GROUND MOVEMENT ASSESSMENT REPORT

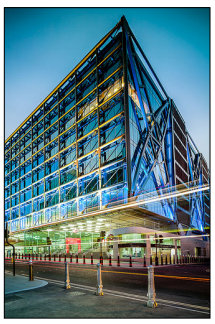
26 Netherhall Gardens
London
NW3 5TL

Client: Atlas Property Company Limited

J15344

August 2019



GEA

Document Control

Project title	26 Netherhall Gardens, London, NW3 5TL	**Project ref**	J15344
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Issue No	Status	Amendment Details	Date	Approved for Issue
1	Final		14 August 2019	
2	Final	Basement reduced in size and depth	22 August 2019	

This report has been issued by the GEA office indicated below. Any enquiries regarding the report should be directed to the office indicated or to Steve Branch in our Herts office.

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This report is intended as a Ground Investigation Report (GIR) as defined in BS EN1997-2, unless specifically noted otherwise. The report is not a Geotechnical Design Report (GDR) as defined in EN1997-2 and recommendations made within this report are for guidance only.

CONTENTS

1.0 INTRODUCTION

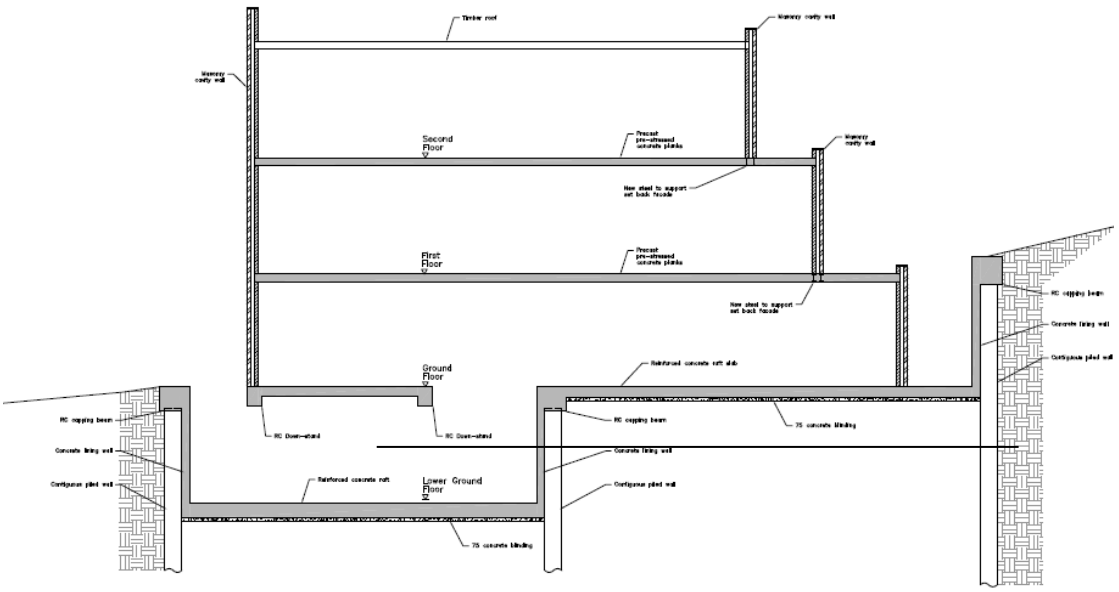
Geotechnical and Environmental Associates (GEA) has been commissioned by Byrne Looby and Partners, formerly Sinclair Johnston and Partners (SJ&P), on behalf of Atlas Property Company Limited, to revise a previous ground movement assessment for the proposed redevelopment of this site at 26 Netherhall Gardens, London, NW3 5TL. The redevelopment is to include a single-storey basement following demolition of the existing building.

The previous ground movement assessment was undertaken in 2015 and was based on a partly single-storey and partly two-storey basement. Information on the ground conditions was obtained from a site investigation by Site Analytical Services Limited (SAS) referenced 14/22068 and dated June 2014. SJ&P structural drawings and Design and Construction Statement were used in the preparation of the previous assessment, which was referenced J15344 Rep Issue 1 and dated December 2015.

The drawings have subsequently been updated and this assessment is based on the SJ&P Structural Design and Construction Statement, ref 8240, dated October 2018.

1.1 Proposed Development

It is understood that it is proposed to demolish part of the existing building and replace it with a new structure which will include a single-storey basement and cutting into part of an existing slope at the rear of the property. A section through the proposed building indicating the extent of the proposed basement is shown below.



The temporary and permanent excavation support will be provided by a perimeter secant bored pile wall on three sides and underpinning of the existing building on the fourth. The structural loadings will ultimately be transferred to a raft slab and any net uplift forces will be resisted by the embedded portions of the bored pile wall.

This report is specific to the proposed development and the advice herein should be reviewed if the development proposals are amended.

1.2 Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil, gas or groundwater samples tested; no liability can be accepted for information in other data sources or conditions not revealed by the sampling or testing. Any comments made on the basis of information obtained from the client or other third parties are given in good faith on the assumption that the information is accurate; no independent validation of such information has been made by GEA.

2.0 THE SITE

2.1 Site Description

The site is located in the London Borough of Camden, northwest London, and in the ward of Frognal and Fitzjohns, approximately 300 m to the north of Finchley Road London Underground station. It fronts onto Netherhall Gardens to the west and is bordered by detached houses to the north and south and by the gardens of the houses on Maresfield Gardens to the east. The site may be additionally located by National Grid Reference 550453, 178498.

A full description of the site and its geographical and environmental settings are included in the site investigation report and within the Basement Impact Assessment (BIA); it is important to note that the site slopes up by some 5 m from front to rear (west to east).

3.0 GROUND MOVEMENT ANALYSIS

This analysis has been limited to the assessment of movements arising from the installation of the bored pile walls and the subsequent excavation.

3.1 Construction Methodology

It is proposed that the basement box will be formed on three sides by secant bored pile walls with the fourth side, beneath the existing southern wall of 26 Netherhall Gardens, being formed by underpinning. The walls will be used to temporarily support the excavation during construction with long term retention provided by composite action of the pile walls and their internal lining walls. Whilst a construction sequence has been outlined by Sinclair Johnston, further consideration of the piling levels and sequencing has been undertaken by GEA to allow the analysis of ground movements to be undertaken.

Initially, piling will be undertaken from the upper rear garden level and this piling level has been assumed to be 75.0 m OD. Piles surrounding the main basement will then be installed from roughly the existing ground level of 72.6 m OD.

Following completion of the piling, the single-level basement will be excavated to 69.0 m OD with the bored pile walls supported temporarily by steel props. The new lower ground floor slab will provide the permanent support at basement level and the new ground floor slab will prop the wall at its head level.

4.0 GROUND MOVEMENTS

An assessment of ground movements surrounding the excavation has been undertaken using the X-Disp computer program licensed from the OASYS suite of geotechnical modelling software from Arup. This program is commonly used within the ground engineering industry and is considered to be an appropriate tool for this analysis. The X-Disp program has been used to predict ground movements likely to arise from the installation of the bored piled walls and then from the subsequent excavation of the basement. For the X-Disp analysis, the soil movement relationships used for the embedded retaining walls are those taken from CIRIA report C760[1].

For the purpose of these analyses, the corners have been defined by x and y coordinates, with the x-direction having been taken as being perpendicular to Netherhall Gardens whilst the y-direction is parallel to it. Vertical movement is in the z-direction.

The full outputs of all of the stages of the analyses can be provided on request but the output movement contour plots are included within the appendix along with the input parameters and the building damage assessment.

