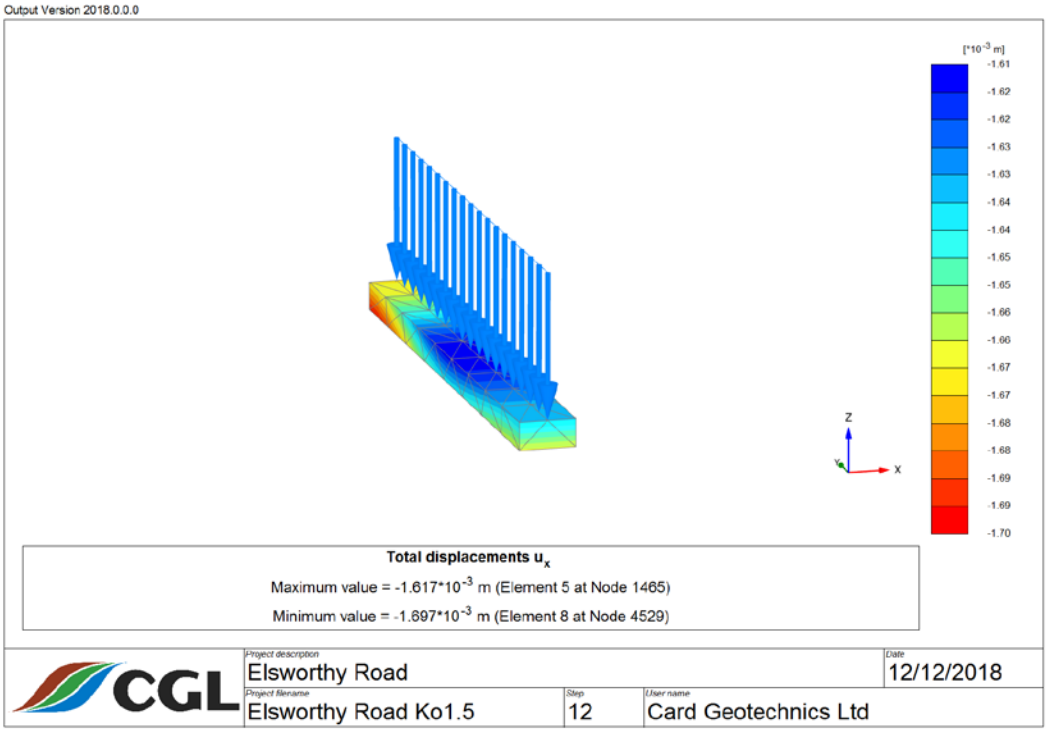


Plate 13: Ko 1.5, horizontal movements

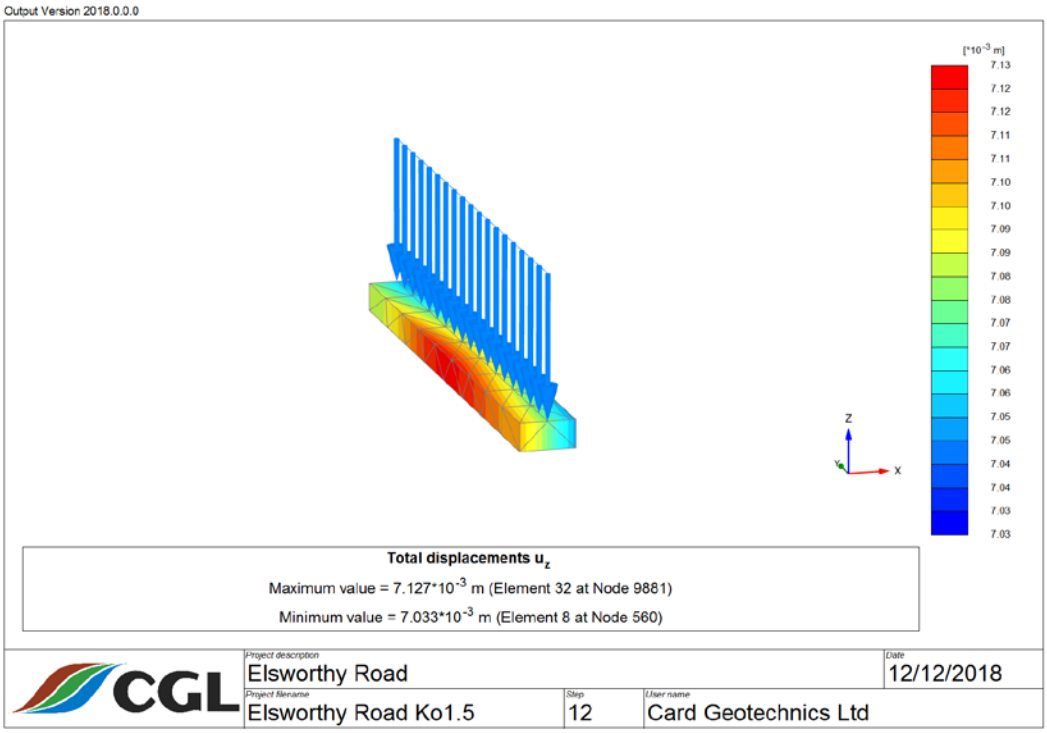


Plate 14: Ko 1.5, vertical movements

2.5 Plaxis results – fixed underpins

It is noted that the displacements calculated above include influences of both installation and deflection of the underpin wall. A separate model was therefore created to assess installation movements only, in this model a fixed surface displacement was applied on each underpin face to prevent it from moving. The resulting foundation movements (for a Ko = 3) are illustrated below.

It is noted that lateral movements are approximately 50% lower than previously recorded, vertical movements are not significantly affected.

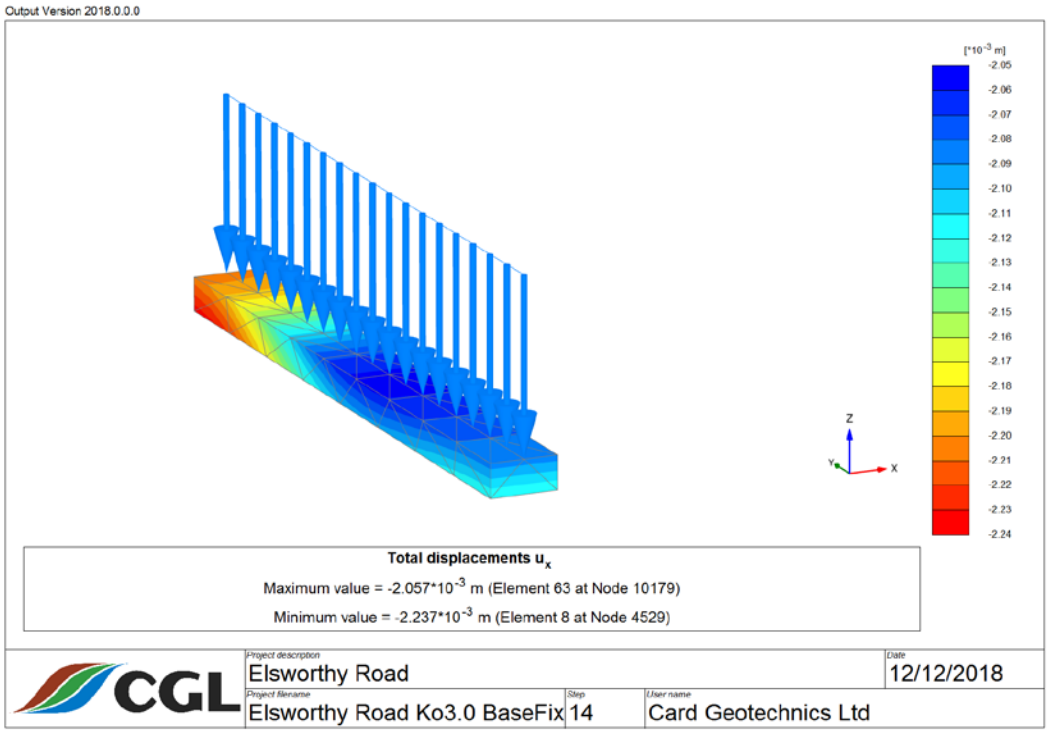


Plate 15: Ko 3.0, lateral movements (fixed underpins)

