

Ground Movement Assessment

40 Frognal Lane
London
NW3 6PP

February 2021



FAIRHURST

CONTROL SHEET

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					DF		
					PB		

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1.0 INTRODUCTION

1.1 Background

Fairhurst has been commissioned by John Paleomylites (The Client) to complete a Ground Movement Assessment (GMA) in connection with a proposed development at 40 Frognal Lane, London NW3 6PP. The location of the site is detailed on Figure 1. The purpose of this assessment is to determine what effects the proposed permanent basement construction may have upon nearby permanent structures.

1.2 Proposed Development

The assessment is required to supplement the planning application ref. 2020/4553/P, in particular the Basement Impact Assessment (BIA) for the construction of a basement level swimming pool below the existing garden of the subject property.

The proposed excavation will be 23.2m long x 6.2m wide, and taken down to a level of 86.5mAOD at the deep end of the pool. The maximum excavation depth may therefore reach a maximum of 7.5m as the current ground levels within the garden range between 92mAOD and 94mAOD. A secant piled wall will be constructed prior to basement excavation, with this to be propped during the temporary excavation stage. The details of the secant piled wall are not known at this stage.

Drawings submitted as part of the planning application are included in Appendix A to show the proposed development. These include plans, elevations and cross section of the proposals relative to the existing buildings.

1.3 Limitations

The conclusions and recommendations made in this report have been provided on the basis of the historical ground investigations undertaken on site, which were scoped, designed, arranged and managed by third parties. Fairhurst have proceeded in good faith with the information made available at the time of writing this report and can take no responsibility or liability for inaccuracies in such information.

In addition to this, the client provided site-specific ground investigation data and has permitted the use of other third party data where appropriate.

The effect of the proposed construction on existing (both known and unrecorded) subterranean assets (including services and tunnels) is outside the scope of this report.

It should be noted that the movements described in this report are indicative only for the purposes of providing pre-planning guidance with regards to the development. It is anticipated the actual movement observed on site will be heavily affected by the form of construction, the construction techniques employed, the level and quality of workmanship and therefore all of these considerations should be reviewed at the detailed design stage following discussions with the project structural engineer and the appointed contractor. The design of temporary works is outside the scope of this report, and is the responsibility of the structural engineer and/or the chosen contractor to adequately consider these stages and aspects of the construction especially since these may present more onerous situations that will be applicable in the final permanent design case.

As this report represents a pre-planning document (and not detailed design), Fairhurst do not take any responsibility for movement that occurs to neighbouring structures (including No. 38) before, during and after the construction works.

2.0 BASELINE CONDITIONS

2.1 Site Description

The site is located within the London Borough of Camden, with a National Grid Reference of 526060,185474. The site location plan is shown as Figure 1. It is bounded by Frogmal Lane to the north, property No. 38 to the west and a private driveway to the east. The surrounding area is predominantly residential.

A site visit has not been undertaken as part of the preparation of this GMA. Topographical data has been extracted from a previous GMA produced by Train and Kemp (Consulting Engineers) in 2017 and it has been assumed that the site conditions and levels have largely remained the same since this time.

The property at 40 Frogmal Lane is a three-storey Grade II listed building with a semi-basement and is located within the eastern part of the site. The western part of the site is used as a garden, above the proposed basement swimming pool footprint. Site levels generally vary from 94mAOD in the north-eastern part of the site to 92mAOD in the south-western part of the site. No. 38 is at 91mAOD and does not have a basement or other below ground structure as far as we understand. Due to the change in topography, there is a boundary retaining wall between the gardens of Nos. 38 and 40. The retaining wall is 2m high at the front northern corner of the pool with No.38 situated on the lower side of the wall.

Site levels and clearances between adjacent structures and the proposed excavation are summarised in Table 2-1 below.

Table 2-1: Summary of Structures Surrounding the Site

Structure	Foundation Level (mAOD)	Approximate Height (m)	Approximate Length (m)	Approximate Width (m)	Perpendicular Distance from Excavation
No. 40	91.5	12	15	10.2	3.5m
No. 38	90.0	8	15	11.6	7.8m to the front northern corner of the basement; 9.8m to the centre of the basement
Boundary Wall	91.0	2	24	Unknown	4.3m to the front northern corner of the basement; and 11.3m to the rear southern corner of the basement

Notes and Assumptions relating to above dimensions:

1. The numbers in bold are dimensions perpendicular to the excavation.
2. The lower ground floor of No. 40 is at a level of 92mAOD. Its foundation is therefore assumed to be at 91.5mAOD, as per the Train and Kemp GMA (2017).
3. The dimensions of No. 40 have been based on architect's drawings, its length excluding the front porch.
4. The length of No. 38 has been assumed based on the distance between two exploratory holes undertaken in the vicinity of the property. Its height has been assumed.
5. Due to the nature of retaining walls with a limited width, the boundary wall has been modelled as a single straight line. The section of the boundary wall located closest to the western side or part of the proposed basement excavation has been assessed.

2.2 Geology

The 1:50,000 Geological Survey of Great Britain (England and Wales) map covering the site area (Sheet 256, 'North London', Solid and Drift Edition, dated 2006) indicates the site to be underlain by superficial deposits of the Bagshot Formation and Claygate Member with bedrock comprising the London Clay Formation.

3.0 GROUND INVESTIGATION AND MONITORING

3.1 Ground Conditions

A ground investigation consisting of two cable percussive boreholes (BH01 and BH02) progressed to a depth of 18.0m below ground level (mbgl) was undertaken by AP Geotechnics in July 2011 in the garden of No. 40. In-situ testing in the form of standard penetration tests (SPT) were undertaken in both boreholes and a permeability test carried out in BH01. Geotechnical laboratory testing undertaken comprised classification tests, undrained unconsolidated triaxial tests, pH and sulphates and one-dimensional consolidation tests.

A second ground investigation consisting of two continuous percussive window sample holes (WS01 and WS02) to a depth of 6.0mbgl was undertaken by Soils Ltd in December 2014 in the garden of No. 38. No in-situ testing or laboratory testing was undertaken as part of this ground investigation.

The ground conditions deviated slightly from published records in that the Bagshot Formation was not encountered. A summary of the ground conditions is presented in Table 3-1.

Table 3-1: Summary of Ground Conditions

Strata	Top Surface of Strata		Thickness Recorded (m)	Description
	Depth (mbgl)	Level (mAOD)		
Made Ground	Ground level	90.8 to 93.2	0.35 to 1.3	Soft silty CLAY containing brick fragments
Claygate Member	0.35 to 1.3	89.9 to 92.3	4.2 to 5.65	Firm brown mottled orange brown and grey silty CLAY
London Clay Formation	5.1 to 5.6	87.6 to 88.1	Base not proven	Stiff fissured brown CLAY with occasional pockets of fine sand in the weathered horizon, becoming stiff fissured dark grey CLAY at depth

3.2 Groundwater

Monitoring standpipes were installed in BH01, WS01 and WS02. Subsequent groundwater monitoring of BH01 was undertaken on two occasions and monitoring of WS01 and WS02 was done on three occasions. Table 3-2 details the groundwater monitoring results obtained from this limited monitoring regime.

Table 3-2: Summary of Groundwater Monitoring

Borehole	Groundwater Depth		Groundwater Level		Response Zone
	Min. (mbgl)	Max. (mbgl)	Min. (mAOD)	Max. (mAOD)	
BH01	2.9	3.9	89.3	90.3	Made Ground/ Claygate Member/ London Clay
WS01	1.5	2.8	88.0	89.3	Claygate Member
WS02	0.8	2.0	88.9	90.1	Claygate Member

3.3 In-situ and Laboratory Testing

A summary of laboratory and in-situ test results from the 2011 ground investigation is presented in this section. Factual data can be found in the Train and Kemp GMA (2017).

Bulk Density

The bulk density of the London Clay Formation was obtained from five undrained unconsolidated triaxial tests undertaken on samples from depths of 6.5mbgl to 12.5mbgl. The results ranged from 2.01kN/m³ to 2.11kN/m³.

Atterberg Limits and Moisture Contents

Two classification tests were undertaken on samples from the London Clay Formation in BH01 at depths of 6.5mbgl and 9.5mbgl. The moisture content results for the clay were both recorded to be 28% and the plasticity indices were 46% and 51%.

Strength Testing

A single SPT was undertaken within the Claygate Member at 1.45mbgl, with an uncorrected value of 6. Using an f_1 value of 4.5, its undrained shear strength is determined to be 27kN/m² based on Stroud's correlation (1974).

Eight SPTs were undertaken within the London Clay Formation at depths of 8.0mbgl to 17.0mbgl, with uncorrected values of 21 to 47. Five undrained unconsolidated triaxial tests were undertaken on samples of the London Clay Formation from depths of 6.5mbgl to 12.5mbgl. The undrained shear strength of the material from laboratory testing and SPT correlations ranged from 95kN/m² to 212kN/m².

4.0 PREDICTION OF GROUND MOVEMENT AND DAMAGE ASSESSMENT

4.1 Introduction

In connection with the proposed basement construction, a ground movement and damage assessment has been prepared for the site. The purpose of this assessment is to determine the effects of the proposed basement excavation upon the existing building within the subject property and the neighbouring structures adjacent to the subject property.

The sources of ground movement over the footprint of the excavated area are different from those for the movement occurring outside and the associated ground movements require assessment using different approaches.

In the area of the new basement, the soil will tend to 'heave' or lift upwards due to unloading of the ground associated with the excavation which will remove a large weight of soil from the basement footprint. However, the full extent of heave is unlikely to manifest fully during typical construction time periods. Subsequent downwards vertical movement will also be expected as a result of the re-application of vertical loading from the completion of the basement and swimming pool construction and the follow-on filling of this with water.

Around the site, ground movements during and after the works are mainly related to the basement excavation and installation of a secant piled wall, which would induce a reduction of vertical and lateral stresses in the ground along the excavation boundaries, with these tending to be at the greatest magnitude closest to the footprint of the basement excavation and closest to the existing ground surface.

The magnitude and distribution of ground movements inside and outside the excavated area are a function of changes of load in the ground and also, potentially more critically, a function of workmanship and construction techniques used.

Ground movements associated with unloading of the ground due to basement excavation have been estimated using the geotechnical software Pdisp whilst the expected movements and impact assessment of the area around the site and surrounding structures have been estimated using the software Xdisp. Xdisp relies on empirical relationships provided in CIRIA report C580 Embedded Retaining Walls – Guidance for Economic Design (superseded by C760, 2017) which is based on field measurements of movements from various basement constructions across London.

The calculations provided are specific to the proposed development and the advice herein should be reviewed should any aspect of the development proposals change.

4.2 Adjacent Properties

The properties or structures pertinent to this GMA as a result of the basement excavation and retaining wall construction are summarised in Table 2-1. The specific properties and walls under consideration for properties Nos. 38 and 40 are the same as those assessed in the Train and Kemp GMA (2017), as follows:-

- West wall of No. 40 Frognal Lane (east of the proposed basement footprint);
- East wall of No. 38 Frognal Lane (west of the proposed basement footprint); and
- Boundary retaining wall between Nos. 38 and 40 (west of the proposed basement).

4.3 Ground Model and Soil Parameters

The ground model determined for this assessment is based on the historical ground investigations undertaken on site and in the garden of No. 38. It should be noted that Fairhurst can take no responsibility or liability for inaccuracies in the factual data from these ground investigations.

The existing ground level has been assumed to be 93.5mAOD based on surveyed levels from the 2011 ground investigation and taken as an average of the sloping ground across the garden.

Ground movement analysis requires soil stiffness parameters to be derived. The undrained Young's Modulus (E_u) is used for short-term analysis while the drained Young's Modulus (E') is used for long-term analysis. Soil stiffness is dependent on the strain rate applicable to a specific engineering problem and consideration has been given to recommendations in BS 8004:2015 which suggests that the strain rate generally applicable to foundation design is in the range of 0.075% to 0.200%.

Table 4-1: Ground Model and Soil Parameters Used in Movement Analysis

Strata	Top of Strata (mAOD)	Unit Weight (kN/m ³)	Undrained		Drained	
			E_u (kN/m ²)	Poisson's Ratio (ν)	E' (kN/m ²)	Poisson's Ratio (ν')
Made Ground	93.5	18	5,000	0.5	3,500	0.2
Claygate Member	92.1	18	12,000	0.5	8,400	0.2
London Clay Formation	87.8	21	36,000 to 90,000	0.5	25,200 to 63,000	0.2

Notes and assumptions:

1. The unit weight of Made Ground and Claygate Member has been determined based on log descriptions and recommendations in BS 8002:2015. The unit weight of London Clay Formation has been derived from laboratory test results.
2. E_u of Made Ground has been determined based on typical values for this material. E_u of Claygate Member and London Clay Formation is derived from their undrained shear strength using the relationship $E_u/c_u = 450$ (Jardine et al, 1985) and based on the appropriate strain rates.
3. E' has been derived using the correlation $E_u/E' = 0.7$ based on recommendations in CIRIA report C143.
4. The Poisson's ratios have been selected based on recommendations for stiff clays.
5. The horizontal rigid boundary has been assumed to be at 72.3mAOD.

4.4 Movement associated with Unloading and Loading of the Ground

Vertical ground movement associated with unloading and subsequent loading of the ground within the basement footprint has been calculated using the Boussinesq method and geotechnical software Oasys Pdisp (version 20.0). This approach assumes linear elastic behaviour of the soil. Elastic vertical strains are calculated on the basis of the calculated stress changes and then integrated to obtain vertical movements.

The following load stages have been considered in the analysis:

1. **Stage 1 (unloading, short-term conditions):** this stage looks at the unloading of the ground due to the formation of the basement excavation from existing ground level (93.5mAOD) to the formation level of 86.5mAOD at the deep end of the swimming pool. Conservative assumptions have been adopted where the excavation has been modelled as one bulk excavation whereas in reality staged excavation techniques are more likely to be employed. An unloading of 130kN/m² has been applied at the formation level, based on the overburden having been removed (i.e. thickness x unit weight of each stratum). Excavation has been considered in the short-term case only, assuming there would be no significant delays before construction of the basement.

2. **Stage 2 (loading, short-term conditions):** there is no information on the anticipated loads from the permanent structures at this stage. Therefore, a nominal uniformly distributed load of 30kN/m² has been applied across the entire basement to account for floor slabs, weight of water in the swimming pool and other ancillary facilities. This approach assumes that all and any concentrated wall line and point load will be evenly distributed across the basement slab footprint due to the relative high stiffness of this construction.
3. **Stage 3 (loading, long-term conditions):** similarly, a nominal 30kN/m² has been applied across the entire basement footprint. Drained geotechnical parameters are used to account for the long-term case following dissipation of pore-water pressures in the clays. Same assumptions as stage 2 above in terms of the assumed distribution of the load across the basement slab footprint.

Vertical ground movement of adjacent structures as a result of load stages 1 to 3 has been estimated to be less than 5mm.

4.5 Movement associated with Basement Excavation and Secant Piled Wall Installation

Oasys Xdisp (version 19.4) has been used to estimate the movements associated with the basement excavation and secant piled wall installation and to subsequently calculate the resultant damage categories of the structures of interest under review and consideration.

Temporary works have not been considered in this ground movement assessment, and it is assumed that the design of temporary works is the responsibility of the structural engineer or chosen contractor. The movements described in this assessment are very dependent on, influenced by and affected by the quality of the workmanship and propping system and arrangement of the basement excavations.

The Xdisp analysis considers 'installation of secant bored pile wall in stiff clay' (CIRIA 580 Fig. 2.8) and 'excavation in front of a high stiffness wall in stiff clay' (CIRIA 580 Fig. 2.11) to simulate any effects from excavation and basement wall construction on neighbouring structures. Stiffened walls with an assumed toe level of 5.0m below the basement level have been utilised in the analysis, an assumption which would require an adequate propping regime and extent of propping in order to achieve this. This means that the walls have been assumed to act as supported or propped walls as opposed to un-propped cantilever walls which would typically require a much greater pile embedment depth to satisfy the ultimate stability requirements. It would not be uncommon for walls such as these to need to be designed as propped walls to satisfy the serviceability criteria design requirements in relation to controlling movements, thus this assumption is not considered unreasonable in this instance. The combined cumulative movements resulting from the wall installation and basement excavation have been used to carry out an assessment of the likely damage to adjacent structures.

In order to model the more realistic effects on movements of sub-surface structures, the ground movement curves have been applied at the levels at which the buildings are founded. This means a level of 91.5mAOD for No. 40, and a level of 90.0mAOD for No. 38 and a level of 91.0mAOD for the boundary wall. This effectively reduces the excavation depth in the Xdisp models which is considered to be more representative of the movement of structures below the existing ground surface level.

For both short- and long-term cases, displacements from the corresponding Pdisp models have been imported to capture movements associated with unloading and loading across the basement footprint, basement excavation and secant piled wall installation.

4.6 Building Damage Assessment

The building damage assessment has been carried out for No. 40, No. 38 and the boundary wall with structure details as summarised in Table 2-1. The expected damage categories as defined by the Burland's scale are presented in Table 4-2.

Based on these predicted ground movements, the following damage categories are anticipated for the structures under consideration:

- A maximum of Damage Category 1 (Very Slight) for the west wall of No. 40;
- Damage Category 0 (Negligible) for the east wall of No. 38; and
- Damage Category 1 (Very Slight) for the boundary retaining wall between Nos. 38 and 40.

The west wall of No. 40 is expected to experience Damage Category 1 (Very Slight) during the excavation stage only. As noted before, staged excavation techniques and an adequate level of propping are likely to be adopted by the contractor and so the damage categories should be lower in reality. Following the construction of the basement structure, the movement and hence strain experienced by the structures will be highly dependent on the quality of workmanship and control of movement during construction. Movement behind the wall will also be significantly restricted by the concrete basement box structure which will act as stiff permanent props. Any localised effects are likely to manifest themselves over a greater extent of the property through normal load and movement redistribution that will occur in practice. Consideration could be given to using an increased level of stiffness construction both in the temporary and permanent cases in certain areas of the proposed basement if required. These specific measures and other options can be considered at the detailed design stage to help mitigate any effects from the basement excavation.

The results of the Xdisp analysis and damage category assessment are presented in Appendix B.

Table 4-2: Ground Movement and Damage Category Summary

Structure	Wall	Short-term Unloading			Short-term Loading			Long-term Loading		
		Max. Settlement	Max. Tensile Strain	Damage Category	Max. Settlement	Max. Tensile Strain	Damage Category	Max. Settlement	Max. Tensile Strain	Damage Category
No. 40	West	7.5	0.06	1 – Very Slight	8.1	0.03	0 – Negligible	9.5	0.03	0 – Negligible
No. 38	East	3.4	0.02	0 – Negligible	3.0	0.03	0 – Negligible	3.2	0.03	0 – Negligible
Boundary Wall	-	6.7	0.06	1 – Very Slight	6.7	0.06	1 – Very Slight	7.1	0.06	1 – Very Slight

5.0 CONCLUSIONS

A Ground Movement Assessment has been carried out for the proposed basement at property No. 40 Frognal Lane, London NW3 6PP as part of the planning application basement impact assessment provided to the London Borough of Camden.

Providing that appropriate consideration is given to the detailed design of the basement in order to use all available measures and employ construction techniques specifically to limit future movement, and that good workmanship and construction sequences are used with appropriate support during excavation, it is considered that the proposed basement construction is unlikely to cause significant damage to the surrounding structures. Based on the predicted ground movements, all structures assessed in the vicinity of the basement excavation are expected to be within the CIRIA C760 Damage Category 1 (Very Slight).