4.1 Models Used

The construction sequence and details of the proposed foundations together with details of the adjacent buildings have all been provided by SJ&P.

4.1.1 Piling and Excavation Related Movements

The bored pile walls will be installed from the ground levels noted previously and will support the excavation in the temporary case with the permanent excavation support provided by the piled walls acting compositely with the walls and floors to form a rigid basement box. A formal pile design will be undertaken by the piling contractor in due course, along with the finalization of the excavation sequence and propping design. However, at this stage there is considered to be sufficient detail in the Sinclair Johnston documents to make certain assumptions upon which the ground movements can be based.

The wall is proposed to be a secant bored pile wall. The SJ&P drawings indicate that the piled wall will be propped at pile head level as well as at basement level in both temporary and permanent conditions and on this basis a piled wall of high stiffness in clay is considered an appropriate wall model for the analysis. Pile lengths of 7.6 m have been adopted for the basement wall, representing a ratio of embedded length to exposed length of 1:1 which is considered reasonable for a multi propped walls such as this. The rear wall piles have been taken as bearing at the same level as the basement piles (65.4 m OD) which results in these piles being 9.6 m long.

The shape of the basement means that some simplification is required to model it within the X-Disp program. Accordingly the re-entrant corner of the piled wall has been simplified in the northwestern corner to a diagonal line.

4.1.2 Basement Heave Considerations

At this site the loads imposed by the proposed building are to be supported upon a raft that bears within the London Clay. The excavation does, however cause unloading of the London Clay which in turn leads to heave and swelling due to elastic 'rebound' following stress relief in the short term and long term swelling due to the recovery of pore water pressures.

[1] Gaba, A, Hardy, S, Powrie, W, Doughty, L and Selemetas, D (2017) *Embedded retaining walls – guidance for economic design* CIRIA Report C760

It is estimated that the total unloading will be in the order of 70 kN/m^2 but the loading from the new structure will be of a similar order. Whilst there may be some short term heave, after construction the reloading will effectively balance the unloading such that ground movements should be negligible.

4.2 Results

4.2.1 Piling and Excavation Related Movements

The X-Disp analysis has been used to estimate the movements behind the walls resulting from pile installation and basement excavation. This includes the settlement of the ground (vertical movement) and the lateral movement of soil behind the wall (horizontal movement). The contour graphs of these movement predictions are appended for the piling phase together with the total movement prediction which has combined the effects of piling and excavation. It is noted that the wall installation movements for a contiguous bored pile wall have been adopted rather than a secant wall. This is based on information from Ball, Langdon and Creighton[2] which reports on a contiguous bored pile wall in central London and represents, in scale and currency of data, a close representation to this site. Ball et al report that measured wall installation movements could be normalised to between 0.006% and 0.012% of pile length. The paper then suggests that a normalised relationship of 0.02%, ie, half of the C760 movements, could be appropriate for a contiguous wall whilst remaining relatively conservative; subject to careful control of installation. On the understanding that equally tight controls of pile installation are maintained it follows that there is no reason why a similar relationship for a secant wall should not exist, particularly given modern piling techniques. It is considered that it is reasonable for the C760 relationship for a secant wall to also be halved and hence the value of 0.04% can be adopted, rather than 0.08%. This equates to the movements predicted by the curves for the installation of contiguous bored pile wall in stiff clay provided within C760.

The predicted movements are summarised in the table below; the results are presented to the degree of accuracy required to allow predicted variations in ground movements around the structure to be illustrated, but may not reflect the anticipated accuracy of the predictions.

Phase of Works	Maximum Movement at 71.6 m OD – sensibly average foundation level	
	Vertical Settlement (mm)	Horizontal Movement (mm)
Piling	5 to 6	<5
Combined Piling and Basement Excavation	5 to 10	5 to 10

The movements set out in the table above are the maximum movements and generally occur immediately or just outside the line of the piled walls; the effects of the excavation reduce with distance away from the piled wall.

2 Ball, R, Langdon, N, and Creighton, M (2014) *Prediction of party wall movements using Ciria report C580.* Ground Engineering, September 2014

5.0 DAMAGE ASSESSMENT

In addition to the above assessment of the likely movements that will result from the proposed development, some of the neighbouring structures are considered to be sensitive structures and have been subject to Building Damage Assessments, on the basis of the classification given in Table 2.5 of CIRIA report C760, referred to hereafter as 'Burland' damage categories. For this assessment the adjacent properties at Nos 24 / 24A and 28 Netherhall Gardens and the single storey structures beyond the eastern site boundary have been adopted as sensitive structures for prediction of the building damage category.

5.1 Piling and Excavation Related Damage

The predicted movements have been further analysed in respect of the key sensitive structures in the front, side and rear walls of Nos 24 / 24A and 28 Netherhall Gardens and the single storey buildings to the rear of the site.

The sensitive structures have been modelled as lines in the analysis and are the lines along which the damage assessment has been undertaken. These critical lines are assumed to be sensitive at their foundation levels which, from the drawings supplied by SJ&P, have been taken as 71.0 m OD for Nos 24 / 24A, 71.6 m OD for No 28 and 77.0 m OD for the single-storey structures to the rear of the property.

The movement predictions above have been assessed against the length and height of the structures from foundation to eaves and the calculated strains compared against the limits defined within the Burland categories of damage. On the basis of these results, the following damage categories have been predicted; calculation sheets and movement contour plots are attached.

Building Damage Assessment		
Sensitive Structure	**Elevation**	**Category of Damage***
24 / 24A Netherhall Gardens	Front (Line 1)	Category 1 (Very Slight)
24 / 24A Netherhall Gardens	Side (Line 2)	Category 0 (Negligible)
24 / 24A Netherhall Gardens	Rear Side (Line 3)	Category 0 (Negligible)
24 / 24A Netherhall Gardens	Rear (Line 4)	Category 0 (Negligible)
28 Netherhall Gardens	Front North (Line 5)	Category 0 (Negligible)
28 Netherhall Gardens	Front South (Line 6)	Category 0 (Negligible)
28 Netherhall Gardens	Side (Line 7)	Category 0 (Negligible)
28 Netherhall Gardens	Rear (Line 8)	Category 0 (Negligible)
Rear Structures	West (Line 9)	Category 0 (Negligible)
Rear Structures	North (Line 10)	Category 0 (Negligible)
Rear Structures	East North (Line11)	Category 0 (Negligible)
Rear Structures	East Mid (Line 12)	Category 0 (Negligible)

Building Damage Assessment		
Sensitive Structure	**Elevation**	**Category of Damage***
Rear Structures	East South (Line 13)	Category 0 (Negligible)
Rear Structures	South (Line 14)	Category 0 (Negligible)

**Refer to Table 2.5 of C580: Classification of visible damage to walls.*

The building damage reports for sensitive structures highlighted in the above table predict that the damage to the adjoining and nearby structures would vary from Category 0 (negligible) to Category 1 (very slight). A site plan annotated with the above categories is appended for clarity.

5.2 Comment

The damage assessments above reflect the critical cases in the phases of construction and to a degree represent a simplification of the construction process and offer worst-case scenarios.

The damage assessments are therefore considered to represent a reasonable estimate of movements at this stage and offer a simple 'global' view of the movement contours around the site. The ground movement analysis will be refined in due course when the pile design has been completed, propping levels and stiffnesses have been defined and the construction finalised. However, it is the experience of GEA that the refinement through detailed design will reduce rather than increase predictions of wall movements and it follows that the final damage categories will be no worse than those above.