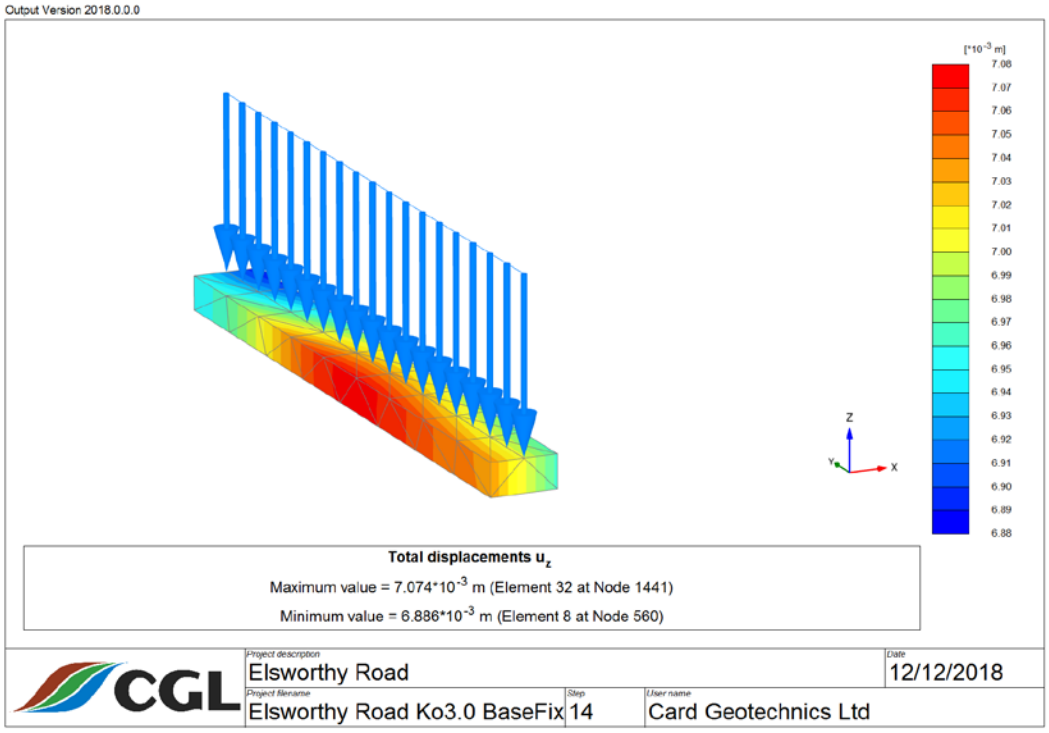


Plate 16: Ko 3.0, vertical movements (fixed underpins)

3. RESULTS SUMMARY AND DISCUSSION

The results of the PLAXIS analysis are summarised in Table 1 below.

Table 1: Summary of results – (foundation displacement, final stage)

Ko	Total Lateral displacement (mm)	Vertical Displacement (mm)[a]
3	4.0	6.7
2	2.3	7.0
1.5	1.7	7.1

a. *Note that these displacements are upwards, and derived from excavation heave. Vertical installation movements/settlements predicted are negligible.*

It is evident that Ko value has a strong influence on horizontal movement with foundation displacements ranging from 4.0mm to 1.7mm over the values selected. Based on the assessment with fixed underpins, the installation movement is approximately 50% of the total, equating to total lateral movements of 0.05% wall depth (taken as 4.1m) equivalent to what has historically been recorded for contig/secant piled walls in stiff clays.

Vertical movements are not predicted, these are dominated by heave movements with all predicted vertical movements being upwards.

APPENDIX C

WALLAP analysis of underpin foundation lateral deflection

CARD GEOTECHNICS LIMITED | Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55 | Job No. CG28854
Licensed from GEOSOLVE | Made by : TBP
Data filename/Run ID: Underpin deflection |
42 Elswprthy Road | Date:12-12-2018
Underpin deflection | Checked :

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Left side	Right side
1	46.33	1 Made Ground	1 Made Ground
2	45.60	2 London Clay	2 London 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	Made Ground	18.00	26000	1.500	OC (0.490)	1.000 (2.570)	1.000 (2.571)	65.00u
2	London Clay (45.60)	20.00	42000 (4200)	1.000	OC (0.490)	1.000 (2.570)	1.000 (2.571)	70.00u (7.000)
3	Made Ground (drained	18.00	19500	0.577	NC (0.200)	0.340 (1.415)	3.627 (5.634)	0.0d
4	London Cl.. (45.60)	20.00	31500 (3150)	0.642	OC (0.200)	0.404 (1.552)	2.858 (4.839)	5.000d

Additional soil parameters associated with Ka and Kp

No.	Soil type	--- parameters for Ka --- Soil friction angle	Wall adhesion coeff.	Back-fill angle	--- parameters for Kp --- Soil friction angle	Wall adhesion coeff.	Back-fill angle
1	Made Ground	0.00	1.000	0.00	0.00	1.000	0.00
2	London Clay	0.00	1.000	0.00	0.00	1.000	0.00
3	Made Ground (drained	25.00	1.000	0.00	25.00	1.000	0.00
4	London Clay (drained	21.00	1.000	0.00	21.00	1.000	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Left side	Right side
Initial water table elevation	0.00	0.00

Automatic water pressure balancing at toe of wall : No

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 42.55
Maximum finite element length = 0.20 m
Youngs modulus of wall E = 2.8000E+08 kN/m2
Moment of inertia of wall I = 5.3333E-03 m4/m run
E.I = 1.4933E+06 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	46.33	2.00	1.000000	50000	1.00	0.00	0	No
2	42.78	1.00	0.450000	2.800E+07	17.00	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	46.33	1.70(L)	1000.00	2.70	200.00	=	N/A	1.00 -

Note: L = Left side, R = Right 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 46.33
	No analysis at this stage
2	Install strut or anchor no.2 at elevation 42.78
3	Install strut or anchor no.1 at elevation 46.33
4	Excavate to elevation 42.78 on RIGHT side
5	Change properties of soil type 1 to soil type 3
	Ko pressures will be reset
6	Change properties of soil type 2 to soil type 4
	Ko pressures will be reset

FACTORS OF SAFETY and ANALYSIS OPTIONS

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

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

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

Bending moment and displacement calculation:
Method - Subgrade reaction model using Influence Coefficients
Open Tension Crack analysis? - No
Non-linear Modulus Parameter (L) = 0 m

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

Width of excavation on Left side of wall = 20.00 m
Width of excavation on Right side of wall = 20.00 m

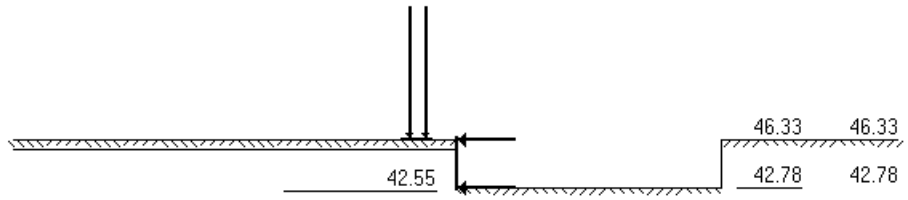
Distance to rigid boundary on Left side = 20.00 m
Distance to rigid boundary on Right side = 20.00 m