Early and comprehensive movement monitoring, through a series of carefully located and designed movement monitoring points, of the neighbouring buildings is recommended during the construction stage and trigger levels at the ground level between the basement excavation and the structures under review should be set in order to protect the neighbouring properties as a precautionary measure. A specification and design for a detailed movement monitoring regime should be incorporated into the final construction scheme for the proposed development to monitor the adjacent properties and establish the extent of any future potential movement to the building at an early a stage as possible. Any temporary and permanent works should be designed to limit eventual movement with a reconsideration of the predicted ground movements following this process.

FIGURES

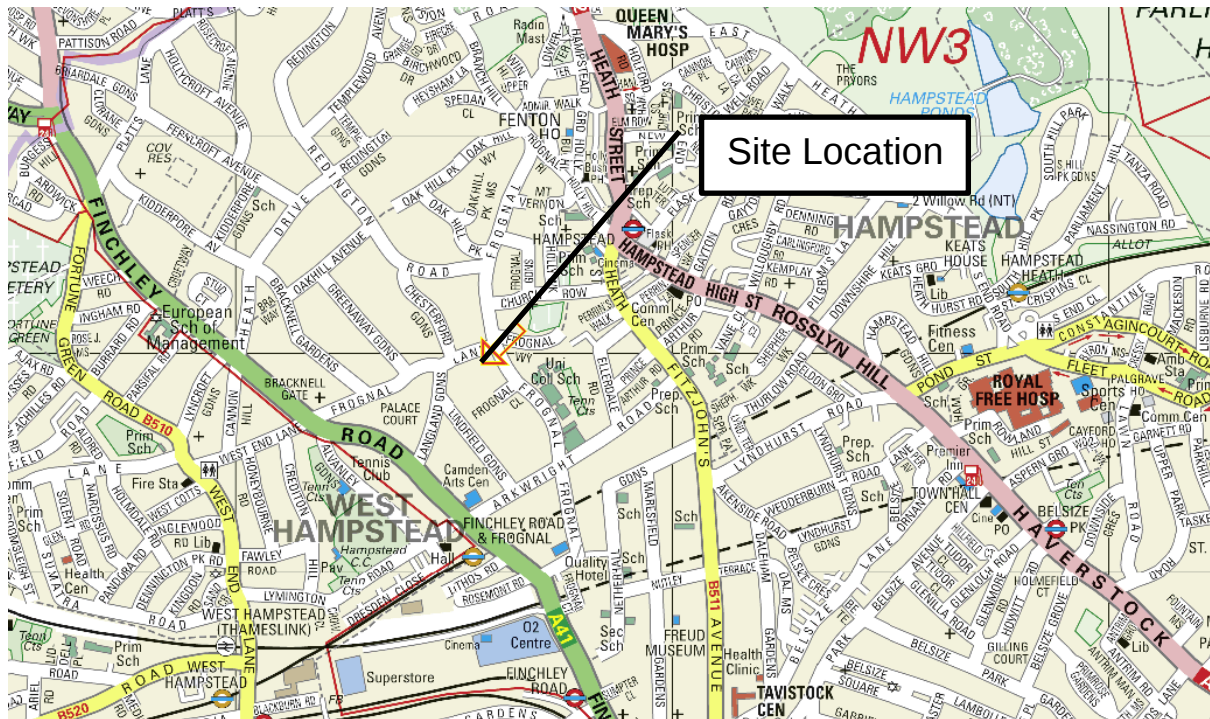
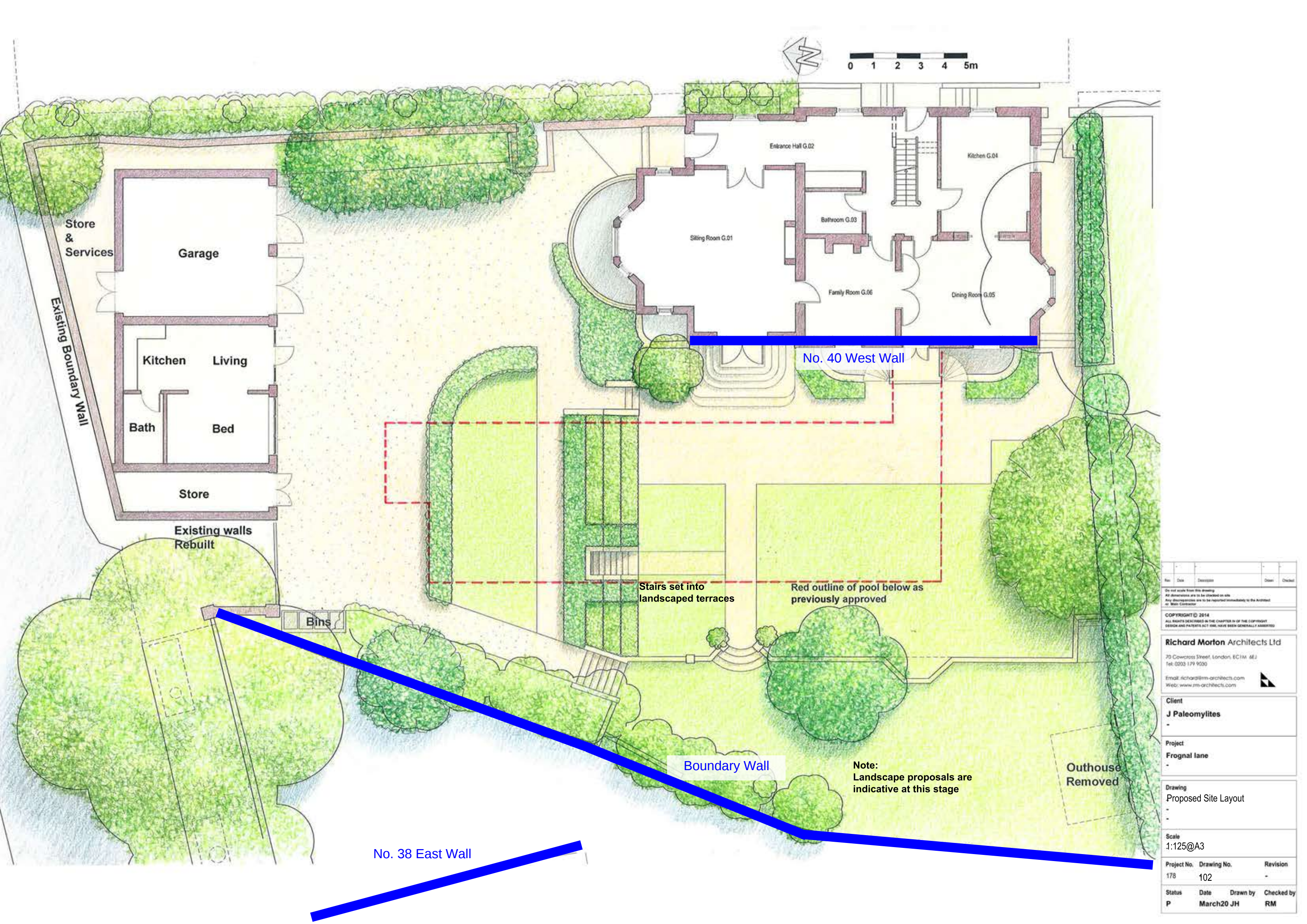


Figure 1: Site Location Plan

(Source: Streetmap.co.uk, 2021)

APPENDIX A
DEVELOPMENT PROPOSAL DRAWINGS



Rev.	Date	Description	Drawn	Checked
1	12/03/14	Initial design	JM	RM
2	15/03/14	Revised design	JM	RM
3	18/03/14	Final design	JM	RM

Do not scale from this drawing.
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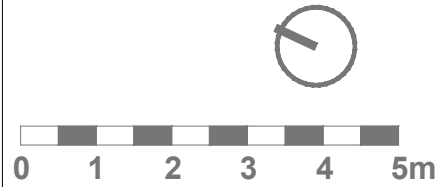
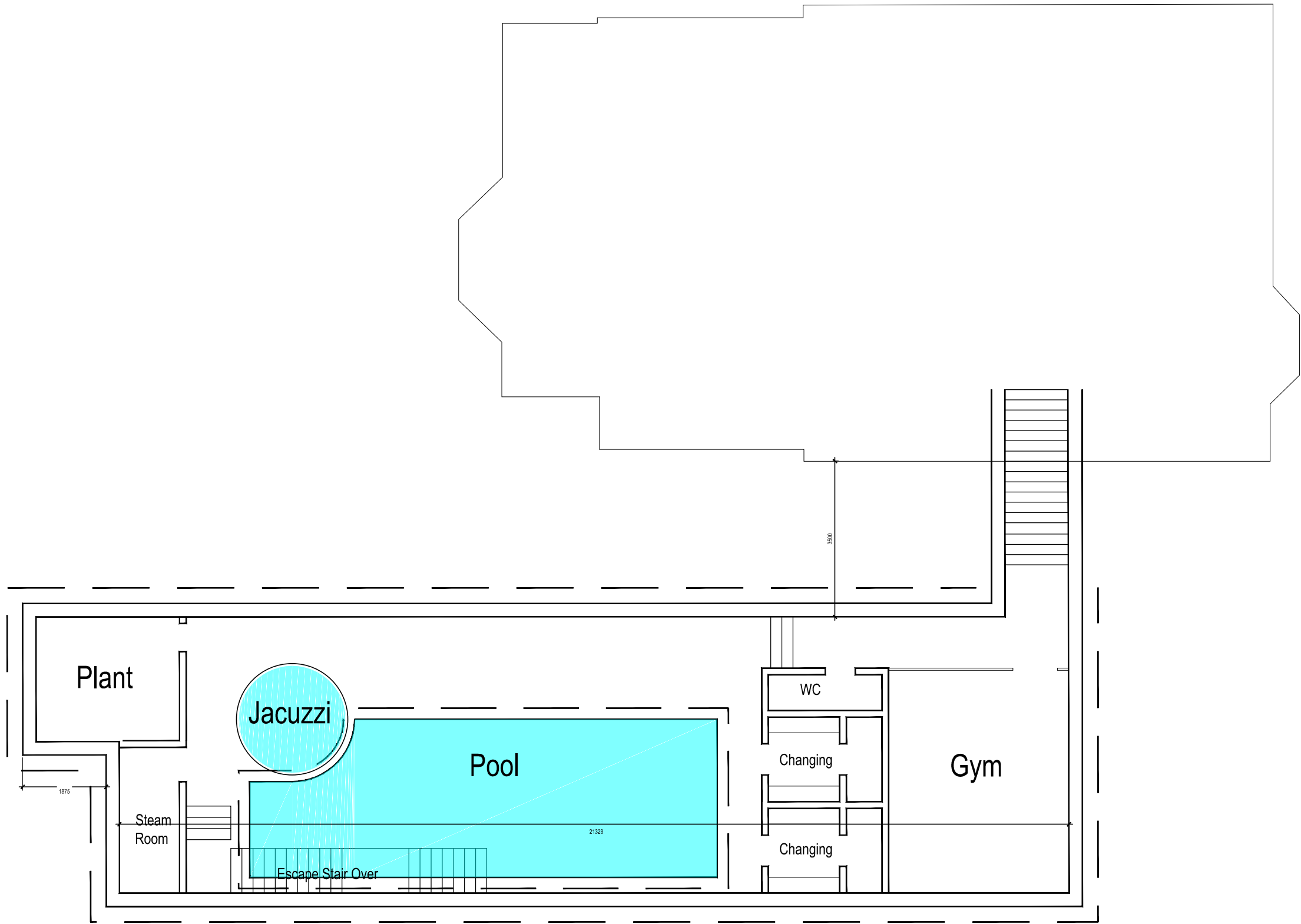
Client
J Paleomyllites
-

Project
Frogna Lane
-

Drawing
Proposed Site Layout
-
-

Scale
1:125@A3

Project No.	Drawing No.	Revision	
178	102	-	
Status	Date	Drawn by	Checked by
P	March20	JH	RM



-	-	-	-	-
Rev	Date	Description	Drawn	Checked

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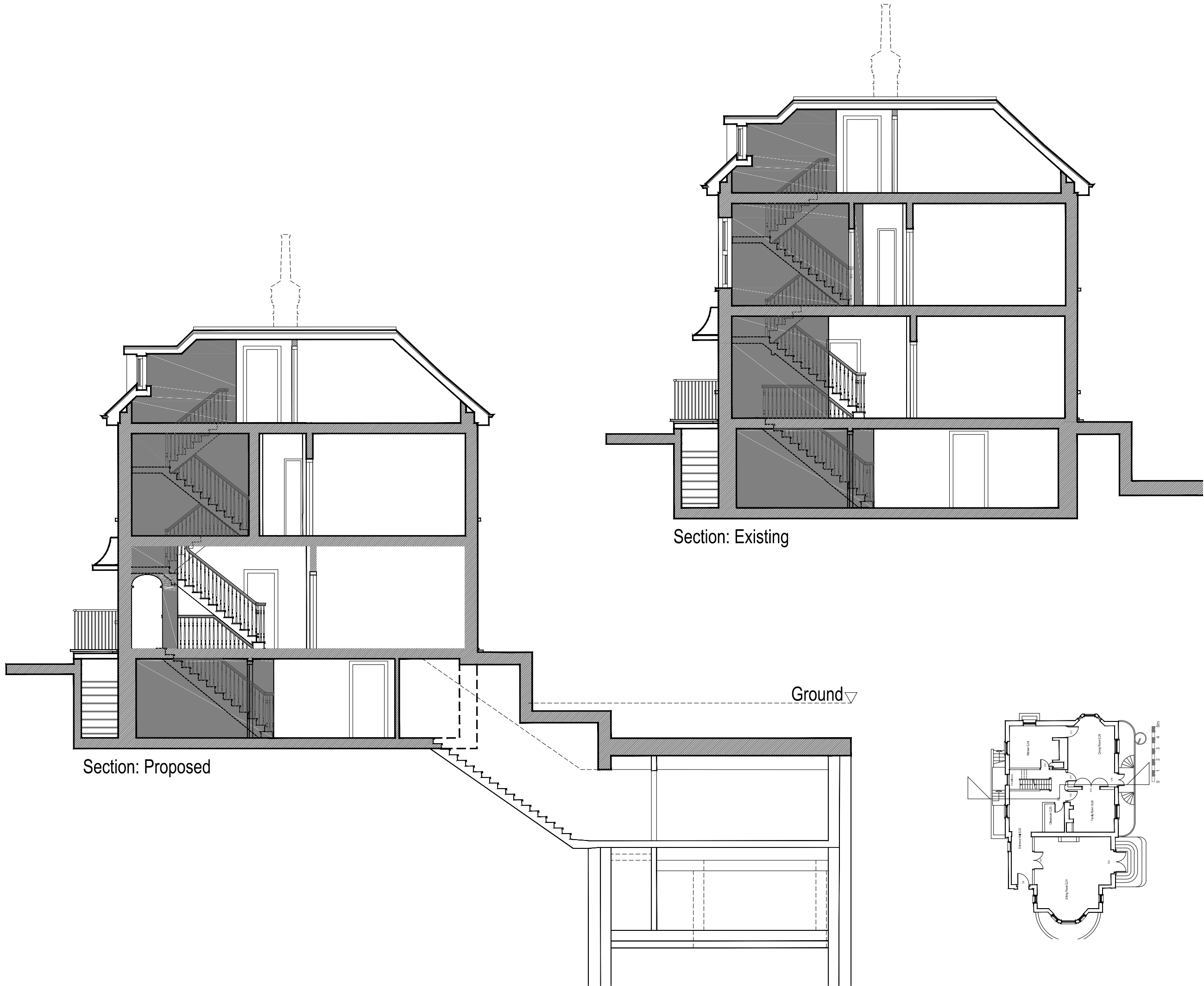
Client J Paleomyllites -
Project Frognal lane -

Drawing Basement Pool Plan Proposed -

Scale 1:100@A3

Project No. 178	Drawing No. 138	Revision -
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Status P	Date Sept 20	Drawn by LN	Checked by RM
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Rev	Date	Description	Drawn	Checked

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Client
J Paleomyllites
-
Project
Frogna Lane
-

Drawing
Main Stair Section - Internal
Existing & Proposed
-

Scale
1:100@A3

Project No.	Drawing No.	Revision
178	142	-

Status	Date	Drawn by	Checked by
P	JUL 20	CBT	RM

APPENDIX B

XDISP GROUND MOVEMENT AND DAMAGE CATEGORY RESULTS



FAIRHURST

40 Frogнал Lane

Short-term Basement Excavation (Unloading, Wall Toe 5mbbl)

Boundary Wall

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Problem Type

Problem Type : Tunnelling and Embedded Wall Excavations

Displacement Data

Type	Name	Direction of extrusion	Point/Line/Line for extrusion			No. of intervals across extrusion/line	Extrusion depth	No. of intervals along extrusion	Calculate Surface type for tunnels
			First point		Second point				
			X [m]	Z(level) [m]	X [m]	Y [m]			
Line	Boundary Wall	-	6.50000	-11.60000	91.00000	13.50000	11.60000	91.00000	24 - Yes Surface

Imported Displacements

The following data points and displacements were found in the import file Pdisp Short term Unloading to be Imported.csv.