5.3 Monitoring of Ground Movements

The predictions of ground movement based on the ground movement analysis will be checked by monitoring of adjacent buildings.

Condition surveys of the above existing structures will be carried out before and after the proposed works will be set out by Sinclair Johnston in a monitoring strategy. This will be subject to discussions and agreements with the owners of the adjacent properties and structures. Contingency measures will also be agreed and will be implemented if movements of the adjacent structures exceed predefined trigger levels.

6.0 CONCLUSIONS

The analysis has concluded that the predicted damage to the neighbouring properties would very between Category 0'negligible' and Category 1 'very slight'. On this basis, the damage that would inevitably occur as a result of such an excavation would fall within the acceptable limits of London Borough of Camden.

The detailed retaining wall design will provide a site specific view of the likely ground movements and will allow refinement of the ground movement analysis. The detailed design will be used to ensure that the predictions of ground movements are within acceptable limits.

The piling and subsequent excavation will in practice be separated by a number of weeks during which time the piles will cure, capping beams will be cast and the upper propping installed. This will provide an opportunity for the ground movements to be measured and the data acquired can be fed back into the design and compared with the predicted values. Such a

comparison will allow the ground model to be reviewed and the wall movement predictions to be reassessed prior to the main excavation taking place so that propping arrangements can be adjusted if required.

This pre-emptive approach to mitigation is considered to provide a robust methodology to minimising predicted ground movements in advance of construction and then monitoring and responding to movements during construction.