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 46.33	No	No	No
2	Install strut no.2 at elev. 42.78	No	No	No
3	Install strut no.1 at elev. 46.33	No	No	No
4	Excav. to elev. 42.78 on RIGHT side	Yes	Yes	Yes
5	Change soil type 1 to soil type 3	Yes	Yes	Yes
6	Change soil type 2 to soil type 4	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

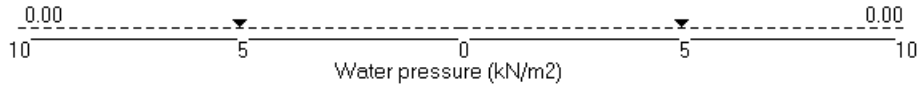
Units: kN,m

Stage No.6 Change soil type 2 to soil type 4



London Clay (drained

London Clay (drained



Units: kN,m

Stage No. 1 Apply surcharge no.1 at elevation 46.33
No analysis at this stage

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. = 42.55 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation	Direction of failure
1	46.33	46.33	Cant.	Conditions not suitable for FoS calc.				

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Left side 20.00 from wall
Right side 20.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	46.33	8.27	-0.000	-5.38E-04	0.0	-0.0	
2	46.17	-0.70	0.000	-5.38E-04	0.6	0.1	
3	46.00	-1.91	0.000	-5.38E-04	0.4	0.2	
4	45.80	-2.39	0.000	-5.38E-04	-0.0	0.3	
5	45.60	-1.58	0.000	-5.38E-04	-0.4	0.2	
		-5.57	0.000	-5.38E-04	-0.4	0.2	
6	45.40	-5.02	0.000	-5.38E-04	-1.5	0.1	
7	45.20	-3.61	0.001	-5.38E-04	-2.3	-0.3	
8	45.00	-1.68	0.001	-5.38E-04	-2.9	-0.8	
9	44.80	0.40	0.001	-5.38E-04	-3.0	-1.4	
10	44.60	2.33	0.001	-5.37E-04	-2.7	-1.9	
11	44.40	3.89	0.001	-5.37E-04	-2.1	-2.4	
12	44.20	4.93	0.001	-5.37E-04	-1.2	-2.7	
13	44.00	5.36	0.001	-5.36E-04	-0.2	-2.8	
14	43.80	5.15	0.001	-5.36E-04	0.9	-2.7	
15	43.60	4.27	0.001	-5.36E-04	1.8	-2.4	
16	43.40	2.74	0.002	-5.35E-04	2.5	-1.9	
17	43.20	0.60	0.002	-5.35E-04	2.8	-1.4	
18	43.00	-2.13	0.002	-5.35E-04	2.7	-0.8	
19	42.89	-3.90	0.002	-5.35E-04	2.3	-0.5	
20	42.78	-5.85	0.002	-5.35E-04	1.8	-0.2	
21	42.66	-7.95	0.002	-5.35E-04	1.0	-0.1	
22	42.55	-10.20	0.002	-5.35E-04	0.0	0.0	

(continued)

Stage No.1 Apply surcharge no.1 at elevation 46.33
No analysis at this stage

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	46.33	Total>	0.00	0.00	167.13	8.27	8.27	173570
2	46.17	Total>	3.04	0.82m	170.17	4.14	4.14	9394
3	46.00	Total>	6.50	1.65m	173.62	8.23	8.23	9394
4	45.80	Total>	11.69	2.65m	178.82	14.15	14.15	9394
5	45.60	Total>	18.25	3.65m	185.37	21.37	21.37	9394
		Total>	18.25	3.65m	198.22	12.81	12.81	15176
6	45.40	Total>	26.51	4.65m	210.08	19.13	19.13	15479
7	45.20	Total>	35.80	5.65m	222.97	26.38	26.38	15783
8	45.00	Total>	45.77	6.65m	236.54	34.21	34.21	16086
9	44.80	Total>	56.02	7.65m	250.39	42.25	42.25	16390
10	44.60	Total>	66.26	8.65m	264.23	50.22	50.22	16693
11	44.40	Total>	76.25	9.65m	277.82	57.87	57.87	16997
12	44.20	Total>	85.83	10.65m	291.00	65.07	65.07	17300
13	44.00	Total>	94.91	11.65m	303.68	71.73	71.73	17604
14	43.80	Total>	103.45	12.65m	315.81	77.80	77.80	17907
15	43.60	Total>	111.43	13.65m	327.39	83.28	83.28	18211
16	43.40	Total>	118.87	14.65m	338.43	88.17	88.17	18514
17	43.20	Total>	125.80	15.65m	348.97	92.50	92.50	18818
18	43.00	Total>	132.26	16.65m	359.02	96.32	96.32	19121
19	42.89	Total>	135.70	17.21m	364.48	98.25	98.25	19292
20	42.78	Total>	139.01	17.77m	369.82	100.04	100.04	19463
21	42.66	Total>	142.19	18.34m	375.03	101.69	101.69	19633
22	42.55	Total>	145.27	18.90m	380.13	103.21	103.21	19804

RIGHT side

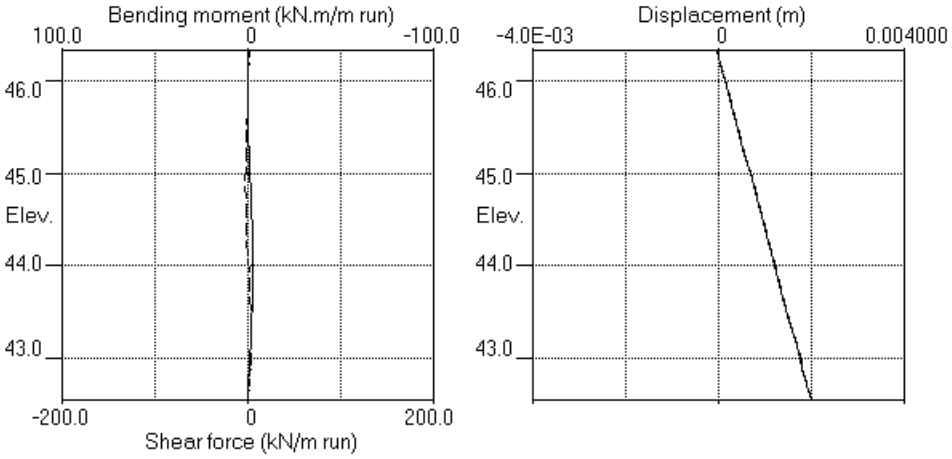
Node no.	Y coord	Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	46.33	Total>	0.00	0.00	167.13	0.00	0.00a	173570
2	46.17	Total>	2.97	0.82m	170.10	4.84	4.84	9394
3	46.00	Total>	5.94	1.65m	173.07	10.13	10.13	9394
4	45.80	Total>	9.54	2.65m	176.67	16.54	16.54	9394
5	45.60	Total>	13.14	3.65m	180.27	22.95	22.95	9394
		Total>	13.14	3.65m	193.11	18.38	18.38	15176
6	45.40	Total>	17.14	4.65m	200.71	24.15	24.15	15479
7	45.20	Total>	21.14	5.65m	208.31	29.99	29.99	15783
8	45.00	Total>	25.14	6.65m	215.91	35.89	35.89	16086
9	44.80	Total>	29.14	7.65m	223.51	41.86	41.86	16390
10	44.60	Total>	33.14	8.65m	231.11	47.89	47.89	16693
11	44.40	Total>	37.14	9.65m	238.71	53.98	53.98	16997
12	44.20	Total>	41.14	10.65m	246.31	60.14	60.14	17300
13	44.00	Total>	45.14	11.65m	253.91	66.37	66.37	17604
14	43.80	Total>	49.14	12.65m	261.50	72.66	72.66	17907
15	43.60	Total>	53.14	13.65m	269.10	79.01	79.01	18211
16	43.40	Total>	57.14	14.65m	276.70	85.42	85.42	18514
17	43.20	Total>	61.14	15.65m	284.30	91.90	91.90	18818
18	43.00	Total>	65.14	16.65m	291.90	98.45	98.45	19121
19	42.89	Total>	67.39	17.21m	296.18	102.16	102.16	19292
20	42.78	Total>	69.64	17.77m	300.45	105.89	105.89	19463
21	42.66	Total>	71.89	18.34m	304.73	109.64	109.64	19633
22	42.55	Total>	74.14	18.90m	309.00	113.41	113.41	19804