Ref.	Coordinates			Displacements		
	x [m]	y [m]	z [m]	x [mm]	y [mm]	z [mm]
1	-7.50000	0.00000	91.50000	0.00000	0.00000	-0.73810
2	-7.50000	1.00000	91.50000	0.00000	0.00000	-0.73690
3	-7.50000	2.00000	91.50000	0.00000	0.00000	-0.73310
4	-7.50000	3.00000	91.50000	0.00000	0.00000	-0.72580
5	-7.50000	4.00000	91.50000	0.00000	0.00000	-0.71350
6	-7.50000	5.00000	91.50000	0.00000	0.00000	-0.69420
7	-7.50000	6.00000	91.50000	0.00000	0.00000	-0.66530
8	-7.50000	7.00000	91.50000	0.00000	0.00000	-0.62330
9	-7.50000	8.00000	91.50000	0.00000	0.00000	-0.56500
10	-7.50000	9.00000	91.50000	0.00000	0.00000	-0.48730
11	-7.50000	10.00000	91.50000	0.00000	0.00000	-0.38960
12	-7.50000	11.00000	91.50000	0.00000	0.00000	-0.27550
13	-7.50000	12.00000	91.50000	0.00000	0.00000	-0.15450
14	-7.50000	13.00000	91.50000	0.00000	0.00000	-0.03940
15	-7.50000	14.00000	91.50000	0.00000	0.00000	0.05940
16	-7.50000	15.00000	91.50000	0.00000	0.00000	0.13690
17	-7.50000	0.00000	91.50000	0.00000	0.00000	-0.73810
18	-8.42730	0.00000	91.50000	0.00000	0.00000	-0.35400
19	-9.35450	0.00000	91.50000	0.00000	0.00000	-0.09160
20	-10.28180	0.00000	91.50000	0.00000	0.00000	0.08700
21	-11.20910	0.00000	91.50000	0.00000	0.00000	0.20650
22	-12.13640	0.00000	91.50000	0.00000	0.00000	0.28400
23	-13.06360	0.00000	91.50000	0.00000	0.00000	0.33150
24	-13.99090	0.00000	91.50000	0.00000	0.00000	0.35760
25	-14.91820	0.00000	91.50000	0.00000	0.00000	0.36860
26	-15.84550	0.00000	91.50000	0.00000	0.00000	0.36900
27	-16.77270	0.00000	91.50000	0.00000	0.00000	0.36230
28	-17.70000	0.00000	91.50000	0.00000	0.00000	0.35090
29	-7.50000	15.00000	91.50000	0.00000	0.00000	0.13690
30	-8.42730	15.00000	91.50000	0.00000	0.00000	0.19460
31	-9.35450	15.00000	91.50000	0.00000	0.00000	0.23710
32	-10.28180	15.00000	91.50000	0.00000	0.00000	0.26640
33	-11.20910	15.00000	91.50000	0.00000	0.00000	0.28490
34	-12.13640	15.00000	91.50000	0.00000	0.00000	0.29490
35	-13.06360	15.00000	91.50000	0.00000	0.00000	0.29820
36	-13.99090	15.00000	91.50000	0.00000	0.00000	0.29650
37	-14.91820	15.00000	91.50000	0.00000	0.00000	0.29100
38	-15.84550	15.00000	91.50000	0.00000	0.00000	0.28290
39	-16.77270	15.00000	91.50000	0.00000	0.00000	0.27300
40	-17.70000	15.00000	91.50000	0.00000	0.00000	0.26190
41	10.00000	-11.60000	90.00000	0.00000	0.00000	0.28140
42	10.16670	-10.63330	90.00000	0.00000	0.00000	0.28250
43	10.33330	-9.66670	90.00000	0.00000	0.00000	0.28530
44	10.50000	-8.70000	90.00000	0.00000	0.00000	0.29010
45	10.66670	-7.73330	90.00000	0.00000	0.00000	0.29640
46	10.83330	-6.76670	90.00000	0.00000	0.00000	0.30390
47	11.00000	-5.80000	90.00000	0.00000	0.00000	0.31220
48	11.16670	-4.83330	90.00000	0.00000	0.00000	0.32070
49	11.33330	-3.86670	90.00000	0.00000	0.00000	0.32900
50	11.50000	-2.90000	90.00000	0.00000	0.00000	0.33670
51	11.66670	-1.93330	90.00000	0.00000	0.00000	0.34350
52	11.83330	-0.96670	90.00000	0.00000	0.00000	0.34920
53	12.00000	0.00000	90.00000	0.00000	0.00000	0.35360
54	10.00000	-11.60000	90.00000	0.00000	0.00000	0.28140
55	11.00000	-11.60000	90.00000	0.00000	0.00000	0.30670
56	12.00000	-11.60000	90.00000	0.00000	0.00000	0.31790
57	13.00000	-11.60000	90.00000	0.00000	0.00000	0.31930
58	14.00000	-11.60000	90.00000	0.00000	0.00000	0.31410
59	15.00000	-11.60000	90.00000	0.00000	0.00000	0.30460
60	16.00000	-11.60000	90.00000	0.00000	0.00000	0.29220
61	17.00000	-11.60000	90.00000	0.00000	0.00000	0.27830
62	18.00000	-11.60000	90.00000	0.00000	0.00000	0.26350
63	19.00000	-11.60000	90.00000	0.00000	0.00000	0.24860
64	20.00000	-11.60000	90.00000	0.00000	0.00000	0.23370
65	21.00000	-11.60000	90.00000	0.00000	0.00000	0.21930
66	22.00000	-11.60000	90.00000	0.00000	0.00000	0.20550
67	23.00000	-11.60000	90.00000	0.00000	0.00000	0.19230
68	24.00000	-11.60000	90.00000	0.00000	0.00000	0.17990
69	25.00000	-11.60000	90.00000	0.00000	0.00000	0.16820
70	12.00000	0.00000	90.00000	0.00000	0.00000	0.35360
71	13.00000	0.00000	90.00000	0.00000	0.00000	0.36780
72	14.00000	0.00000	90.00000	0.00000	0.00000	0.36920
73	15.00000	0.00000	90.00000	0.00000	0.00000	0.36200
74	16.00000	0.00000	90.00000	0.00000	0.00000	0.34940
75	17.00000	0.00000	90.00000	0.00000	0.00000	0.33350
76	18.00000	0.00000	90.00000	0.00000	0.00000	0.31570
77	19.00000	0.00000	90.00000	0.00000	0.00000	0.29720
78	20.00000	0.00000	90.00000	0.00000	0.00000	0.27860
79	21.00000	0.00000	90.00000	0.00000	0.00000	0.26030
80	22.00000	0.00000	90.00000	0.00000	0.00000	0.24280
81	23.00000	0.00000	90.00000	0.00000	0.00000	0.22620
82	24.00000	0.00000	90.00000	0.00000	0.00000	0.21050
83	25.00000	0.00000	90.00000	0.00000	0.00000	0.19590
84	26.00000	0.00000	90.00000	0.00000	0.00000	0.18220
85	27.00000	0.00000	90.00000	0.00000	0.00000	0.16950
86	6.50000	-11.60000	91.00000	0.00000	0.00000	-0.03490 1,2,6
87	6.79170	-10.63330	91.00000	0.00000	0.00000	-0.05030 1,2,6
88	7.08330	-9.66670	91.00000	0.00000	0.00000	-0.04850 1,2,6
89	7.37500	-8.70000	91.00000	0.00000	0.00000	-0.03220 1,2,6
90	7.66670	-7.73330	91.00000	0.00000	0.00000	-0.00540 1,2,6
91	7.95830	-6.76670	91.00000	0.00000	0.00000	0.02830 1,2,6
92	8.25000	-5.80000	91.00000	0.00000	0.00000	0.06540 1,2,6
93	8.54170	-4.83330	91.00000	0.00000	0.00000	0.10340 1,2,6
94	8.83330	-3.86670	91.00000	0.00000	0.00000	0.14050 1,2,6
95	9.12500	-2.90000	91.00000	0.00000	0.00000	0.17530 1,2,6
96	9.41670	-1.93330	91.00000	0.00000	0.00000	0.20710 1,2,6
97	9.70830	-0.96670	91.00000	0.00000	0.00000	0.23530 1,2,6
98	10.00000	0.00000	91.00000	0.00000	0.00000	0.25990 1,2,6
99	10.29170	0.96670	91.00000	0.00000	0.00000	0.28080 1,2,6
100	10.58330	1.93330	91.00000	0.00000	0.00000	0.29810 1,2,6
101	10.87500	2.90000	91.00000	0.00000	0.00000	0.31210 1,2,6
102	11.16670	3.86670	91.00000	0.00000	0.00000	0.32290 1,2,6



FAIRHURST

40 Frogmal Lane

Short-term Basement Excavation (Unloading, Wall Toe 5mbbl)

Boundary Wall

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Ref.	Coordinates			Displacements		
	x [m]	y [m]	z [m]	x [mm]	y [mm]	z [mm]
103	11.45830	4.83330	91.00000	0.00000	0.00000	0.33070 1,2,6
104	11.75000	5.80000	91.00000	0.00000	0.00000	0.33590 1,2,6
105	12.04170	6.76670	91.00000	0.00000	0.00000	0.33840 1,2,6
106	12.33330	7.73330	91.00000	0.00000	0.00000	0.33850 1,2,6
107	12.62500	8.70000	91.00000	0.00000	0.00000	0.33630 1,2,6
108	12.91670	9.66670	91.00000	0.00000	0.00000	0.33190 1,2,6
109	13.20830	10.63330	91.00000	0.00000	0.00000	0.32560 1,2,6
110	13.50000	11.60000	91.00000	0.00000	0.00000	0.31740 1,2,6
1 - Data point coincident with displacement data. Its displacement has been added to those calculated by Xdisp.						
2 - Data point coincident with horizontal movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.						
6 - Data point coincident with vertical movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.						

Vertical Ground Movement Curves (Excavations)

Curve Name:	Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)] [0.000,0.000,0.050][2.000,0.000,0.000]
Curve Fitting Method:	Polynomial
x Order:	1
y Order:	0
Polynomial: z =	-2.5E-2x + 5.0E-2
Coeff. of Determination:	1.0
Curve Name:	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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][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 (Excavations)

Curve Name:	Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)] [0.000,0.000,0.081][0.050,0.000,0.076][0.100,0.000,0.072][0.150,0.000,0.067][0.200,0.000,0.063][0.250,0.000,0.059][0.300,0.000,0.056][0.350,0.000,0.052][0.400,0.000,0.049][0.450,0.000,0.045][0.500,0.000,0.043][0.550,0.000,0.040][0.600,0.000,0.037][0.650,0.000,0.034][0.700,0.000,0.032][0.750,0.000,0.029][0.800,0.000,0.027][0.850,0.000,0.024][0.900,0.000,0.022][0.950,0.000,0.020][1.000,0.000,0.018][1.050,0.000,0.016][1.100,0.000,0.014][1.150,0.000,0.012][1.200,0.000,0.011][1.250,0.000,0.009][1.300,0.000,0.007][1.350,0.000,0.005][1.400,0.000,0.004][1.450,0.000,0.002][1.500,0.000,0.000]
Curve Fitting Method:	Polynomial
x Order:	3
y Order:	0
Polynomial: z =	-1.0610E-2x ³ + 4.4203E-2x ² - 9.6358E-2x + 8.0901E-2
Coeff. of Determination:	1.0000
Curve Name:	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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

Polygonal Excavations

Excavation Name:	Pool excavation
Surface level [m]:	91.000
Contribution:	Positive
Enabled:	Yes

Corner	x	y	Base Level	Stiffened	Previous Side	Next Side
	[m]	[m]	[m]		d	p1 p2*
					[m] [%]	[m] [%]
1	-4.0000	-11.600	86.500	Yes	0.0 67.000	25.000 0.0 67.000 25.000
2	2.2000	-11.600	86.500	Yes	0.0 67.000	25.000 0.0 67.000 25.000
3	2.2000	11.600	86.500	Yes	0.0 67.000	25.000 0.0 67.000 25.000
4	-4.0000	11.600	86.500	Yes	0.0 67.000	25.000 0.0 67.000 25.000

Side	Corner 1		Corner 2		Ground Movement Curve	
	x	y	x	y	Vertical	Horizontal
	[m]	[m]	[m]	[m]		
1	-4.0000	-11.600	2.2000	-11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
2	2.2000	-11.600	2.2000	11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
3	2.2000	11.600	-4.0000	11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
4	-4.0000	11.600	-4.0000	-11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))

Excavation Name:	Secant Pile Wall Installation
Surface level [m]:	91.000
Contribution:	Positive
Enabled:	Yes

Corner	x	y	Base	Stiffened	Previous Side	Next Side
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40 Frognal Lane

Short-term Basement Excavation (Unloading, Wall Toe 5mbbl)

Boundary Wall

	Level			d	p1	p2*	d	p1	p2*
	[m]	[m]	[m]	[m]	[%]	[%]	[m]	[%]	[%]
1	-4.0000	-11.6000	81.5000	Yes	0.0	50.0000	20.0000	0.0	50.0000
2	2.2000	-11.6000	81.5000	Yes	0.0	50.0000	20.0000	0.0	50.0000
3	2.2000	11.6000	81.5000	Yes	0.0	50.0000	20.0000	0.0	50.0000
4	-4.0000	11.6000	81.5000	Yes	0.0	50.0000	20.0000	0.0	50.0000

Side	Corner 1		Corner 2		Ground Movement Curve	
	x (m)	y (m)	x (m)	y (m)	Vertical	Horizontal
1	-4.0000	-11.600	2.2000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
2	2.2000	-11.600	2.2000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
3	2.2000	11.600	-4.0000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
4	-4.0000	11.600	-4.0000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))

Damage Category Strains

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

Specific Structures - Geometry

Structure Name	Sub-Structure Name	Displacement Line	Start Distance Along Line	End Distance Along Line	Vertical Offsets from Line for Movement Calculations	Vertical Displacement Limit Sensitivity	Damage Category	Strains	Poisson's Ratio	E/G
Boundary Wall	Boundary Wall	Boundary Wall	[m] 0.00000	[m] 24.23300	[m] 0.0	[mm] 0.10000	Burland Strain Limits		0.20000	2.60000

Specific Structures - Bending Parameters

Structure Name	Sub-Structure Name	Height	Default Properties	Hogging			Sagging		
				2nd Moment of Area (per unit width)	Distance of Bending Strain from N.A.	Distance of N.A. from Edge of Beam in Tension	2nd Moment of Area (per unit width)	Distance of Bending Strain from N.A.	Distance of N.A. from Edge of Beam in Tension
Boundary Wall	Boundary Wall Foundation	2.0000	Yes	[m ³]	[m]	[m]	[m ³]	[m]	[m]
				2.6667	2.0000	2.0000	0.66667	1.0000	1.0000

Building Segment Combinations

Structure Name	Sub-Structure Name	Vertical Offset from Line for Vertical Movement Calculations	Segment Start	Length	Curvature	Combined Segment
		[m]	[m]	[m]		

No structures have segments combined.

Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Warnings

- 1 Multiple excavations have been specified. The displacements resulting from these excavations are calculated by summing the displacements resulting from each individual excavation. No account has been taken of the interactions between excavations (e.g. overlapping zones of influence or 'shielding' of one excavation by another).

Errors

None

Displacement and Strain Results

Type/No.		Coordinates				Displacements				Angle of Line	
Name	Dist.	x	y	z	x	y	z	Horizontal displacement along Line	Horizontal displacement perpendicular to Line	to x Axis	
		[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[°]	
Boundary Wall	Line 1	[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[°]	
		6.50000	-11.60000	91.00000	-5.5967	0.0	3.9393	-1.6167	5.3581	73.210 *	
		1.0097	6.79167	-10.13333	91.00000	-9.1565	0.0	6.6836	8.7662	73.210 *	
		2.0194	7.08333	-9.66667	91.00000	-8.8716	0.0	6.5440	8.4934	73.210 *	
		3.0291	7.37500	-9.00000	91.00000	-8.5916	0.0	6.4088	8.2254	73.210 *	
		4.0388	7.66667	-8.73333	91.00000	-8.3165	0.0	6.2753	7.9620	73.210 *	
		5.0485	7.95833	-8.76667	91.00000	-8.0460	0.0	6.1411	7.7030	73.210 *	
		6.0583	8.25000	-8.50000	91.00000	-7.7800	0.0	6.0039	7.4483	73.210 *	
		7.0680	8.54167	-8.43333	91.00000	-7.5182	0.0	5.8622	7.1977	73.210 *	
		8.0777	8.83333	-8.66667	91.00000	-7.2606	0.0	5.7151	6.9511	73.210 *	
		9.0874	9.12500	-2.90000	91.00000	-7.0069	0.0	5.5624	6.7082	73.210 *	
		10.097	9.41667	-1.93333	91.00000	-6.7570	0.0	5.4043	6.4689	73.210 *	
		11.107	9.70833	-0.96667	91.00000	-6.5106	0.0	5.2409	6.2331	73.210 *	
		12.117	10.00000	0.00000	91.00000	-6.2677	0.0	5.0731	6.0005	73.210 *	
		13.126	10.29167	0.00000	91.00000	-6.0280	0.0	4.9016	5.7710	73.210 *	
		14.136	10.58333	1.93333	91.00000	-5.7913	0.0	4.7272	5.5444	73.210 *	
		15.146	10.87500	2.90000	91.00000	-5.5576	0.0	4.5509	5.3207	73.210 *	
		16.155	11.16667	3.86667	91.00000	-5.3265	0.0	4.3734	5.0995	73.210 *	
		17.165	11.45833	4.83333	91.00000	-5.0980	0.0	4.1955	4.8807	73.210 *	
		18.175	11.75000	5.80000	91.00000	-4.8719	0.0	4.0181	4.6642	73.210 *	
		19.184	12.04167	6.76667	91.00000	-4.6479	0.0	3.8414	4.4498	73.210 *	
		20.194	12.33333	7.73333	91.00000	-4.4259	0.0	3.6664	4.2373	73.210 *	
		21.204	12.62500	8.70000	91.00000	-4.2058	0.0	3.4935	4.0265	73.210 *	
		22.214	12.91667	9.66667	91.00000	-3.9874	0.0	3.3230	3.8174	73.210 *	
		23.223	13.20833	10.63333	91.00000	-3.7704	0.0	3.1555	3.6097	73.210 *	



FAIRHURST

40 Frogna Lane

Short-term Basement Excavation (Unloading, Wall Toe 5mbbl)

Boundary Wall

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Type/No.	Coordinates				Displacements			Angle of Line to x Axis				
Name	Dist.	x	y	z	x	y	z	Horizontal displacement	Horizontal displacement	to x Axis		
	24.233	13.50000	11.60000	91.00000	-2.2045	0.0	1.7816	-0.63679	2.1105	73.210 *		
* Result includes imported displacement(s).												
Specific Building Damage Results - Horizontal Displacements												
Structure: Boundary Wall Sub-structure: Boundary Wall Foundation												
Dist.	Coordinates			Displacements			Horizontal displacement along the Line		Horizontal displacement perpendicular to Line			
	x	y	z	x	y		Horizontal displacement along the Line	Horizontal displacement perpendicular to Line				
[m]	[m]	[m]	[m]	[mm]	[mm]		[mm]	[mm]				
0.0	6.50000	-11.60000	91.00000	-5.5967	0.0		-1.6167	5.3581	d			
1.0097	6.79167	-10.63333	91.00000	-9.1565	0.0		-2.6450	8.7662	d			
2.0194	7.08333	-9.66667	91.00000	-8.8716	0.0		-2.5627	8.4934	d			
3.0291	7.37500	-8.70000	91.00000	-8.5916	0.0		-2.4818	8.2254	d			
4.0388	7.66667	-7.73333	91.00000	-8.3165	0.0		-2.4023	7.9620	d			
5.0485	7.95833	-6.76667	91.00000	-8.0460	0.0		-2.3242	7.7030	d			
6.0583	8.25000	-5.80000	91.00000	-7.7800	0.0		-2.2473	7.4483	d			
7.0680	8.54167	-4.83333	91.00000	-7.5182	0.0		-2.1717	7.1977	d			
8.0777	8.83333	-3.86667	91.00000	-7.2606	0.0		-2.0973	6.9511	d			
9.0874	9.12500	-2.90000	91.00000	-7.0069	0.0		-2.0240	6.7082	d			
10.097	9.41667	-1.93333	91.00000	-6.7570	0.0		-1.9518	6.4689	d			
11.107	9.70833	-0.96667	91.00000	-6.5106	0.0		-1.8807	6.2331	d			
12.117	10.00000	0.00000	91.00000	-6.2677	0.0		-1.8105	6.0005	d			
13.126	10.29167	0.96667	91.00000	-6.0280	0.0		-1.7413	5.7710	d			
14.136	10.58333	1.93333	91.00000	-5.7913	0.0		-1.6729	5.5444	d			
15.146	10.87500	2.90000	91.00000	-5.5576	0.0		-1.6054	5.3207	d			
16.155	11.16667	3.86667	91.00000	-5.3265	0.0		-1.5386	5.0995	d			
17.165	11.45833	4.83333	91.00000	-5.0980	0.0		-1.4726	4.8807	d			
18.175	11.75000	5.80000	91.00000	-4.8719	0.0		-1.4073	4.6642	d			
19.184	12.04167	6.76667	91.00000	-4.6479	0.0		-1.3426	4.4498	d			
20.194	12.33333	7.73333	91.00000	-4.4259	0.0		-1.2785	4.2373	d			
21.204	12.62500	8.70000	91.00000	-4.2058	0.0		-1.2149	4.0265	d			
22.214	12.91667	9.66667	91.00000	-3.9874	0.0		-1.1518	3.8174	d			
23.223	13.20833	10.63333	91.00000	-3.7704	0.0		-1.0891	3.6097	d			
24.233	13.50000	11.60000	91.00000	-2.2045	0.0		-0.63679	2.1105	d			
d - Displacements include imported displacements.												
Specific Building Damage Results - Vertical Displacements												
Structure: Boundary Wall Sub-structure: Boundary Wall Foundation												
Dist.	Coordinates			Displacements								
	x	y	z	x	y	z						
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]						
Vertical Offset 1												
0.0	6.50000	-11.60000	91.00000	3.9393	d							
1.0097	6.79167	-10.63333	91.00000	6.6836	d							
2.0194	7.08333	-9.66667	91.00000	6.5440	d							
3.0291	7.37500	-8.70000	91.00000	6.4088	d							
4.0388	7.66667	-7.73333	91.00000	6.2753	d							
5.0485	7.95833	-6.76667	91.00000	6.1411	d							
6.0583	8.25000	-5.80000	91.00000	6.0039	d							
7.0680	8.54167	-4.83333	91.00000	5.8622	d							
8.0777	8.83333	-3.86667	91.00000	5.7152	d							
9.0874	9.12500	-2.90000	91.00000	5.5624	d							
10.097	9.41667	-1.93333	91.00000	5.4043	d							
11.107	9.70833	-0.96667	91.00000	5.2409	d							
12.117	10.00000	0.00000	91.00000	5.0731	d							
13.126	10.29167	0.96667	91.00000	4.9016	d							
14.136	10.58333	1.93333	91.00000	4.7272	d							
15.146	10.87500	2.90000	91.00000	4.5509	d							
16.155	11.16667	3.86667	91.00000	4.3734	d							
17.165	11.45833	4.83333	91.00000	4.1955	d							
18.175	11.75000	5.80000	91.00000	4.0180	d							
19.184	12.04167	6.76667	91.00000	3.8414	d							
20.194	12.33333	7.73333	91.00000	3.6664	d							
21.204	12.62500	8.70000	91.00000	3.4935	d							
22.214	12.91667	9.66667	91.00000	3.3230	d							
23.223	13.20833	10.63333	91.00000	3.1555	d							
24.233	13.50000	11.60000	91.00000	1.7816	d							
d - Displacements include imported displacements.												
Specific Building Damage Results - All Segments												
Structure: Boundary Wall Sub-structure: Boundary Wall Foundation												
Vertical Offset from Line for Vertical Movement	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature	Damage Category	
Calculations												
[m]		[m]	[m]		[%]	[%]	[%]			[m]		
0.0	1	0.0	3.0266	Sagging	0.063481	-0.028591	0.064525	0.0010194	-0.0027207	282.34	1 (Very Slight)	
	2	3.0266	0.73552	Hogging	0.0	0.0078715	0.0078716	-80.080E-6	133.88E-6	565630.	0 (Negligible)	
	3	3.7621	12.926	Sagging	683.86E-6	0.0071197	0.0077004	-78.704E-6	176.21E-6	184150.	0 (Negligible)	
	4	16.689	4.5237	Hogging	78.535E-6	0.0063972	0.0065001	-65.369E-6	176.21E-6	410670.	0 (Negligible)	
	5	21.212	3.0207	Sagging	0.026464	0.019120	0.057919	-447.78E-6	0.0013600	676.22	1 (Very Slight)	
Tensile horizontal strains are +ve, compressive horizontal strains are -ve.												
Specific Building Damage Results - Critical Values for All Segments within Each Sub-Structure												
Structure: Boundary Wall Sub-structure: Boundary Wall Foundation												
Vertical Offset from Line for Vertical Movement	Deflection Ratio	Average Horizontal Strain	Max Slope	Max Settlement	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category		
Calculations												
[m]	[%]	[%]		[mm]	[%]			[m]	[m]			
0.0	0.063481	-0.028591	-0.0027207	6.6834	0.064525	0.0010194	-0.0027207	410670.	282.34	1 (Very Slight)		
Specific Building Damage Results - Critical Segments within Each Structure												
Structure Name	Parameter	Critical Sub-Structure	Critical Segment	Start	End	Curvature	Max Slope	Max Settlement	Max Tensile Strain	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category