APPENDICES

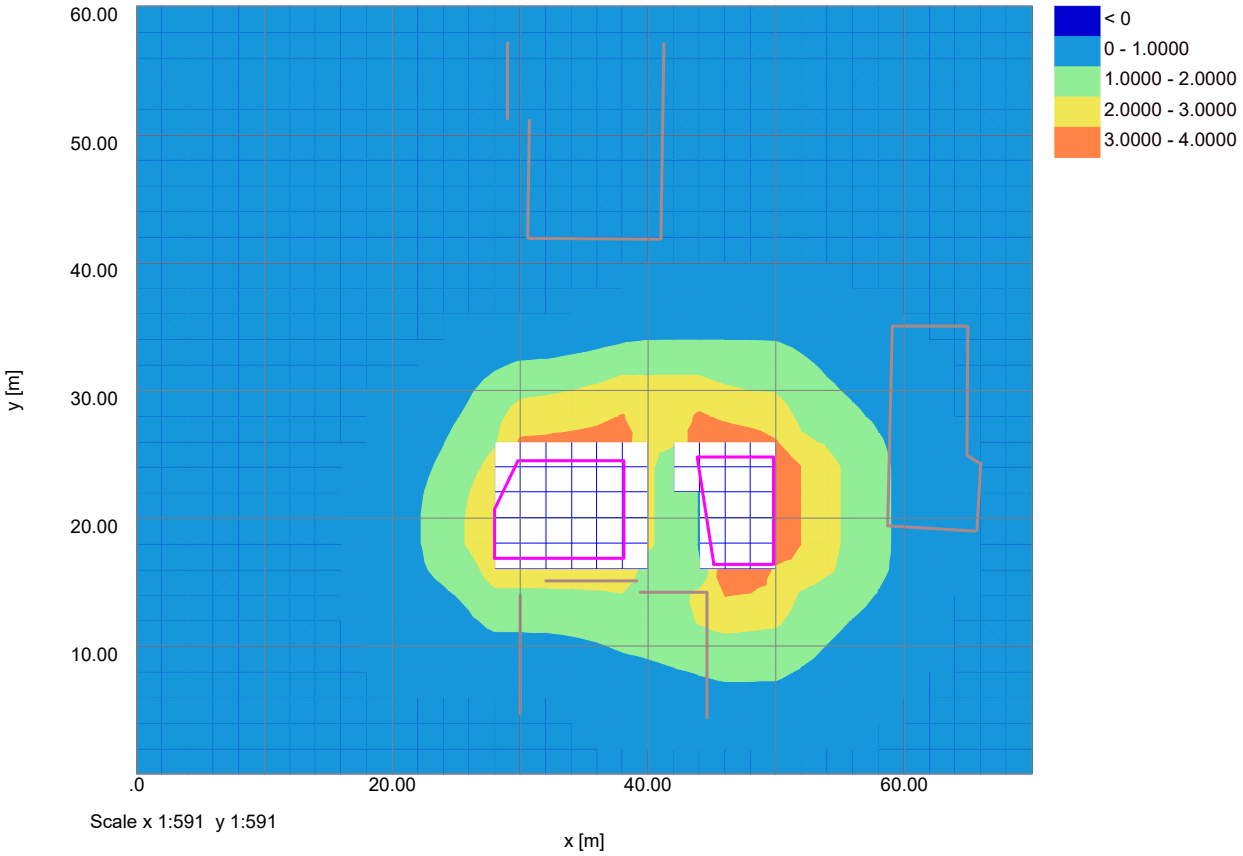
SOIL DISPLACEMENT MODEL RESULTS

X-DISP ANALYSIS

Movements following underpinning and piling

Movements following underpinning, piling and excavation

Horizontal Displacement Contours: Grid 1 (level 71.600m) Interval 1mm

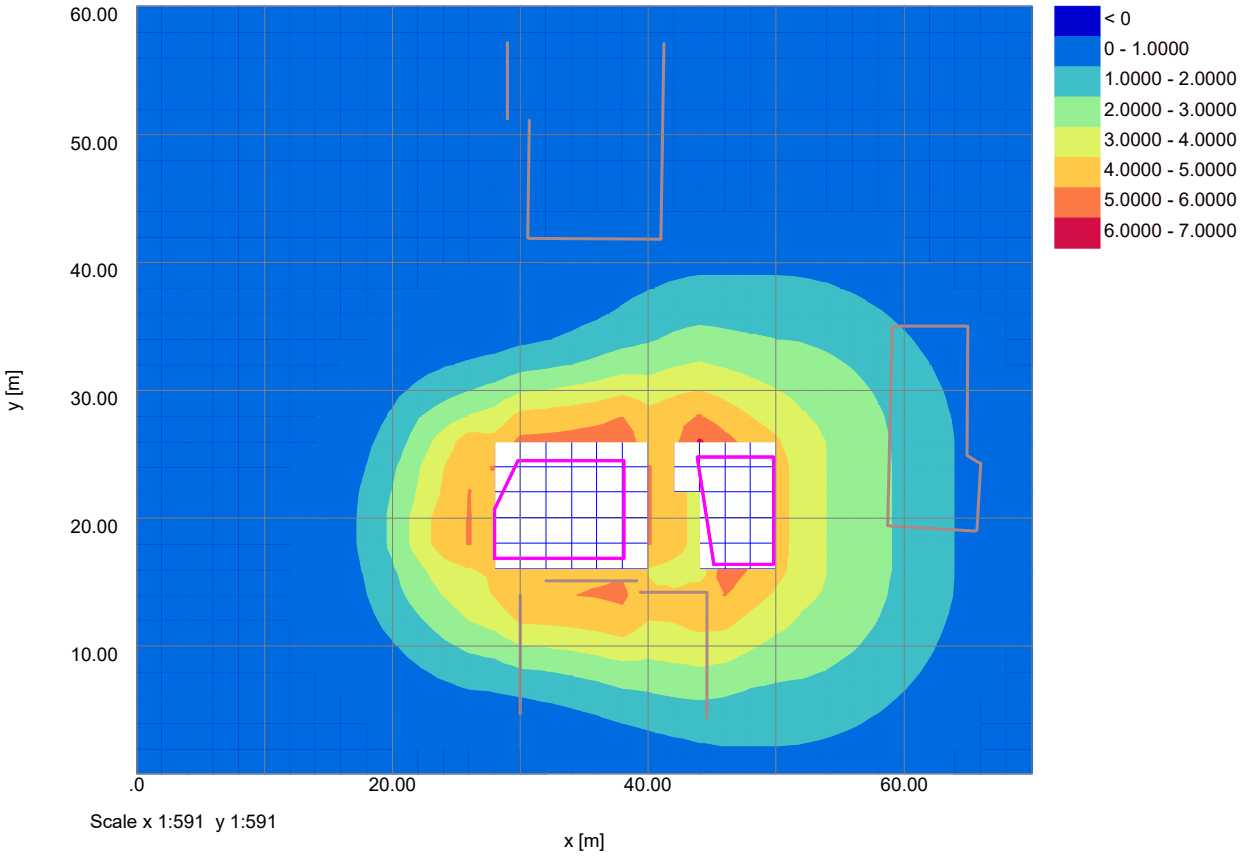


Scale x 1:591 y 1:591

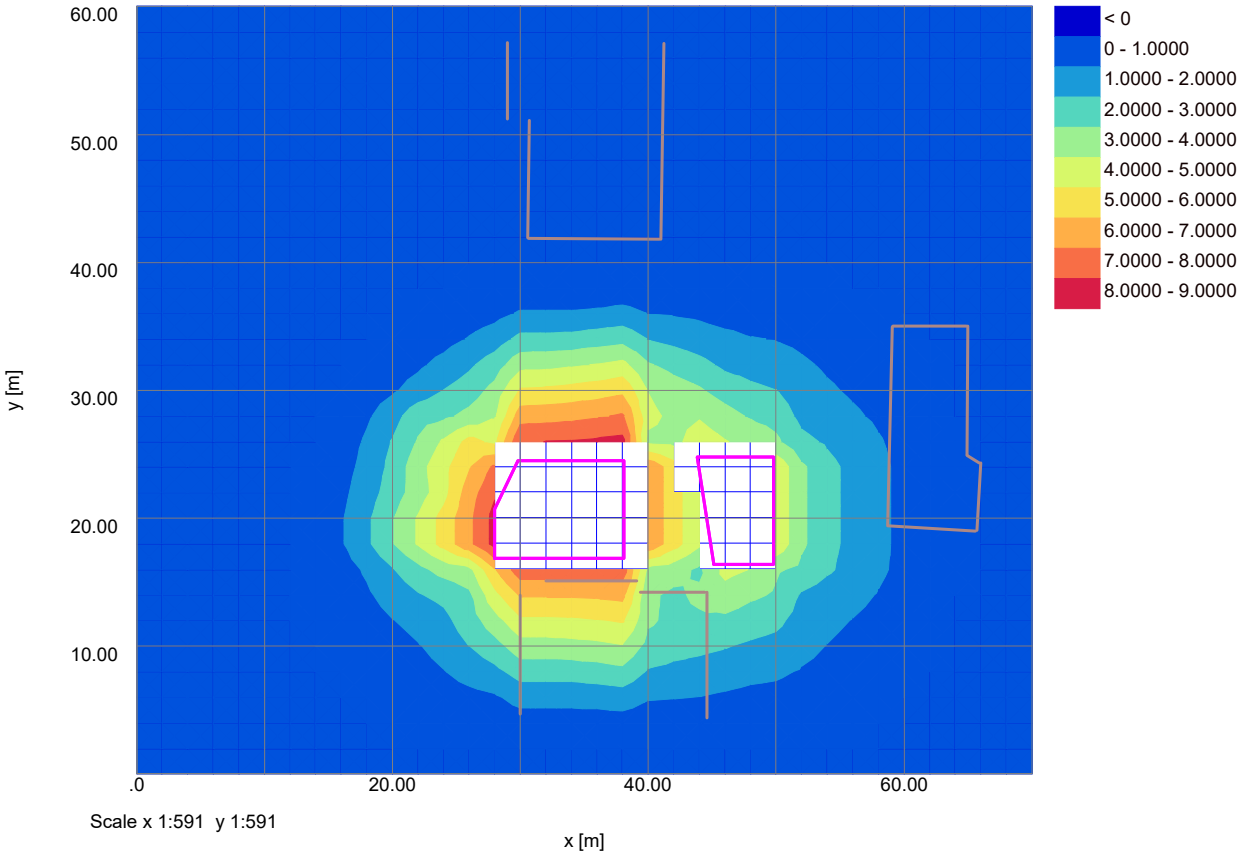
Specific Building Damage Results - Critical Values for All Segments within Each Sub-Building

Stage: Stage: Name Category Ref.	Specific Building: Ref.	Specific Building: Name	Sub-building Name	Vertical Offset from Line for Vertical Movement Calculations [m]	Deflection Ratio [%]	Average Horizontal Strain [%]	Max Slope	Max Settlement [mm]	Max Tensile Strain [%]	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature (Hogging) [m]	Min Radius of Curvature (Sagging) [m]	Damage
0 Base Model (Negligible)	1	24 Netherhall Gardens	Front	0.0	0.0010296	0.019327	-236.65E-6	2.3032	0.020459	-307.98E-6	-236.65E-6	-	100940.	0
(Negligible)	2	24 Netherhall Gardens	Side	0.0	964.68E-6	-0.037104	-40.116E-6	2.5756	0.0074413	648.92E-6	-40.116E-6	78124.	18016.	0
(Negligible)	3	24 netherhall Gardens	Rear Side	0.0	0.010276	-994.41E-6	-755.86E-6	4.1634	0.0097614	223.02E-6	-755.86E-6	2923.5	-	0
(Negligible)	4	24 Netherhall Gardens	Rear	0.0	0.0031450	0.023023	365.87E-6	4.3267	0.026605	-294.92E-6	365.87E-6	-	8171.7	0
(Negligible)	7	28 Netherhall Gardens	Side	0.0	233.74E-6	0.0	-65.806E-6	0.35013	223.70E-6	0.0	-65.806E-6	-	151510.	0
(Negligible)	8	28 Netherhall Gardens	Rear	0.0	0.0	0.0	179.66E-6	0.35687	35.763E-9	0.0	179.66E-6	-	-	0
(Negligible)	9	Rear Structures	West	0.0	0.0024797	-224.10E-6	147.99E-6	2.0600	0.0028181	64.894E-6	147.99E-6	-	49962.	0
(Negligible)	10	Rear Structures	North	0.0	374.36E-6	841.20E-6	164.18E-6	1.0726	0.0013809	-49.599E-6	164.18E-6	-	141640.	0
(Negligible)	11	Rear Structures	East - North	0.0	0.0013756	0.0	-109.21E-6	0.81893	0.0020329	0.0	-109.21E-6	-	71357.	0
(Negligible)	12	Rear Structures	East - Mid	0.0	2.7940E-6	0.0	171.50E-6	0.80993	2.7537E-6	0.0	171.50E-6	-	4.8587E+6	0
(Negligible)	13	Rear Structures	East - South	0.0	0.0	0.0	-11.303E-6	0.65934	35.763E-9	0.0	-11.303E-6	1.1009E+18	1.4084E+18	0
(Negligible)	14	Rear Structures	South	0.0	565.95E-9	0.015099	199.66E-6	2.0500	0.015100	-209.23E-6	199.66E-6	-	48.355E+6	0

