Card Geotechnics Limited
Providing Ground Solutions

Barratt West London

Kidderpore Avenue, London

Addendum Basement Impact Assessment – Block E

February, 2015

Card Geotechnics Limited
4 Godalming Business Centre, Woolsack Way,
Godalming, Surrey, GU7 1XW
Telephone: 01483 310 600
www.cardgeotechnics.co.uk

Author	Robert Benson, Senior Engineer *BSc MSc FGS*		
Checked	Nick Langdon, Director *MSc BEng DIC CEnv CEng CMgr FICE FGS FCMI MIoD*		
Approved	Nick Langdon, Director *MSc BEng DIC CEnv CEng CMgr FICE FGS FCMI MIoD*		
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Contents

FIGURES

APPENDICES

1. INTRODUCTION

A previous Basement Impact Assessment (BIA)[1] has been completed for the redevelopment of the King's College Hampstead Campus at Kidderpore Avenue, London. The original BIA covers both the Phase 1 reconstruction of the Caroline Skeel Library as a private apartment block (Block D) and the larger Phase 2 basement development beneath Blocks K, L and M. The construction proposals for these Phases have been developed since the original BIA was issued in 2012. A letter report was issued by CGL in January 2015[2] confirming that the conclusions made in the previous BIA remain valid based on the finalised construction proposals.

There is now a requirement to produce a specific impact assessment for Block E, which comprises a 3.0m to 6.0m deep basement (varying with topography) and 2/3 storey above ground structure.

Card Geotechnics Limited (CGL) has been instructed to prepare an addendum Basement Impact Assessment (BIA) for Block E to assess the potential impact on surrounding structures and hydrological features. This addendum report should be read in conjunction with the original BIA, with references to appropriate sections of that report provided to prevent unnecessary duplication.

[1] Card Geotechnics Limited (November 2012) *Kidderpore Avenue, London – Basement Impact Assessment*. Rev. 3 Ref. CG/5946
[2] Letter report from Nick Langdon to Mr Paul Fisher (08/01/15) *Phase 2 basement, Kidderpore Avenue.* Ref. CG/18157

2. SITE CONTEXT

2.1 Site location

Block E is located adjacent to the Phase 1 redevelopment of Block D (former Caroline Skeel Library) in Camden, London, NW3. The National Grid Reference for the approximate centre of the site is 525253, 185814. The site location is shown in Figure 1.

2.2 Proposed development - Block E

The basement covers an area of approximately ~180m^2. It is proposed to construct the basement within a mini secant piled wall (340mm diameter with hard piles spaced at 600mm spacings) which will be propped at mid height on the higher retained height and ground level of the lower retained height. A reinforced concrete liner wall and basement slab will be constructed with the internal structure supported on piles.

Architectural floor plans and sections for Block E are included in Appendix A. The piled crane base for the construction of Block D is in place immediately south east of the basement and is shown on these drawings.

As shown in the architectural plans, the floor level references -03, -02, -01 and 00 will be referred to in this addendum report.

2.3 Site History

Refer to previous BIA . The wider Kidderpore Avenue site was developed for residential use in the late 1800s / early 1900s, prior to which the site was undeveloped and most likely used for agriculture. Areas of the site were redeveloped in the 1970s as student accommodation and the library that exist today, with a few of the original houses remaining along Finchley Road and Kidderpore Avenue.

2.4 Topography

Refer to previous BIA . Figure 2 (*Site topography*) has been retained within this addendum for clarity showing the position of Block E. The basement will be constructed across a slope which drops in level by approximately 3m, representing a localised slope gradient of 1V:8H. (see also drawing 809_03_06_301 in Appendix A).

2.5 Geology

Refer to previous BIA . The British Geological Survey sheet[3] of the area indicates the site to be underlain by the Claygate Member of the London Clay Formation, overlying the London Clay Formation.

2.6 Hydrogeology

Refer to previous BIA . It is considered likely that groundwater flow follows the general topography of the area, flowing down-gradient in a south to south-westerly direction, migrating through permeable lenses of the Claygate Member. The Environment Agency[4] (EA) has classified the Claygate Member as a Secondary 'A' aquifer.

2.7 Flood risk

Refer to previous BIA . The site is not within an Environment Agency Flood Risk Zone. However, reference to Figure 15 ('Flood Map') of the CGHHS report produced by Arup indicates that both Finchley Road and Platt's Lane were flooded during a period of very heavy rainfall in 2002. It is understood that the flooding resulted from existing drainage infrastructure not having adequate capacity and was unrelated to risks of river flooding.

[3] British Geological Survey Sheet 256 (1994) *North London – Solid and Drift Geology 1:50,000*
[4] http://www.environment-agency.gov.uk/wiyby

3. SCREENING – STAGE 1

Refer to previous BIA . A summary of potential impacts to be assessed specifically in relation Block E is provided below.

Table 1: Summary of Block E Basement Impact Assessment requirements

Item	Description
	Subterranean (Groundwater flow)
1.	The impact of the basement on groundwater flows is considered to be negligible based on the findings of the original BIA.
	Slope (land stability)
2.	Movements associated with heave due to basement excavation and ground movements around the basement perimeter resulting from installation and lateral deflection of the basement retaining wall.
3.	Impact assessment on structures, albeit Block E is set within a wider construction site and therefore existing structures should not be vulnerable to ground movement
4.	Possible slope stability issues due to the existing topography.
	Surface flow and flooding
5.	The impact of the basement on surface flows is considered to be negligible based on the finding of the original BIA.

4. SCOPING – STAGE 2

Refer to previous BIA . The scoping section of this addendum report remains the same as the original, namely that there is a requirement to complete a site investigation to provide details on ground conditions and stratum levels, and potential variance in ground and groundwater conditions across the site. The scope of the previous AP Geotechnics site investigations [5,6] are considered appropriate for the purposes of the Block E basement impact assessment. As such no further site investigation is considered necessary.

[5] AP Geotechnics (31 August 2006) *King's College Hampstead Campus, Kidderpore Avenue, London NW3*. Report No. 2796.
[6] AP Geotechnics (11 October 2011) *King's College Hampstead Campus, Kidderpore Avenue, London NW3*. Report No. 3648-1.

5. EXISTING SITE INVESTIGATION – STAGE 3

Refer to previous BIA . Figure 3 (*level to the base of the Claygate Member*) has been retained within this addendum for clarity showing the position of Block E. Borehole BH1[7] has been included in Appendix B for information given its proximity to Block E. The ground conditions encountered in BH1 are summarised in Table 2 below:

Table 2: Summary of ground conditions from BH1

Strata description	**Depth to top of strata (m)**	**Thickness of strata (m)**
MADE GROUND / FILL comprising topsoil over firm brown clay with brick, slate and flint gravel.	Ground Level	1.70
Firm to stiff fissured dark brown and grey brown mottled sandy CLAY with very sandy water bearing layers [CLAYGATE MEMBER – LONDON CLAY FORMATION]	1.70	4.50
Firm becoming very stiff fissured dark grey sandy CLAY with sand parting, Occasional shells and shell fragments from 11.5m [LONDON CLAY FORMATION]	6.20	Proven to 20m

Geotechnical parameters outlined in the previous BIA have been used in the Block E assessment. This are reproduced below in Table 3 for clarity.

Table 7: Geotechnical design parameters

Stratum	**Design Level (mOD)**	**Bulk Unit Weight γ_b (kN/m^3)**	**Undrained Cohesion c_u (kPa)**	**Effective Cohesion, c' (kPa)**	**Friction Angle ϕ' (°)**	**Young's Modulus E_u (MPa) [E']**
Made Ground	Ground level	18	-	-	28[a]	[14]
Claygate Member (London Clay Formation)	Variable	19	40 + 5.7z[b]	0	25[a]	40 + 5.7z[c] [30 + 4.3z][d]
London Clay Formation	Variable (see Figure 3)	20		5	25[a]	

[7] From AP Geotechnics (31/08/2006) *King's College, Hampstead Campus, Kidderpore Avenue, London NW3*. Report ref. 2796

6. SUBTERRANEAN (GROUNDWATER) FLOW – STAGE 4

Refer to previous BIA . The conclusions made in that report for the much larger Phase 2 basement have been reviewed in the context of the Block E basement and remain valid. The volume and flows of groundwater pre-construction are anticipated to be minimal on the basis of the monitoring completed by AP Geotechnics, and are limited to permeable horizons within the Claygate Member. These horizons are likely to be isolated and discontinuous, as evidenced by a lack of downslope springs or watercourses, and recharged by limited surface water infiltration upslope of the site. It is therefore considered the impact on local groundwater will be negligible.

7. SLOPE (LAND STABILITY) ASSESSMENT – STAGE 4

7.1 Introduction

This section addresses outstanding issues raised by the screening process regarding land stability as summarised in Table 1. It is emphasised that there are no sensitive structures in the immediate vicinity of the new basement as Block E is set centrally within the wider Phase 1 construction site. The nearest existing property is 326 Finchley Road located approximately 15m from the new basement at its nearest point. It is assumed however that there may be new infrastructure installed adjacent to the Block D development during the Phase 1 construction.

7.2 Proposed development Block E

The proposed basement comprises a 3m to 6m deep basement formed within a secant piled wall. The FFL for the basement is at 85.825mOD with ground levels external to the basement varying between 92mOD to the north and 89mOD to the south. The loads from the structure will be supported on bearing piles with the basement slab suspended between pile caps.

The previous slope stability assessment for Block D indicated satisfactory long term factors of safety (see Section of 7.2.2 of the original BIA) for the existing 1:8 slope. The secant piling works will service to improve associated factors of safety in the vicinity of Block E.

7.3 Construction sequence

Following correspondence with the structural engineer (Gravity Consulting Engineers), the Block E basement construction will follow a typical bottom-up construction sequence, outlined below:

- Installation of hard/soft secant pile perimeter retaining wall. Piles of 340mm diameter with a centre to centre spacing 600mm are assumed;
- Staged excavation allowing for temporary cantilever of secant wall at highest retained height to ~3m depth, before installation of horizontal propping at mid-height (~89mOD). Horizontal prop at ground level on southern side of basement;
- Excavation to underside of basement slab (taken as FFL – 500mm = 85.325mOD);

- Sequential casting of basement raft slab (Level -03), internal RC wall lining and a lower ground floor / ground floor slabs (Levels -02 and -01).

This assumed sequence will be taken forward into the analyses for the impact assessment.

7.4 Ground movements arising from basement excavation

During excavation the soils at formation level will be subject to stress relief as overburden is removed. Due to the cohesive and plastic nature of the London Clay, it is subject to volume change (heave) during unloading. An assessment of volume change has been undertaken using OASYS Limited *PDisp* analysis software. *PDisp* assumes that the ground behaves as an elastic material under loading, with movements calculated based on the applied loads and the soil stiffness for each stratum input by the user.

The excavation gives rise to a net unloading of the Claygate Member and London Clay during construction and over the long term. The combined effect of both the immediate 'undrained' unloading and the long term recovery of pore pressures ('drained' heave) have been analysed.

The analysis assumes that approximately 6.7m of soil will be removed at the northern end of the new basement (between the existing ground level at 92mOD and underside of the basement floor slab at 85.3mOD) equivalent to an unloading of approximately 127kPa (assuming an overburden unit weight of 19kN/m^3). This unloading decreases approximately linearly from north to south due to the drop in slope, to approximately 70kPa at the southern end of the basement (existing ground level at 89mOD and underside of the basement floor slab at 85.3mOD).

Contour plots from the *PDisp* analysis are provided in Appendix C.

7.5 Short term heave

Short term heave is of the order of some 10mm at the northern end of the excavation, reducing to 5mm at the southern end. Heave movements around the basement perimeter reduce to around 3mm to 4mmm, and are negligible (<1mm) at distances of 5m from the basement. Short term heave occurs immediately on excavation, and will be removed during construction by re-levelling to achieve foundation/slab formation levels.

7.6 Long term heave beneath basement slab

At the deeper northern section of the basement, maximum long term heave will be of the order of 15mm, reducing to about 7mm to 8mm in the south. Maximum long term heave

of the soil outside the basement perimeter is not likely to exceed 5mm. *PDisp* does not account for the skin friction of the basement wall piles acting in resistance, and it is anticipated that heave values around the basement perimeter both in the short and long term will be lower than calculated, limiting heave movements to the internal areas of the basement. The impact of pile installation and lateral deflection will also serve to limit heave movements (see Section 7.3.6.).

The relative difference in potential heave movements should be accommodated within the structural design as appropriate (e.g. void former beneath suspended basement slab).

7.7 Secant piled wall – Ground movements

This section provides an analysis of ground movements arising from the installation of, and excavation in front of, the basement walls, and an assessment of the impact this will have on nearby properties, highways and infrastructure.

7.7.1 Ground movements due to pile wall installation

With reference to CIRIA C580[8], vertical movements due to installation of a secant piled wall are likely to be in the region of 0.05% of the wall depth, and lateral movements 0.08% of wall depth, both dissipating linearly with distance from the wall.

For the purposes of this analysis a worst case wall depth has been assumed for the maximum retained height (i.e. northern perimeter), and assuming an embedment of 6m below the basement formation. The total depth is therefore taken as 12m. It is likely that with the inclusion of a horizontal prop level, the designed wall will allow a shallower wall toe depth to achieve the required design criteria and factors of safety. The toe level of the walls is subject to final design by the piling contractor.

Based on this wall depth, the pile wall installation is likely to generate maximum vertical and lateral ground movements of between 6mm and 9.6mm, respectively, immediately adjacent to the new basement, reducing to 0 at a distance of 2x the wall depth (i.e. 24m). It is noted that these relationships are the 'worst credible' based on case history field measurements in London (see Section 2.5.2 in CIRIA C580).

[8] CIRIA C580 (2003) *Embedded Retaining Walls – guidance for economic design*

7.7.2 Ground movements during excavation

A single critical section of the highest retained wall height (i.e. worst case) along the northern basement perimeter has been analysed using Geosolve WALLAP retaining wall analysis software to determine lateral wall deflections.

Unfactored SLS parameters have been utilised to determine wall deflections in accordance with BS8002. The SLS analysis assumes no overdig and no softening of formation soils, and includes the use of a mid height temporary prop. Given the relative basement size and short construction duration anticipated (<2 months for the basement excavation), undrained parameters for the Claygate Beds and London Clay have been used in the temporary condition for the calculation of earth pressures. The basement walls will be fully restrained by the new reinforced basement box in the permanent condition.

Maximum horizontal deflections of 19mm at the top of the wall were calculated during the reduced level dig to the mid height prop i.e. 3m high cantilever. Vertical movements have been derived from approximations incorporated in CIRIA C580 to determine the settlement profile at the ground surface (e.g. at the level of the top of the retaining wall).

Maximum surface settlements resulting from the wall deflections, including settlement from installation, are likely to be of the order of 15mm. Lateral ground movements of up to 25mm maybe expected in the immediate proximity of the wall. It is emphasised that there is no sensitive structures or utilities in the immediate proximity of the wall.

Full results of the WALLAP output are provided in Appendix D.