FAIRHURST

40 Frogmal Lane

Short-term Basement Excavation (Unloading, Wall Toe 5mbbl)

Boundary Wall

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Boundary Wall	Max Slope	Boundary Wall Foundation	1	[m]	0.0	3.0266	Sagging	0.0027207	[mm]	6.6834	[%]	0.064525	[m]	-	[m]	282.34	1 (Very Slight)
	Max Settlement	Boundary Wall Foundation	1	0.0	3.0266	Sagging	0.0027207		6.6834	0.064525		-			282.34	1 (Very Slight)	
	Max Tensile Strain	Boundary Wall Foundation	1	0.0	3.0266	Sagging	0.0027207		6.6834	0.064525		-			282.34	1 (Very Slight)	
	Min Radius of Curvature (Hogging)	Boundary Wall Foundation	4	16.689	21.212	Hogging	176.21E-6		4.2794	0.0065001	410670.		-		0	(Negligible)	
	Min Radius of Curvature (Sagging)	Boundary Wall Foundation	1	0.0	3.0266	Sagging	0.0027207		6.6834	0.064525		-			282.34	1 (Very Slight)	



Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Problem Type

Problem Type : Tunnelling and Embedded Wall Excavations

Displacement Data

Type	Name	Direction of extrusion	Point/Line/Line for extrusion						No. of intervals across extrusion/line	Extrusion depth	No. of intervals along extrusion	Calculate Surface type for tunnels	
			First point			Second point							
			X [m]	Y [m]	Z(level) [m]	X [m]	Y [m]	Z(level) [m]					
Line	Boundary Wall	-	6.50000	-11.60000	91.00000	13.50000	11.60000	91.00000	24	-	-	Yes	Surface

Imported Displacements

The following data points and displacements were found in the import file Pdisp Short term Loading to be Imported.csv.

Ref.	Coordinates			Displacements		
	x [m]	y [m]	z [m]	x [mm]	y [mm]	z [mm]
1	-7.50000	0.00000	91.50000	0.00000	0.00000	0.17030
2	-7.50000	1.00000	91.50000	0.00000	0.00000	0.17010
3	-7.50000	2.00000	91.50000	0.00000	0.00000	0.16920
4	-7.50000	3.00000	91.50000	0.00000	0.00000	0.16750
5	-7.50000	4.00000	91.50000	0.00000	0.00000	0.16470
6	-7.50000	5.00000	91.50000	0.00000	0.00000	0.16020
7	-7.50000	6.00000	91.50000	0.00000	0.00000	0.15350
8	-7.50000	7.00000	91.50000	0.00000	0.00000	0.14380
9	-7.50000	8.00000	91.50000	0.00000	0.00000	0.13040
10	-7.50000	9.00000	91.50000	0.00000	0.00000	0.11250
11	-7.50000	10.00000	91.50000	0.00000	0.00000	0.08990
12	-7.50000	11.00000	91.50000	0.00000	0.00000	0.06360
13	-7.50000	12.00000	91.50000	0.00000	0.00000	0.03560
14	-7.50000	13.00000	91.50000	0.00000	0.00000	0.00910
15	-7.50000	14.00000	91.50000	0.00000	0.00000	-0.01370
16	-7.50000	15.00000	91.50000	0.00000	0.00000	-0.03160
17	-7.50000	0.00000	91.50000	0.00000	0.00000	0.17030
18	-8.42730	0.00000	91.50000	0.00000	0.00000	0.08170
19	-9.35450	0.00000	91.50000	0.00000	0.00000	0.02110
20	-10.28180	0.00000	91.50000	0.00000	0.00000	-0.02020
21	-11.20910	0.00000	91.50000	0.00000	0.00000	-0.04770
22	-12.13640	0.00000	91.50000	0.00000	0.00000	-0.06550
23	-13.06360	0.00000	91.50000	0.00000	0.00000	-0.07650
24	-13.99090	0.00000	91.50000	0.00000	0.00000	-0.08250
25	-14.91820	0.00000	91.50000	0.00000	0.00000	-0.08510
26	-15.84550	0.00000	91.50000	0.00000	0.00000	-0.08520
27	-16.77270	0.00000	91.50000	0.00000	0.00000	-0.08360
28	-17.70000	0.00000	91.50000	0.00000	0.00000	-0.08100
29	-7.50000	15.00000	91.50000	0.00000	0.00000	-0.03160
30	-8.42730	15.00000	91.50000	0.00000	0.00000	-0.04490
31	-9.35450	15.00000	91.50000	0.00000	0.00000	-0.05470
32	-10.28180	15.00000	91.50000	0.00000	0.00000	-0.06150
33	-11.20910	15.00000	91.50000	0.00000	0.00000	-0.06580
34	-12.13640	15.00000	91.50000	0.00000	0.00000	-0.06810
35	-13.06360	15.00000	91.50000	0.00000	0.00000	-0.06880
36	-13.99090	15.00000	91.50000	0.00000	0.00000	-0.06840
37	-14.91820	15.00000	91.50000	0.00000	0.00000	-0.06720
38	-15.84550	15.00000	91.50000	0.00000	0.00000	-0.06530
39	-16.77270	15.00000	91.50000	0.00000	0.00000	-0.06300
40	-17.70000	15.00000	91.50000	0.00000	0.00000	-0.06040
41	10.00000	-11.60000	90.00000	0.00000	0.00000	-0.06490
42	10.16670	-10.63330	90.00000	0.00000	0.00000	-0.06520
43	10.33330	-9.66670	90.00000	0.00000	0.00000	-0.06580
44	10.50000	-8.70000	90.00000	0.00000	0.00000	-0.06690
45	10.66670	-7.73330	90.00000	0.00000	0.00000	-0.06840
46	10.83330	-6.76670	90.00000	0.00000	0.00000	-0.07010
47	11.00000	-5.80000	90.00000	0.00000	0.00000	-0.07210
48	11.16670	-4.83330	90.00000	0.00000	0.00000	-0.07400
49	11.33330	-3.86670	90.00000	0.00000	0.00000	-0.07590
50	11.50000	-2.90000	90.00000	0.00000	0.00000	-0.07770
51	11.66670	-1.93330	90.00000	0.00000	0.00000	-0.07930
52	11.83330	-0.96670	90.00000	0.00000	0.00000	-0.08060
53	12.00000	0.00000	90.00000	0.00000	0.00000	-0.08160
54	10.00000	-11.60000	90.00000	0.00000	0.00000	-0.06490
55	11.00000	-11.60000	90.00000	0.00000	0.00000	-0.07080
56	12.00000	-11.60000	90.00000	0.00000	0.00000	-0.07340
57	13.00000	-11.60000	90.00000	0.00000	0.00000	-0.07370
58	14.00000	-11.60000	90.00000	0.00000	0.00000	-0.07250
59	15.00000	-11.60000	90.00000	0.00000	0.00000	-0.07030
60	16.00000	-11.60000	90.00000	0.00000	0.00000	-0.06740
61	17.00000	-11.60000	90.00000	0.00000	0.00000	-0.06420
62	18.00000	-11.60000	90.00000	0.00000	0.00000	-0.06080
63	19.00000	-11.60000	90.00000	0.00000	0.00000	-0.05740
64	20.00000	-11.60000	90.00000	0.00000	0.00000	-0.05390
65	21.00000	-11.60000	90.00000	0.00000	0.00000	-0.05060
66	22.00000	-11.60000	90.00000	0.00000	0.00000	-0.04740
67	23.00000	-11.60000	90.00000	0.00000	0.00000	-0.04440
68	24.00000	-11.60000	90.00000	0.00000	0.00000	-0.04150
69	25.00000	-11.60000	90.00000	0.00000	0.00000	-0.03880
70	12.00000	0.00000	90.00000	0.00000	0.00000	-0.08160
71	13.00000	0.00000	90.00000	0.00000	0.00000	-0.08490
72	14.00000	0.00000	90.00000	0.00000	0.00000	-0.08520
73	15.00000	0.00000	90.00000	0.00000	0.00000	-0.08350
74	16.00000	0.00000	90.00000	0.00000	0.00000	-0.08060
75	17.00000	0.00000	90.00000	0.00000	0.00000	-0.07700
76	18.00000	0.00000	90.00000	0.00000	0.00000	-0.07290
77	19.00000	0.00000	90.00000	0.00000	0.00000	-0.06860
78	20.00000	0.00000	90.00000	0.00000	0.00000	-0.06430
79	21.00000	0.00000	90.00000	0.00000	0.00000	-0.06010
80	22.00000	0.00000	90.00000	0.00000	0.00000	-0.05600
81	23.00000	0.00000	90.00000	0.00000	0.00000	-0.05220
82	24.00000	0.00000	90.00000	0.00000	0.00000	-0.04860
83	25.00000	0.00000	90.00000	0.00000	0.00000	-0.04520
84	26.00000	0.00000	90.00000	0.00000	0.00000	-0.04200
85	27.00000	0.00000	90.00000	0.00000	0.00000	-0.03910
86	6.50000	-11.60000	91.00000	0.00000	0.00000	0.00800 1,2,6
87	6.79170	-10.63330	91.00000	0.00000	0.00000	0.01160 1,2,6
88	7.08330	-9.66670	91.00000	0.00000	0.00000	0.01120 1,2,6
89	7.37500	-8.70000	91.00000	0.00000	0.00000	0.00740 1,2,6
90	7.66670	-7.73330	91.00000	0.00000	0.00000	0.00120 1,2,6
91	7.95830	-6.76670	91.00000	0.00000	0.00000	-0.00650 1,2,6
92	8.25000	-5.80000	91.00000	0.00000	0.00000	-0.01510 1,2,6
93	8.54170	-4.83330	91.00000	0.00000	0.00000	-0.02390 1,2,6
94	8.83330	-3.86670	91.00000	0.00000	0.00000	-0.03240 1,2,6
95	9.12500	-2.90000	91.00000	0.00000	0.00000	-0.04050 1,2,6
96	9.41670	-1.93330	91.00000	0.00000	0.00000	-0.04780 1,2,6
97	9.70830	-0.96670	91.00000	0.00000	0.00000	-0.05430 1,2,6
98	10.00000	0.00000	91.00000	0.00000	0.00000	-0.06000 1,2,6
99	10.29170	0.96670	91.00000	0.00000	0.00000	-0.06480 1,2,6
100	10.58330	1.93330	91.00000	0.00000	0.00000	-0.06880 1,2,6
101	10.87500	2.90000	91.00000	0.00000	0.00000	-0.07200 1,2,6
102	11.16670	3.86670	91.00000	0.00000	0.00000	-0.07450 1,2,6



FAIRHURST

40 Frogнал Lane

Short-term Loading, Wall Toe 5mbbl

Boundary Wall

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Ref.	Coordinates			Displacements		
	x [m]	y [m]	z [m]	x [mm]	y [mm]	z [mm]
103	11.45830	4.83330	91.00000	0.00000	0.00000	-0.07630 1,2,6
104	11.75000	5.80000	91.00000	0.00000	0.00000	-0.07750 1,2,6
105	12.04170	6.76670	91.00000	0.00000	0.00000	-0.07810 1,2,6
106	12.33330	7.73330	91.00000	0.00000	0.00000	-0.07810 1,2,6
107	12.62500	8.70000	91.00000	0.00000	0.00000	-0.07760 1,2,6
108	12.91670	9.66670	91.00000	0.00000	0.00000	-0.07660 1,2,6
109	13.20830	10.63330	91.00000	0.00000	0.00000	-0.07510 1,2,6
110	13.50000	11.60000	91.00000	0.00000	0.00000	-0.07320 1,2,6
1 - Data point coincident with displacement data. Its displacement has been added to those calculated by Xdisp.						
2 - Data point coincident with horizontal movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.						
6 - Data point coincident with vertical movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.						

Vertical Ground Movement Curves (Excavations)

Curve Name:	Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)] [0.000,0.000,0.050][2.000,0.000,0.000]
Curve Fitting Method:	Polynomial
x Order:	1
y Order:	0
Polynomial: z =	-2.5E-2x + 5.0E-2
Coeff. of Determination:	1.0
Curve Name:	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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][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 (Excavations)

Curve Name:	Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)] [0.000,0.000,0.081][0.050,0.000,0.076][0.100,0.000,0.072][0.150,0.000,0.067][0.200,0.000,0.063][0.250,0.000,0.059][0.300,0.000,0.056][0.350,0.000,0.052][0.400,0.000,0.049][0.450,0.000,0.045][0.500,0.000,0.043][0.550,0.000,0.040][0.600,0.000,0.037][0.650,0.000,0.034][0.700,0.000,0.032][0.750,0.000,0.029][0.800,0.000,0.027][0.850,0.000,0.024][0.900,0.000,0.022][0.950,0.000,0.020][1.000,0.000,0.018][1.050,0.000,0.016][1.100,0.000,0.014][1.150,0.000,0.012][1.200,0.000,0.011][1.250,0.000,0.009][1.300,0.000,0.007][1.350,0.000,0.005][1.400,0.000,0.004][1.450,0.000,0.002][1.500,0.000,0.000]
Curve Fitting Method:	Polynomial
x Order:	3
y Order:	0
Polynomial: z =	-1.0610E-2x ³ + 4.4203E-2x ² - 9.6358E-2x + 8.0901E-2
Coeff. of Determination:	1.0000
Curve Name:	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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

Polygonal Excavations

Excavation Name:				Pool excavation						
Surface level [m]:				91.000						
Contribution:				Positive						
Enabled:				Yes						
Corner	x	y	Base Level	Stiffened	Previous Side		Next Side			
	[m]	[m]	[m]		d [m]	p1 [%]	p2* [%]	d [m]	p1 [%]	p2* [%]
1	-4.0000	-11.600	86.500	Yes	0.0	67.000	25.000	0.0	67.000	25.000
2	2.2000	-11.600	86.500	Yes	0.0	67.000	25.000	0.0	67.000	25.000
3	2.2000	11.600	86.500	Yes	0.0	67.000	25.000	0.0	67.000	25.000
4	-4.0000	11.600	86.500	Yes	0.0	67.000	25.000	0.0	67.000	25.000
Side	Corner 1		Corner 2		Ground Movement					
	x [m]	y [m]	x [m]	y [m]	Vertical					
1	-4.0000	-11.600	2.2000	-11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))					
2	2.2000	-11.600	2.2000	11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))					
3	2.2000	11.600	-4.0000	11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))					
4	-4.0000	11.600	-4.0000	-11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))					
Excavation Name:				Secant Pile Wall Installation						
Surface level [m]:				91.000						
Contribution:				Positive						
Enabled:				Yes						
Corner	x	y	Base	Stiffened	Previous Side		Next Side			



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	Level			d	p1	p2*	d	p1	p2*
	[m]	[m]	[m]	[m]	[%]	[%]	[m]	[%]	[%]
1	-4.0000	-11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000
2	2.2000	-11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000
3	2.2000	11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000
4	-4.0000	11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000

Side	Corner 1		Corner 2		Ground Movement		Curve	
	x	y	x	y	Vertical	Horizontal		
	[m]	[m]	[m]	[m]				
1	-4.0000	-11.600	2.2000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))		
2	2.2000	-11.600	2.2000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))		
3	2.2000	11.600	-4.0000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))		
4	-4.0000	11.600	-4.0000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))		

Damage Category Strains

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

Specific Structures - Geometry

Structure Name	Sub-Structure Name	Displacement Line	Start Distance Along Line	End Distance Along Line	Vertical Offsets from Line for Movement Calculations	Vertical Displacement Limit	Damage Category Strains	Poisson's Ratio	E/G
Boundary Wall	Boundary Wall Foundation	Boundary Wall	[m]	[m]	[m]	[mm]	Burland Strain Limits	0.20000	2.6000
			0.00000	24.23300	0.0	0.10000			

Specific Structures - Bending Parameters

Structure Name	Sub-Structure Name	Height	Default Properties	Hogging		Sagging	
				2nd Moment of Area (per unit width)	Distance of Bending Strain from N.A.	2nd Moment of Area (per unit width)	Distance of Bending Strain from N.A.
		[m]		[m ⁴]	[m]	[m ⁴]	[m]
Boundary Wall	Boundary Wall Foundation	2.0000	Yes	2.6667	2.0000	0.66667	1.0000

Building Segment Combinations

Structure Name	Sub-Structure Name	Vertical Offset from Line for Movement Calculations	Segment Start	Length	Curvature	Combined Segment
		[m]	[m]	[m]		
No structures have segments combined.						

Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Warnings

- 1 Multiple excavations have been specified. The displacements resulting from these excavations are calculated by summing the displacements resulting from each individual excavation. No account has been taken of the interactions between excavations (e.g. overlapping zones of influence or 'shielding' of one excavation by another).

Errors

None

Displacement and Strain Results

Type/No.	Coordinates				Displacements			Angle of Line	
Name	Dist.	x	y	z	x	y	z	Horizontal displacement along Line	Horizontal displacement perpendicular to Line
		[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]
Boundary Wall	Line 1	6.50000	-11.60000	91.00000	-5.5967	0.0	3.9822	-1.6167	5.3581
	1.0097	6.79167	-10.63333	91.00000	-9.1565	0.0	6.7455	-2.6450	8.7662
	2.0194	7.08333	-9.66667	91.00000	-8.8716	0.0	6.6037	-2.5627	8.4934
	3.0291	7.37500	-8.70000	91.00000	-8.5916	0.0	6.4484	-2.4818	8.2254
	4.0388	7.66667	-7.73333	91.00000	-8.3165	0.0	6.2819	-2.4023	7.9620
	5.0485	7.95833	-6.76667	91.00000	-8.0460	0.0	6.1063	-2.3242	7.7030
	6.0583	8.25000	-5.80000	91.00000	-7.7800	0.0	5.9234	-2.2473	7.4483
	7.0680	8.54167	-4.83333	91.00000	-7.5182	0.0	5.7349	-2.1717	7.1977
	8.0777	8.83333	-3.86667	91.00000	-7.2606	0.0	5.5423	-2.0973	6.9511
	9.0874	9.12500	-2.90000	91.00000	-7.0069	0.0	5.3466	-2.0240	6.7082
	10.097	9.41667	-1.93333	91.00000	-6.7570	0.0	5.1494	-1.9518	6.4689
	11.107	9.70833	-0.96667	91.00000	-6.5106	0.0	4.9513	-1.8807	6.2331
	12.117	10.00000	0.00000	91.00000	-6.2677	0.0	4.7532	-1.8105	6.0005
	13.126	10.29167	0.96667	91.00000	-6.0280	0.0	4.5560	-1.7413	5.7710
	14.136	10.58333	1.93333	91.00000	-5.7913	0.0	4.3603	-1.6729	5.5444
	15.146	10.87500	2.90000	91.00000	-5.5576	0.0	4.1668	-1.6054	5.3207
	16.155	11.16667	3.86667	91.00000	-5.3265	0.0	3.9760	-1.5386	5.0995
	17.165	11.45833	4.83333	91.00000	-5.0980	0.0	3.7885	-1.4726	4.8807
	18.175	11.75000	5.80000	91.00000	-4.8719	0.0	3.6046	-1.4073	4.6642
	19.184	12.04167	6.76667	91.00000	-4.6479	0.0	3.4249	-1.3426	4.4498
	20.194	12.33333	7.73333	91.00000	-4.4259	0.0	3.2498	-1.2785	4.2373
	21.204	12.62500	8.70000	91.00000	-4.2058	0.0	3.0796	-1.2149	4.0265
	22.214	12.91667	9.66667	91.00000	-3.9874	0.0	2.9145	-1.1518	3.8174
	23.223	13.20833	10.63333	91.00000	-3.7704	0.0	2.7548	-1.0891	3.6097



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Boundary Wall

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Type/No.	Coordinates				Displacements			Angle of					
Name	Dist.	x	y	z	x	y	z	Horizontal displacement	Horizontal displacement	to x Axis			
	24.233	13.50000	11.60000	91.00000	-2.2045	0.0	1.3910	-0.63679	2.1105	73.210 *			
* Result includes imported displacement(s).													
Specific Building Damage Results - Horizontal Displacements													
Structure: Boundary Wall Sub-structure: Boundary Wall Foundation													
Dist.	Coordinates			Displacements			Horizontal displacement		Horizontal displacement				
	x	y	z	x	y	z	along the Line	perpendicular to Line					
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]					
0.0	6.50000	-11.60000	91.00000	-5.5967	0.0		-1.6167	5.3581	d				
1.0097	6.79167	-10.63333	91.00000	-9.1565	0.0		-2.6450	8.7662	d				
2.0194	7.08333	-9.66667	91.00000	-8.8716	0.0		-2.5627	8.4934	d				
3.0291	7.37500	-8.70000	91.00000	-8.5916	0.0		-2.4818	8.2254	d				
4.0388	7.66667	-7.73333	91.00000	-8.3165	0.0		-2.4023	7.9620	d				
5.0485	7.95833	-6.76667	91.00000	-8.0460	0.0		-2.3242	7.7030	d				
6.0583	8.25000	-5.80000	91.00000	-7.7800	0.0		-2.2473	7.4483	d				
7.0680	8.54167	-4.83333	91.00000	-7.5182	0.0		-2.1717	7.1977	d				
8.0777	8.83333	-3.86667	91.00000	-7.2606	0.0		-2.0973	6.9511	d				
9.0874	9.12500	-2.90000	91.00000	-7.0069	0.0		-2.0240	6.7082	d				
10.097	9.41667	-1.93333	91.00000	-6.7570	0.0		-1.9518	6.4689	d				
11.107	9.70833	-0.96667	91.00000	-6.5106	0.0		-1.8807	6.2331	d				
12.117	10.00000	0.00000	91.00000	-6.2677	0.0		-1.8105	6.0005	d				
13.126	10.29167	0.96667	91.00000	-6.0280	0.0		-1.7413	5.7710	d				
14.136	10.58333	1.93333	91.00000	-5.7913	0.0		-1.6729	5.5444	d				
15.146	10.87500	2.90000	91.00000	-5.5576	0.0		-1.6054	5.3207	d				
16.155	11.16667	3.86667	91.00000	-5.3265	0.0		-1.5386	5.0995	d				
17.165	11.45833	4.83333	91.00000	-5.0980	0.0		-1.4726	4.8807	d				
18.175	11.75000	5.80000	91.00000	-4.8719	0.0		-1.4073	4.6642	d				
19.184	12.04167	6.76667	91.00000	-4.6479	0.0		-1.3426	4.4498	d				
20.194	12.33333	7.73333	91.00000	-4.4259	0.0		-1.2785	4.2373	d				
21.204	12.62500	8.70000	91.00000	-4.2058	0.0		-1.2149	4.0265	d				
22.214	12.91667	9.66667	91.00000	-3.9874	0.0		-1.1518	3.8174	d				
23.223	13.20833	10.63333	91.00000	-3.7704	0.0		-1.0891	3.6097	d				
24.233	13.50000	11.60000	91.00000	-2.2045	0.0		-0.63679	2.1105	d				
d - Displacements include imported displacements.													
Specific Building Damage Results - Vertical Displacements													
Structure: Boundary Wall Sub-structure: Boundary Wall Foundation													
Dist.	Coordinates			Displacements									
	x	y	z	x	y	z							
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]							
Vertical Offset 1													
0.0	6.50000	-11.60000	91.00000	3.9822	d								
1.0097	6.79167	-10.63333	91.00000	6.7455	d								
2.0194	7.08333	-9.66667	91.00000	6.6037	d								
3.0291	7.37500	-8.70000	91.00000	6.4484	d								
4.0388	7.66667	-7.73333	91.00000	6.2819	d								
5.0485	7.95833	-6.76667	91.00000	6.1063	d								
6.0583	8.25000	-5.80000	91.00000	5.9234	d								
7.0680	8.54167	-4.83333	91.00000	5.7349	d								
8.0777	8.83333	-3.86667	91.00000	5.5423	d								
9.0874	9.12500	-2.90000	91.00000	5.3466	d								
10.097	9.41667	-1.93333	91.00000	5.1494	d								
11.107	9.70833	-0.96667	91.00000	4.9513	d								
12.117	10.00000	0.00000	91.00000	4.7532	d								
13.126	10.29167	0.96667	91.00000	4.5560	d								
14.136	10.58333	1.93333	91.00000	4.3603	d								
15.146	10.87500	2.90000	91.00000	4.1668	d								
16.155	11.16667	3.86667	91.00000	3.9760	d								
17.165	11.45833	4.83333	91.00000	3.7885	d								
18.175	11.75000	5.80000	91.00000	3.6046	d								
19.184	12.04167	6.76667	91.00000	3.4249	d								
20.194	12.33333	7.73333	91.00000	3.2498	d								
21.204	12.62500	8.70000	91.00000	3.0796	d								
22.214	12.91667	9.66667	91.00000	2.9145	d								
23.223	13.20833	10.63333	91.00000	2.7548	d								
24.233	13.50000	11.60000	91.00000	1.3910	d								
d - Displacements include imported displacements.													
Specific Building Damage Results - All Segments													
Structure: Boundary Wall Sub-structure: Boundary Wall Foundation													
Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature	Damage Category		
[m]		[m]	[m]		[%]	[%]	[%]			[m]			
0.0	1	0.0	11.074	Sagging	0.024104	-0.0024053	0.020767	0.0010194	-0.0027395	280.63	0 (Negligible)		
	2	11.074	10.148	Hogging	395.39E-6	0.0065945	0.0071768	-70.472E-6	196.18E-6	198940.	0 (Negligible)		
	3	21.221	3.0119	Sagging	0.026349	0.019158	0.057758	-447.78E-6	0.0013500	677.24	1 (Very Slight)		
Tensile horizontal strains are +ve, compressive horizontal strains are -ve.													
Specific Building Damage Results - Critical Values for All Segments within Each Sub-Structure													
Structure: Boundary Wall Sub-structure: Boundary Wall Foundation													
Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Max Slope	Max Settlement	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category			
[m]	[%]	[%]		[mm]	[%]			[m]	[m]				
0.0	0.026349	0.019158	-0.0027395	6.7400	0.057758	0.0010194	-0.0027395	198940.	280.63	1 (Very Slight)			
Specific Building Damage Results - Critical Segments within Each Structure													
Structure Name	Parameter	Critical Sub-Structure	Critical Segment	Start	End	Curvature	Max Slope	Max Settlement	Max Tensile Strain	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category	
				[m]	[m]			[mm]	[%]	[m]	[m]		
Boundary Wall	Max Slope	Boundary Wall Foundation		1	0.0	11.074	Sagging	0.0027395	6.7400	0.020767	-	280.63	0 (Negligible)
	Max Settlement	Boundary Wall		1	0.0	11.074	Sagging	0.0027395	6.7400	0.020767	-	280.63	0 (Negligible)



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Structure Name	Parameter	Critical Sub-Structure	Critical Start Segment	End	Curvature	Max Slope	Max Settlement	Max Tensile Strain	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
	Max Tensile Strain	Foundation	3	21.221	24.233	Sagging	0.0013500	3.0767	0.057758	-	677.24 1 (Very Slight)
	Min Radius of Curvature (Hogging)	Foundation	2	11.074	21.221	Hogging	196.18E-6	4.9578	0.0071768	198940.	- 0 (Negligible)
	Min Radius of Curvature (Sagging)	Foundation	1	0.0	11.074	Sagging	0.0027395	6.7400	0.020767	-	280.63 0 (Negligible)



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Long-term Loading (Wall Toe 5mbbl)

Boundary Wall

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Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Problem Type

Problem Type : Tunnelling and Embedded Wall Excavations

Displacement Data

Type	Name	Direction of extrusion	Point/Line/Line for extrusion						No. of intervals across extrusion/line	Extrusion depth	No. of intervals along extrusion	Calculate Surface type for tunnels	
			First point			Second point							
			X [m]	Y [m]	Z(level) [m]	X [m]	Y [m]	Z(level) [m]					
Line	Boundary Wall	-	6.50000	-11.60000	91.00000	13.50000	11.60000	91.00000	24	-	-	Yes	Surface

Imported Displacements

The following data points and displacements were found in the import file Pdisp Long term Loading to be Imported.csv.

Ref.	Coordinates			Displacements		
	x	y	z	x	y	z
	[m]	[m]	[m]	[mm]	[mm]	[mm]
1	-7.50000	0.00000	91.50000	0.00000	0.00000	0.86030
2	-7.50000	1.00000	91.50000	0.00000	0.00000	0.85840
3	-7.50000	2.00000	91.50000	0.00000	0.00000	0.85260
4	-7.50000	3.00000	91.50000	0.00000	0.00000	0.84250
5	-7.50000	4.00000	91.50000	0.00000	0.00000	0.82750
6	-7.50000	5.00000	91.50000	0.00000	0.00000	0.80660
7	-7.50000	6.00000	91.50000	0.00000	0.00000	0.77880
8	-7.50000	7.00000	91.50000	0.00000	0.00000	0.74270
9	-7.50000	8.00000	91.50000	0.00000	0.00000	0.69680
10	-7.50000	9.00000	91.50000	0.00000	0.00000	0.64020
11	-7.50000	10.00000	91.50000	0.00000	0.00000	0.57280
12	-7.50000	11.00000	91.50000	0.00000	0.00000	0.49670
13	-7.50000	12.00000	91.50000	0.00000	0.00000	0.41690
14	-7.50000	13.00000	91.50000	0.00000	0.00000	0.33950
15	-7.50000	14.00000	91.50000	0.00000	0.00000	0.26980
16	-7.50000	15.00000	91.50000	0.00000	0.00000	0.21050
17	-7.50000	0.00000	91.50000	0.00000	0.00000	0.86030
18	-8.42730	0.00000	91.50000	0.00000	0.00000	0.64620
19	-9.35450	0.00000	91.50000	0.00000	0.00000	0.48830
20	-10.28180	0.00000	91.50000	0.00000	0.00000	0.37000
21	-11.20910	0.00000	91.50000	0.00000	0.00000	0.28060
22	-12.13640	0.00000	91.50000	0.00000	0.00000	0.21260
23	-13.06360	0.00000	91.50000	0.00000	0.00000	0.16070
24	-13.99090	0.00000	91.50000	0.00000	0.00000	0.12090
25	-14.91820	0.00000	91.50000	0.00000	0.00000	0.09040
26	-15.84550	0.00000	91.50000	0.00000	0.00000	0.06700
27	-16.77270	0.00000	91.50000	0.00000	0.00000	0.04900
28	-17.70000	0.00000	91.50000	0.00000	0.00000	0.03510
29	-7.50000	15.00000	91.50000	0.00000	0.00000	0.21050
30	-8.42730	15.00000	91.50000	0.00000	0.00000	0.16990
31	-9.35450	15.00000	91.50000	0.00000	0.00000	0.13430
32	-10.28180	15.00000	91.50000	0.00000	0.00000	0.10570
33	-11.20910	15.00000	91.50000	0.00000	0.00000	0.08240
34	-12.13640	15.00000	91.50000	0.00000	0.00000	0.06350
35	-13.06360	15.00000	91.50000	0.00000	0.00000	0.04830
36	-13.99090	15.00000	91.50000	0.00000	0.00000	0.03610
37	-14.91820	15.00000	91.50000	0.00000	0.00000	0.02640
38	-15.84550	15.00000	91.50000	0.00000	0.00000	0.01870
39	-16.77270	15.00000	91.50000	0.00000	0.00000	0.01250
40	-17.70000	15.00000	91.50000	0.00000	0.00000	0.00770
41	10.00000	-11.60000	90.00000	0.00000	0.00000	0.12510
42	10.16670	-10.63330	90.00000	0.00000	0.00000	0.13470
43	10.33330	-9.66670	90.00000	0.00000	0.00000	0.14240
44	10.50000	-8.70000	90.00000	0.00000	0.00000	0.14810
45	10.66670	-7.73330	90.00000	0.00000	0.00000	0.15170
46	10.83330	-6.76670	90.00000	0.00000	0.00000	0.15350
47	11.00000	-5.80000	90.00000	0.00000	0.00000	0.15350
48	11.16670	-4.83330	90.00000	0.00000	0.00000	0.15190
49	11.33330	-3.86670	90.00000	0.00000	0.00000	0.14910
50	11.50000	-2.90000	90.00000	0.00000	0.00000	0.14510
51	11.66670	-1.93330	90.00000	0.00000	0.00000	0.14020
52	11.83330	-0.96670	90.00000	0.00000	0.00000	0.13460
53	12.00000	0.00000	90.00000	0.00000	0.00000	0.12830
54	10.00000	-11.60000	90.00000	0.00000	0.00000	0.12510
55	11.00000	-11.60000	90.00000	0.00000	0.00000	0.09250
56	12.00000	-11.60000	90.00000	0.00000	0.00000	0.06780
57	13.00000	-11.60000	90.00000	0.00000	0.00000	0.04900
58	14.00000	-11.60000	90.00000	0.00000	0.00000	0.03480
59	15.00000	-11.60000	90.00000	0.00000	0.00000	0.02390
60	16.00000	-11.60000	90.00000	0.00000	0.00000	0.01570
61	17.00000	-11.60000	90.00000	0.00000	0.00000	0.00940
62	18.00000	-11.60000	90.00000	0.00000	0.00000	0.00470
63	19.00000	-11.60000	90.00000	0.00000	0.00000	0.00110
64	20.00000	-11.60000	90.00000	0.00000	0.00000	-0.00150
65	21.00000	-11.60000	90.00000	0.00000	0.00000	-0.00350
66	22.00000	-11.60000	90.00000	0.00000	0.00000	-0.00490
67	23.00000	-11.60000	90.00000	0.00000	0.00000	-0.00600
68	24.00000	-11.60000	90.00000	0.00000	0.00000	-0.00670
69	25.00000	-11.60000	90.00000	0.00000	0.00000	-0.00710
70	12.00000	0.00000	90.00000	0.00000	0.00000	0.12830
71	13.00000	0.00000	90.00000	0.00000	0.00000	0.09390
72	14.00000	0.00000	90.00000	0.00000	0.00000	0.06800
73	15.00000	0.00000	90.00000	0.00000	0.00000	0.04850
74	16.00000	0.00000	90.00000	0.00000	0.00000	0.03380
75	17.00000	0.00000	90.00000	0.00000	0.00000	0.02270
76	18.00000	0.00000	90.00000	0.00000	0.00000	0.01440
77	19.00000	0.00000	90.00000	0.00000	0.00000	0.00810
78	20.00000	0.00000	90.00000	0.00000	0.00000	0.00350
79	21.00000	0.00000	90.00000	0.00000	0.00000	0.00000
80	22.00000	0.00000	90.00000	0.00000	0.00000	-0.00250
81	23.00000	0.00000	90.00000	0.00000	0.00000	-0.00440
82	24.00000	0.00000	90.00000	0.00000	0.00000	-0.00570
83	25.00000	0.00000	90.00000	0.00000	0.00000	-0.00660
84	26.00000	0.00000	90.00000	0.00000	0.00000	-0.00720
85	27.00000	0.00000	90.00000	0.00000	0.00000	-0.00760
86	6.50000	-11.60000	91.00000	0.00000	0.00000	0.35240 1,2,6
87	6.79170	-10.63330	91.00000	0.00000	0.00000	0.37310 1,2,6
88	7.08330	-9.66670	91.00000	0.00000	0.00000	0.38390 1,2,6
89	7.37500	-8.70000	91.00000	0.00000	0.00000	0.38570 1,2,6
90	7.66670	-7.73330	91.00000	0.00000	0.00000	0.38030 1,2,6
91	7.95830	-6.76670	91.00000	0.00000	0.00000	0.36940 1,2,6
92	8.25000	-5.80000	91.00000	0.00000	0.00000	0.35460 1,2,6
93	8.54170	-4.83330	91.00000	0.00000	0.00000	0.33700 1,2,6
94	8.83330	-3.86670	91.00000	0.00000	0.00000	0.31770 1,2,6
95	9.12500	-2.90000	91.00000	0.00000	0.00000	0.29740 1,2,6
96	9.41670	-1.93330	91.00000	0.00000	0.00000	0.27670 1,2,6
97	9.70830	-0.96670	91.00000	0.00000	0.00000	0.25580 1,2,6
98	10.00000	0.00000	91.00000	0.00000	0.00000	0.23520 1,2,6
99	10.29170	0.96670	91.00000	0.00000	0.00000	0.21480 1,2,6
100	10.58330	1.93330	91.00000	0.00000	0.00000	0.19490 1,2,6
101	10.87500	2.90000	91.00000	0.00000	0.00000	0.17560 1,2,6
102	11.16670	3.86670	91.00000	0.00000	0.00000	0.15690 1,2,6



FAIRHURST

40 Frogнал Lane

Long-term Loading (Wall Toe 5mbbl)

Boundary Wall

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Ref.	Coordinates			Displacements		
	x [m]	y [m]	z [m]	x [mm]	y [mm]	z [mm]
103	11.45830	4.83330	91.00000	0.00000	0.00000	0.13890 1,2,6
104	11.75000	5.80000	91.00000	0.00000	0.00000	0.12170 1,2,6
105	12.04170	6.76670	91.00000	0.00000	0.00000	0.10550 1,2,6
106	12.33330	7.73330	91.00000	0.00000	0.00000	0.09020 1,2,6
107	12.62500	8.70000	91.00000	0.00000	0.00000	0.07610 1,2,6
108	12.91670	9.66670	91.00000	0.00000	0.00000	0.06320 1,2,6
109	13.20830	10.63330	91.00000	0.00000	0.00000	0.05170 1,2,6
110	13.50000	11.60000	91.00000	0.00000	0.00000	0.04140 1,2,6
1 - Data point coincident with displacement data. Its displacement has been added to those calculated by Xdisp.						
2 - Data point coincident with horizontal movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.						
6 - Data point coincident with vertical movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.						