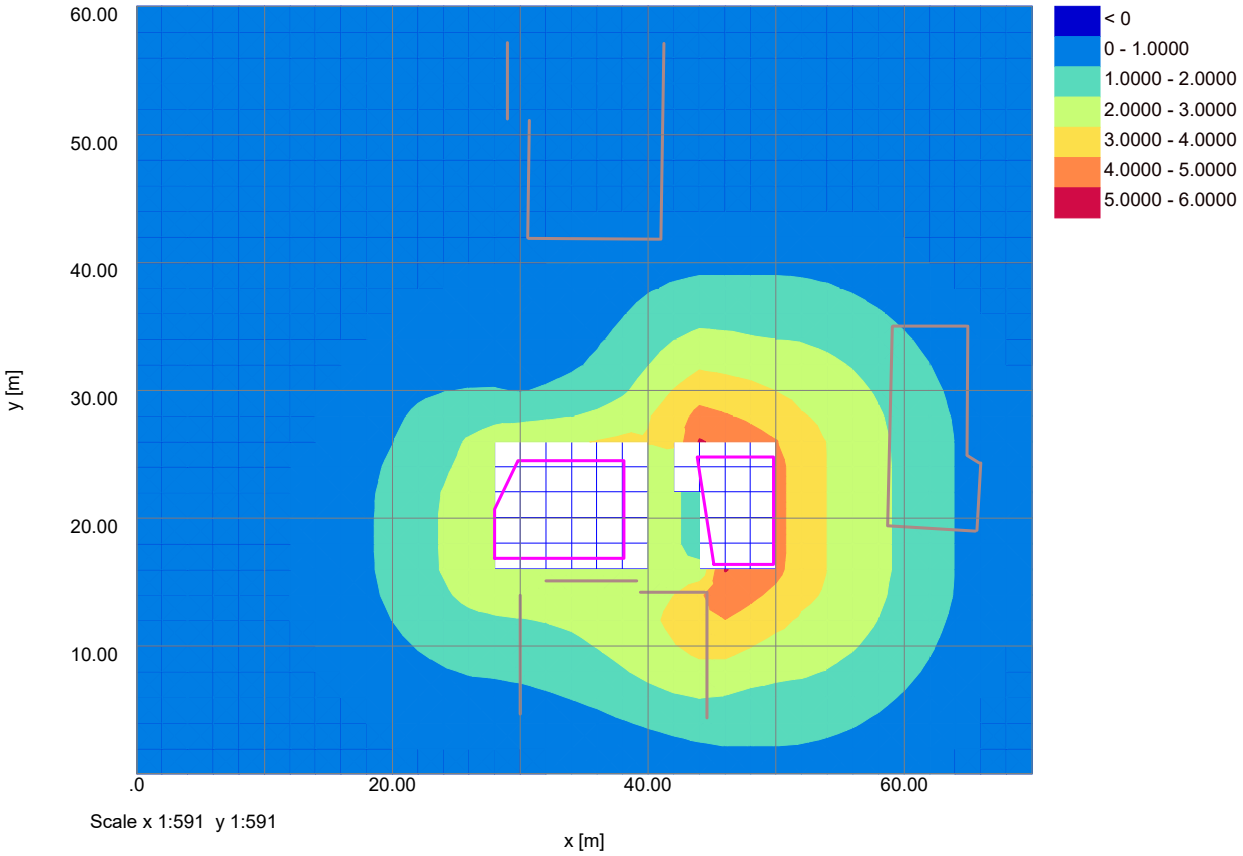
Vertical Settlement Contours: Grid 1 (level 71.600m) (Interval 1mm)



Horizontal Displacement Contours: Grid 1 (level 71.600m) Interval 1mm



Vertical Settlement Contours: Grid 1 (level 71.600m) (Interval 1mm)



Specific Building Damage Results - Critical Values for All Segments within Each Sub-Building

Stage: Stage: Name	Specific Building: Ref.	Specific Building: Name	Sub-building Name	Vertical Offset from Line for Vertical Movement Calculations [m]	Deflection Ratio [%]	Average Horizontal Strain [%]	Max Slope	Max Settlement [mm]	Max Tensile Strain [%]	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature (Hogging) [m]	Min Radius of Curvature (Sagging) [m]	Damage Category
0 Base Model	1	24 Netherhall Gardens	Front	0.0	0.0047024	0.064279	-590.90E-6	4.9077	0.066678	-682.60E-6	-590.90E-6	15952.	6141.0	1 (Very Slight)
	2	24 Netherhall Gardens	Side	0.0	0.012770	-0.092243	790.54E-6	5.0570	0.019863	0.0013748	790.54E-6	1128.3	4072.4	0 (Negligible)
	3	24 netherhall Gardens	Rear Side	0.0	0.0091134	-0.014403	-561.99E-6	4.9552	0.0067119	538.63E-6	-561.99E-6	3141.0	-	0 (Negligible)
	4	24 Netherhall Gardens	Rear	0.0	0.0027240	0.030459	400.55E-6	5.0793	0.030524	-337.73E-6	400.55E-6	153840.	7896.1	0 (Negligible)
	7	28 Netherhall Gardens	Side	0.0	233.74E-6	0.0	-65.806E-6	0.35013	223.70E-6	0.0	-65.806E-6	-	151510.	0 (Negligible)
	8	28 Netherhall Gardens	Rear	0.0	0.0	0.0	179.66E-6	0.35687	35.763E-9	0.0	179.66E-6	-	-	0 (Negligible)
	9	Rear Structures	West	0.0	0.0020253	-49.035E-6	147.99E-6	2.2718	0.0027183	98.289E-6	147.99E-6	17.109E+6	38813.	0 (Negligible)
	10	Rear Structures	North	0.0	374.36E-6	841.20E-6	164.18E-6	1.0726	0.0013809	-49.599E-6	164.18E-6	-	141640.	0 (Negligible)
	11	Rear Structures	East - North	0.0	0.0013756	0.0	-109.21E-6	0.81893	0.0020329	0.0	-109.21E-6	-	71357.	0 (Negligible)
	12	Rear Structures	East - Mid	0.0	2.7940E-6	0.0	171.50E-6	0.80993	2.7537E-6	0.0	171.50E-6	-	4.8587E+6	0 (Negligible)
	13	Rear Structures	East - South	0.0	0.0	0.0	-11.303E-6	0.65934	35.763E-9	0.0	-11.303E-6	1.1009E+18	1.4084E+18	0 (Negligible)
	14	Rear Structures	South	0.0	0.0015553	0.036768	301.40E-6	2.2546	0.038320	-582.68E-6	301.40E-6	14683.	48.355E+6	0 (Negligible)

Titles

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Job Title: 26 Netherhall Gardens
Sub-title: Issue 2
Calculation Heading: Pile Installation and Excavation
Initials: MC
Checker:
Date Saved: 20-Aug-2019
Date Checked:
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History

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20-Aug-2019	23:36	MartinCooper	Open