7.8 Impact assessment

A plot showing combined vertical movements external to the basement perimeter, amalgamating ground movements from the excavation and installation/deflection of the secant wall, is summarised in Figure 4. Again this is based on the highest retained wall height (i.e. northern boundary).

There are no structures within the proximity of the Block E basement outside of the wider development site. Block E is located quite centrally with the Phase 1 site and there are various construction works ongoing. The nearest property to Block E outside of the development area is 326 Finchley Road, located approximately 15m south of the Block E basement perimeter at its nearest point. This is comfortably outside a 45° zone of influence of the Block E basement, particularly with the shallower retained height on the

southern edge of the basement. As such ground movements resulting from the basement excavation would be expected to have a negligible impact on existing structures, and the requirement to complete a damage category assessment[9,10] is not warranted. Indeed Figure 4 illustrates that maximum calculated movements of 2mm may be expected at 326 Finchley Road. This 2mm movement is derived from wall installation, and it is again emphasised these movements are based on 'worst credible' case history field measurements.

Lateral and vertical ground movements in the immediate vicinity of the basement of ±20mm may be expected and movements of this magnitude would not be expected to impact upon existing infrastructure. Similarly it is assumed that the majority of the new Phase 1 infrastructure (roads, drainage, utilities etc.) will be installed or completed after the construction of the Block E basement.

[9] Burland, J.B., and Wroth, C.P. (1974). *Settlement of buildings and associated damage*, State of the art review. Conf on Settlement of Structures, Cambridge, Pentech Press, London, pp611-654

[10] Burland, Standing J.R., and Jardine F.M. (eds) (2001), *Building response to tunnelling, case studies from construction of the Jubilee Line Extension London*, CIRIA Special Publication 200.

8. SURFACE FLOW AND FLOODING – STAGE 4

Refer to previous BIA [1] and drainage strategy/flood risk assessment produced by Ardent Consulting Engineers[11]. The conclusions made in those reports for the wider development site have been reviewed in the context of the Block E basement and remain valid i.e. the impact on local surface water flow will be negligible.

[11] Ardent Consulting Engineers (May 2012) *Proposed Residential Development: Kidderpore Avenue, London – Flood Risk and Drainage Assessment DRAFT.* Report ref. K640-01 Project No. K640.

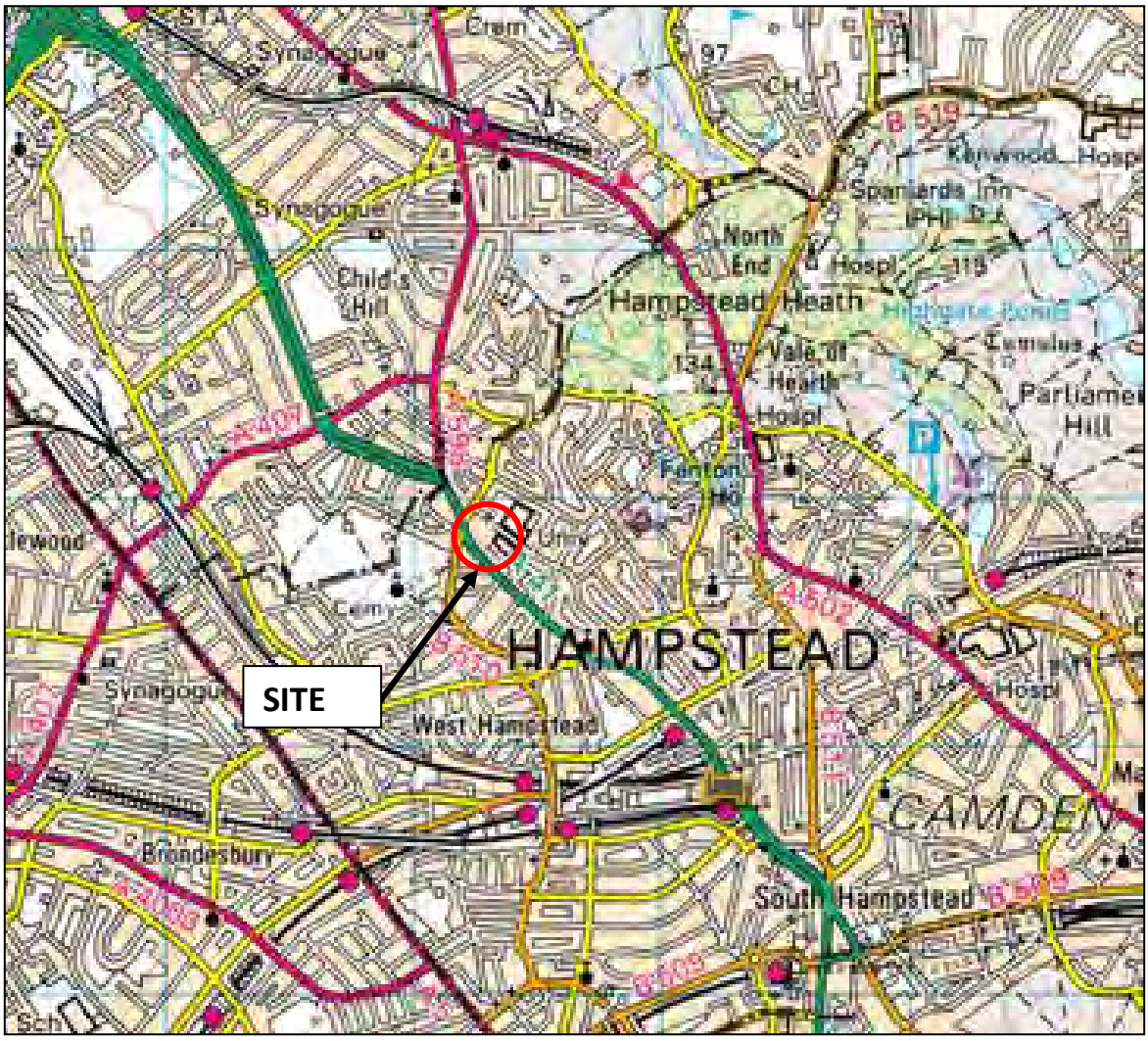
9. CONCLUSIONS

The findings of this addendum BIA are informed by site investigation data available for the site, preliminary architectural drawings and correspondence with the structural engineer for the project. This addendum report refers specifically to the Block E basement should be read in conjunction with the original BIA .

It is considered that the proposed Block E development will not have a detrimental effect on groundwater or surface water flows in the vicinity of the site, following the conclusions provided in the previous BIA.

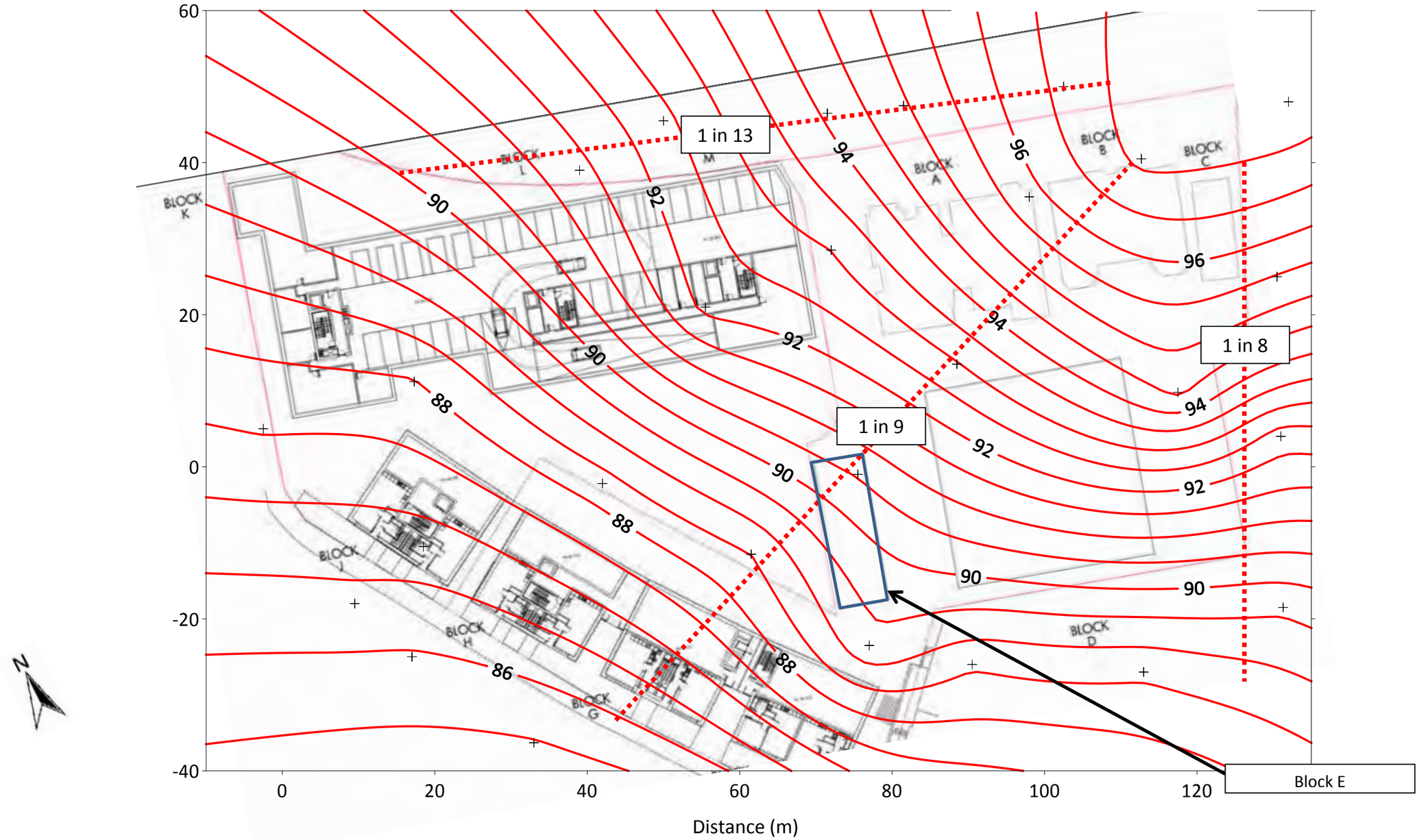
The construction of the Block E will generate ground movements due to a variety of causes, however, based on a conservative preliminary assessment it is considered that these movements can be controlled through appropriate construction techniques and calculated ground movements will not have a detrimental impact on existing or proposed structures/utilities.

FIGURES

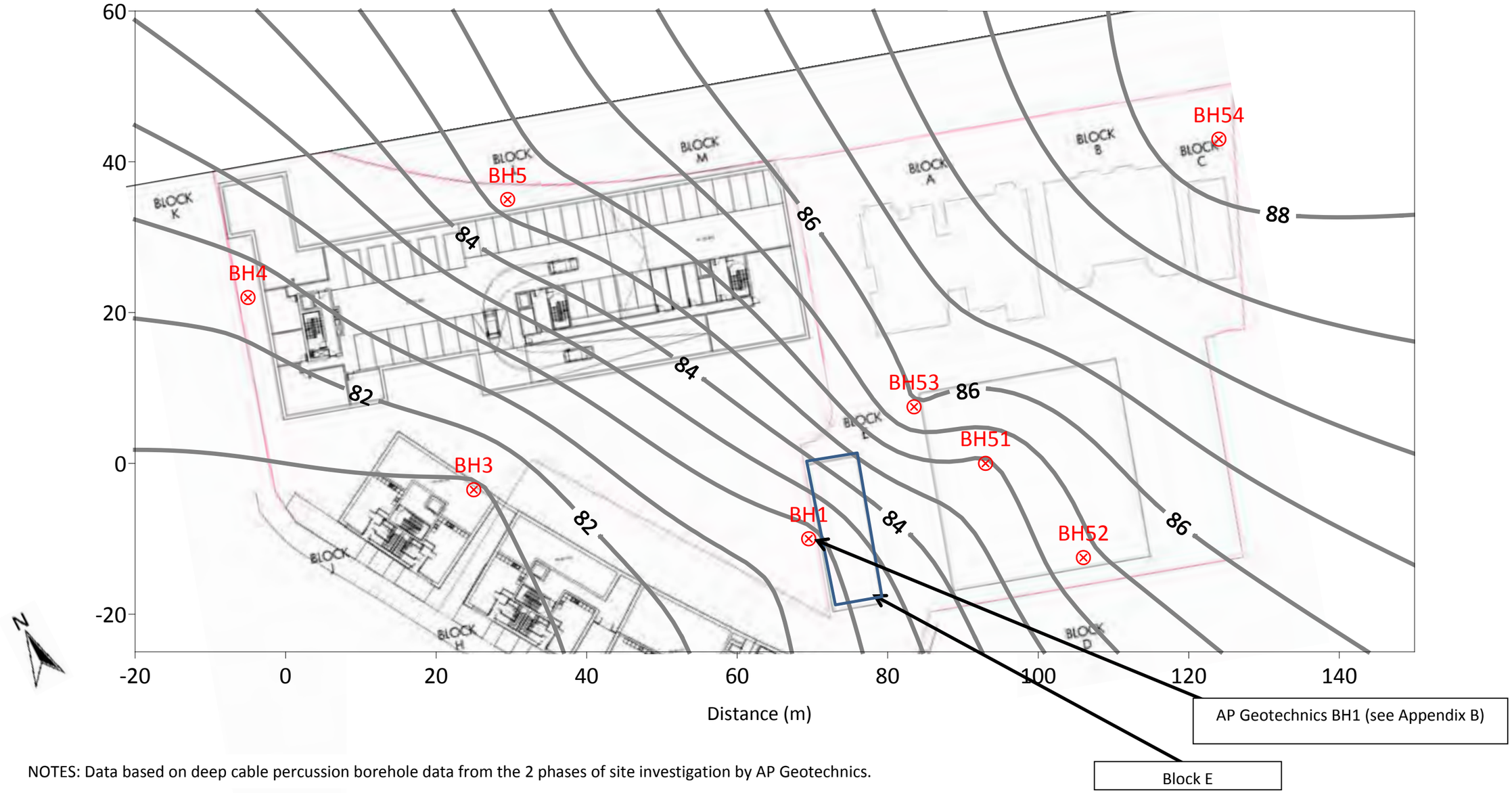


N

Client	Project	Job No
Barratt West London	**Block E, Kidderpore Avenue, London**	**CG/5946**
CGL	Title **Site location plan**	**Figure 1**

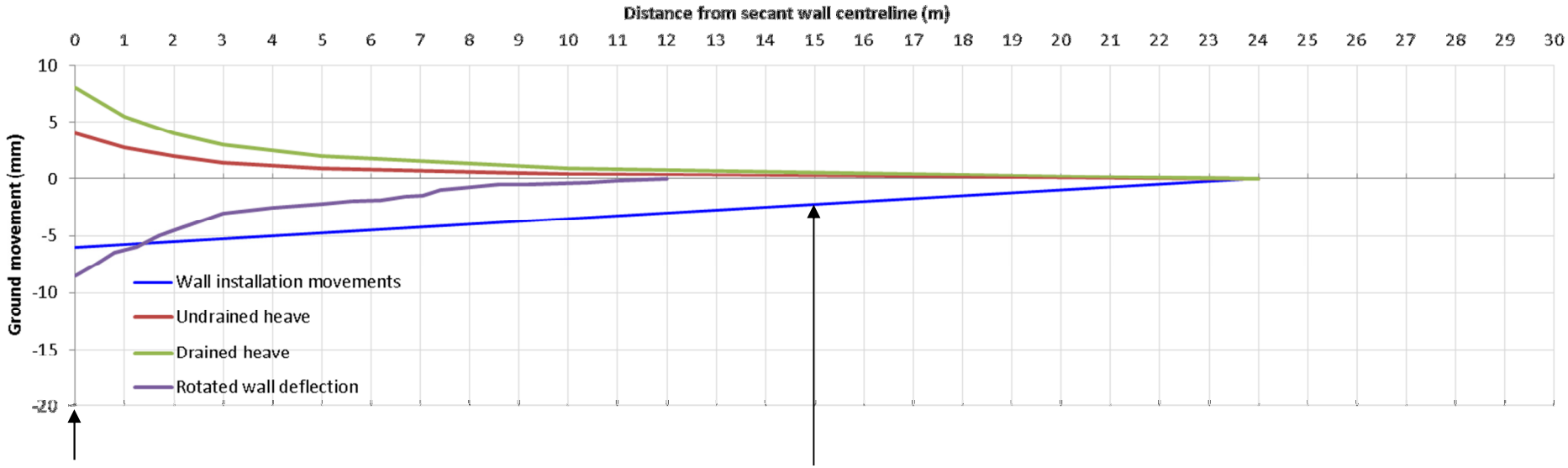


Client	Project	Job No
Barratt West London	**Block E, Kidderpore Avenue, London**	**CG/5946**
CGL	Title **Site topography (units in mOD)**	**Figure 2**



NOTES: Data based on deep cable percussion borehole data from the 2 phases of site investigation by AP Geotechnics.