Vertical Ground Movement Curves (Excavations)

Curve Name:	Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)] [0.000,0.000,0.050][2.000,0.000,0.000]
Curve Fitting Method:	Polynomial
x Order:	1
y Order:	0
Polynomial: z =	-2.5E-2x + 5.0E-2
Coeff. of Determination:	1.0
Curve Name:	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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][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 (Excavations)

Curve Name:	Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)] [0.000,0.000,0.081][0.050,0.000,0.076][0.100,0.000,0.072][0.150,0.000,0.067][0.200,0.000,0.063][0.250,0.000,0.059][0.300,0.000,0.056][0.350,0.000,0.052][0.400,0.000,0.049][0.450,0.000,0.045][0.500,0.000,0.043][0.550,0.000,0.040][0.600,0.000,0.037][0.650,0.000,0.034][0.700,0.000,0.032][0.750,0.000,0.029][0.800,0.000,0.027][0.850,0.000,0.024][0.900,0.000,0.022][0.950,0.000,0.020][1.000,0.000,0.018][1.050,0.000,0.016][1.100,0.000,0.014][1.150,0.000,0.012][1.200,0.000,0.011][1.250,0.000,0.009][1.300,0.000,0.007][1.350,0.000,0.005][1.400,0.000,0.004][1.450,0.000,0.002][1.500,0.000,0.000]
Curve Fitting Method:	Polynomial
x Order:	3
y Order:	0
Polynomial: z =	-1.0610E-2x ³ + 4.4203E-2x ² - 9.6358E-2x + 8.0901E-2
Coeff. of Determination:	1.0000
Curve Name:	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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

Polygonal Excavations

Excavation Name:	Pool excavation
Surface level [m]:	91.000
Contribution:	Positive
Enabled:	Yes

Corner	x	y	Base Level	Stiffened	Previous Side		Next Side	
					d	p1	d	p1
	[m]	[m]	[m]		[m]	[%]	[m]	[%]
1	-4.0000	-11.600	86.500	Yes	0.0	67.000	25.000	0.0
2	2.2000	-11.600	86.500	Yes	0.0	67.000	25.000	0.0
3	2.2000	11.600	86.500	Yes	0.0	67.000	25.000	0.0
4	-4.0000	11.600	86.500	Yes	0.0	67.000	25.000	0.0

Side	Corner 1		Corner 2		Vertical	Ground Movement Curve	Horizontal
	x [m]	y [m]	x [m]	y [m]			
1	-4.0000	-11.600	2.2000	-11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))		Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
2	2.2000	-11.600	2.2000	11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))		Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
3	2.2000	11.600	-4.0000	11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))		Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
4	-4.0000	11.600	-4.0000	-11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))		Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))

Excavation Name:	Secant Pile Wall Installation
Surface level [m]:	91.000
Contribution:	Positive
Enabled:	Yes

Corner	x	y	Base	Stiffened	Previous Side	Next Side
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	Level				d	p1	p2*	d	p1	p2*
	[m]	[m]	[m]		[m]	[%]	[%]	[m]	[%]	[%]
1	-4.0000	-11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000
2	2.2000	-11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000
3	2.2000	11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000
4	-4.0000	11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000

Side	Corner 1		Corner 2		Ground Movement Curve	
	x [m]	y [m]	x [m]	y [m]	Vertical	Horizontal
1	-4.0000	-11.600	2.2000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
2	2.2000	-11.600	2.2000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
3	2.2000	11.600	-4.0000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
4	-4.0000	11.600	-4.0000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))

Damage Category Strains

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

Specific Structures - Geometry

Structure Name	Sub-Structure Name	Displacement Line	Start Distance Along Line	End Distance Along Line	Vertical Offsets from Line for Vertical Movement Calculations	Vertical Displacement Limit Sensitivity	Damage Category	Strains	Poisson's Ratio	E/G
Boundary Wall	Boundary Wall	Boundary Wall	0.00000	24.23300	0.0	0.10000	Burland	Strain Limits	0.20000	2.60000

Specific Structures - Bending Parameters

Structure Name	Sub-Structure Name	Height	Default Properties	Hogging		Sagging			
				2nd Moment of Area (per unit width)	Distance of Bending Strain from N.A.	Distance of N.A. from Edge of Beam in Tension	2nd Moment of Area (per unit width)	Distance of Bending Strain from N.A.	Distance of N.A. from Edge of Beam in Tension
Boundary Wall	Boundary Wall Foundation	[m] 2.0000	Yes	[m ⁴] 2.6667	[m] 2.0000	[m] 2.0000	[m ⁴] 0.6667	[m] 1.0000	[m] 1.0000

Building Segment Combinations

Structure Name	Sub-Structure Name	Vertical Offset from Line for Vertical Movement Calculations	Segment Start	Length	Curvature	Combined Segment
		[m]	[m]	[m]		

No structures have segments combined.

Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Warnings

- 1 Multiple excavations have been specified. The displacements resulting from these excavations are calculated by summing the displacements resulting from each individual excavation. No account has been taken of the interactions between excavations (e.g. overlapping zones of influence or 'shielding' of one excavation by another).

Errors

None

Displacement and Strain Results

Type/No.	Coordinates				Displacements			Angle of Line		
Name	Dist.	x	y	z	x	y	z	Horizontal displacement along Line	Horizontal displacement perpendicular to Line	to x Axis
	[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[°]
Boundary Wall	Line 1	6.50000	-11.60000	91.00000	-5.5967	0.0	4.3266	-1.6167	5.3581	73.210 *
	1.0097	6.79167	-10.63333	91.00000	-9.1565	0.0	7.1070	-2.6450	8.7662	73.210 *
	2.0194	7.08333	-9.66667	91.00000	-8.8716	0.0	6.9764	-2.5627	8.4934	73.210 *
	3.0291	7.37500	-8.70000	91.00000	-5.9116	0.0	6.8267	-2.4858	8.2258	73.210 *
	4.0388	7.66667	-7.73333	91.00000	-8.3165	0.0	6.6610	-2.4023	7.9620	73.210 *
	5.0485	7.95833	-6.76667	91.00000	-8.0460	0.0	6.4822	-2.3242	7.7030	73.210 *
	6.0583	8.25000	-5.80000	91.00000	-7.7800	0.0	6.2931	-2.2473	7.4483	73.210 *
	7.0680	8.54167	-4.83333	91.00000	-7.5182	0.0	6.0958	-2.1717	7.1977	73.210 *
	8.0777	8.83333	-3.86667	91.00000	-7.2606	0.0	5.8924	-2.0973	6.9513	73.210 *
	9.0874	9.12500	-2.90000	91.00000	-7.0069	0.0	5.6845	-2.0240	6.7082	73.210 *
	10.097	9.41667	-1.93333	91.00000	-6.7570	0.0	5.4739	-1.9518	6.4689	73.210 *
	11.107	9.70833	-0.96667	91.00000	-6.5106	0.0	5.2614	-1.8807	6.2331	73.210 *
	12.117	10.00000	0.00000	91.00000	-6.2677	0.0	5.0484	-1.8105	6.0005	73.210 *
	13.126	10.29167	0.96667	91.00000	-6.0280	0.0	4.8356	-1.7413	5.7743	73.210 *
	14.136	10.58333	1.93333	91.00000	-5.7913	0.0	4.6240	-1.6729	5.5444	73.210 *
	15.146	10.87500	2.90000	91.00000	-5.5576	0.0	4.4144	-1.6054	5.3207	73.210 *
	16.155	11.16667	3.86667	91.00000	-5.3265	0.0	4.2074	-1.5386	5.0995	73.210 *
	17.165	11.45833	4.83333	91.00000	-5.0960	0.0	4.0037	-1.4726	4.8807	73.210 *
	18.175	11.75000	5.80000	91.00000	-4.8719	0.0	3.8038	-1.4073	4.6642	73.210 *
	19.184	12.04167	6.76667	91.00000	-4.6479	0.0	3.6085	-1.3426	4.4498	73.210 *
	20.194	12.33333	7.73333	91.00000	-4.4259	0.0	3.4181	-1.2785	4.2373	73.210 *
	21.204	12.62500	8.70000	91.00000	-4.2058	0.0	3.2333	-1.2149	4.0265	73.210 *
	22.214	12.91667	9.66667	91.00000	-3.9874	0.0	3.0543	-1.1518	3.8174	73.210 *
	23.223	13.20833	10.63333	91.00000	-3.7704	0.0	2.8816	-1.0891	3.6097	73.210 *



FAIRHURST

40 Frogнал Lane

Long-term Loading (Wall Toe 5mbbl)

Boundary Wall

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Type/No.	Coordinates				Displacements			Angle of Line to x Axis				
Name	Dist.	x	y	z	x	y	z	Horizontal displacement	Horizontal displacement			
	24.233	13.50000	11.60000	91.00000	-2.2045	0.0	1.5056	-0.63679	2.1105	73.210 *		
* Result includes imported displacement(s).												
Specific Building Damage Results - Horizontal Displacements												
Structure: Boundary Wall Sub-structure: Boundary Wall Foundation												
Dist.	Coordinates			Displacements								
	x	y	z	x	y	z	Horizontal displacement along the Line	Horizontal displacement perpendicular to Line				
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]				
0.0	6.50000	-11.60000	91.00000	-5.5967	0.0	-1.6167	5.3581 d					
1.0097	6.79167	-10.63333	91.00000	-9.1565	0.0	-2.6450	8.7662 d					
2.0194	7.08333	-9.66667	91.00000	-8.8716	0.0	-2.5627	8.4934 d					
3.0291	7.37500	-8.70000	91.00000	-8.5916	0.0	-2.4818	8.2254 d					
4.0388	7.66667	-7.73333	91.00000	-8.3165	0.0	-2.4023	7.9620 d					
5.0485	7.95833	-6.76667	91.00000	-8.0460	0.0	-2.3242	7.7030 d					
6.0583	8.25000	-5.80000	91.00000	-7.7800	0.0	-2.2473	7.4483 d					
7.0680	8.54167	-4.83333	91.00000	-7.5182	0.0	-2.1717	7.1977 d					
8.0777	8.83333	-3.86667	91.00000	-7.2606	0.0	-2.0973	6.9511 d					
9.0874	9.12500	-2.90000	91.00000	-7.0069	0.0	-2.0240	6.7082 d					
10.097	9.41667	-1.93333	91.00000	-6.7570	0.0	-1.9518	6.4689 d					
11.107	9.70833	-0.96667	91.00000	-6.5106	0.0	-1.8807	6.2331 d					
12.117	10.00000	0.00000	91.00000	-6.2677	0.0	-1.8105	6.0005 d					
13.126	10.29167	0.96667	91.00000	-6.0280	0.0	-1.7413	5.7710 d					
14.136	10.58333	1.93333	91.00000	-5.7913	0.0	-1.6729	5.5444 d					
15.146	10.87500	2.90000	91.00000	-5.5576	0.0	-1.6054	5.3207 d					
16.155	11.16667	3.86667	91.00000	-5.3265	0.0	-1.5386	5.0995 d					
17.165	11.45833	4.83333	91.00000	-5.0980	0.0	-1.4726	4.8807 d					
18.175	11.75000	5.80000	91.00000	-4.8719	0.0	-1.4073	4.6642 d					
19.184	12.04167	6.76667	91.00000	-4.6479	0.0	-1.3426	4.4498 d					
20.194	12.33333	7.73333	91.00000	-4.4259	0.0	-1.2785	4.2373 d					
21.204	12.62500	8.70000	91.00000	-4.2058	0.0	-1.2149	4.0265 d					
22.214	12.91667	9.66667	91.00000	-3.9874	0.0	-1.1518	3.8174 d					
23.223	13.20833	10.63333	91.00000	-3.7704	0.0	-1.0891	3.6097 d					
24.233	13.50000	11.60000	91.00000	-2.2045	0.0	-0.63679	2.1105 d					
d - Displacements include imported displacements.												
Specific Building Damage Results - Vertical Displacements												
Structure: Boundary Wall Sub-structure: Boundary Wall Foundation												
Dist.	Coordinates			Displacements								
	x	y	z	x	y	z						
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]						
Vertical Offset 1												
0.0	6.50000	-11.60000	91.00000	4.3266 d								
1.0097	6.79167	-10.63333	91.00000	7.1070 d								
2.0194	7.08333	-9.66667	91.00000	6.9764 d								
3.0291	7.37500	-8.70000	91.00000	6.8267 d								
4.0388	7.66667	-7.73333	91.00000	6.6610 d								
5.0485	7.95833	-6.76667	91.00000	6.4822 d								
6.0583	8.25000	-5.80000	91.00000	6.2931 d								
7.0680	8.54167	-4.83333	91.00000	6.0958 d								
8.0777	8.83333	-3.86667	91.00000	5.8924 d								
9.0874	9.12500	-2.90000	91.00000	5.6845 d								
10.097	9.41667	-1.93333	91.00000	5.4739 d								
11.107	9.70833	-0.96667	91.00000	5.2614 d								
12.117	10.00000	0.00000	91.00000	5.0484 d								
13.126	10.29167	0.96667	91.00000	4.8356 d								
14.136	10.58333	1.93333	91.00000	4.6240 d								
15.146	10.87500	2.90000	91.00000	4.4144 d								
16.155	11.16667	3.86667	91.00000	4.2074 d								
17.165	11.45833	4.83333	91.00000	4.0037 d								
18.175	11.75000	5.80000	91.00000	3.8038 d								
19.184	12.04167	6.76667	91.00000	3.6085 d								
20.194	12.33333	7.73333	91.00000	3.4181 d								
21.204	12.62500	8.70000	91.00000	3.2333 d								
22.214	12.91667	9.66667	91.00000	3.0543 d								
23.223	13.20833	10.63333	91.00000	2.8816 d								
24.233	13.50000	11.60000	91.00000	1.5056 d								
d - Displacements include imported displacements.												
Specific Building Damage Results - All Segments												
Structure: Boundary Wall Sub-structure: Boundary Wall Foundation												
Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature	Damage Category	
[m]		[m]	[m]		[%]	[%]	[%]			[m]		
0.0	1	0.0	11.816	Sagging	0.022856	-0.0018173	0.019062	0.0010194	-0.0027565	280.17	0 (Negligible)	
	2	11.816	9.4079	Hogging	403.55E-6	0.0065660	0.0071698	-69.497E-6	210.92E-6	173790.	0 (Negligible)	
	3	21.224	3.0094	Sagging	0.026310	0.019169	0.057704	-447.78E-6	0.0013621	677.59	1 (Very Slight)	
Tensile horizontal strains are +ve, compressive horizontal strains are -ve.												
Specific Building Damage Results - Critical Values for All Segments within Each Sub-Structure												
Structure: Boundary Wall Sub-structure: Boundary Wall Foundation												
Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Max Slope	Max Settlement	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category		
[m]	[%]	[%]		[mm]	[%]			[m]	[m]			
0.0	0.026310	0.019169	-0.0027565	7.0986	0.057704	0.0010194	-0.0027565	173790.	280.17	1 (Very Slight)		
Specific Building Damage Results - Critical Segments within Each Structure												
Structure Name	Parameter	Critical Sub-Structure	Critical Segment	Start	End	Curvature	Max Slope	Max Settlement	Max Tensile Strain	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
				[m]	[m]			[mm]	[%]	[m]	[m]	
Boundary Wall	Max Slope	Boundary Wall Foundation		1	0.0	11.816	Sagging	0.0027565	7.0986	0.019062	-	280.17 0 (Negligible)
	Max Settlement	Boundary Wall		1	0.0	11.816	Sagging	0.0027565	7.0986	0.019062	-	280.17 0 (Negligible)



FAIRHURST

40 Frogmal Lane

Long-term Loading (Wall Toe 5mbbl)

Boundary Wall

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Structure Name	Parameter	Critical Sub-Structure	Critical Start Segment	End	Curvature	Max Slope	Max Settlement	Max Tensile Strain	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
	Max Tensile Strain	Foundation	3	21.224	24.233	Sagging	0.0013621	3.2298	0.057704	-	677.59 1 (Very Slight)
	Min Radius of Curvature (Hogging)	Foundation	2	11.816	21.224	Hogging	210.92E-6	5.1118	0.0071698	173790.	- 0 (Negligible)
	Min Radius of Curvature (Sagging)	Foundation	1	0.0	11.816	Sagging	0.0027565	7.0986	0.019062	-	280.17 0 (Negligible)



FAIRHURST

40 Frogna Lane

Short-term Basement Excavation (Unloading, Wall Toe 5mbbl)

No. 38

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Problem Type

Problem Type : Tunnelling and Embedded Wall Excavations

Displacement Data

Type	Name	Direction of extrusion	Point/Line/Line for extrusion						No. of intervals across extrusion/line	Extrusion depth	No. of intervals along extrusion	Calculate	Surface type for tunnels
			First point			Second point							
			X [m]	Y [m]	Z(level) [m]	X [m]	Y [m]	Z(level) [m]					
Line	No. 38 East	-	10.00000	-11.60000	90.00000	12.00000	0.00000	90.00000		[m]			
									12	-	-	Yes	Surface

Imported Displacements

The following data points and displacements were found in the import file Pdisp Short term Unloading to be Imported.csv.