Displacement Lines

Ref.	Name	x1 [m]	y1 [m]	z1 [m]	x2 [m]	y2 [m]	z2 [m]	Intervals [No.]	Calculate	Surface type for tunnels
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2	Line 2	32.00000	15.10000	71.00000	39.20000	15.10000	71.00000	7	Surface	Yes
3	Line 3	39.40000	14.20000	71.00000	44.50000	14.20000	71.00000	6	Surface	Yes
4	Line 4	44.60000	14.20000	71.00000	44.60000	4.30000	71.00000	10	Surface	Yes
5	Line 5	29.00000	57.20000	71.60000	29.00000	51.10000	71.60000	6	Surface	Yes
6	Line 6	30.70000	51.10000	71.60000	30.60000	41.90000	71.60000	9	Surface	Yes
7	Line 7	30.65000	41.90000	71.60000	40.90000	41.80000	71.60000	10	Surface	Yes
8	Line 8	41.00000	41.80000	71.60000	41.20000	57.20000	71.60000	16	Surface	Yes
9	Line 9	58.70000	19.40000	77.00000	59.10000	35.00000	77.00000	16	Surface	Yes
10	Line 10	59.15000	35.00000	77.00000	64.95000	35.00000	77.00000	6	Surface	Yes
11	Line 11	65.00000	35.00000	77.00000	64.90000	24.90000	77.00000	10	Surface	Yes
12	Line 12	64.95000	24.90000	77.00000	65.95000	24.30000	77.00000	2	Surface	Yes
13	Line 13	66.00000	24.30000	77.00000	65.70000	19.00000	77.00000	5	Surface	Yes
14	Line 14	58.75000	19.40000	77.00000	65.65000	19.00000	77.00000	7	Surface	Yes

Displacement Grids

Ref.	Name	Extrusion: Direction	Base line start: X [m]	Base line start: Y [m]	Base line start: Z(level) [m]	Base line end: X [m]	Base line end: Y [m]	Base line end: Z(level) [m]	Base line: Intervals [No.]	Extrusion: Distance [m]	Extrusion: Intervals [No.]	Surface type for tunnels	Calculate
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Polygonal Excavations

Ref. 1
Excavation Name: Piling Basement
Surface level [m]: 72.600
Contribution: Positive
Surface movement curves which are selected are applied between surface and [m]: 65.400

Corner	x [m]	y [m]	Base Level [m]	Arc Enabled	Stiffened	Prev. Side: d [m]	Prev. Side: p1 [%]	Prev. Side: p2* [%]	Next Side: d [m]	Next Side: p1 [%]	Next Side: p2* [%]
1	28.000	16.900	65.400	Yes	No	-	-	-	-	-	-
2	38.100	16.900	65.400	Yes	No	-	-	-	-	-	-
3	38.100	24.500	65.400	Yes	No	-	-	-	-	-	-
4	29.800	24.500	65.400	Yes	No	-	-	-	-	-	-
5	28.000	20.700	65.400	Yes	No	-	-	-	-	-	-

Side	x1 [m]	y1 [m]	x2 [m]	y2 [m]	G.M. Curve: Vertical	G.M. Curve: Horizontal
1	28.000	16.900	38.100	16.900	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(a))
2	38.100	16.900	38.100	24.500	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(a))
3	38.100	24.500	29.800	24.500	Inst. of planar diaphragm wall in stiff clay (CIRIA C580 Fig. 2.9(b))	Inst. of planar diaphragm wall in stiff clay (CIRIA C580 Fig. 2.9(a))
4	29.800	24.500	28.000	20.700	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(a))
5	28.000	20.700	28.000	16.900	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(a))

Ref. 2
Excavation Name: Piling half at upper level
Surface level [m]: 75.000
Contribution: Positive
Surface movement curves which are selected are applied between surface and [m]: 65.400

Corner	x [m]	y [m]	Base Level [m]	Arc Enabled	Stiffened	Prev. Side: d [m]	Prev. Side: p1 [%]	Prev. Side: p2* [%]	Next Side: d [m]	Next Side: p1 [%]	Next Side: p2* [%]
1	45.100	16.400	65.400	Yes	No	-	-	-	-	-	-
2	49.800	16.400	65.400	Yes	No	-	-	-	-	-	-
3	49.800	24.800	65.400	Yes	No	-	-	-	-	-	-
4	43.800	24.800	65.400	Yes	No	-	-	-	-	-	-

Side	x1 [m]	y1 [m]	x2 [m]	y2 [m]	G.M. Curve: Vertical	G.M. Curve: Horizontal
1	45.100	16.400	49.800	16.400	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580

Side	x1 [m]	y1 [m]	x2 [m]	y2 [m]	G.M. Curve: Vertical	G.M. Curve: Horizontal
					Fig. 2.8(b))	Fig. 2.8(a))
2	49.800	16.400	49.800	24.800	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(a))
3	49.800	24.800	43.800	24.800	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(a))
4	43.800	24.800	45.100	16.400	No vertical ground movement	No horizontal ground movement

Ref. 3
Excavation Name: **Excavation Basement**
Surface level [m]: 72.600
Contribution: Positive
Surface movement curves which are selected are applied between surface and [m]: 69.100

Corner	x [m]	y [m]	Base Level [m]	Arc Enabled	Stiffened	Prev. Side: d [m]	Prev. Side: p1 [%]	Prev. Side: p2* [%]	Next Side: d [m]	Next Side: p1 [%]	Next Side: p2* [%]
1	28.000	16.900	69.000	Yes	Yes	0.0	67.000	25.000	0.0	67.000	25.000
2	38.100	16.900	69.000	Yes	Yes	0.0	67.000	25.000	0.0	67.000	25.000
3	38.100	24.500	69.000	Yes	Yes	0.0	67.000	25.000	0.0	67.000	25.000
4	29.800	24.500	69.000	Yes	Yes	0.0	67.000	25.000	0.0	67.000	25.000
5	28.000	20.700	69.000	Yes	Yes	0.0	67.000	25.000	0.0	67.000	25.000

Side	x1 [m]	y1 [m]	x2 [m]	y2 [m]	G.M. Curve: Vertical	G.M. Curve: Horizontal
1	28.000	16.900	38.100	16.900	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(a))
2	38.100	16.900	38.100	24.500	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(a))
3	38.100	24.500	29.800	24.500	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(a))
4	29.800	24.500	28.000	20.700	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(a))
5	28.000	20.700	28.000	16.900	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(a))

Ref. 4
Excavation Name: **Excavation of half at upper level**
Surface level [m]: 75.000
Contribution: Positive
Surface movement curves which are selected are applied between surface and [m]: 72.000

Corner	x [m]	y [m]	Base Level [m]	Arc Enabled	Stiffened	Prev. Side: d [m]	Prev. Side: p1 [%]	Prev. Side: p2* [%]	Next Side: d [m]	Next Side: p1 [%]	Next Side: p2* [%]
1	45.100	16.400	72.000	Yes	No	-	-	-	-	-	-
2	49.800	16.400	72.000	Yes	Yes	0.0	67.000	25.000	0.0	67.000	25.000
3	49.800	24.800	72.000	Yes	Yes	0.0	67.000	25.000	0.0	67.000	25.000
4	43.800	24.800	72.000	Yes	No	-	-	-	-	-	-

Side	x1 [m]	y1 [m]	x2 [m]	y2 [m]	G.M. Curve: Vertical	G.M. Curve: Horizontal
1	45.100	16.400	49.800	16.400	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(a))
2	49.800	16.400	49.800	24.800	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(a))
3	49.800	24.800	43.800	24.800	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(a))
4	43.800	24.800	45.100	16.400	No vertical ground movement	No horizontal ground movement

Circular Excavations

Vertical Ground Movement Curves

Curve Name: **No vertical ground movement**
Coordinates: [Distance from wall / wall depth or max. excavation depth (x), Depth / wall depth or max. excavation depth (y), Settlement / wall depth or max. excavation depth (z)(%)]

[0.000,0.000,0.000][1.000,0.000,0.000][0.000,1.000,0.000][1.000,1.000,0.000]

Curve Fitting Method: Polynomial
x Order: 1
y Order: 0
Polynomial: z = 0.0x + 0.0
Coeff. of Determination:

Curve Name: **Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(b))**
Coordinates: [Distance from wall / wall depth or max. excavation depth (x), Depth / wall depth or max. excavation depth (y), Settlement / wall depth or max. excavation depth (z)(%)]

[0.000,0.000,0.040][2.000,0.000,0.000]

Curve Fitting Method: Polynomial
x Order: 1
y Order: 0
Polynomial: z = -2.0E-2x + 4.0E-2
Coeff. of Determination: 1.0

Curve Name: **Inst. of planar diaphragm wall in stiff clay (CIRIA C580 Fig. 2.9(b))**
Coordinates: [Distance from wall / wall depth or max. excavation depth (x), Depth / wall depth or max. excavation depth (y), Settlement / wall depth or max. excavation depth (z)(%)]

[0.000,0.000,0.050][0.050,0.000,0.047][0.100,0.000,0.043][0.150,0.000,0.040]
[0.200,0.000,0.037][0.250,0.000,0.034][0.300,0.000,0.031][0.350,0.000,0.028]
[0.400,0.000,0.025][0.450,0.000,0.022][0.500,0.000,0.020][0.550,0.000,0.018]
[0.600,0.000,0.015][0.650,0.000,0.013][0.700,0.000,0.012][0.750,0.000,0.010]
[0.800,0.000,0.008][0.850,0.000,0.007][0.900,0.000,0.006][0.950,0.000,0.005]
[1.000,0.000,0.004][1.050,0.000,0.003][1.100,0.000,0.003][1.150,0.000,0.002]
[1.200,0.000,0.002][1.250,0.000,0.001][1.300,0.000,0.001][1.350,0.000,0.001]
[1.400,0.000,0.001][1.450,0.000,0.000][1.500,0.000,0.000]

Curve Fitting Method: Polynomial
x Order: 4
y Order: 0
Polynomial: z = $-1.2355E-2x^4 + 3.4814E-2x^3 - 2.8885E-3x^2 - 6.5618E-2x + 4.9987E-2$
Coeff. of Determination: 1.0000

Curve Name: **Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(b))**
Coordinates: [Distance from wall / wall depth or max. excavation depth (x), Depth / wall depth or max. excavation depth (y), Settlement / wall depth or max. excavation depth (z)(%)]

[0.000,0.000,0.039][0.100,0.000,0.049][0.200,0.000,0.056][0.300,0.000,0.062]

Side	x1 [m]	y1 [m]	x2 [m]	y2 [m]	G.M. Curve: Vertical	G.M. Curve: Horizontal
					[0.400,0.000,0.067][0.500,0.000,0.070][0.600,0.000,0.072][0.700,0.000,0.073] [0.800,0.000,0.073][0.900,0.000,0.072][1.000,0.000,0.070][1.100,0.000,0.068] [1.200,0.000,0.065][1.300,0.000,0.061][1.400,0.000,0.058][1.500,0.000,0.054] [1.600,0.000,0.050][1.700,0.000,0.046][1.800,0.000,0.042][1.900,0.000,0.038] [2.000,0.000,0.034][2.100,0.000,0.030][2.200,0.000,0.027][2.300,0.000,0.023] [2.400,0.000,0.020][2.500,0.000,0.017][2.600,0.000,0.014][2.700,0.000,0.012] [2.800,0.000,0.010][2.900,0.000,0.008][3.000,0.000,0.007][3.100,0.000,0.005] [3.200,0.000,0.004][3.300,0.000,0.004][3.400,0.000,0.003][3.500,0.000,0.002] [3.600,0.000,0.002][3.700,0.000,0.002][3.800,0.000,0.001][3.900,0.000,0.001] [4.000,0.000,0.000]	

Curve Fitting Method: Polynomial
x Order: 4
y Order: 0
Polynomial: z = $-2.6455E-3x^4 + 2.8495E-2x^3 - 1.0051E-1x^2 + 1.0569E-1x + 3.8990E-2$
Coeff. of Determination: 9.9991E-1

Horizontal Ground Movement Curves

Curve Name: **No horizontal ground movement**
Coordinates: [Distance from wall / wall depth or max. excavation depth (x), Depth / wall depth or max. excavation depth (y), Horizontal movement / wall depth or max. excavation depth (z)(%)]
[0.000,0.000,0.000][1.000,0.000,0.000][0.000,1.000,0.000][1.000,1.000,0.000]
Curve Fitting Method: Polynomial
x Order: 0
y Order: 0
Polynomial: z = 0.0
Coeff. of Determination:

Curve Name: **Inst. of contiguous bored pile wall in stiff clay (CIRIA C580 Fig. 2.8(a))**
Coordinates: [Distance from wall / wall depth or max. excavation depth (x), Depth / wall depth or max. excavation depth (y), Horizontal movement / wall depth or max. excavation depth (z)(%)]
[0.000,0.000,0.041][0.050,0.000,0.038][0.100,0.000,0.036][0.150,0.000,0.034]
[0.200,0.000,0.032][0.250,0.000,0.030][0.300,0.000,0.029][0.350,0.000,0.027]
[0.400,0.000,0.025][0.450,0.000,0.023][0.500,0.000,0.022][0.550,0.000,0.020]
[0.600,0.000,0.019][0.650,0.000,0.018][0.700,0.000,0.016][0.750,0.000,0.015]
[0.800,0.000,0.014][0.850,0.000,0.013][0.900,0.000,0.011][0.950,0.000,0.010]
[1.000,0.000,0.009][1.050,0.000,0.008][1.100,0.000,0.007][1.150,0.000,0.006]
[1.200,0.000,0.005][1.250,0.000,0.004][1.300,0.000,0.004][1.350,0.000,0.003]
[1.400,0.000,0.002][1.450,0.000,0.001][1.500,0.000,0.000]
Curve Fitting Method: Polynomial
x Order: 3
y Order: 0
Polynomial: z = $-4.2486E-3x^3 + 1.9096E-2x^2 - 4.6221E-2x + 4.0729E-2$
Coeff. of Determination: 1.0000

Curve Name: **Inst. of planar diaphragm wall in stiff clay (CIRIA C580 Fig. 2.9(a))**
Coordinates: [Distance from wall / wall depth or max. excavation depth (x), Depth / wall depth or max. excavation depth (y), Horizontal movement / wall depth or max. excavation depth (z)(%)]
[0.000,0.000,0.050][1.500,0.000,0.000]
Curve Fitting Method: Polynomial
x Order: 1
y Order: 0
Polynomial: z = -3.33E-2x + 5.00E-2
Coeff. of Determination: 1.00

Curve Name: **Exc. in front of high stiffness wall in stiff clay (CIRIA C580 Fig. 2.11(a))**
Coordinates: [Distance from wall / wall depth or max. excavation depth (x), Depth / wall depth or max. excavation depth (y), Horizontal movement / wall depth or max. excavation depth (z)(%)]
[0.000,0.000,0.150][4.000,0.000,0.000]
Curve Fitting Method: Polynomial
x Order: 1
y Order: 0
Polynomial: z = -3.75E-2x + 1.50E-1
Coeff. of Determination: 1.00

Damage Category Strains

Ref.	Name	0 (Negligible) to 1 (Very Slight)	1 (Very Slight) to 2 (Slight)	2 (Slight) to 3 (Moderate)	3 (Moderate) to 4 (Severe)
1	Burland Strain Limits	0.0	500.00E-6	750.00E-6	0.0015000