Client	Project	Job No
Barratt West London	**Block E, Kidderpore Avenue, London**	**CG/5946**
CGL	Title **Level of the base of the Claygate Member (units in mOD)**	**Figure 3**



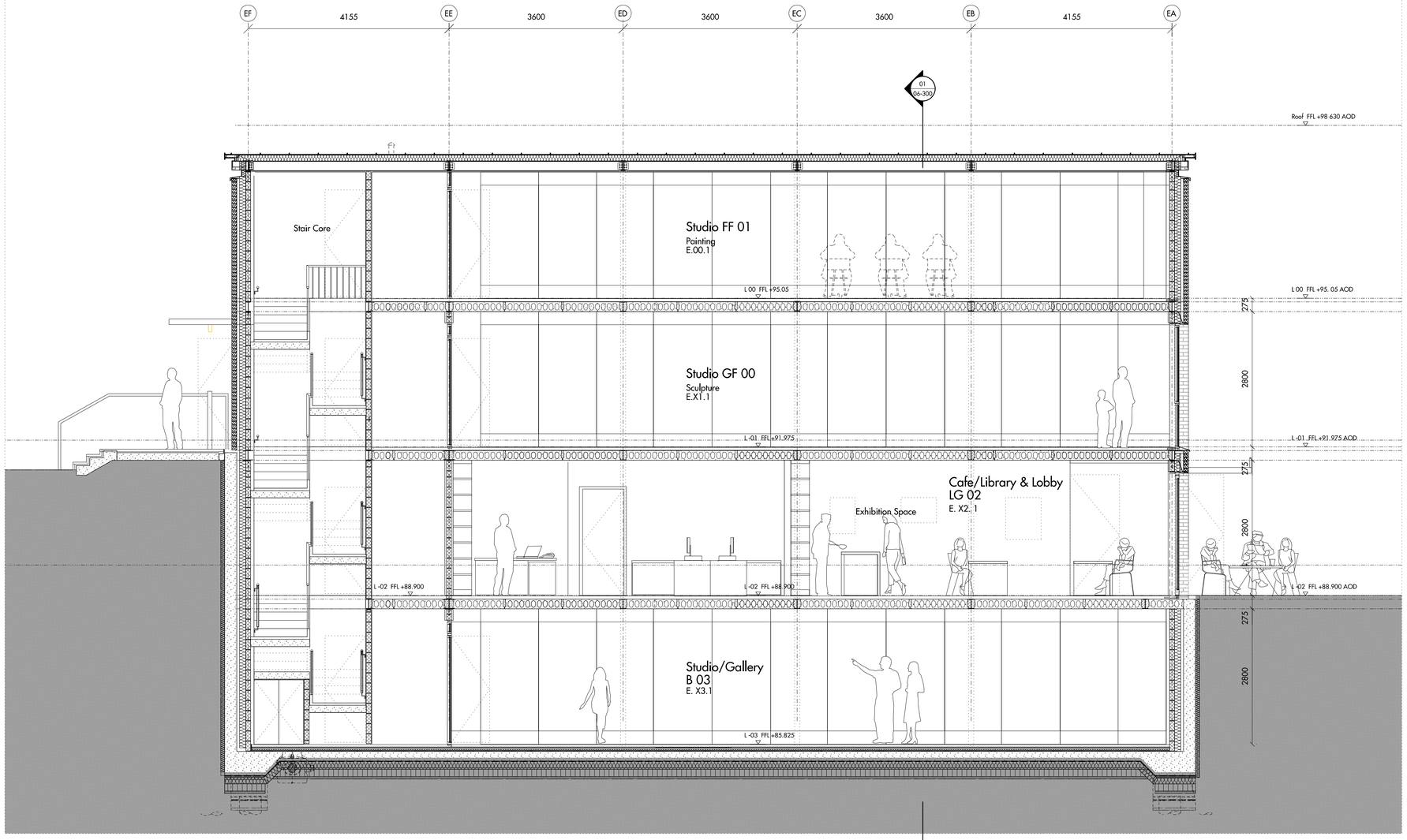
Secant wall centre line

Distance to nearest property = 15m;
326 Finchley Road
(max. 2mm settlement)

Client	Project	Job No
Barratt West London	**Block E, Kidderpore Avenue, London**	**CG/18167**
CGL	Title **Vertical displacement profile**	**Figure 4**

APPENDIX A

Proposed Development



01 LONG SECTION
SCALE 1:50

Do not scale from this drawing. Use figured dimensions only. Figured dimensions are in millimetres. All levels are in metres. All dimensions and levels shall be verified on site before proceeding with works. Detailed site survey to be carried out to verify positions and level relationships with site features and ordnance survey. Boundaries are indicative only and are to be verified by others. The architect must be notified of any discrepancy.
Where building components are described in the specification as contractor designed, "construction" information relating to those components on this drawing represents design intent only

REV	DATE	DESCRIPTION	CKD
P1	03.12.2014	FOR INFORMATION	NR
P2	12.01.2015	FOR INFORMATION	NR

REV	DATE	DESCRIPTION	CKD

Allies and Morrison
85 Southwark Street
London SE1 0HX
telephone 020 7921 0100
facsimile 020 7921 0101
email info@alliesandmorrison.co.uk

A&M JOB NO: 809

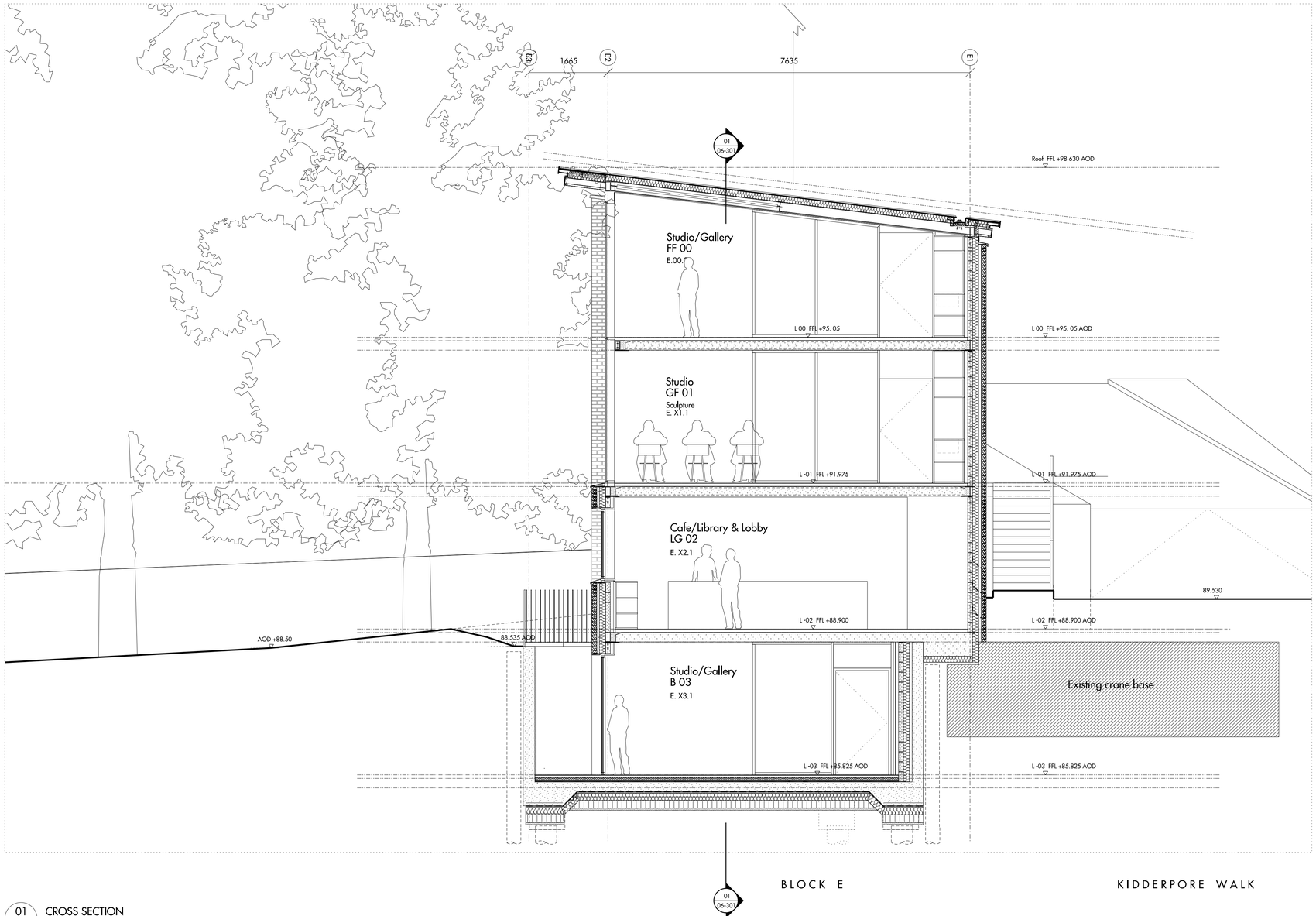
KIDDERPORE AVENUE

BLOCK E : LONG SECTION GENERAL ARRANGEMENT

809_03_06_301

SCALE 1:50@A1 1:100@A3

P2
Revision



01 CROSS SECTION
SCALE 1:50

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Where building components are described in the specification as contractor designed, "construction" information relating to those components on this drawing represents design intent only

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P1	17.02.2014	ISSUED FOR INFORMATION	HH
P2	19.03.2014	ISSUED FOR INFORMATION	SCS
P3	03.12.2014	ISSUED FOR INFORMATION	NR
P4	12.01.2015	ISSUED FOR COMMENT	NR
P5	26.01.2015	ISSUED FOR INFORMATION	NR

REV	DATE	DESCRIPTION	CKD

Allies and Morrison
85 Southwark Street
London SE1 0HX
telephone 020 7921 0100
facsimile 020 7921 0101
email info@alliesandmorrison.co.uk

A&M JOB NO: 809

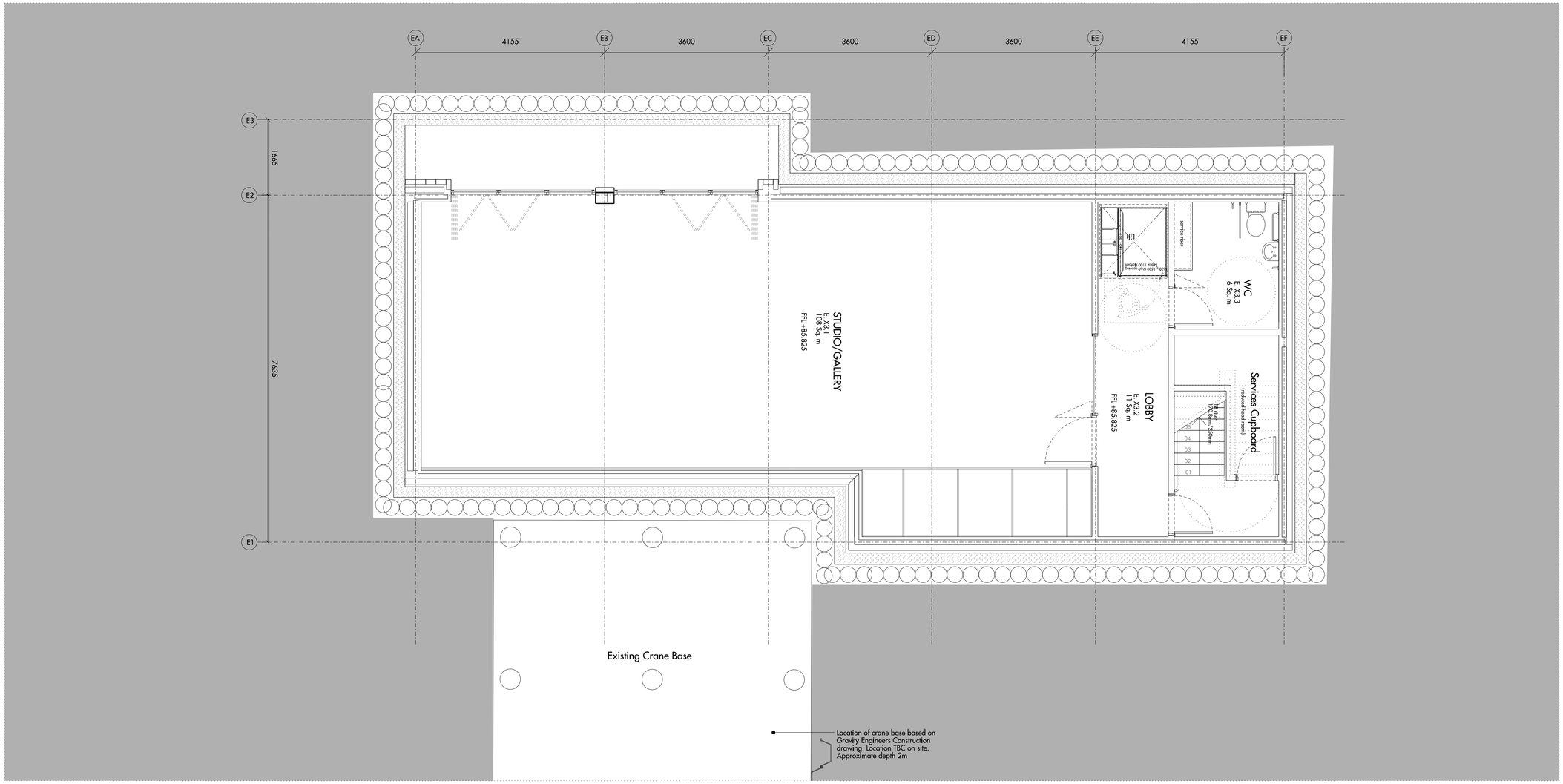
KIDDERPORE AVENUE

BLOCK E : CROSS SECTION GENERAL ARRANGEMENT

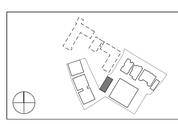
809_03_06_300

SCALE 1:50@A1 1:100@A3

P5
Revision



01 BLOCK E / LEVEL -03 PLAN
SCALE 1:50



Do not scale from this drawing. Use figured dimensions only. Figured dimensions are in millimetres. All levels are in metres. All dimensions and levels shall be verified on site before proceeding with works. Detailed site survey to be carried out to verify positions and level relationships with site features and ordnance survey. Boundaries are indicative only and are to be verified by others. The architect must be notified of any discrepancy.
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REV	DATE	DESCRIPTION	CKD
P1	04.11.2014	ISSUED FOR INFORMATION	NR
P2	03.12.2014	ISSUED FOR INFORMATION	NR
P3	12.01.2015	ISSUED FOR COMMENT	NR
P4	26.01.2015	ISSUED FOR INFORMATION	NR