Ref.	Coordinates			Displacements		
	x [m]	y [m]	z [m]	x [mm]	y [mm]	z [mm]
1	-7.50000	0.00000	91.50000	0.00000	0.00000	-0.73810
2	-7.50000	1.00000	91.50000	0.00000	0.00000	-0.73690
3	-7.50000	2.00000	91.50000	0.00000	0.00000	-0.73310
4	-7.50000	3.00000	91.50000	0.00000	0.00000	-0.72580
5	-7.50000	4.00000	91.50000	0.00000	0.00000	-0.71350
6	-7.50000	5.00000	91.50000	0.00000	0.00000	-0.69420
7	-7.50000	6.00000	91.50000	0.00000	0.00000	-0.66530
8	-7.50000	7.00000	91.50000	0.00000	0.00000	-0.62330
9	-7.50000	8.00000	91.50000	0.00000	0.00000	-0.56500
10	-7.50000	9.00000	91.50000	0.00000	0.00000	-0.48730
11	-7.50000	10.00000	91.50000	0.00000	0.00000	-0.38960
12	-7.50000	11.00000	91.50000	0.00000	0.00000	-0.27550
13	-7.50000	12.00000	91.50000	0.00000	0.00000	-0.15450
14	-7.50000	13.00000	91.50000	0.00000	0.00000	-0.03940
15	-7.50000	14.00000	91.50000	0.00000	0.00000	0.05940
16	-7.50000	15.00000	91.50000	0.00000	0.00000	0.13690
17	-7.50000	0.00000	91.50000	0.00000	0.00000	-0.73810
18	-8.42730	0.00000	91.50000	0.00000	0.00000	-0.35400
19	-9.35450	0.00000	91.50000	0.00000	0.00000	-0.09160
20	-10.28180	0.00000	91.50000	0.00000	0.00000	0.08700
21	-11.20910	0.00000	91.50000	0.00000	0.00000	0.20650
22	-12.13640	0.00000	91.50000	0.00000	0.00000	0.28400
23	-13.06360	0.00000	91.50000	0.00000	0.00000	0.33150
24	-13.99090	0.00000	91.50000	0.00000	0.00000	0.35760
25	-14.91820	0.00000	91.50000	0.00000	0.00000	0.36860
26	-15.84550	0.00000	91.50000	0.00000	0.00000	0.36900
27	-16.77270	0.00000	91.50000	0.00000	0.00000	0.36230
28	-17.70000	0.00000	91.50000	0.00000	0.00000	0.35090
29	-7.50000	15.00000	91.50000	0.00000	0.00000	0.13690
30	-8.42730	15.00000	91.50000	0.00000	0.00000	0.19460
31	-9.35450	15.00000	91.50000	0.00000	0.00000	0.23710
32	-10.28180	15.00000	91.50000	0.00000	0.00000	0.26640
33	-11.20910	15.00000	91.50000	0.00000	0.00000	0.28490
34	-12.13640	15.00000	91.50000	0.00000	0.00000	0.29490
35	-13.06360	15.00000	91.50000	0.00000	0.00000	0.29820
36	-13.99090	15.00000	91.50000	0.00000	0.00000	0.29650
37	-14.91820	15.00000	91.50000	0.00000	0.00000	0.29100
38	-15.84550	15.00000	91.50000	0.00000	0.00000	0.28290
39	-16.77270	15.00000	91.50000	0.00000	0.00000	0.27300
40	-17.70000	15.00000	91.50000	0.00000	0.00000	0.26190
41	10.00000	-1.60000	90.00000	0.00000	0.00000	0.28140 1,2,6
42	10.16670	-10.63330	90.00000	0.00000	0.00000	0.28250 1,2,6
43	10.33330	-9.66670	90.00000	0.00000	0.00000	0.28530 1,2,6
44	10.50000	-8.70000	90.00000	0.00000	0.00000	0.29010 1,2,6
45	10.66670	-7.73330	90.00000	0.00000	0.00000	0.29640 1,2,6
46	10.83330	-6.76670	90.00000	0.00000	0.00000	0.30390 1,2,6
47	11.00000	-5.80000	90.00000	0.00000	0.00000	0.31220 1,2,6
48	11.16670	-4.83330	90.00000	0.00000	0.00000	0.32070 1,2,6
49	11.33330	-3.86670	90.00000	0.00000	0.00000	0.32900 1,2,6
50	11.50000	-2.90000	90.00000	0.00000	0.00000	0.33670 1,2,6
51	11.66670	-1.93330	90.00000	0.00000	0.00000	0.34350 1,2,6
52	11.83330	-0.96670	90.00000	0.00000	0.00000	0.34920 1,2,6
53	12.00000	0.00000	90.00000	0.00000	0.00000	0.35360 1,2,6
54	10.00000	-11.60000	90.00000	0.00000	0.00000	0.28140 1,2,6
55	11.00000	-11.60000	90.00000	0.00000	0.00000	0.30670
56	12.00000	-11.60000	90.00000	0.00000	0.00000	0.31790
57	13.00000	-11.60000	90.00000	0.00000	0.00000	0.31930
58	14.00000	-11.60000	90.00000	0.00000	0.00000	0.31410
59	15.00000	-11.60000	90.00000	0.00000	0.00000	0.30460
60	16.00000	-11.60000	90.00000	0.00000	0.00000	0.29220
61	17.00000	-11.60000	90.00000	0.00000	0.00000	0.27830
62	18.00000	-11.60000	90.00000	0.00000	0.00000	0.26350
63	19.00000	-11.60000	90.00000	0.00000	0.00000	0.24860
64	20.00000	-11.60000	90.00000	0.00000	0.00000	0.23370
65	21.00000	-11.60000	90.00000	0.00000	0.00000	0.21930
66	22.00000	-11.60000	90.00000	0.00000	0.00000	0.20550
67	23.00000	-11.60000	90.00000	0.00000	0.00000	0.19230
68	24.00000	-11.60000	90.00000	0.00000	0.00000	0.17990
69	25.00000	-11.60000	90.00000	0.00000	0.00000	0.16820
70	12.00000	0.00000	90.00000	0.00000	0.00000	0.35360 1,2,6
71	13.00000	0.00000	90.00000	0.00000	0.00000	0.36780
72	14.00000	0.00000	90.00000	0.00000	0.00000	0.36920
73	15.00000	0.00000	90.00000	0.00000	0.00000	0.36200
74	16.00000	0.00000	90.00000	0.00000	0.00000	0.34940
75	17.00000	0.00000	90.00000	0.00000	0.00000	0.33350
76	18.00000	0.00000	90.00000	0.00000	0.00000	0.31570
77	19.00000	0.00000	90.00000	0.00000	0.00000	0.29720
78	20.00000	0.00000	90.00000	0.00000	0.00000	0.27860
79	21.00000	0.00000	90.00000	0.00000	0.00000	0.26030
80	22.00000	0.00000	90.00000	0.00000	0.00000	0.24280
81	23.00000	0.00000	90.00000	0.00000	0.00000	0.22620
82	24.00000	0.00000	90.00000	0.00000	0.00000	0.21050
83	25.00000	0.00000	90.00000	0.00000	0.00000	0.19590
84	26.00000	0.00000	90.00000	0.00000	0.00000	0.18220
85	27.00000	0.00000	90.00000	0.00000	0.00000	0.16950
86	6.50000	-11.60000	91.00000	0.00000	0.00000	-0.03490
87	6.79170	-10.63330	91.00000	0.00000	0.00000	-0.05030
88	7.08330	-9.66670	91.00000	0.00000	0.00000	-0.04850
89	7.37500	-8.70000	91.00000	0.00000	0.00000	-0.03220
90	7.66670	-7.73330	91.00000	0.00000	0.00000	-0.00540
91	7.95830	-6.76670	91.00000	0.00000	0.00000	0.02830
92	8.25000	-5.80000	91.00000	0.00000	0.00000	0.06540
93	8.54170	-4.83330	91.00000	0.00000	0.00000	0.10340
94	8.83330	-3.86670	91.00000	0.00000	0.00000	0.14050
95	9.12500	-2.90000	91.00000	0.00000	0.00000	0.17530
96	9.41670	-1.93330	91.00000	0.00000	0.00000	0.20710
97	9.70830	-0.96670	91.00000	0.00000	0.00000	0.23530
98	10.00000	0.00000	91.00000	0.00000	0.00000	0.25990
99	10.29170	0.96670	91.00000	0.00000	0.00000	0.28080
100	10.58330	1.93330	91.00000	0.00000	0.00000	0.29810
101	10.87500	2.90000	91.00000	0.00000	0.00000	0.31210
102	11.16670	3.86670	91.00000	0.00000	0.00000	0.32290
103	11.45830	4.83330	91.00000	0.00000	0.00000	0.33070

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Ref.	Coordinates		Displacements		Displacements	
	x [m]	y [m]	z [m]	x [mm]	y [mm]	z [mm]
104	11.75000	5.80000	91.00000	0.00000	0.00000	0.33590
105	12.04170	6.76670	91.00000	0.00000	0.00000	0.33840
106	12.33330	7.73330	91.00000	0.00000	0.00000	0.33850
107	12.62500	8.70000	91.00000	0.00000	0.00000	0.33630
108	12.91670	9.66670	91.00000	0.00000	0.00000	0.33190
109	13.20830	10.63330	91.00000	0.00000	0.00000	0.32560
110	13.50000	11.60000	91.00000	0.00000	0.00000	0.31740
1 - Data point coincident with displacement data. Its displacement has been added to those calculated by Xdisp.						
2 - Data point coincident with horizontal movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.						
6 - Data point coincident with vertical movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.						
Vertical Ground Movement Curves (Excavations)						
Curve Name: Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)						
[0.000,0.000,0.050][2.000,0.000,0.000]						
Curve Fitting Polynomial						
Method:						
x Order: 1						
y Order: 0						
Polynomial: z = -2.5E-2x + 5.0E-2						
Coeff. of 1.0						
Determination:						
Curve Name: Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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]						
[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 Polynomial						
Method:						
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 9.9991E-1						
Determination:						
Horizontal Ground Movement Curves (Excavations)						
Curve Name: Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)						
[0.000,0.000,0.081][0.050,0.000,0.076][0.100,0.000,0.072][0.150,0.000,0.067]						
[0.200,0.000,0.063][0.250,0.000,0.059][0.300,0.000,0.056][0.350,0.000,0.052]						
[0.400,0.000,0.049][0.450,0.000,0.045][0.500,0.000,0.043][0.550,0.000,0.040]						
[0.600,0.000,0.037][0.650,0.000,0.034][0.700,0.000,0.032][0.750,0.000,0.029]						
[0.800,0.000,0.027][0.850,0.000,0.024][0.900,0.000,0.022][0.950,0.000,0.020]						
[1.000,0.000,0.018][1.050,0.000,0.016][1.100,0.000,0.014][1.150,0.000,0.012]						
[1.200,0.000,0.011][1.250,0.000,0.009][1.300,0.000,0.007][1.350,0.000,0.005]						
[1.400,0.000,0.004][1.450,0.000,0.002][1.500,0.000,0.000]						
Curve Fitting Polynomial						
Method:						
x Order: 3						
y Order: 0						
Polynomial: z = -1.0610E-2x ³ + 4.4203E-2x ² - 9.6358E-2x + 8.0901E-2						
Coeff. of 1.0000						
Determination:						
Curve Name: Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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 Polynomial						
Method:						
x Order: 1						
y Order: 0						
Polynomial: z = -3.75E-2x + 1.50E-1						
Coeff. of 1.00						
Determination:						
Polygonal Excavations						
Excavation Name: Pool excavation						
Surface Level [m]: 90.000						
Contribution: Positive						
Enabled: Yes						
Corner	x	y	Base Level	Stiffened	Previous Side	Next Side
	[m]	[m]	[m]		d p1 p2*	d p1 p2*
					[m] [%] [%]	[m] [%] [%]
1	-4.0000	-11.600	86.500	Yes	0.0 67.000 25.000	0.0 67.000 25.000
2	2.2000	-11.600	86.500	Yes	0.0 67.000 25.000	0.0 67.000 25.000
3	2.2000	11.600	86.500	Yes	0.0 67.000 25.000	0.0 67.000 25.000
4	-4.0000	11.600	86.500	Yes	0.0 67.000 25.000	0.0 67.000 25.000
Side	Corner 1	Corner 2	Ground Movement Curve			
	x y	x y	Vertical		Horizontal	
	[m] [m]	[m] [m]				
1	-4.0000 -11.600	2.2000 -11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))		Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))	
2	2.2000 -11.600	2.2000 11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))		Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))	
3	2.2000 11.600	-4.0000 11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))		Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))	
4	-4.0000 11.600	-4.0000 -11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))		Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))	
Excavation Name: Secant Pile Wall Installation						
Surface Level [m]: 90.000						
Contribution: Positive						
Enabled: Yes						
Corner	x	y	Base Level	Stiffened	Previous Side	Next Side
	[m]	[m]	[m]		d p1 p2*	d p1 p2*
					[m] [%] [%]	[m] [%] [%]



FAIRHURST

40 Frogmal Lane

Short-term Basement Excavation (Unloading, Wall Toe 5mbbl)

No. 38

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Corner	x	y	Base Level	Stiffened	Previous Side	Next Side
	[m]	[m]	[m]		d p1 p2*	d p1 p2*
					[m] [%] [%]	[m] [%] [%]
1	-4.0000	-11.600	81.500	Yes	0.0 50.000 20.000	0.0 50.000 20.000
2	2.2000	-11.600	81.500	Yes	0.0 50.000 20.000	0.0 50.000 20.000
3	2.2000	11.600	81.500	Yes	0.0 50.000 20.000	0.0 50.000 20.000
4	-4.0000	11.600	81.500	Yes	0.0 50.000 20.000	0.0 50.000 20.000

Side	Corner 1		Corner 2		Ground Movement Curve	
	x	y	x	y	Vertical	Horizontal
	[m]	[m]	[m]	[m]		
1	-4.0000	-11.600	2.2000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
2	2.2000	-11.600	2.2000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
3	2.2000	11.600	-4.0000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
4	-4.0000	11.600	-4.0000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))

Damage Category Strains

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

Specific Structures - Geometry

Structure Name	Sub-Structure Name	Displacement Line	Start Distance Along Line	End Distance Along Line	Vertical Offsets from Line for Vertical Movement Calculations	Vertical Displacement Limit	Damage Category Strains	Poisson's Ratio	E/G
No. 38	East Wall	No. 38 East	[m] 0.00000	[m] 11.77100	[m] 0.0	[mm] 0.10000	Burland Strain Limits	0.20000	2.6000

Specific Structures - Bending Parameters

Structure Name	Sub-Structure Name	Height	Default Properties	Hogging		Sagging			
				2nd Moment of Area (per unit width)	Distance of Bending Strain from N.A.	Distance of Area of Beam in Tension	2nd Moment of Area (per unit width)	Distance of Bending Strain from N.A.	Distance of Area of Beam in Tension
No. 38	East Wall	[m] 8.0000	Yes	[m²] 170.67	[m] 8.0000	[m²] 8.0000	[m²] 42.667	[m] 4.0000	[m] 4.0000

Building Segment Combinations

Structure Name	Sub-Structure Name	Vertical Offset from Line for Vertical Movement Calculations	Segment Start	Length	Curvature	Combined Segment
No. 38	East Wall	[m] 0.00000	[m] 0.00000	[m] 11.77100	0.00000	0.00000

No structures have segments combined.

Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Warnings

1

Multiple excavations have been specified. The displacements resulting from these excavations are calculated by summing the displacements resulting from each individual excavation. No account has been taken of the interactions between excavations (e.g. overlapping zones of influence or 'shielding' of one excavation by another).

Errors

None

Displacement and Strain Results

Type/No.	Coordinates			Displacements				Angle of Line
Name	Dist.	x	y	z	x	y	z	to x Axis
No. 38	Line 1	[m] 10.00000	[m] -11.60000	[m] 90.00000	[mm] -2.4716	[mm] 0.0	[mm] 2.3108	[mm] -0.41994
East								[mm] 2.4357
	0.98093	10.16667	-10.63333	90.00000	-4.0206	0.0	3.3762	-0.68313
	1.9619	10.33333	-9.66667	90.00000	-3.8895	0.0	3.2820	-0.66085
	2.9428	10.50000	-8.70000	90.00000	-3.7593	0.0	3.1918	-0.63872
	3.9237	10.66667	-7.73333	90.00000	-3.6299	0.0	3.1052	-0.61674
	4.9046	10.83333	-6.76667	90.00000	-3.5013	0.0	3.0219	-0.59490
	5.8856	11.00000	-5.80000	90.00000	-3.3735	0.0	2.9416	-0.57319
	6.8665	11.16667	-4.83333	90.00000	-3.2465	0.0	2.8637	-0.55160
	7.8474	11.33333	-3.86667	90.00000	-3.1201	0.0	2.7879	-0.53013
	8.8284	11.50000	-2.90000	90.00000	-2.9944	0.0	2.7138	-0.50877
	9.8093	11.66667	-1.93333	90.00000	-2.8693	0.0	2.6411	-0.48752
	10.790	11.83333	-0.96667	90.00000	-2.7448	0.0	2.5696	-0.46636
	11.771	12.00000	0.00000	90.00000	-2.6208	0.0	2.4927	-0.44529

* Result includes imported displacement(s).

Specific Building Damage Results - Horizontal Displacements

Structure: No. 38 | Sub-structure: East Wall

Dist.	Coordinates			Displacements	
	x	y	z	Horizontal displacement along Line	Horizontal displacement perpendicular to Line
[m]	[m]	[m]	[mm]	[mm]	[mm]
0.0	10.00000	-11.60000	90.00000	-2.4716	0.0
				-0.41994	2.4357 d

Dist.	Coordinates			Displacements		
	x	y	z	x	y	z
				Horizontal displacement along the	Horizontal displacement perpendicular to the	
0.98093	10.16667	-10.63333	90.00000	-4.0206	0.0	-0.68313
1.9619	10.33333	-9.66667	90.00000	-3.8895	0.0	-0.66085
2.9428	10.50000	-8.70000	90.00000	-3.7593	0.0	-0.63872
3.9237	10.66667	-7.73333	90.00000	-3.6299	0.0	-0.61674
4.9046	10.83333	-6.76667	90.00000	-3.5013	0.0	-0.59490
5.8856	11.00000	-5.80000	90.00000	-3.3735	0.0	-0.57319
6.8665	11.16667	-4.83333	90.00000	-3.2465	0.0	-0.55160
7.8474	11.33333	-3.86667	90.00000	-3.1201	0.0	-0.53013
8.8284	11.50000	-2.90000	90.00000	-2.9944	0.0	-0.50877
9.8093	11.66667	-1.93333	90.00000	-2.8693	0.0	-0.48752
10.790	11.83333	-0.96667	90.00000	-2.7448	0.0	-0.46636
11.771	12.00000	0.00000	90.00000	-2.6208	0.0	-0.44529
d - Displacements include imported displacements.						

Specific Building Damage Results - Vertical Displacements

Structure: No. 38 | Sub-structure: East Wall

Dist.	Coordinates			Displacements		
	x	y	z	x	y	z
[m]	[m]	[m]	[m]	[mm]		
Vertical Offset 1						
0.0	10.00000	-11.60000	90.00000	2.3108	d	
0.98093	10.16667	-10.63333	90.00000	3.3762	d	
1.9619	10.33333	-9.66667	90.00000	3.2820	d	
2.9428	10.50000	-8.70000	90.00000	3.1918	d	
3.9237	10.66667	-7.73333	90.00000	3.1052	d	
4.9046	10.83333	-6.76667	90.00000	3.0219	d	
5.8856	11.00000	-5.80000	90.00000	2.9416	d	
6.8665	11.16667	-4.83333	90.00000	2.8637	d	
7.8474	11.33333	-3.86667	90.00000	2.7879	d	
8.8284	11.50000	-2.90000	90.00000	2.7138	d	
9.8093	11.66667	-1.93333	90.00000	2.6411	d	
10.790	11.83333	-0.96667	90.00000	2.5696	d	
11.771	12.00000	0.00000	90.00000	2.5027	d	
d - Displacements include imported displacements.						