(continued)

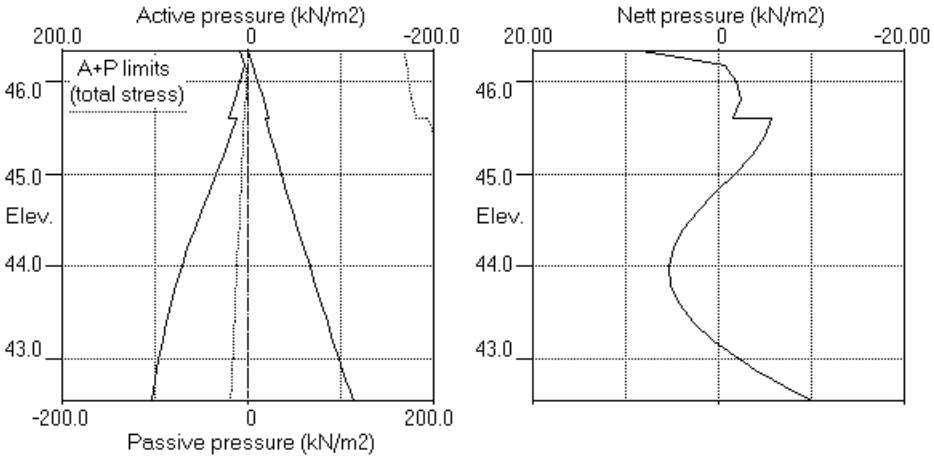
Stage No.1 Apply surcharge no.1 at elevation 46.33
No analysis at this stage
Note: 0.00a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.1 Apply surcharge no.1 at elev. 46.33



Stage No.1 Apply surcharge no.1 at elev. 46.33



Units: kN,m

Stage No. 4 Excavate to elevation 42.78 on RIGHT side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 42.55 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation	Direction of failure
4	46.33	42.78		More than one strut. No FoS calc.				

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

Length of wall perpendicular to section = 1000.00m

Subgrade reaction model - Boussinesq Influence coefficients

Soil deformations are elastic until the active or passive limit is reached

Open Tension Crack analysis - No

Rigid boundaries: Left side 20.00 from wall
Right side 20.00 from wall

Limit State: Serviceability Limit State

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

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	46.33	0.00	0.002	-1.85E-04	-39.1	0.0	39.1
2	46.17	0.82	0.002	-1.85E-04	-39.0	-6.4	
3	46.00	1.65	0.002	-1.84E-04	-38.8	-12.8	
4	45.80	2.65	0.002	-1.81E-04	-38.4	-20.5	
5	45.60	10.15	0.002	-1.78E-04	-37.1	-28.0	
		3.65	0.002	-1.78E-04	-37.1	-28.0	
6	45.40	4.65	0.002	-1.74E-04	-36.2	-35.3	
7	45.20	9.64	0.002	-1.69E-04	-34.8	-42.3	
8	45.00	18.25	0.002	-1.63E-04	-32.0	-49.0	
9	44.80	27.13	0.002	-1.56E-04	-27.5	-54.9	
10	44.60	35.99	0.002	-1.48E-04	-21.2	-59.8	
11	44.40	44.61	0.002	-1.40E-04	-13.1	-63.3	
12	44.20	52.85	0.002	-1.31E-04	-3.4	-64.9	
13	44.00	60.61	0.002	-1.22E-04	8.0	-64.5	
14	43.80	67.86	0.002	-1.14E-04	20.8	-61.6	
15	43.60	74.59	0.002	-1.06E-04	35.1	-56.0	
16	43.40	80.81	0.002	-9.96E-05	50.6	-47.4	
17	43.20	86.54	0.002	-9.41E-05	67.3	-35.6	
18	43.00	91.81	0.002	-9.03E-05	85.2	-20.4	
19	42.89	94.59	0.002	-8.92E-05	95.7	-10.2	
20	42.78	97.24	0.002	-8.88E-05	106.4	1.2	116.5
		40.00	0.002	-8.88E-05	-10.0	1.2	
21	42.66	44.51	0.002	-8.89E-05	-5.3	0.3	
22	42.55	48.98	0.002	-8.89E-05	0.0	0.0	

At elev. 46.33 Strut force = 78.1 kN/strut = 39.1 kN/m run

At elev. 42.78 Strut force = 116.5 kN/strut = 116.5 kN/m run

(continued)

Stage No.4 Excavate to elevation 42.78 on RIGHT side

LEFT side

Node no.	Y coord		Effective stresses			Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m3
1	46.33	Total>	0.00	0.00	167.13	0.00	0.00a	8607
2	46.17	Total>	3.04	0.82m	170.17	0.82	0.82a	8607
3	46.00	Total>	6.50	1.65m	173.62	1.65	1.65a	8607
4	45.80	Total>	11.69	2.65m	178.82	2.65	2.65a	8607
5	45.60	Total>	18.25	3.65m	185.37	10.15	10.15	8607
		Total>	18.25	3.65m	198.22	3.65	3.65a	13904
6	45.40	Total>	26.51	4.65m	210.08	4.65	4.65a	14182
7	45.20	Total>	35.80	5.65m	222.97	9.64	9.64	14460
8	45.00	Total>	45.77	6.65m	236.54	18.25	18.25	14738
9	44.80	Total>	56.02	7.65m	250.39	27.13	27.13	15016
10	44.60	Total>	66.26	8.65m	264.23	35.99	35.99	15295
11	44.40	Total>	76.25	9.65m	277.82	44.61	44.61	15573
12	44.20	Total>	85.83	10.65m	291.00	52.85	52.85	15851
13	44.00	Total>	94.91	11.65m	303.68	60.61	60.61	16129
14	43.80	Total>	103.45	12.65m	315.81	67.86	67.86	16407
15	43.60	Total>	111.43	13.65m	327.39	74.59	74.59	16685
16	43.40	Total>	118.87	14.65m	338.43	80.81	80.81	16963
17	43.20	Total>	125.80	15.65m	348.97	86.54	86.54	17241
18	43.00	Total>	132.26	16.65m	359.02	91.81	91.81	17519
19	42.89	Total>	135.70	17.21m	364.48	94.59	94.59	17676
20	42.78	Total>	139.01	17.77m	369.82	97.24	97.24	17832
21	42.66	Total>	142.19	18.34m	375.03	99.77	99.77	17988
22	42.55	Total>	145.27	18.90m	380.13	102.18	102.18	18145