REV	DATE	DESCRIPTION	CKD

Allies and Morrison
85 Southwark Street
London SE1 0HX
telephone 020 7921 0100
facsimile 020 7921 0101
email info@alliesandmorrison.co.uk

A&M JOB NO: 809

KIDDERPORE AVENUE

BLOCK E : LEVEL -03 PLAN
GENERAL ARRANGEMENT
809_03_06_099

SCALE 1:50@A1 1:100@A3

P4
Revision

APPENDIX B

Borehole BH1 – AP Geotechnics

AP GEOTECHNICS
T 01784 438038
F 01784 472870
E mail@apgeotechnics.co.uk

Site	Borehole Number
KING'S COLLEGE HAMPSTEAD CAMPUS, KIDDERPORE AVENUE, LONDON NW3 7ST	1

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150mm cased to 12.00m		Barratt West London	2796
	Location	**Dates**	**Engineer**	**Sheet**
	See site plan	26/06/2006-27/06/2006		1/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
						0.10 (0.30)	Turf over TOPSOIL FILL: Grey Limestone			
0.50 0.65	D1 D2					0.40 (0.25) 0.65	FILL: Claybound brick and concrete fragments			
				26/06/2006		(0.70)	FILL: Firm brown clay with brick, slate and flint gravel			
				27/06/2006						
1.00-1.35 1.35 1.35-1.70 1.70	U3 D4 B5 D6	1.00		60 blows		1.35 (0.35) 1.70	FILL: Compact layers of bricks and mortar with rootlets			
2.00-2.45	U7	2.00		28 blows			Firm to stiff fissured dark brown and grey brown mottled sandy CLAY with very sandy water bearing layers. Roots noted to 3 m depth			
2.45	D8									
3.00-3.45	U9	2.00		22 blows						
3.45	D10									
4.00-4.45	U11	2.00		30 blows		(4.50)				
4.45	D12									
5.00-5.45	U13	2.00		32 blows						
5.45	D14			Slow(1) at 5.20m, rose to 5.15m in 20 mins, sealed at 6.00m.					▼1	
6.20	D15					6.20	Firm to stiff dark grey sandy CLAY with light grey silty sandy partings			
6.50-6.95	U16	6.00		35 blows						
6.95	D17			Seep(2) at 7.30m, rose to 7.30m in 20 mins, sealed at 7.70m.					▼*	
8.00-8.45	U18	7.70		30 blows						
8.45	D19			Seep(3) at 8.80m, rose to 8.75m in 20 mins, sealed at 9.20m.					▼3	
9.50-9.95 9.50-9.95	SPT N=17 D20	9.00 9.00		1,3/4,5,4,4						

Remarks
Clean up working area - 1 hour
Dismantle Herras fencing and re-erect at BH3 - 1.5 hrs
Excavating from 0.00m to 1.20m for 1.5 hours.

Scale (approx)	Logged By
1:50	

Figure No. 2796.1

AP GEOTECHNICS
T 01784 438038
F 01784 472870
E mail@apgeotechnics.co.uk

Site	Borehole Number
KING'S COLLEGE HAMPSTEAD CAMPUS, KIDDERPORE AVENUE, LONDON NW3 7ST	1

Boring Method	Casing Diameter	Ground Level (mOD)	Client	Job Number
Cable Percussion	150mm cased to 12.00m		Barratt West London	2796
	Location	**Dates**	**Engineer**	**Sheet**
	See site plan	26/06/2006-27/06/2006		2/3

Depth (m)	Sample / Tests	Casing Depth (m)	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water	Instr
						(5.30)				
11.00-11.45	U21	9.00		40 blows						
11.45	D22					11.50	Stiff to very stiff fissured dark grey CLAY with occasional shells and shell fragments			
12.50-12.95	SPT N=21	12.00		3,4/4,5,5,7						
12.50-12.95	D23			12 blows						
14.00-14.45	U24	12.00		60 blows						
14.45	D25									
15.50-15.95	SPT N=27	12.00		3,4/5,6,8,8						
15.50-15.95	D26	12.00				(8.50)				
17.00-17.45	U27	12.00		60 blows						
17.45	D28									
18.50-18.95	SPT N=30	12.00		3,5/6,7,9,8						
18.50-18.95	D29	12.00								
20.00-20.45	SPT N=31	12.00		3,5/7,7,8,9		20.00				