Specific Buildings - Geometry

Ref.	Building Name	Sub-Building Name	Displacement Line	Distance Along Line: Start [m]	Distance Along Line: End [m]	Vertical Offsets from Line for Vertical Movement Calculations [m]	Vertical Displacement Limit Sensitivity [mm]	Damage Category Strains	Poisson's Ratio	E/G
1	24 Netherhall Gardens	Front	Line 1	0.00000	9.30000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
2	24 Netherhall Gardens	Side	Line 2	0.00000	7.10000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
3	24 netherhall Gardens	Rear Side	Line 3	0.00000	5.00000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
4	24 Netherhall Gardens	Rear	Line 4	0.00000	9.80000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
5	28 Netherhall Gardens	Front North	Line 5	0.00000	6.00000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
6	28 Netherhall Gardens	Front South	Line 6	0.00000	9.15000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
7	28 Netherhall Gardens	Side	Line 7	0.00000	10.20000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
8	28 Netherhall Gardens	Rear	Line 8	0.00000	15.30000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
9	Rear Structures	West	Line 9	0.00000	15.55000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
10	Rear Structures	North	Line 10	0.00000	5.70000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
11	Rear Structures	East - North	Line 11	0.00000	10.00000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
12	Rear Structures	East - Mid	Line 12	0.00000	1.10000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
13	Rear Structures	East - South	Line 13	0.00000	5.25000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
14	Rear Structures	South	Line 14	0.00000	6.85000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000

Specific Buildings - Bending Parameters

Ref.	Building Name	Sub-Building Name	Height [m]	Default	Hogging: 2nd Mom. of Area (per unit width) [m³]	Hogging: Dist. of Bending Strain from N.A. [m]	Hogging: Dist. of N.A. from Edge of Beam in Tension [m]	Sagging: 2nd Mom. of Area (per unit width) [m³]	Sagging: Dist. of Bending Strain from N.A. [m]	Sagging: Dist. of N.A. from Edge of Beam in Tension [m]
1	24 Netherhall Gardens	Front	11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
2	24 Netherhall Gardens	Side	11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
3	24 netherhall Gardens	Rear Side	11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
4	24 Netherhall Gardens	Rear	11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
5	28 Netherhall Gardens	Front North	11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
6	28 Netherhall Gardens	Front South	9.0000	Yes	243.00	9.0000	9.0000	60.750	4.5000	4.5000
7	28 Netherhall Gardens	Side	9.0000	Yes	243.00	9.0000	9.0000	60.750	4.5000	4.5000
8	28 Netherhall Gardens	Rear	9.0000	Yes	243.00	9.0000	9.0000	60.750	4.5000	4.5000
9	Rear Structures	West	4.0000	Yes	21.333	4.0000	4.0000	5.3333	2.0000	2.0000
10	Rear Structures	North	4.0000	Yes	21.333	4.0000	4.0000	5.3333	2.0000	2.0000
11	Rear Structures	East - North	4.0000	Yes	21.333	4.0000	4.0000	5.3333	2.0000	2.0000
12	Rear Structures	East - Mid	4.0000	Yes	21.333	4.0000	4.0000	5.3333	2.0000	2.0000
13	Rear Structures	East - South	4.0000	Yes	21.333	4.0000	4.0000	5.3333	2.0000	2.0000
14	Rear Structures	South	4.0000	Yes	21.333	4.0000	4.0000	5.3333	2.0000	2.0000

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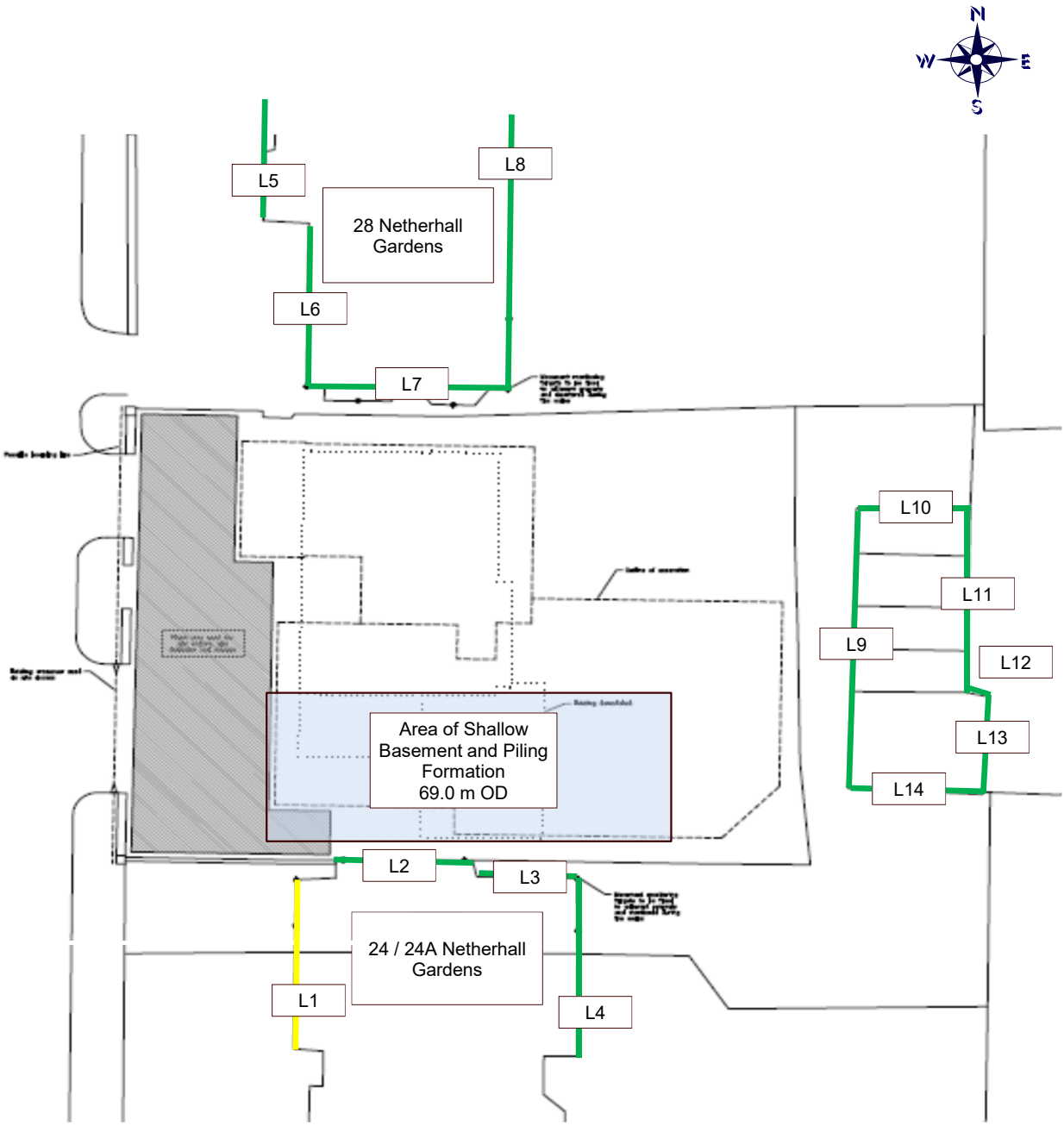
Damage Category Plan

Site	26 Netherhall Gardens, London, NW3 5TL
Client	Atlas Property Company Limited
Engineer	Byrne Looby and Partners

Job Number J15344

Sheet 1 / 1



Burland Damage Category

- Category 2 Slight
- Category 1 Very Slight
- Category 0 Negligible

Geotechnical & Environmental Associates (GEA) is an engineer-led and client-focused independent specialist providing a complete range of geotechnical and contaminated land investigation, analytical and consultancy services to the property and construction industries.

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