RIGHT side

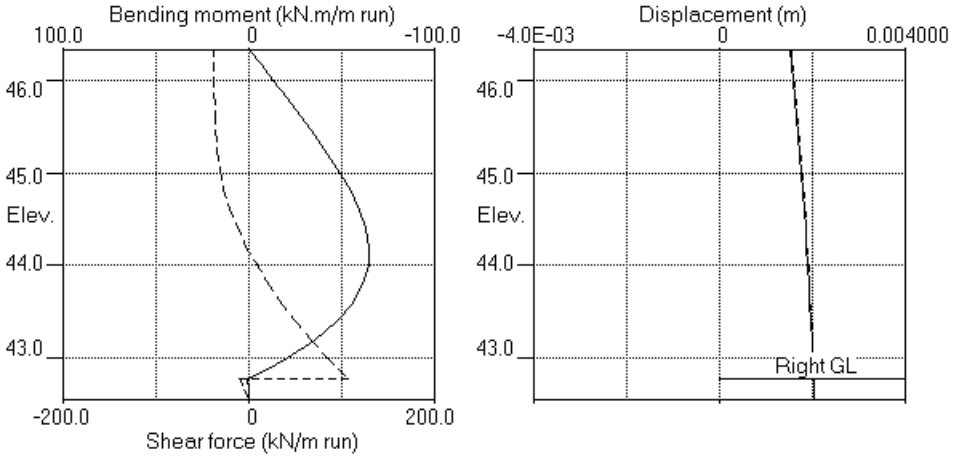
Node no.	Y coord		Effective stresses			Total earth pressure	Coeff. of subgrade reaction
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m3
1	46.33	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	46.17	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	46.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	45.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	45.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	45.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	45.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	45.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	44.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	44.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	44.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	44.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	44.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	43.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	43.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	43.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17	43.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
18	43.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
19	42.89	0.00	0.00	0.00	0.00	0.00	0.00	0.0
20	42.78	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	230.81	57.23	57.23	116182
21	42.66	Total>	2.25	0.56m	235.09	55.26	55.26	117201
22	42.55	Total>	4.50	1.13m	239.36	53.20	53.20	118220

(continued)

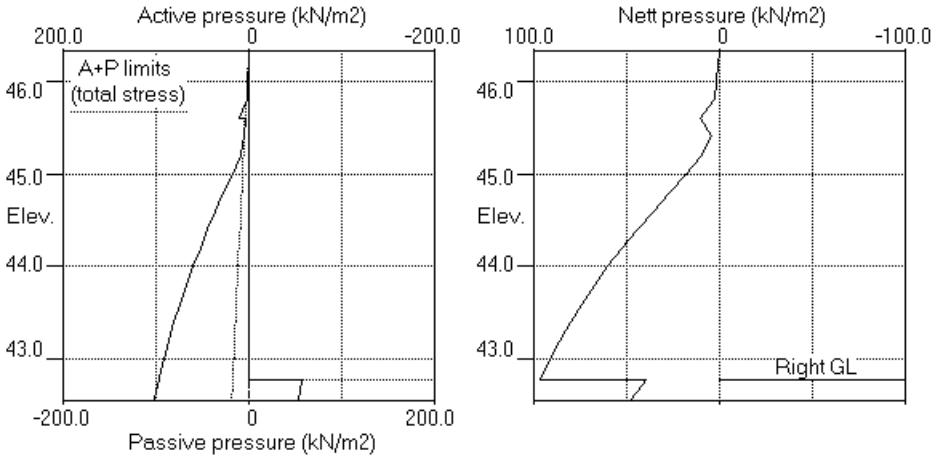
Stage No.4 Excavate to elevation 42.78 on RIGHT side
Note: 4.65a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.4 Excav. to elev. 42.78 on RIGHT side



Stage No.4 Excav. to elev. 42.78 on RIGHT side



Units: kN,m

Stage No. 5 Change properties of soil type 1 to soil type 3
Ko pressures will 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. = 42.55 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation	Direction of failure
5	46.33	42.78		More than one strut. No FoS calc.				

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Left side 20.00 from wall
Right side 20.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	46.33	0.00	0.002	-1.75E-04	-39.9	0.0	39.9
2	46.17	1.58	0.002	-1.75E-04	-39.8	-6.5	
3	46.00	3.59	0.002	-1.74E-04	-39.4	-13.1	
4	45.80	6.59	0.002	-1.72E-04	-38.4	-20.8	
5	45.60	10.38	0.002	-1.68E-04	-36.7	-28.3	
		3.65	0.002	-1.68E-04	-36.7	-28.3	
6	45.40	4.65	0.002	-1.64E-04	-35.8	-35.5	
7	45.20	9.26	0.002	-1.59E-04	-34.4	-42.4	
8	45.00	17.88	0.002	-1.53E-04	-31.7	-49.0	
9	44.80	26.79	0.002	-1.46E-04	-27.3	-54.9	
10	44.60	35.68	0.002	-1.38E-04	-21.0	-59.8	
11	44.40	44.33	0.002	-1.30E-04	-13.0	-63.2	
12	44.20	52.60	0.002	-1.21E-04	-3.3	-64.8	
13	44.00	60.40	0.002	-1.13E-04	8.0	-64.3	
14	43.80	67.68	0.002	-1.04E-04	20.8	-61.5	
15	43.60	74.44	0.002	-9.67E-05	35.0	-55.9	
16	43.40	80.69	0.002	-8.98E-05	50.5	-47.3	
17	43.20	86.46	0.002	-8.43E-05	67.2	-35.6	
18	43.00	91.77	0.002	-8.05E-05	85.1	-20.3	
19	42.89	94.57	0.002	-7.94E-05	95.5	-10.2	
20	42.78	97.25	0.002	-7.90E-05	106.3	1.2	116.4
		40.02	0.002	-7.90E-05	-10.1	1.2	
21	42.66	44.89	0.002	-7.91E-05	-5.3	0.3	
22	42.55	49.74	0.002	-7.91E-05	0.0	0.0	

At elev. 46.33 Strut force = 79.9 kN/strut = 39.9 kN/m run
At elev. 42.78 Strut force = 116.4 kN/strut = 116.4 kN/m run

(continued)

Stage No.5 Change properties of soil type 1 to soil type 3
Ko pressures will be reset

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	46.33	0.00	0.00	0.00	0.00	0.00	0.00	5150
2	46.17	0.00	3.04	1.03	11.03	1.58	1.58	5150
3	46.00	0.00	6.50	2.21	23.57	3.59	3.59	5150
4	45.80	0.00	11.69	3.98	42.42	6.59	6.59	5150
5	45.60	0.00	18.25	6.21	66.18	10.38	10.38	5150
		Total>	18.25	3.65m	198.22	3.65	3.65a	15598
6	45.40	Total>	26.51	4.65m	210.08	4.65	4.65a	15910
7	45.20	Total>	35.80	5.65m	222.97	9.26	9.26	16222
8	45.00	Total>	45.77	6.65m	236.54	17.88	17.88	16534
9	44.80	Total>	56.02	7.65m	250.39	26.79	26.79	16846
10	44.60	Total>	66.26	8.65m	264.23	35.68	35.68	17158
11	44.40	Total>	76.25	9.65m	277.82	44.33	44.33	17470
12	44.20	Total>	85.83	10.65m	291.00	52.60	52.60	17782
13	44.00	Total>	94.91	11.65m	303.68	60.40	60.40	18094
14	43.80	Total>	103.45	12.65m	315.81	67.68	67.68	18406
15	43.60	Total>	111.43	13.65m	327.39	74.44	74.44	18718
16	43.40	Total>	118.87	14.65m	338.43	80.69	80.69	19030
17	43.20	Total>	125.80	15.65m	348.97	86.46	86.46	19342
18	43.00	Total>	132.26	16.65m	359.02	91.77	91.77	19654
19	42.89	Total>	135.70	17.21m	364.48	94.57	94.57	19829
20	42.78	Total>	139.01	17.77m	369.82	97.25	97.25	164840
21	42.66	Total>	142.19	18.34m	375.03	99.96	99.96	166286
22	42.55	Total>	145.27	18.90m	380.13	102.56	102.56	167732