Remarks

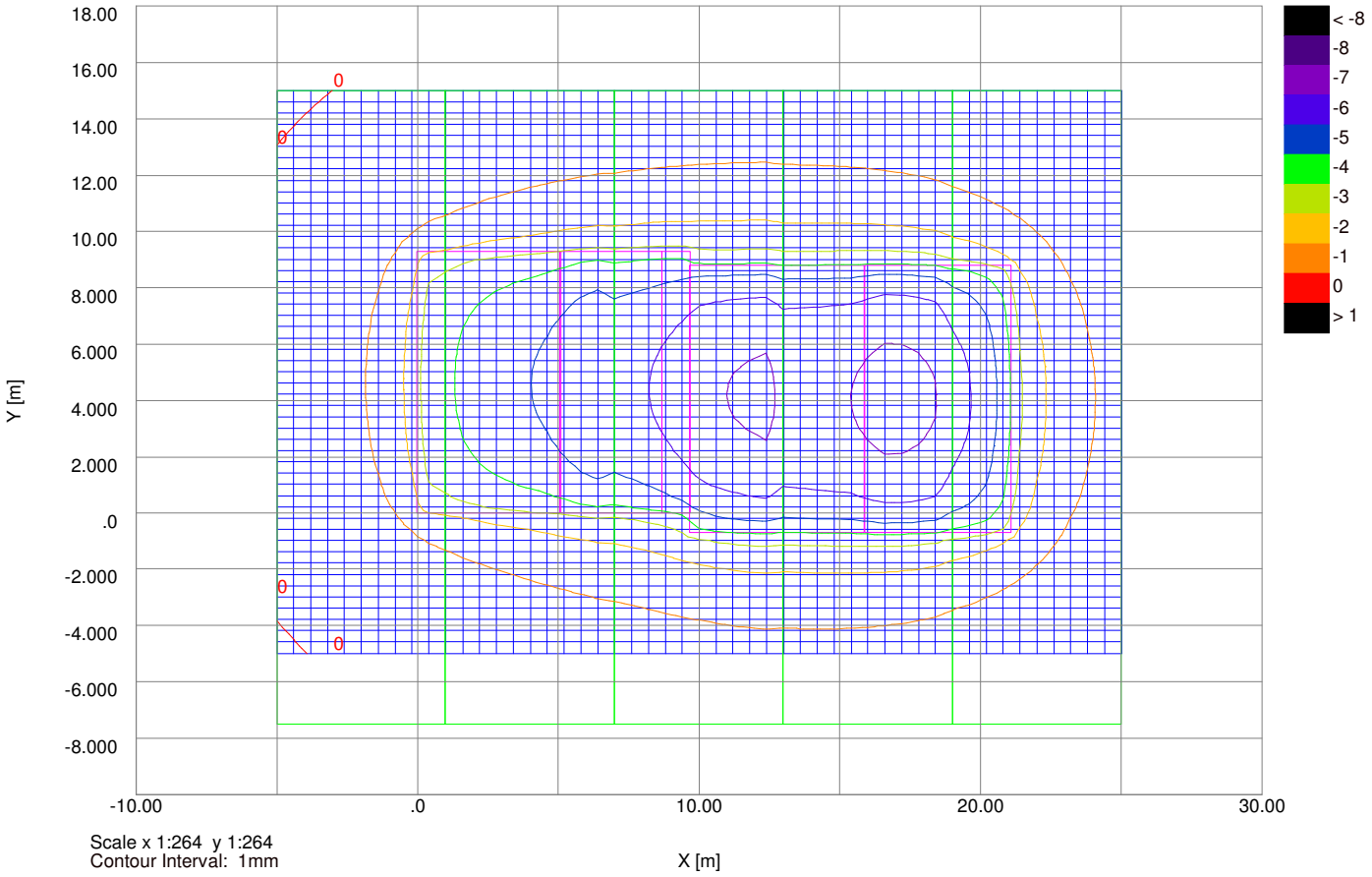
Scale (approx)	Logged By
1:50	

Figure No. 2796.1

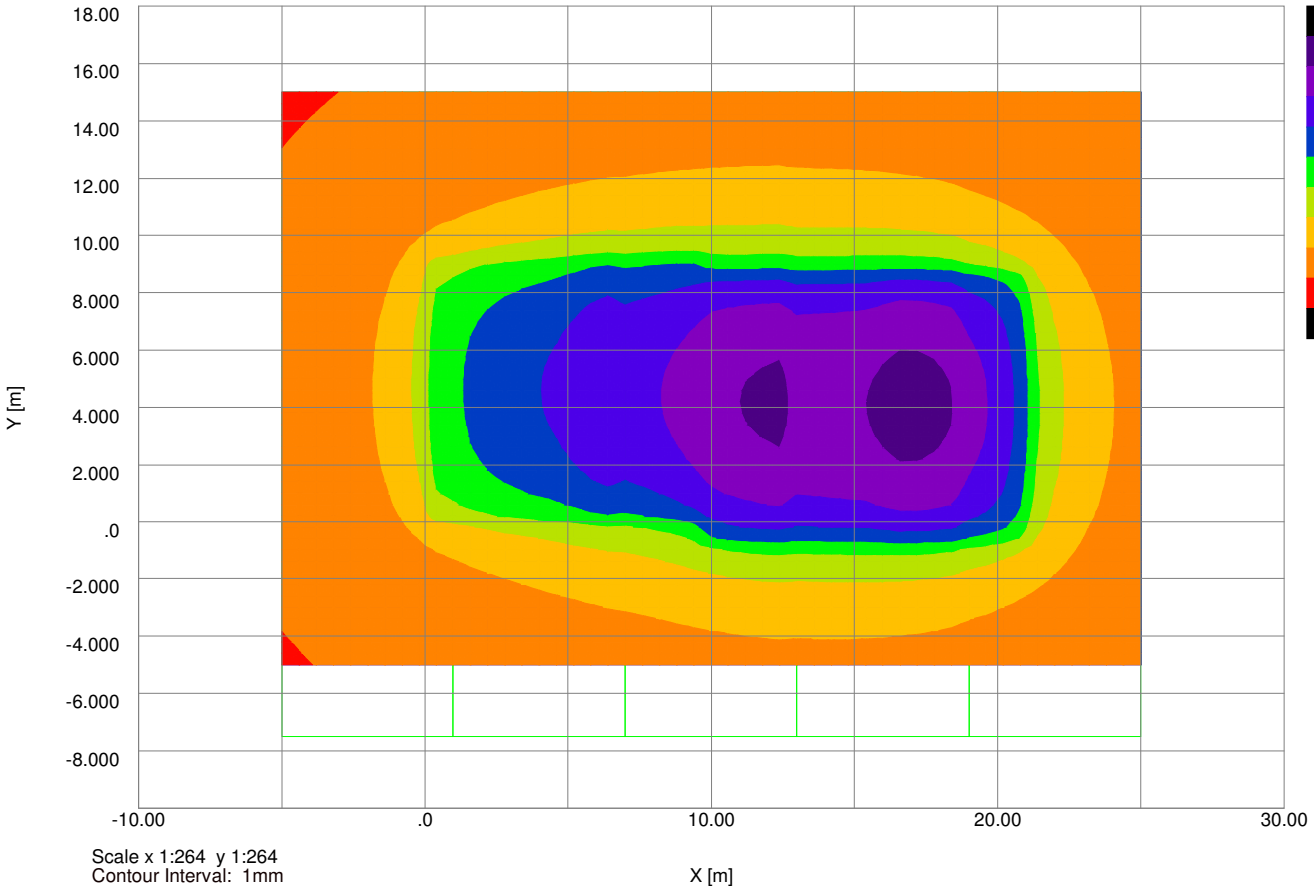
APPENDIX C

PDisp Output

Settlement Contours : Grid 1 at 85.35m

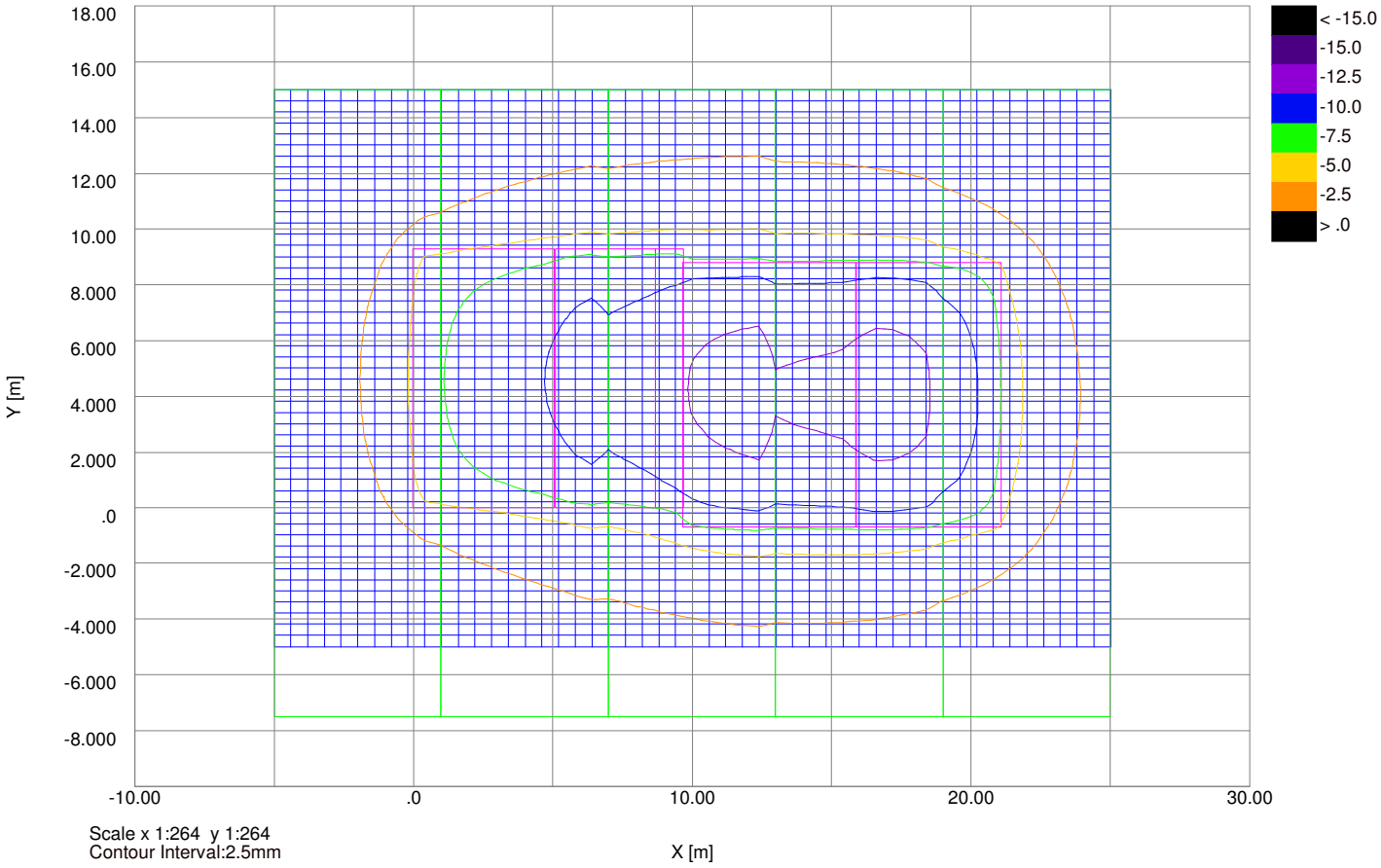


Settlement Contours : Grid 1 at 85.35m



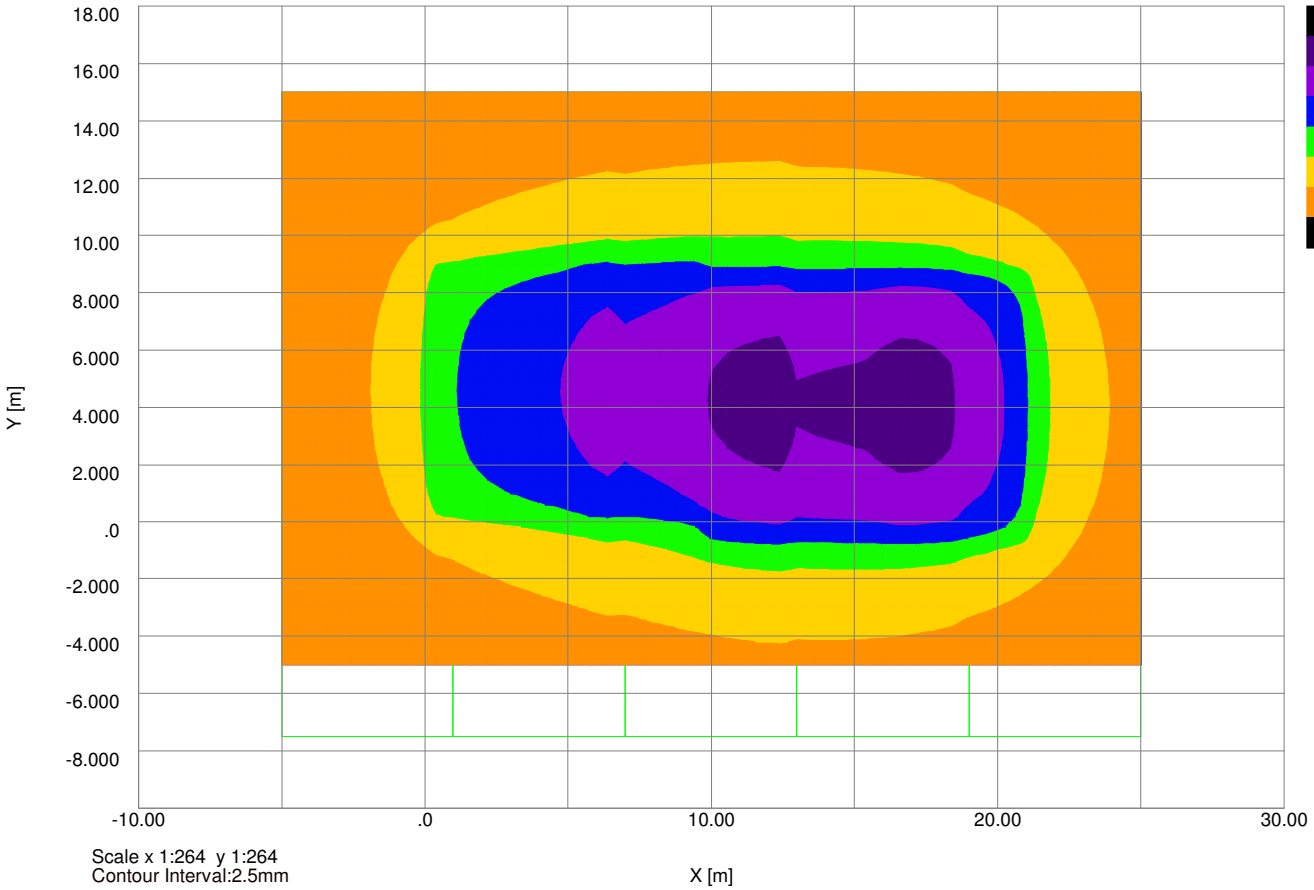
Scale x 1:264 y 1:264
Contour Interval: 1mm

Settlement Contours : Grid 1 at 85.35m



Scale x 1:264 y 1:264
Contour Interval:2.5mm

Settlement Contours : Grid 1 at 85.35m



Scale x 1:264 y 1:264
Contour Interval:2.5mm

APPENDIX D

WALLAP Output

Units: kN,m

INPUT DATA

SOIL PROFILE

Stratum no.	Elevation of top of stratum	Soil types Active side	Passive side
1	92.00	1 Made Ground	1 Made Ground
2	90.30	2 Claygate Member	2 Claygate Member
3	85.80	3 LCF Undrained	3 LCF Undrained

SOIL PROPERTIES

-- Soil type -- No.	Description (Datum elev.)	Bulk density kN/m3	Young's Modulus Eh,kN/m2 (dEh/dy)	At rest coeff. Ko (dKo/dy)	Consol state. NC/OC (Nu)	Active limit Ka (Kac)	Passive limit Kp (Kpc)	Cohesion kN/m2 (dc/dy)
1	Made Ground	18.00	14000	0.531	OC (0.200)	0.298 (0.000)	4.393 (0.000)	
2	Claygate .. (90.30)	19.00	40000 (3700)	1.000	OC (0.490)	1.000 (2.570)	1.000 (2.571)	40.00u (5.700)
3	LCF Undra.. (85.80)	20.00	65000 (5700)	1.000	OC (0.490)	1.000 (2.570)	1.000 (2.571)	65.00u (5.700)

Additional soil parameters associated with Ka and Kp

	--- parameters for Ka ---			--- parameters for Kp ---		
------- Soil type ------- No. Description	Soil friction angle	Wall adhesion coeff.	Back-fill angle	Soil friction angle	Wall adhesion coeff.	Back-fill angle
1 Made Ground	28.00	1.000	0.00	28.00	1.000	0.00
2 Claygate Member	0.00	1.000	0.00	0.00	1.000	0.00
3 LCF Undrained	0.00	1.000	0.00	0.00	1.000	0.00

GROUND WATER CONDITIONS

Density of water = 10.00 kN/m3

	Active side	Passive side
Initial water table elevation	88.00	88.00

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	88.00	88.00	0.0	1	85.32	85.32	0.0	MC+WC

WALL PROPERTIES

Type of structure = Fully Embedded Wall
Elevation of toe of wall = 80.00
Maximum finite element length = 0.60 m
Youngs modulus of wall E = 3.0000E+07 kN/m2
Moment of inertia of wall I = 1.1000E-03 m4/m run
E.I = 33000 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	89.00	1.00	0.030000	2.000E+08	12.50	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	92.00	0.00(A)	70.00	15.00	10.00	=	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 92.00
2	Excavate to elevation 88.50 on PASSIVE side
3	Install strut or anchor no.1 at elevation 89.00
4	Apply water pressure profile no.1 (Mod. Conserv.)
5	Excavate to elevation 85.32 on PASSIVE side

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 = 1.20

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

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

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

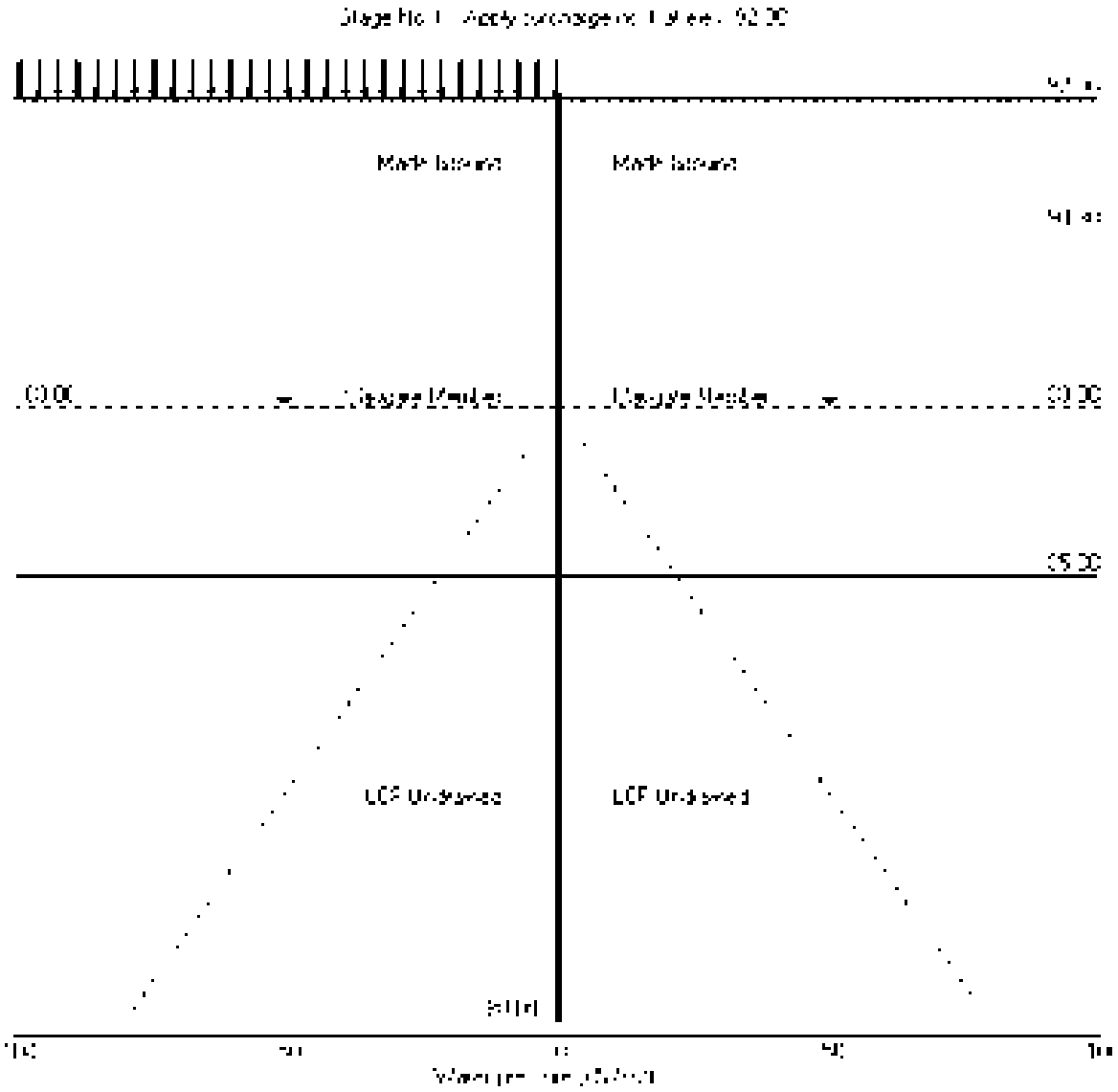
Width of excavation on active side of wall = 20.00 m
Width of excavation on passive side of wall = 20.00 m

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

OUTPUT OPTIONS

Stage no.	Stage description	Output options: Displacement Bending mom. Shear force	Active, Passive pressures	Graph. output
1	Apply surcharge no.1 at elev. 92.00	Yes	Yes	Yes
2	Excav. to elev. 88.50 on PASSIVE side	Yes	Yes	Yes
3	Install strut no.1 at elev. 89.00	Yes	Yes	Yes
4	Apply water pressure profile no.1	No	No	No
5	Excav. to elev. 85.32 on PASSIVE side	Yes	Yes	Yes
*	Summary output	Yes	-	Yes

Units: kN,m



Units: kN,m

Stage No. 1 Apply surcharge no.1 at elevation 92.00

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. = 80.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.200 Toe elev.	Wall Penetr -ation
1	92.00	92.00	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: Active side 20.00 from wall
Passive side 20.00 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	92.00	2.98	0.001	1.23E-04	0.0	-0.0	
2	91.60	-0.18	0.001	1.22E-04	0.6	0.2	
3	91.20	-0.31	0.001	1.18E-04	0.5	0.4	
4	90.75	-0.13	0.001	1.11E-04	0.4	0.6	
5	90.30	0.04	0.001	1.01E-04	0.3	0.8	
		-0.82	0.001	1.01E-04	0.3	0.8	
6	89.98	-0.64	0.001	9.40E-05	0.1	0.8	
7	89.65	-0.48	0.001	8.58E-05	-0.1	0.8	
8	89.33	-0.34	0.001	7.80E-05	-0.2	0.8	
9	89.00	-0.21	0.001	7.08E-05	-0.3	0.7	
10	88.50	-0.05	0.001	6.17E-05	-0.4	0.5	
11	88.00	0.07	0.001	5.55E-05	-0.4	0.3	
12	87.50	0.19	0.000	5.21E-05	-0.3	0.1	
13	87.00	0.32	0.000	5.09E-05	-0.2	0.0	
14	86.40	0.51	0.000	5.11E-05	0.1	-0.0	
15	85.80	0.74	0.000	5.05E-05	0.5	0.1	
		-0.53	0.000	5.05E-05	0.5	0.1	
16	85.32	-0.40	0.000	4.79E-05	0.2	0.3	
17	84.96	-0.29	0.000	4.48E-05	0.1	0.3	
18	84.60	-0.20	0.000	4.12E-05	0.0	0.3	
19	84.00	-0.09	0.000	3.54E-05	-0.1	0.3	
20	83.40	-0.01	0.000	3.04E-05	-0.1	0.2	
21	82.80	0.02	0.000	2.65E-05	-0.1	0.2	
22	82.20	0.03	0.000	2.38E-05	-0.1	0.1	
23	81.60	0.03	0.000	2.21E-05	-0.1	0.1	
24	81.00	0.03	0.000	2.11E-05	-0.0	0.0	
25	80.50	0.04	0.000	2.07E-05	-0.0	0.0	
26	80.00	0.07	0.000	2.07E-05	0.0	0.0	