RIGHT side

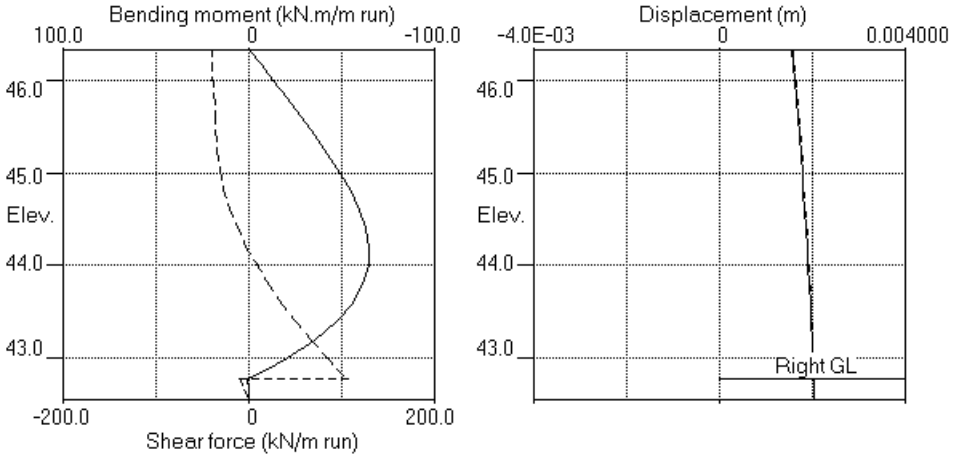
Node no.	Y coord	Water press. kN/m2	Effective stresses: Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	46.33	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	46.17	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	46.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	45.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	45.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	45.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	45.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	45.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	44.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	44.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	44.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	44.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	44.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	43.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	43.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	43.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17	43.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
18	43.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
19	42.89	0.00	0.00	0.00	0.00	0.00	0.00	0.0
20	42.78	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	230.81	57.23	57.23	164840
21	42.66	Total>	2.25	0.56m	235.09	55.07	55.07	166286
22	42.55	Total>	4.50	1.13m	239.36	52.82	52.82	167732

(continued)

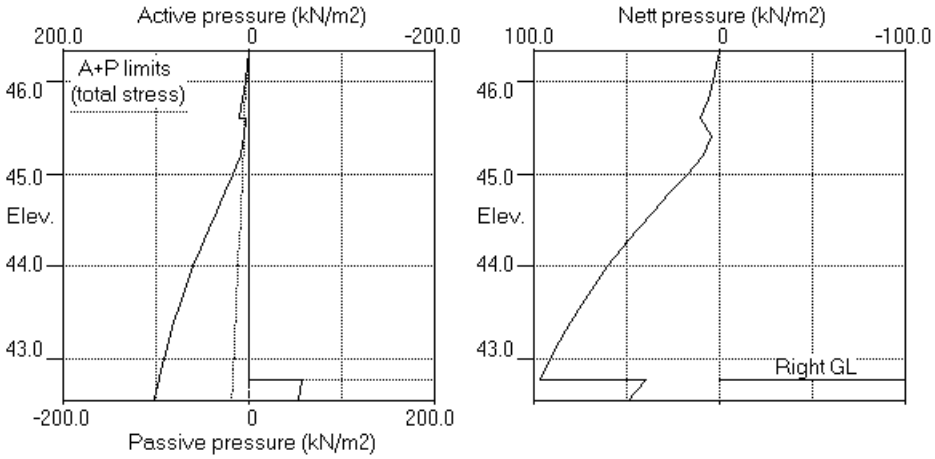
Stage No.5 Change properties of soil type 1 to soil type 3
Ko pressures will be reset
Note: 4.65a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m

Stage No.5 Change soil type 1 to soil type 3



Stage No.5 Change soil type 1 to soil type 3



Units: kN,m

Stage No. 6 Change properties of soil type 2 to soil type 4
Ko pressures will 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. = 42.55 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation	Direction of failure
6	46.33	42.78		More than one strut. No FoS calc.				

** FLOW Warning - Weak strata at or below toe of wall:
Active limit > Passive limit
50.95kN/m2 (left) > 37.05kN/m2 (right) at elev. 42.55
[50.95+0.00(u)] [37.05+0.00(u)]
The above pressures include water pressure.

Failure and flow of soil BELOW the toe of the wall may occur if the wall is not toed in to a firm stratum. This may occur even when acceptable factors of safety and displacements have been calculated.

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall
Analysis options
Length of wall perpendicular to section = 1000.00m
Subgrade reaction model - Boussinesq Influence coefficients
Soil deformations are elastic until the active or passive limit is reached
Open Tension Crack analysis - No

Rigid boundaries: Left side 20.00 from wall
Right side 20.00 from wall
Limit State: Serviceability Limit State
Calculated Bending Moments and Strut Forces are to be multiplied by a factor of 1.35 to obtain values for structural design. See summary for factored values.

Node no.	Y coord	Nett pressure kN/m2	Wall disp. m	Wall rotation rad.	Shear force kN/m	Bending moment kN.m/m	Strut forces kN/m
1	46.33	0.00	0.002	-1.14E-04	-46.1	0.0	46.1
2	46.17	1.03	0.002	-1.14E-04	-46.0	-7.6	
3	46.00	2.49	0.002	-1.13E-04	-45.7	-15.1	
4	45.80	5.56	0.002	-1.10E-04	-44.9	-24.2	
5	45.60	9.41	0.002	-1.06E-04	-43.4	-32.9	
		10.14	0.002	-1.06E-04	-43.4	-32.9	
6	45.40	15.51	0.002	-1.01E-04	-40.9	-41.4	
7	45.20	21.55	0.002	-9.57E-05	-37.1	-49.0	
8	45.00	28.03	0.002	-8.87E-05	-32.2	-56.0	
9	44.80	34.70	0.002	-8.08E-05	-25.9	-61.8	
10	44.60	41.36	0.002	-7.22E-05	-18.3	-66.2	
11	44.40	47.87	0.002	-6.32E-05	-9.4	-69.0	
12	44.20	54.12	0.002	-5.39E-05	0.8	-69.8	
13	44.00	60.05	0.002	-4.46E-05	12.2	-68.5	
14	43.80	66.91	0.002	-3.57E-05	24.9	-64.8	
15	43.60	73.79	0.002	-2.74E-05	39.0	-58.4	
16	43.40	80.16	0.002	-2.02E-05	54.4	-49.1	
17	43.20	86.05	0.002	-1.45E-05	71.0	-36.6	
18	43.00	91.49	0.002	-1.07E-05	88.8	-20.6	
19	42.89	94.37	0.002	-9.55E-06	99.2	-10.0	

(continued)

Stage No.6 Change properties of soil type 2 to soil type 4
Ko pressures will be reset

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
20	42.78	97.12	0.002	-9.24E-06	110.0	1.8	125.7
		72.93	0.002	-9.24E-06	-15.7	1.8	
21	42.66	69.29	0.002	-9.32E-06	-7.7	0.4	
22	42.55	67.90	0.002	-9.34E-06	0.0	0.0	

At elev. 46.33 Strut force = 92.2 kN/strut = 46.1 kN/m run
At elev. 42.78 Strut force = 125.7 kN/strut = 125.7 kN/m run

LEFT side

Node no.	Y coord	Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	46.33	0.00	0.00	0.00	0.00	0.00	0.00	4817
2	46.17	0.00	3.04	1.03	11.03	1.03	1.03a	4817
3	46.00	0.00	6.50	2.21	23.57	2.49	2.49	4817
4	45.80	0.00	11.69	3.98	42.42	5.56	5.56	4817
5	45.60	0.00	18.25	6.21	66.18	9.41	9.41	4817
		0.00	18.25	0.00	76.33	10.14	10.14	7781
6	45.40	0.00	26.51	2.95	99.94	15.51	15.51	7937
7	45.20	0.00	35.80	6.71	126.51	21.55	21.55	8093
8	45.00	0.00	45.77	10.74	154.97	28.03	28.03	8248
9	44.80	0.00	56.02	14.88	184.28	34.70	34.70	8404
10	44.60	0.00	66.26	19.02	213.54	41.36	41.36	8559
11	44.40	0.00	76.25	23.05	242.08	47.87	47.87	8715
12	44.20	0.00	85.83	26.93	269.45	54.12	54.12	8871
13	44.00	0.00	94.91	30.60	295.40	60.05	60.05	9026
14	43.80	0.00	103.45	34.05	319.79	66.91	66.91	9182
15	43.60	0.00	111.43	37.27	342.60	73.79	73.79	9338
16	43.40	0.00	118.87	40.28	363.87	80.16	80.16	9493
17	43.20	0.00	125.80	43.08	383.68	86.05	86.05	9649
18	43.00	0.00	132.26	45.69	402.13	91.49	91.49	9804
19	42.89	0.00	135.70	47.08	411.95	94.37	94.37	9892
20	42.78	0.00	139.01	48.42	421.41	97.12	97.12	9980
21	42.66	0.00	142.19	49.70	430.52	99.91	99.91	10067
22	42.55	0.00	145.27	50.95	439.29	103.76	103.76	374892

RIGHT side

Node no.	Y coord	Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
1	46.33	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	46.17	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	46.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	45.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	45.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	45.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	45.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	45.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	44.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	44.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	44.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	44.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	44.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	43.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0

(continued)

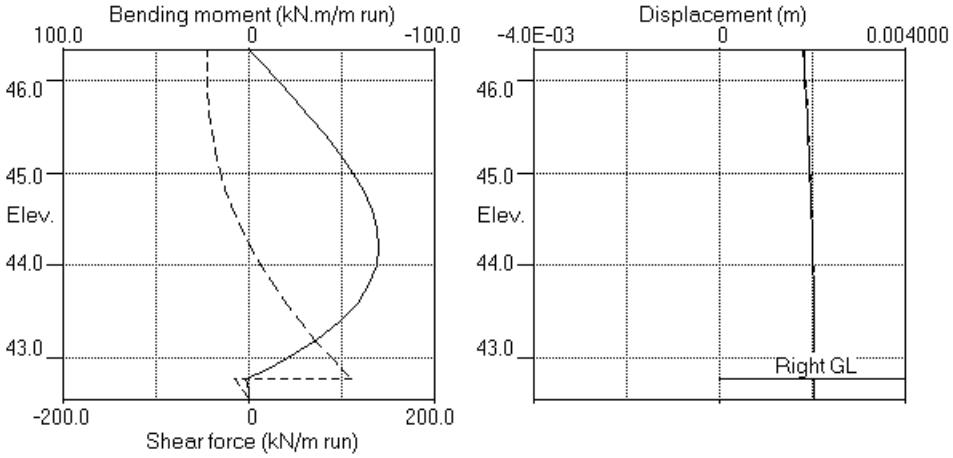
Stage No.6 Change properties of soil type 2 to soil type 4
Ko pressures will be reset

Node no.	Y coord	RIGHT side Water press. kN/m2	Effective stresses Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Coeff. of subgrade reaction kN/m3
15	43.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	43.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
17	43.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
18	43.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
19	42.89	0.00	0.00	0.00	0.00	0.00	0.00	0.0
20	42.78	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		0.00	0.00	0.00	24.20	24.20	24.20p	113892
21	42.66	0.00	2.25	0.00	30.62	30.62	30.62p	114891
22	42.55	0.00	4.50	0.00	37.05	35.86	35.86	374892

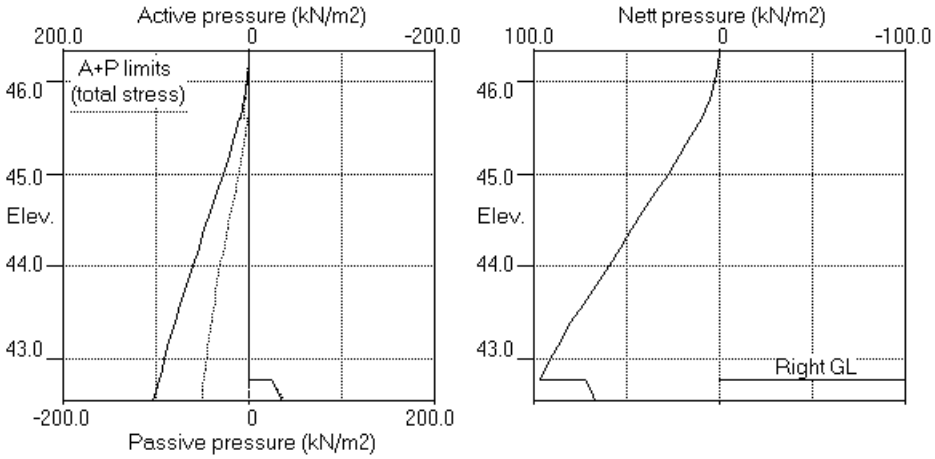
Note: 1.03a Soil pressure at active limit
30.62p Soil pressure at passive limit

Units: kN,m

Stage No.6 Change soil type 2 to soil type 4



Stage No.6 Change soil type 2 to soil type 4



Units: kN,m

Summary of results

LIMIT STATE PARAMETERS

Limit State: Serviceability Limit State

All loads and soil strengths are unfactored

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	--- G.L. --- Act.	Pass.	Strut Elev.	FoS for toe elev. = 42.55 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.000 Toe elev.	Wall Penetr -ation	Direction of failure
1	46.33	46.33	Cant.	Conditions not suitable for FoS calc.				
2	46.33	46.33		No analysis at this stage				
3	46.33	46.33		No analysis at this stage				
4	46.33	42.78		More than one strut. No FoS calc.				
5	46.33	42.78		More than one strut. No FoS calc.				
6	46.33	42.78		More than one strut. No FoS calc.				**FLOW Warning

Legend: **FLOW Warning

Failure and flow of soil BELOW the toe of the wall may occur if the wall is not toed in to a firm stratum. It may occur even when acceptable factors of safety and displacements have been calculated. See individual stage results for details.