(continued)

Stage No.1 Apply surcharge no.1 at elevation 92.00

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	92.00	0.00	10.00	2.98	43.93	2.98	2.98a	1778
2	91.60	0.00	17.20	5.13	75.55	5.13	5.13a	1778
3	91.20	0.00	24.40	7.28	107.18	8.74	8.74	1778
4	90.75	0.00	32.50	9.70	142.75	13.13	13.13	1778
5	90.30	0.00	40.59	12.11	178.31	17.52	17.52	1778
		Total>	40.59	8.50m	143.44	34.99	34.99	7532
6	89.98	Total>	46.76	10.12m	154.37	41.25	41.25	7758
7	89.65	Total>	52.93	11.75m	165.31	47.51	47.51	7985
8	89.33	Total>	59.10	13.37m	176.24	53.75	53.75	8211
9	89.00	Total>	65.27	15.00m	187.17	59.98	59.98	8437
10	88.50	Total>	74.75	17.50m	203.97	69.55	69.55	8786
11	88.00	Total>	84.22	20.00m	220.78	79.10	79.10	9134
12	87.50	Total>	93.69	22.50m	237.58	88.65	88.65	9482
13	87.00	Total>	103.16	25.00m	254.37	98.20	98.20	9831
14	86.40	Total>	114.50	28.00m	274.51	109.66	109.66	10249
15	85.80	Total>	125.84	31.00m	294.64	121.15	121.15	10667
		Total>	125.84	31.00m	292.97	120.52	120.52	12239
16	85.32	Total>	135.29	33.38m	309.37	130.06	130.06	12749
17	84.96	Total>	142.49	35.19m	321.89	137.33	137.33	13138
18	84.60	Total>	149.69	37.00m	334.41	144.61	144.61	13527
19	84.00	Total>	161.60	40.00m	355.11	156.62	156.62	14171
20	83.40	Total>	173.51	43.00m	375.81	168.61	168.61	14815
21	82.80	Total>	185.40	46.00m	396.50	180.58	180.58	15459
22	82.20	Total>	197.29	49.00m	417.18	192.53	192.53	16103
23	81.60	Total>	209.18	52.00m	437.86	204.48	204.48	16747
24	81.00	Total>	221.06	55.00m	458.53	216.42	216.42	17391
25	80.50	Total>	230.95	57.50m	475.76	226.37	226.37	17927
26	80.00	Total>	240.85	60.00m	492.98	236.33	236.33	18464

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	92.00	0.00	0.00	0.00	0.00	0.00	0.00	1778
2	91.60	0.00	7.20	2.15	31.63	5.32	5.32	1778
3	91.20	0.00	14.40	4.30	63.25	9.05	9.05	1778
4	90.75	0.00	22.50	6.71	98.83	13.26	13.26	1778
5	90.30	0.00	30.60	9.13	134.41	17.48	17.48	1778
		Total>	30.60	8.50m	133.45	35.81	35.81	7532
6	89.98	Total>	36.77	10.12m	144.39	41.90	41.90	7758
7	89.65	Total>	42.95	11.75m	155.32	47.99	47.99	7985
8	89.33	Total>	49.12	13.37m	166.26	54.09	54.09	8211
9	89.00	Total>	55.30	15.00m	177.20	60.19	60.19	8437
10	88.50	Total>	64.80	17.50m	194.03	69.61	69.61	8786
11	88.00	Total>	74.30	20.00m	210.86	79.03	79.03	9134
12	87.50	Total>	83.80	22.50m	227.68	88.46	88.46	9482
13	87.00	Total>	93.30	25.00m	244.51	97.87	97.87	9831
14	86.40	Total>	104.70	28.00m	264.70	109.15	109.15	10249
15	85.80	Total>	116.10	31.00m	284.90	120.41	120.41	10667
		Total>	116.10	31.00m	283.23	121.05	121.05	12239
16	85.32	Total>	125.60	33.38m	299.69	130.45	130.45	12749
17	84.96	Total>	132.85	35.19m	312.25	137.63	137.63	13138
18	84.60	Total>	140.10	37.00m	324.81	144.81	144.81	13527

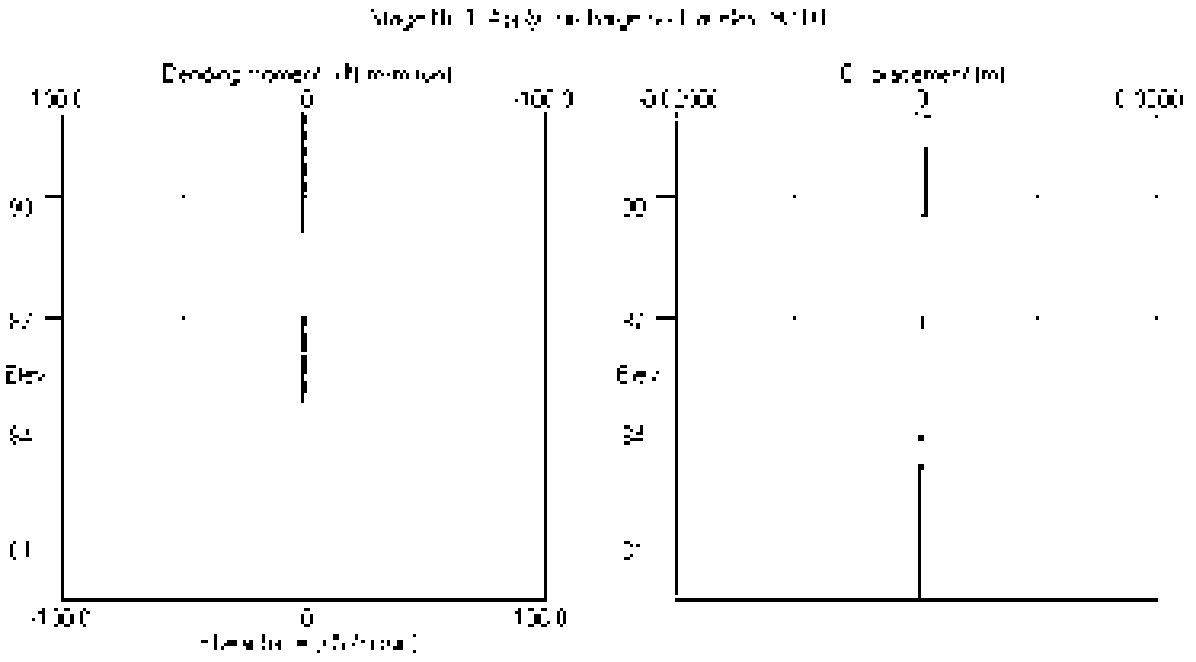
(continued)

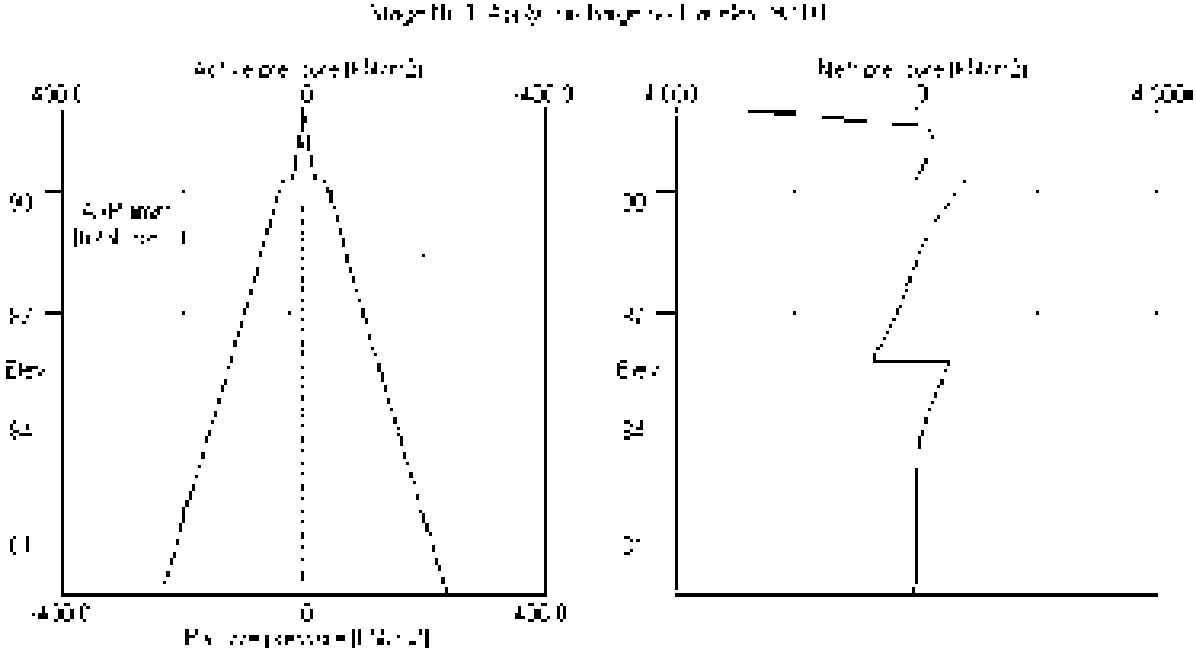
Stage No.1 Apply surcharge no.1 at elevation 92.00

Node no.	Y coord	PASSIVE side						
		Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
19	84.00	Total>	152.10	40.00m	345.61	156.71	156.71	14171
20	83.40	Total>	164.10	43.00m	366.40	168.63	168.63	14815
21	82.80	Total>	176.10	46.00m	387.19	180.56	180.56	15459
22	82.20	Total>	188.10	49.00m	407.99	192.50	192.50	16103
23	81.60	Total>	200.10	52.00m	428.78	204.45	204.45	16747
24	81.00	Total>	212.10	55.00m	449.57	216.39	216.39	17391
25	80.50	Total>	222.10	57.50m	466.90	226.33	226.33	17927
26	80.00	Total>	232.10	60.00m	484.23	236.27	236.27	18464

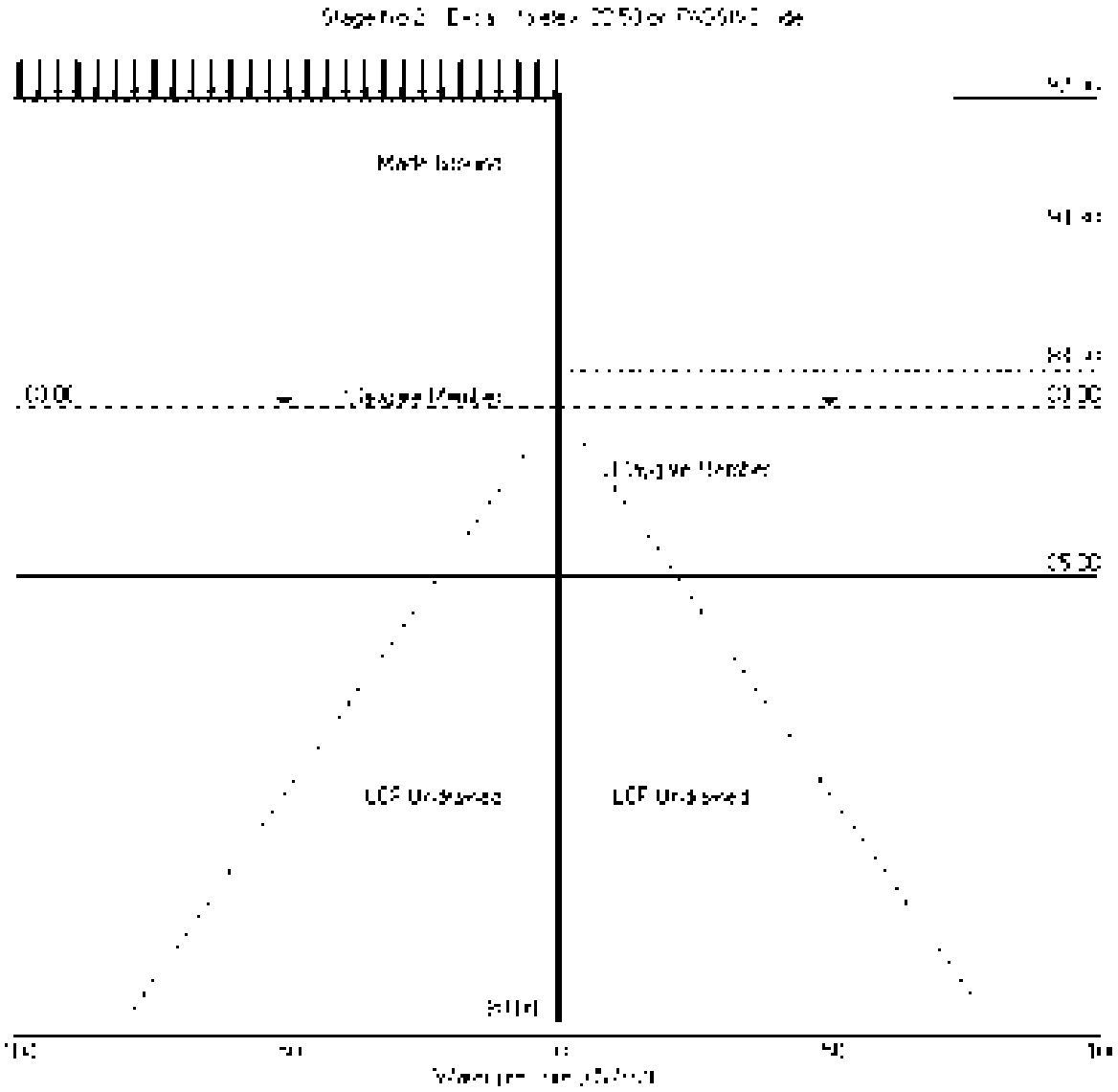
Note: 5.13a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m





Units: kN,m



Units: kN,m

Stage No. 2 Excavate to elevation 88.50 on PASSIVE side

STABILITY ANALYSIS of Fully Embedded Wall according to Strength Factor method

Factor of safety on soil strength

Stage No.	G.L. Act.	G.L. Pass.	Strut Elev.	FoS for toe elev. = 80.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.200 Toe elev.	Wall Penetr -ation
2	92.00	88.50	Cant.	3.430	80.85	86.47	2.03