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

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

Rigid boundaries: Left side 20.00 from wall
Right side 20.00 from wall

Limit State: Serviceability Limit State

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

Bending moment, shear force and displacement envelopes

Node no.	Y coord	Displacement max. m	Displacement min. m	Bending moment Calculated max. kN.m/m	Bending moment Calculated min. kN.m/m	Bending moment Factored max. kN.m/m	Bending moment Factored min. kN.m/m	Shear force Calculated max. kN/m	Shear force Calculated min. kN/m	Shear force Factored max. kN/m	Shear force Factored min. kN/m
1	46.33	0.002	-0.000	0	-0	0	-0	0	-46	0	-62
2	46.17	0.002	0.000	0	-8	0	-10	1	-46	1	-62
3	46.00	0.002	0.000	0	-15	0	-20	0	-46	1	-62
4	45.80	0.002	0.000	0	-24	0	-33	0	-45	0	-61
5	45.60	0.002	0.000	0	-33	0	-44	0	-43	0	-59
6	45.40	0.002	0.000	0	-41	0	-56	0	-41	0	-55
7	45.20	0.002	0.000	0	-49	0	-66	0	-37	0	-50
8	45.00	0.002	0.000	0	-56	0	-76	0	-32	0	-43
9	44.80	0.002	0.000	0	-62	0	-83	0	-27	0	-37
10	44.60	0.002	0.000	0	-66	0	-89	0	-21	0	-29
11	44.40	0.002	0.000	0	-69	0	-93	0	-13	0	-18
12	44.20	0.002	0.000	0	-70	0	-94	1	-3	1	-5
13	44.00	0.002	0.000	0	-69	0	-93	12	-0	17	-0
14	43.80	0.002	0.000	0	-65	0	-88	25	0	34	0
15	43.60	0.002	0.000	0	-58	0	-79	39	0	53	0
16	43.40	0.002	0.000	0	-49	0	-66	54	0	73	0
17	43.20	0.002	0.000	0	-37	0	-49	71	0	96	0
18	43.00	0.002	0.000	0	-21	0	-28	89	0	120	0
19	42.89	0.002	0.000	0	-10	0	-14	99	0	134	0
20	42.78	0.002	0.000	2	-0	2	-0	110	-16	148	-21
21	42.66	0.002	0.000	0	-0	1	-0	1	-8	1	-10
22	42.55	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 Calculated max. kN.m/m	Bending moment Calculated max. elev.	Bending moment Calculated min. kN.m/m	Bending moment Calculated min. elev.	Bending moment Factored max. kN.m/m	Bending moment Factored min. kN.m/m	Shear force Calculated max. kN/m	Shear force Calculated max. elev.	Shear force Calculated min. kN/m	Shear force Calculated min. elev.	Shear force Factored max. kN/m	Shear force Factored min. kN/m
1	0	45.80	-3	44.00	0	-4	3	43.20	-3	44.80	4	-4
2	No calculation at this stage											
3	No calculation at this stage											
4	1	42.78	-65	44.20	2	-88	106	42.78	-39	46.33	144	-53
5	1	42.78	-65	44.20	2	-87	106	42.78	-40	46.33	144	-54
6	2	42.78	-70	44.20	2	-94	110	42.78	-46	46.33	148	-62

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	42.55	-0.000	46.33	Apply surcharge no.1 at elev. 46.33
2	No calculation at this stage				Install strut no.2 at elev. 42.78
3	No calculation at this stage				Install strut no.1 at elev. 46.33
4	0.002	42.55	0.000	46.33	Excav. to elev. 42.78 on RIGHT side
5	0.002	42.55	0.000	46.33	Change soil type 1 to soil type 3
6	0.002	42.55	0.000	46.33	Change soil type 2 to soil type 4

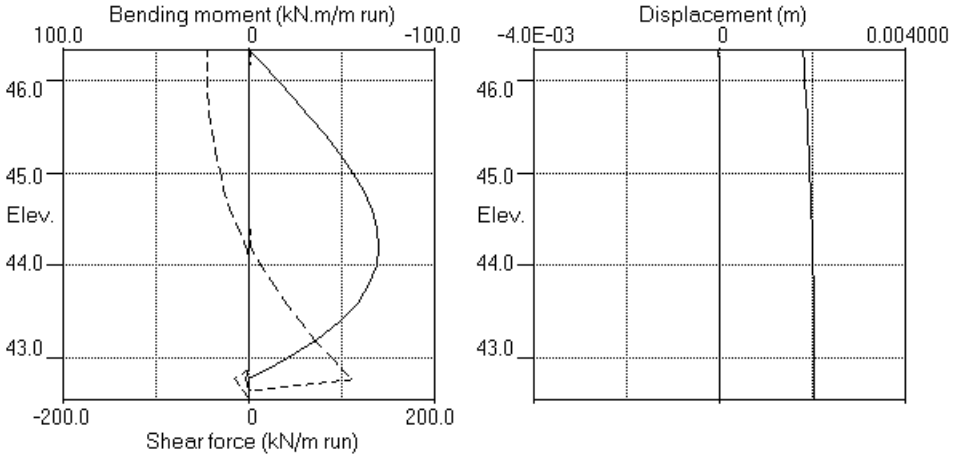
Strut forces at each stage (horizontal components)

Stage no.	Strut no. 1 at elev. 46.33 --Calculated-- kN per m run	Factored kN per strut	Factored kN per strut	Strut no. 2 at elev. 42.78 --Calculated-- kN per m run	Factored kN per strut	Factored kN per strut
4	39	78	105	116	116	157
5	40	80	108	116	116	157
6	46	92	124	126	126	170

CARD GEOTECHNICS LIMITED | Sheet No.
Program: WALLAP Version 6.06 Revision A51.B69.R55 | Job No. CG28854
Licensed from GEOSOLVE | Made by : TBP
Data filename/Run ID: Underpin deflection |
42 Elswprthy Road | Date:12-12-2018
Underpin deflection | Checked :

Units: kN,m

Bending moment, shear force, displacement envelopes



APPENDIX D

Structural loads

Thomas Perry

From: Candice Fathy <candicef@form-sd.com>
Sent: 06 December 2018 14:47
To: Thomas Perry
Subject: RE: 42 Elsworthy Road - BIA and GMA Check

Hi Tom,

The line loads are as follows, in the format DL//LL:

GL A – 126//26 kN/m
GL E – 126//26 kN/m
GL 1 – 61//19 kN/m
GL 5 – 70//17 kN/m

The worst-case column load is 540//145 kN.

Regarding the sacrificial piles, they will become redundant once the building is completed.

Hope this helps.

Kind Regards,

Candice

Candice Fathy MEng (Hons) | Graduate Engineer

FORM Structural Design

DD: 020 7251 7822 | E: candicef@form-sd.com | T: 020 7253 2893 | W: www.form-sd.com

From: Thomas Perry <ThomasP@cgl-uk.com>
Sent: 06 December 2018 11:35
To: Candice Fathy <candicef@form-sd.com>
Subject: RE: 42 Elsworthy Road - BIA and GMA Check

Hello Candice,

If you could calculate a general line load for the pile retaining walls and underpin walls (say a line load along gridline 1, A, 5, etc) , and then base the column loads off the worst case for the raft that is fine.

Appendix D
Building Damage Classification Table

Classification of visible damage to walls (after Burland et al, *1977, Boscardin and Cording, 1989; and Burland, 2001)*

Category of damage	Description of typical damage (ease of repair is underlined)	Approximate crack width (mm)	Limiting tensile strain ε_{lim} (per cent)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible.	< 0.1	0.0–0.05
1 Very slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection.	< 1	0.05–0.075
2 Slight	Cracks easily filled. Redecoration probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weathertightness. Doors and windows may stick slightly.	< 5	0.075–0.15
3 Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5–15 or a number of cracks > 3	0.15–0.3
4 Severe	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Windows and frames distorted, floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 but also depends on number of cracks	> 0.3
5 Very severe	This requires a major repair involving partial or complete rebuilding. Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	usually > 25 but depends on number of cracks.	

Notes

1. In assessing the degree of damage, account must be taken of its location in the building or structure.
2. Crack width is only one aspect of damage and should not be used on its own as a direct measure of it.