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

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

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

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	92.00	2.98	0.019	4.63E-03	0.0	0.0	
2	91.60	5.13	0.018	4.63E-03	1.6	0.3	
3	91.20	7.28	0.016	4.62E-03	4.1	1.5	
4	90.75	9.70	0.014	4.58E-03	7.9	4.1	
5	90.30	12.11	0.012	4.49E-03	12.8	8.8	
		8.50	0.012	4.49E-03	12.8	8.8	
6	89.98	10.12	0.010	4.38E-03	15.9	13.4	
7	89.65	11.75	0.009	4.22E-03	19.4	19.1	
8	89.33	13.37	0.007	4.00E-03	23.5	26.1	
9	89.00	15.00	0.006	3.70E-03	28.1	34.5	
10	88.50	17.50	0.004	3.06E-03	36.2	50.5	
		-102.52	0.004	3.06E-03	36.2	50.5	
11	88.00	-58.33	0.003	2.24E-03	-4.0	58.0	
12	87.50	-20.44	0.002	1.43E-03	-23.7	48.7	
13	87.00	2.66	0.002	8.05E-04	-28.1	34.3	
14	86.40	15.56	0.001	3.31E-04	-22.6	17.9	
15	85.80	18.69	0.001	1.04E-04	-12.4	7.1	
		10.90	0.001	1.04E-04	-12.4	7.1	
16	85.32	9.34	0.001	3.56E-05	-7.6	2.4	
17	84.96	7.31	0.001	2.04E-05	-4.5	0.3	
18	84.60	5.20	0.001	2.34E-05	-2.3	-0.9	
19	84.00	2.27	0.001	4.29E-05	-0.0	-1.3	
20	83.40	0.45	0.001	6.31E-05	0.8	-0.9	
21	82.80	-0.40	0.001	7.51E-05	0.8	-0.4	
22	82.20	-0.60	0.001	7.88E-05	0.5	-0.0	
23	81.60	-0.49	0.001	7.74E-05	0.2	0.2	
24	81.00	-0.25	0.001	7.47E-05	-0.1	0.1	
25	80.50	0.04	0.001	7.31E-05	-0.1	0.1	
26	80.00	0.42	0.001	7.26E-05	0.0	0.0	

(continued)

Stage No.2 Excavate to elevation 88.50 on PASSIVE side

Node no.	Y coord	ACTIVE side						
		Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
1	92.00	0.00	10.00	2.98	43.93	2.98	2.98a	3303
2	91.60	0.00	17.20	5.13	75.55	5.13	5.13a	3303
3	91.20	0.00	24.40	7.28	107.18	7.28	7.28a	3303
4	90.75	0.00	32.50	9.70	142.75	9.70	9.70a	3303
5	90.30	0.00	40.59	12.11	178.31	12.11	12.11a	3303
		Total>	40.59	8.50m	143.44	8.50	8.50a	13342
6	89.98	Total>	46.76	10.12m	154.37	10.12	10.12a	13743
7	89.65	Total>	52.93	11.75m	165.31	11.75	11.75a	14145
8	89.33	Total>	59.10	13.37m	176.24	13.37	13.37a	14546
9	89.00	Total>	65.27	15.00m	187.17	15.00	15.00a	14947
10	88.50	Total>	74.75	17.50m	203.97	17.50	17.50a	15564
11	88.00	Total>	84.22	20.00m	220.78	36.70	36.70	16181
12	87.50	Total>	93.69	22.50m	237.58	59.52	59.52	16798
13	87.00	Total>	103.16	25.00m	254.37	77.14	77.14	17415
14	86.40	Total>	114.50	28.00m	274.51	93.09	93.09	18156
15	85.80	Total>	125.84	31.00m	294.64	105.60	105.60	18896
		Total>	125.84	31.00m	292.97	102.67	102.67	21681
16	85.32	Total>	135.29	33.38m	309.37	111.63	111.63	22584
17	84.96	Total>	142.49	35.19m	321.89	118.18	118.18	23274
18	84.60	Total>	149.69	37.00m	334.41	124.69	124.69	23963
19	84.00	Total>	161.60	40.00m	355.11	135.67	135.67	25104
20	83.40	Total>	173.51	43.00m	375.81	147.04	147.04	26244
21	82.80	Total>	185.40	46.00m	396.50	158.75	158.75	27385
22	82.20	Total>	197.29	49.00m	417.18	170.69	170.69	28526
23	81.60	Total>	209.18	52.00m	437.86	182.75	182.75	29667
24	81.00	Total>	221.06	55.00m	458.53	194.86	194.86	30807
25	80.50	Total>	230.95	57.50m	475.76	204.99	204.99	31758
26	80.00	Total>	240.85	60.00m	492.98	215.16	215.16	32709

Node no.	Y coord	PASSIVE side						
		Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
1	92.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	91.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	91.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	90.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	90.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	89.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	89.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	89.33	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	89.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	88.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	129.23	120.02	120.02	28724
11	88.00	Total>	9.50	2.50m	146.06	95.03	95.03	29863
12	87.50	Total>	19.00	5.00m	162.89	79.96	79.96	31002
13	87.00	Total>	28.51	7.50m	179.72	74.48	74.48	32140
14	86.40	Total>	39.93	10.50m	199.94	77.52	77.52	33507
15	85.80	Total>	51.37	13.50m	220.16	86.91	86.91	34874
		Total>	51.37	13.50m	218.49	91.78	91.78	40014
16	85.32	Total>	60.91	15.88m	234.99	102.30	102.30	41681
17	84.96	Total>	68.20	17.69m	247.60	110.86	110.86	42953
18	84.60	Total>	75.49	19.50m	260.21	119.49	119.49	44225

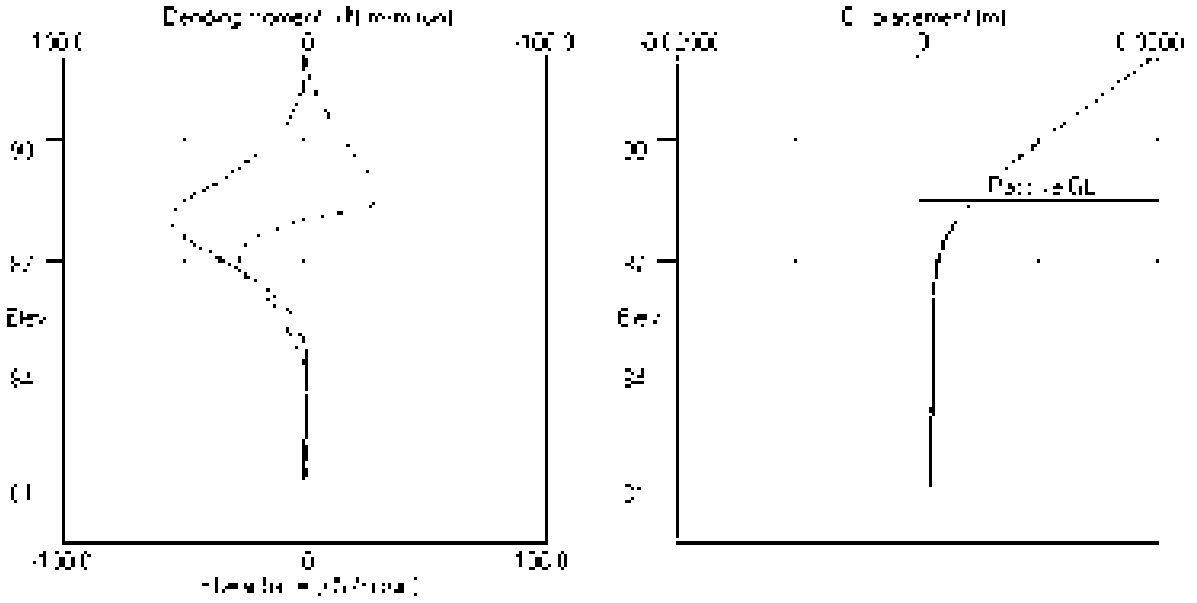
(continued)

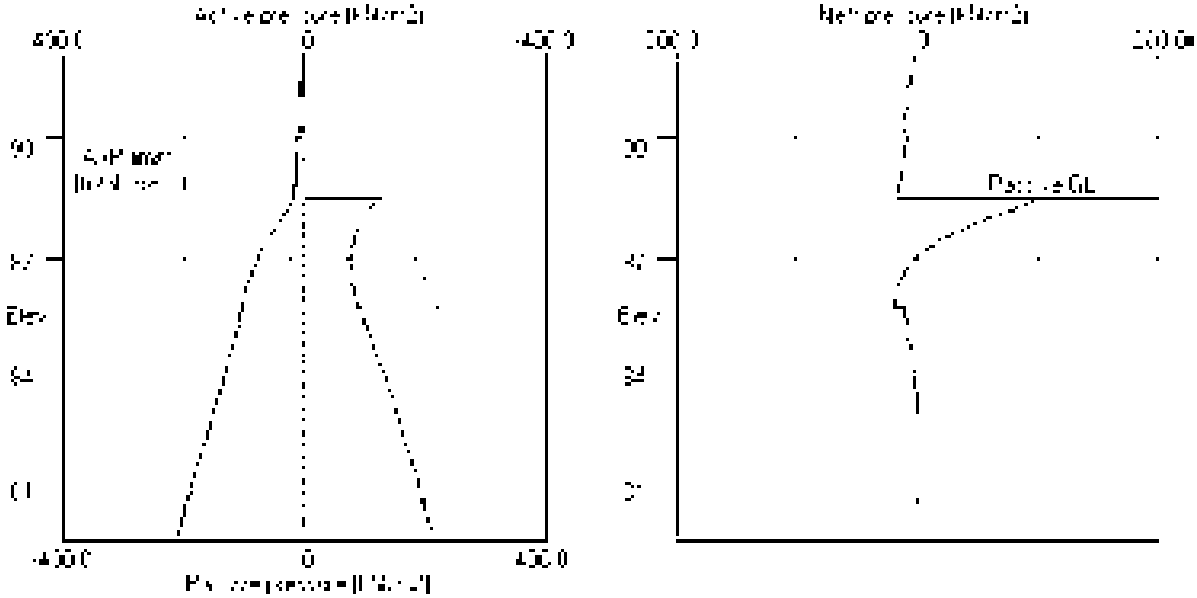
Stage No.2 Excavate to elevation 88.50 on PASSIVE side

Node no.	Y coord	PASSIVE side						
		Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
19	84.00	Total>	87.60	22.50m	281.10	133.40	133.40	46330
20	83.40	Total>	99.72	25.50m	302.02	146.59	146.59	48435
21	82.80	Total>	111.88	28.50m	322.97	159.15	159.15	50541
22	82.20	Total>	124.07	31.50m	343.95	171.29	171.29	52646
23	81.60	Total>	136.29	34.50m	364.97	183.24	183.24	54751
24	81.00	Total>	148.54	37.50m	386.01	195.11	195.11	56857
25	80.50	Total>	158.77	40.00m	403.57	204.95	204.95	58611
26	80.00	Total>	169.03	42.50m	421.16	214.74	214.74	60366

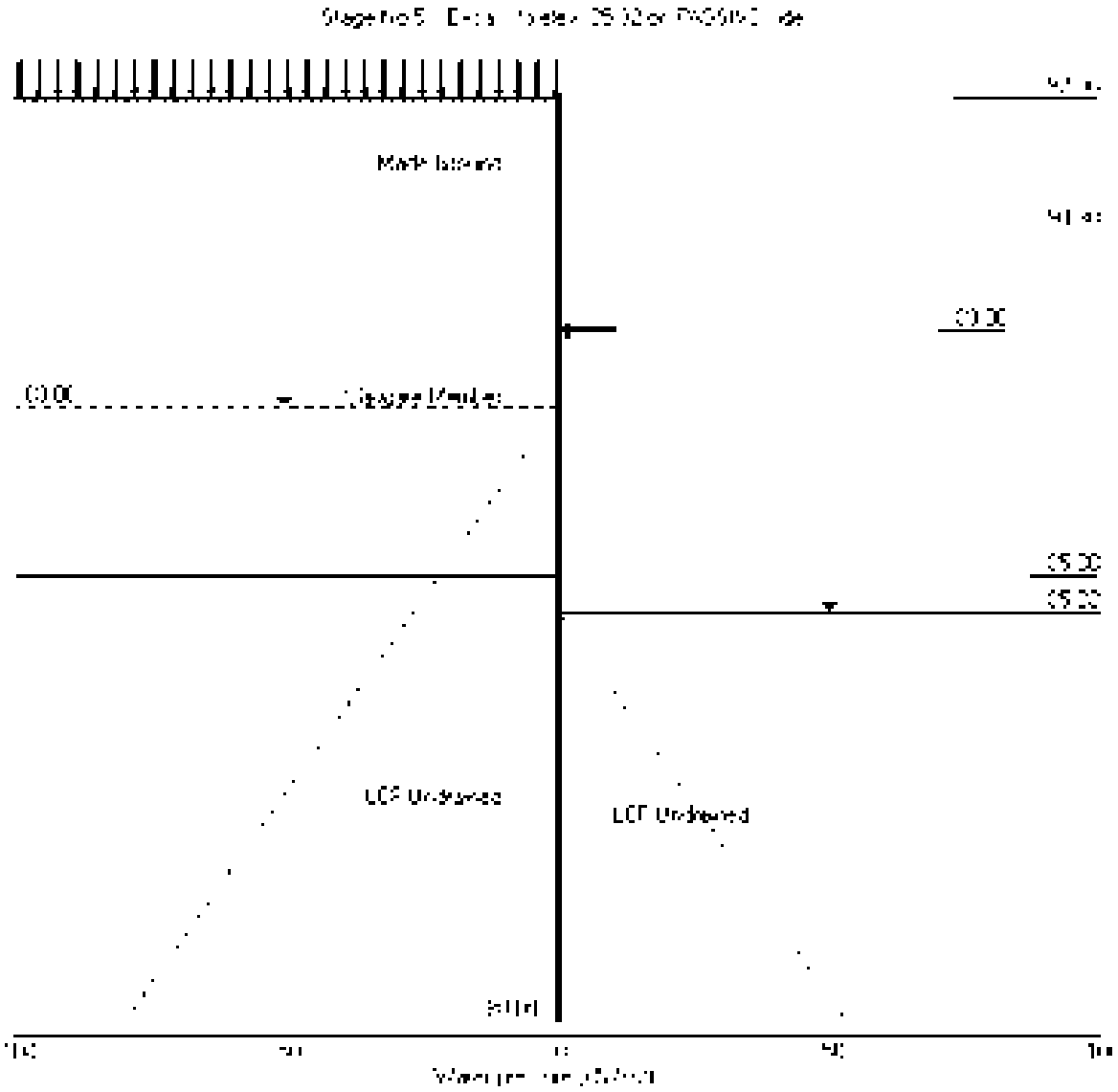
Note: 17.50a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m





Units: kN,m



Units: kN,m

Stage No. 5 Excavate to elevation 85.32 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.	FoS for toe elev. = 80.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.200 Toe elev.	Wall Penetr -ation
5	92.00	85.32	89.00	3.026	n/a	85.00	0.32

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

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

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

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	92.00	13.57	0.017	3.91E-03	0.0	0.0	
2	91.60	14.66	0.015	3.90E-03	5.6	1.2	
3	91.20	15.74	0.013	3.87E-03	11.7	4.7	
4	90.75	16.87	0.012	3.76E-03	19.1	11.7	
5	90.30	17.82	0.010	3.53E-03	26.9	22.0	
		31.45	0.010	3.53E-03	26.9	22.0	
6	89.98	28.66	0.009	3.26E-03	36.6	32.4	
7	89.65	24.60	0.008	2.87E-03	45.3	45.9	
8	89.33	18.81	0.007	2.34E-03	52.3	61.9	
9	89.00	15.00	0.006	1.64E-03	57.8	80.0	125.5
		15.00	0.006	1.64E-03	-67.7	80.0	
10	88.50	17.50	0.006	6.77E-04	-59.6	48.1	
11	88.00	20.00	0.006	1.55E-04	-50.2	20.9	
12	87.50	22.50	0.006	2.10E-05	-39.6	-3.2	
13	87.00	30.13	0.006	1.87E-04	-26.4	-18.8	
14	86.40	42.95	0.005	6.23E-04	-4.5	-29.1	
15	85.80	58.66	0.005	1.10E-03	26.0	-23.5	
		48.81	0.005	1.10E-03	26.0	-23.5	
16	85.32	64.10	0.004	1.30E-03	52.8	-5.2	
		-68.11	0.004	1.30E-03	52.8	-5.2	
17	84.96	-52.73	0.004	1.28E-03	30.9	9.4	
18	84.60	-37.65	0.003	1.13E-03	14.5	17.2	
19	84.00	-17.10	0.003	8.09E-04	-1.9	19.1	
20	83.40	-3.85	0.002	5.00E-04	-8.2	14.9	
21	82.80	2.78	0.002	2.81E-04	-8.5	9.2	
22	82.20	4.79	0.002	1.55E-04	-6.2	4.6	
23	81.60	4.29	0.002	9.74E-05	-3.5	1.7	
24	81.00	2.78	0.002	7.82E-05	-1.4	0.4	
25	80.50	1.37	0.002	7.51E-05	-0.4	0.0	
26	80.00	0.05	0.002	7.50E-05	0.0	0.0	

Strut force at elev. 89.00 = 125.54 kN/m run = 125.54 kN/strut

(continued)

Stage No.5 Excavate to elevation 85.32 on PASSIVE side

Node no.	Y coord	ACTIVE side: Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	92.00	0.00	10.00	2.98	43.93	13.57	13.57	3647
2	91.60	0.00	17.20	5.13	75.55	14.66	14.66	3647
3	91.20	0.00	24.40	7.28	107.18	15.74	15.74	3647
4	90.75	0.00	32.50	9.70	142.75	16.87	16.87	3647
5	90.30	0.00	40.59	12.11	178.31	17.82	17.82	3647
		Total>	40.59	8.50m	143.44	31.45	31.45	14662
6	89.98	Total>	46.76	10.12m	154.37	28.66	28.66	15103
7	89.65	Total>	52.93	11.75m	165.31	24.60	24.60	15544
8	89.33	Total>	59.10	13.37m	176.24	18.81	18.81	15985
9	89.00	Total>	65.27	15.00m	187.17	15.00	15.00a	10267
10	88.50	Total>	74.75	17.50m	203.97	17.50	17.50a	10691
11	88.00	Total>	84.22	20.00m	220.78	20.00	20.00a	11115
12	87.50	Total>	93.69	22.50m	237.58	22.50	22.50a	11538
13	87.00	Total>	103.16	25.00m	254.37	30.13	30.13	11962
14	86.40	Total>	114.50	28.00m	274.51	42.95	42.95	12471
15	85.80	Total>	125.84	31.00m	294.64	58.66	58.66	12980
		Total>	125.84	31.00m	292.97	48.81	48.81	14893
16	85.32	Total>	135.29	33.38m	309.37	64.10	64.10	15513
17	84.96	Total>	142.49	35.19m	321.89	76.65	76.65	15987
18	84.60	Total>	149.69	37.00m	334.41	89.08	89.08	16460
19	84.00	Total>	161.60	40.00m	355.11	108.15	108.15	17244
20	83.40	Total>	173.51	43.00m	375.81	124.69	124.69	18027
21	82.80	Total>	185.40	46.00m	396.50	138.95	138.95	18811
22	82.20	Total>	197.29	49.00m	417.18	151.63	151.63	19594
23	81.60	Total>	209.18	52.00m	437.86	163.45	163.45	20378
24	81.00	Total>	221.06	55.00m	458.53	174.93	174.93	21162
25	80.50	Total>	230.95	57.50m	475.76	184.47	184.47	21815
26	80.00	Total>	240.85	60.00m	492.98	194.04	194.04	22468

Node no.	Y coord	PASSIVE side: Water press. kN/m2	Effective stresses: Vertic-al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	Total earth pressure kN/m2	Soil stiffness coeff. kN/m3
1	92.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
2	91.60	0.00	0.00	0.00	0.00	0.00	0.00	0.0
3	91.20	0.00	0.00	0.00	0.00	0.00	0.00	0.0
4	90.75	0.00	0.00	0.00	0.00	0.00	0.00	0.0
5	90.30	0.00	0.00	0.00	0.00	0.00	0.00	0.0
6	89.98	0.00	0.00	0.00	0.00	0.00	0.00	0.0
7	89.65	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8	89.33	0.00	0.00	0.00	0.00	0.00	0.00	0.0
9	89.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
10	88.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
11	88.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
12	87.50	0.00	0.00	0.00	0.00	0.00	0.00	0.0
13	87.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
14	86.40	0.00	0.00	0.00	0.00	0.00	0.00	0.0
15	85.80	0.00	0.00	0.00	0.00	0.00	0.00	0.0
16	85.32	0.00	0.00	0.00	0.00	0.00	0.00	0.0
		Total>	0.00	0.00	174.09	132.22	132.22	29337
17	84.96	Total>	7.25	1.81m	186.65	129.38	129.38	30232
18	84.60	Total>	14.50	3.62m	199.22	126.73	126.73	31127
19	84.00	Total>	26.52	6.62m	220.02	125.25	125.25	32609

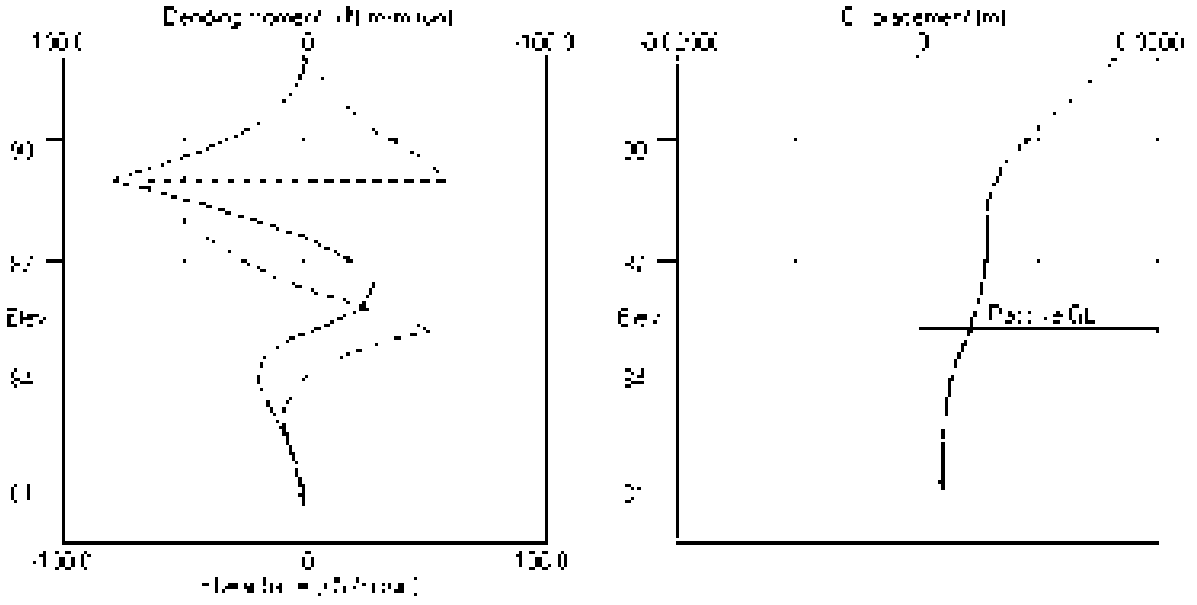
(continued)

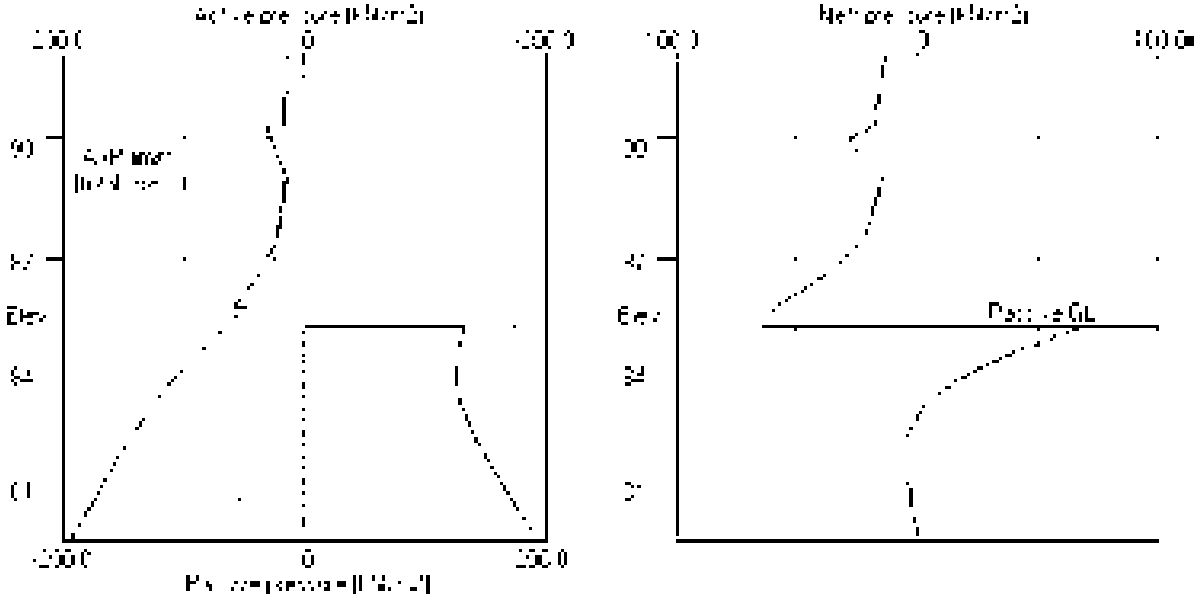
Stage No.5 Excavate to elevation 85.32 on PASSIVE side

Node no.	Y coord	PASSIVE side						
		Effective stresses				Total earth pressure	Soil stiffness coeff.
		Water press. kN/m2	Vertic -al kN/m2	Active limit kN/m2	Passive limit kN/m2	Earth pressure kN/m2	kN/m2	kN/m3
20	83.40	Total>	38.55	9.62m	240.85	128.54	128.54	34091
21	82.80	Total>	50.61	12.62m	261.70	136.18	136.18	35573
22	82.20	Total>	62.70	15.62m	282.58	146.84	146.84	37054
23	81.60	Total>	74.83	18.62m	303.51	159.16	159.16	38536
24	81.00	Total>	87.01	21.62m	324.48	172.15	172.15	40018
25	80.50	Total>	97.20	24.12m	342.00	183.09	183.09	41253
26	80.00	Total>	107.43	26.62m	359.56	193.99	193.99	42488

Note: 22.50a Soil pressure at active limit
123.45p Soil pressure at passive limit

Units: kN,m





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. = 80.00 Factor of Safety	Moment equilib. at elev.	Toe elev. for FoS = 1.200 Toe elev.	Wall Penetr -ation
1	92.00	92.00	Cant.	Conditions not suitable for FoS calc.			
2	92.00	88.50	Cant.	3.430	80.85	86.47	2.03
3	92.00	88.50		No analysis at this stage			
4	92.00	88.50	89.00	Conditions not suitable for FoS calc.			
5	92.00	85.32	89.00	3.026	n/a	85.00	0.32

Units: kN,m

Summary of results

BENDING MOMENT and DISPLACEMENT ANALYSIS of Fully Embedded Wall

Analysis options

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

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

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	92.00	0.019	0.000	0.0	-0.0	0.0	0.0
2	91.60	0.018	0.000	1.2	0.0	5.6	0.0
3	91.20	0.016	0.000	4.7	0.0	11.7	0.0
4	90.75	0.014	0.000	11.7	0.0	19.1	0.0
5	90.30	0.012	0.000	22.0	0.0	26.9	0.0
6	89.98	0.010	0.000	32.4	0.0	36.6	0.0
7	89.65	0.009	0.000	45.9	0.0	45.3	-0.1
8	89.33	0.007	0.000	61.9	0.0	52.3	-0.2
9	89.00	0.006	0.000	80.0	0.0	57.8	-67.7
10	88.50	0.006	0.000	50.6	0.0	36.2	-59.6
11	88.00	0.006	0.000	58.1	0.0	0.0	-50.2
12	87.50	0.006	0.000	48.7	-3.2	0.0	-39.6
13	87.00	0.006	0.000	34.3	-18.8	0.0	-28.3
14	86.40	0.005	0.000	17.9	-29.1	0.1	-22.8
15	85.80	0.005	0.000	7.1	-23.5	26.0	-12.4
16	85.32	0.004	0.000	2.4	-5.2	52.8	-7.6
17	84.96	0.004	0.000	9.4	0.0	30.9	-4.5
18	84.60	0.003	0.000	17.2	-1.0	14.5	-2.3
19	84.00	0.003	0.000	19.1	-1.4	0.0	-1.9
20	83.40	0.002	0.000	14.9	-1.0	0.8	-8.2
21	82.80	0.002	0.000	9.2	-0.4	0.8	-8.5
22	82.20	0.002	0.000	4.6	-0.0	0.5	-6.2
23	81.60	0.002	0.000	1.7	0.0	0.2	-3.5
24	81.00	0.002	0.000	0.4	0.0	0.0	-1.4
25	80.50	0.002	0.000	0.1	0.0	0.0	-0.4
26	80.00	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	0.8	89.98	-0.0	86.40	0.6	91.60	-0.4	88.50
2	58.0	88.00	-1.3	84.00	36.2	88.50	-28.1	87.00
3	No calculation at this stage							
4	58.1	88.00	-1.4	84.00	36.2	88.50	-28.3	87.00
5	80.0	89.00	-29.1	86.40	57.8	89.00	-67.7	89.00

Summary of results (continued)

Maximum and minimum displacement at each stage

Stage no.	Displacement maximum	elev.	minimum	elev.	Stage description
	m		m		
1	0.001	92.00	0.000	92.00	Apply surcharge no.1 at elev. 92.00
2	0.019	92.00	0.000	92.00	Excav. to elev. 88.50 on PASSIVE side
3	No calculation at this stage				Install strut no.1 at elev. 89.00
4	0.019	92.00	0.000	92.00	Apply water pressure profile no.1
5	0.017	92.00	0.000	92.00	Excav. to elev. 85.32 on PASSIVE side

Strut forces at each stage (horizontal components)

Stage no.	--- Strut no. 1 --- at elev. 89.00	
	kN/m run	kN/strut
4	0.17	0.17
5	125.54	125.54

Units: kN,m