Specific Building Damage Results - All Segments

Structure: No. 38 | Sub-structure: East Wall

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]			[m]	
0.0		1	0.0	2.9306	Sagging	0.026178	-0.0074747	0.022712	268.38E-6	-0.0010864	663.18 0 (Negligible)
		2	2.9306	8.8404	Hogging	0.0036285	0.0021911	0.0050515	-22.558E-6	-288.62E-6	2172.2 0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

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

Structure: No. 38 | Sub-structure: East Wall

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Max Slope	Max Settlement	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0.0	0.026178	-0.0074747	-0.0010864	3.3737	0.022712	268.38E-6	-0.0010864	2172.2	663.18 0 (Negligible)	

Specific Building Damage Results - Critical Segments within Each Structure

Structure Name	Parameter	Critical Sub-Structure	Critical Segment	Start	End	Curvature	Max Slope	Max Settlement	Max Tensile Strain	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
				[m]	[m]			[mm]	[%]	[m]	[m]	
No. 38	Max Slope	East Wall	1	0.0	2.9306	Sagging	0.0010864	3.3737	0.022712	-	663.18 0 (Negligible)	
	Max Settlement	East Wall	1	0.0	2.9306	Sagging	0.0010864	3.3737	0.022712	-	663.18 0 (Negligible)	
	Max Tensile Strain	East Wall	1	0.0	2.9306	Sagging	0.0010864	3.3737	0.022712	-	663.18 0 (Negligible)	
	Min Radius of Curvature (Hogging)	East Wall	2	2.9306	11.771	Hogging	288.62E-6	3.1929	0.0050515	2172.2	- 0 (Negligible)	
	Min Radius of Curvature (Sagging)	East Wall	1	0.0	2.9306	Sagging	0.0010864	3.3737	0.022712	-	663.18 0 (Negligible)	



FAIRHURST

40 Frogнал Lane

Short-term Loading (Wall Toe 5mbbl)

No. 38

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Problem Type

Problem Type : Tunnelling and Embedded Wall Excavations

Displacement Data

Type	Name	Direction of extrusion	Point/Line/Line for extrusion						No. of intervals across extrusion/line	Extrusion depth	No. of intervals along extrusion	Calculate	Surface type for tunnels
			First point			Second point							
			X	Y	Z(level)	X	Y	Z(level)					
			[m]	[m]	[m]	[m]	[m]	[m]					
Line	No. 38 East	-	10.00000	-11.60000	90.00000	12.00000	0.00000	90.00000	12	[m]	-	Yes	Surface

Imported Displacements

The following data points and displacements were found in the import file Pdisp Short term Loading to be Imported.csv.

Ref.	Coordinates			Displacements		
	x	y	z	x	y	z
	[m]	[m]	[m]	[mm]	[mm]	[mm]
1	-7.50000	0.00000	91.50000	0.00000	0.00000	0.17030
2	-7.50000	1.00000	91.50000	0.00000	0.00000	0.17010
3	-7.50000	2.00000	91.50000	0.00000	0.00000	0.16920
4	-7.50000	3.00000	91.50000	0.00000	0.00000	0.16750
5	-7.50000	4.00000	91.50000	0.00000	0.00000	0.16470
6	-7.50000	5.00000	91.50000	0.00000	0.00000	0.16020
7	-7.50000	6.00000	91.50000	0.00000	0.00000	0.15350
8	-7.50000	7.00000	91.50000	0.00000	0.00000	0.14380
9	-7.50000	8.00000	91.50000	0.00000	0.00000	0.13040
10	-7.50000	9.00000	91.50000	0.00000	0.00000	0.11250
11	-7.50000	10.00000	91.50000	0.00000	0.00000	-0.08990
12	-7.50000	11.00000	91.50000	0.00000	0.00000	0.06360
13	-7.50000	12.00000	91.50000	0.00000	0.00000	0.03560
14	-7.50000	13.00000	91.50000	0.00000	0.00000	0.00910
15	-7.50000	14.00000	91.50000	0.00000	0.00000	-0.01370
16	-7.50000	15.00000	91.50000	0.00000	0.00000	-0.03160
17	-7.50000	0.00000	91.50000	0.00000	0.00000	0.17030
18	-8.42730	0.00000	91.50000	0.00000	0.00000	0.08170
19	-9.35450	0.00000	91.50000	0.00000	0.00000	0.02110
20	-10.28180	0.00000	91.50000	0.00000	0.00000	-0.02010
21	-11.20910	0.00000	91.50000	0.00000	0.00000	-0.04770
22	-12.13640	0.00000	91.50000	0.00000	0.00000	-0.06550
23	-13.06360	0.00000	91.50000	0.00000	0.00000	-0.07650
24	-13.99090	0.00000	91.50000	0.00000	0.00000	-0.08250
25	-14.91820	0.00000	91.50000	0.00000	0.00000	-0.08510
26	-15.84550	0.00000	91.50000	0.00000	0.00000	-0.08520
27	-16.77270	0.00000	91.50000	0.00000	0.00000	-0.08360
28	-17.70000	0.00000	91.50000	0.00000	0.00000	-0.08100
29	-7.50000	15.00000	91.50000	0.00000	0.00000	-0.03160
30	-8.42730	15.00000	91.50000	0.00000	0.00000	-0.04490
31	-9.35450	15.00000	91.50000	0.00000	0.00000	-0.05470
32	-10.28180	15.00000	91.50000	0.00000	0.00000	-0.06150
33	-11.20910	15.00000	91.50000	0.00000	0.00000	-0.06580
34	-12.13640	15.00000	91.50000	0.00000	0.00000	-0.06810
35	-13.06360	15.00000	91.50000	0.00000	0.00000	-0.06880
36	-13.99090	15.00000	91.50000	0.00000	0.00000	-0.06840
37	-14.91820	15.00000	91.50000	0.00000	0.00000	-0.06720
38	-15.84550	15.00000	91.50000	0.00000	0.00000	-0.06530
39	-16.77270	15.00000	91.50000	0.00000	0.00000	-0.06300
40	-17.70000	15.00000	91.50000	0.00000	0.00000	-0.06040
41	10.00000	-11.60000	90.00000	0.00000	0.00000	-0.06490 1,2,6
42	10.16670	-10.63330	90.00000	0.00000	0.00000	-0.06520 1,2,6
43	10.33330	-9.66670	90.00000	0.00000	0.00000	-0.06580 1,2,6
44	10.50000	-8.70000	90.00000	0.00000	0.00000	-0.06690 1,2,6
45	10.66670	-7.73330	90.00000	0.00000	0.00000	-0.06840 1,2,6
46	10.83330	-6.76670	90.00000	0.00000	0.00000	-0.07010 1,2,6
47	11.00000	-5.80000	90.00000	0.00000	0.00000	-0.07210 1,2,6
48	11.16670	-4.83330	90.00000	0.00000	0.00000	-0.07400 1,2,6
49	11.33330	-3.86670	90.00000	0.00000	0.00000	-0.07590 1,2,6
50	11.50000	-2.90000	90.00000	0.00000	0.00000	-0.07770 1,2,6
51	11.66670	-1.93330	90.00000	0.00000	0.00000	-0.07930 1,2,6
52	11.83330	-0.96670	90.00000	0.00000	0.00000	-0.08060 1,2,6
53	12.00000	0.00000	90.00000	0.00000	0.00000	-0.08160 1,2,6
54	10.00000	-11.60000	90.00000	0.00000	0.00000	-0.06490 1,2,6
55	11.00000	-11.60000	90.00000	0.00000	0.00000	-0.07080
56	12.00000	-11.60000	90.00000	0.00000	0.00000	-0.07340
57	13.00000	-11.60000	90.00000	0.00000	0.00000	-0.07370
58	14.00000	-11.60000	90.00000	0.00000	0.00000	-0.07250
59	15.00000	-11.60000	90.00000	0.00000	0.00000	-0.07030
60	16.00000	-11.60000	90.00000	0.00000	0.00000	-0.06740
61	17.00000	-11.60000	90.00000	0.00000	0.00000	-0.06420
62	18.00000	-11.60000	90.00000	0.00000	0.00000	-0.06080
63	19.00000	-11.60000	90.00000	0.00000	0.00000	-0.05740
64	20.00000	-11.60000	90.00000	0.00000	0.00000	-0.05390
65	21.00000	-11.60000	90.00000	0.00000	0.00000	-0.05060
66	22.00000	-11.60000	90.00000	0.00000	0.00000	-0.04740
67	23.00000	-11.60000	90.00000	0.00000	0.00000	-0.04440
68	24.00000	-11.60000	90.00000	0.00000	0.00000	-0.04150
69	25.00000	-11.60000	90.00000	0.00000	0.00000	-0.03880
70	12.00000	0.00000	90.00000	0.00000	0.00000	-0.08160 1,2,6
71	13.00000	0.00000	90.00000	0.00000	0.00000	-0.08490
72	14.00000	0.00000	90.00000	0.00000	0.00000	-0.08520
73	15.00000	0.00000	90.00000	0.00000	0.00000	-0.08350
74	16.00000	0.00000	90.00000	0.00000	0.00000	-0.08060
75	17.00000	0.00000	90.00000	0.00000	0.00000	-0.07700
76	18.00000	0.00000	90.00000	0.00000	0.00000	-0.07290
77	19.00000	0.00000	90.00000	0.00000	0.00000	-0.06860
78	20.00000	0.00000	90.00000	0.00000	0.00000	-0.06430
79	21.00000	0.00000	90.00000	0.00000	0.00000	-0.06010
80	22.00000	0.00000	90.00000	0.00000	0.00000	-0.05600
81	23.00000	0.00000	90.00000	0.00000	0.00000	-0.05220
82	24.00000	0.00000	90.00000	0.00000	0.00000	-0.04860
83	25.00000	0.00000	90.00000	0.00000	0.00000	-0.04520
84	26.00000	0.00000	90.00000	0.00000	0.00000	-0.04200
85	27.00000	0.00000	90.00000	0.00000	0.00000	-0.03910
86	6.50000	-11.60000	91.00000	0.00000	0.00000	0.00800
87	6.79170	-10.63330	91.00000	0.00000	0.00000	0.01160
88	7.08330	-9.66670	91.00000	0.00000	0.00000	0.01120
89	7.37500	-8.70000	91.00000	0.00000	0.00000	0.00740
90	7.66670	-7.73330	91.00000	0.00000	0.00000	0.00120
91	7.95830	-6.76670	91.00000	0.00000	0.00000	-0.00650
92	8.25000	-5.80000	91.00000	0.00000	0.00000	-0.01510
93	8.54170	-4.83330	91.00000	0.00000	0.00000	-0.02390
94	8.83330	-3.86670	91.00000	0.00000	0.00000	-0.03240
95	9.12500	-2.90000	91.00000	0.00000	0.00000	-0.04050
96	9.41670	-1.93330	91.00000	0.00000	0.00000	-0.04780
97	9.70830	-0.96670	91.00000	0.00000	0.00000	-0.05450
98	10.00000	0.00000	91.00000	0.00000	0.00000	-0.06000
99	10.29170	0.96670	91.00000	0.00000	0.00000	-0.06480
100	10.58330	1.93330	91.00000	0.00000	0.00000	-0.06880
101	10.87500	2.90000	91.00000	0.00000	0.00000	-0.07200
102	11.16670	3.86670	91.00000	0.00000	0.00000	-0.07450
103	11.45830	4.83330	91.00000	0.00000	0.00000	-0.07630



FAIRHURST

40 Frogmal Lane
Short-term Loading (Wall Toe 5mbbl)
No. 38

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Ref.	Coordinates		Displacements					
	x [m]	y [m]	x [m]	y [mm]	z [mm]			
104	11.75000	5.80000	91.00000	0.00000	-0.07750			
105	12.04170	6.76670	91.00000	0.00000	-0.07810			
106	12.33330	7.73330	91.00000	0.00000	-0.07810			
107	12.62500	8.70000	91.00000	0.00000	-0.07760			
108	12.91670	9.66670	91.00000	0.00000	-0.07660			
109	13.20830	10.63330	91.00000	0.00000	-0.07510			
110	13.50000	11.60000	91.00000	0.00000	-0.07320			
1 - Data point coincident with displacement data. Its displacement has been added to those calculated by Xdisp.								
2 - Data point coincident with horizontal movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.								
6 - Data point coincident with vertical movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.								
Vertical Ground Movement Curves (Excavations)								
Curve Name: Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)]								
[0.000,0.000,0.050][2.000,0.000,0.000]								
Curve Fitting Polynomial								
Method:								
x Order: 1								
y Order: 0								
Polynomial: z = -2.5E-2x + 5.0E-2								
Coeff. of 1.0								
Determination:								
Curve Name: Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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]								
[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 Polynomial								
Method:								
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 9.9991E-1								
Determination:								
Horizontal Ground Movement Curves (Excavations)								
Curve Name: Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)]								
[0.000,0.000,0.081][0.050,0.000,0.076][0.100,0.000,0.072][0.150,0.000,0.067]								
[0.200,0.000,0.063][0.250,0.000,0.059][0.300,0.000,0.056][0.350,0.000,0.052]								
[0.400,0.000,0.049][0.450,0.000,0.045][0.500,0.000,0.043][0.550,0.000,0.040]								
[0.600,0.000,0.037][0.650,0.000,0.034][0.700,0.000,0.032][0.750,0.000,0.029]								
[0.800,0.000,0.027][0.850,0.000,0.024][0.900,0.000,0.022][0.950,0.000,0.020]								
[1.000,0.000,0.018][1.050,0.000,0.016][1.100,0.000,0.014][1.150,0.000,0.012]								
[1.200,0.000,0.011][1.250,0.000,0.009][1.300,0.000,0.007][1.350,0.000,0.005]								
[1.400,0.000,0.004][1.450,0.000,0.002][1.500,0.000,0.000]								
Curve Fitting Polynomial								
Method:								
x Order: 3								
y Order: 0								
Polynomial: z = -1.0610E-2x ³ + 4.4203E-2x ² - 9.6358E-2x + 8.0901E-2								
Coeff. of 1.0000								
Determination:								
Curve Name: Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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 Polynomial								
Method:								
x Order: 1								
y Order: 0								
Polynomial: z = -3.75E-2x + 1.50E-1								
Coeff. of 1.00								
Determination:								
Polygonal Excavations								
Excavation Name: Pool excavation								
Surface Level [m]: 90.000								
Contribution: Positive								
Enabled: Yes								
Corner	x	y	Base Level	Stiffened	Previous Side		Next Side	
	[m]	[m]	[m]		d	p1 p2*	d	p1 p2*
					[m]	[%]	[m]	[%]
1	-4.0000	-11.600	86.500	Yes	0.0	67.000 25.000	0.0	67.000 25.000
2	2.2000	-11.600	86.500	Yes	0.0	67.000 25.000	0.0	67.000 25.000
3	2.2000	11.600	86.500	Yes	0.0	67.000 25.000	0.0	67.000 25.000
4	-4.0000	11.600	86.500	Yes	0.0	67.000 25.000	0.0	67.000 25.000
Side	Corner 1		Corner 2		Ground Movement Curve			
	x	y	x	y	Vertical		Horizontal	
	[m]	[m]	[m]	[m]				
1	-4.0000	-11.600	2.2000	-11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))		Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))	
2	2.2000	-11.600	2.2000	11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))		Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))	
3	2.2000	11.600	-4.0000	11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))		Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))	
4	-4.0000	11.600	-4.0000	-11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))		Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))	
Excavation Name: Secant Pile Wall Installation								
Surface Level [m]: 90.000								
Contribution: Positive								
Enabled: Yes								
Corner	x	y	Base Level	Stiffened	Previous Side		Next Side	
	[m]	[m]	[m]		d	p1 p2*	d	p1 p2*
					[m]	[%]	[m]	[%]



FAIRHURST

40 Frogmal Lane
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Corner	x	y	Base Level	Stiffened	Previous Side	Next Side
	[m]	[m]	[m]		d p1 p2*	d p1 p2*
					[m] [%] [%]	[m] [%] [%]
1	-4.0000	-11.6000	81.500	Yes	0.0 50.000 20.000	0.0 50.000 20.000
2	2.2000	-11.6000	81.500	Yes	0.0 50.000 20.000	0.0 50.000 20.000
3	2.2000	11.6000	81.500	Yes	0.0 50.000 20.000	0.0 50.000 20.000
4	-4.0000	11.6000	81.500	Yes	0.0 50.000 20.000	0.0 50.000 20.000

Side	Corner 1	Corner 2	Ground Movement Curve	
	x y	x y	Vertical	Horizontal
	[m] [m]	[m] [m]		
1	-4.0000 -11.600	2.2000 -11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
2	2.2000 -11.600	2.2000 11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
3	2.2000 11.600	-4.0000 11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
4	-4.0000 11.600	-4.0000 -11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))

Damage Category Strains

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

Specific Structures - Geometry

Structure Name	Sub-Structure Name	Displacement Line	Start Distance Along Line	End Distance Along Line	Vertical Offsets from Line for Movement Calculations	Vertical Displacement Limit	Damage Category Strains	Poisson's Ratio	E/G
No. 38	East Wall	No. 38 East	0.00000	11.77100	0.0	0.10000	Burland Strain Limits	0.20000	2.6000

Specific Structures - Bending Parameters

Structure Name	Sub-Structure Name	Height	Default Properties	Hogging		Sagging		
				2nd Moment of Area (per unit width)	Distance of Bending from N.A.	2nd Moment of Area (per unit width)	Distance of Bending from N.A.	Distance of Bending from Edge of Beam in Tension
No. 38	East Wall	8.0000	Yes	[m ⁴]	[m]	[m ⁴]	[m]	[m]
				170.67	8.0000	8.0000	42.667	4.0000

Building Segment Combinations

Structure Name	Sub-Structure Name	Vertical Offset from Line for Vertical Movement Calculations	Segment Start	Length	Curvature	Combined Segment
No structures have segments combined.		[m]	[m]	[m]		

Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Warnings

- 1 Multiple excavations have been specified. The displacements resulting from these excavations are calculated by summing the displacements resulting from each individual excavation. No account has been taken of the interactions between excavations (e.g. overlapping zones of influence or 'shielding' of one excavation by another).

Errors

None

Displacement and Strain Results

Type/No.	Coordinates			Displacements			Angle of Line
Name	Dist.	x	y	x	y	z	to x Axis
		[m]	[m]	[mm]	[mm]	[mm]	
No. 38	Line 1	10.00000	-11.60000	90.00000	-2.4716	0.0	80.218 *
East							
	0.98093	10.16667	-10.63333	90.00000	-4.0206	0.0	80.218 *
	1.9619	10.33333	-9.66667	90.00000	-3.8895	0.0	80.218 *
	2.9428	10.50000	-8.70000	90.00000	-3.7593	0.0	80.218 *
	3.9237	10.66667	-7.73333	90.00000	-3.6299	0.0	80.218 *
	4.9046	10.83333	-6.76667	90.00000	-3.5013	0.0	80.218 *
	5.8856	11.00000	-5.80000	90.00000	-3.3735	0.0	80.218 *
	6.8665	11.16667	-4.83333	90.00000	-3.2465	0.0	80.218 *
	7.8474	11.33333	-3.86667	90.00000	-3.1201	0.0	80.218 *
	8.8284	11.50000	-2.90000	90.00000	-2.9944	0.0	80.218 *
	9.8093	11.66667	-1.93333	90.00000	-2.8693	0.0	80.218 *
	10.790	11.83333	-0.96667	90.00000	-2.7448	0.0	80.218 *
	11.771	12.00000	0.00000	90.00000	-2.6208	0.0	80.218 *

* Result includes imported displacement(s).

Specific Building Damage Results - Horizontal Displacements

Structure: No. 38 | Sub-structure: East Wall

Dist.	Coordinates			Displacements	
	x	y	z	Horizontal displacement along line	Horizontal displacement perpendicular to line
	[m]	[m]	[m]	[mm]	[mm]
0.0	10.00000	-11.60000	90.00000	-2.4716	0.0
				-0.41994	2.4357 d

Dist.	Coordinates			Displacements		
	x	y	z	x	y	z
				Horizontal displacement along the	Horizontal displacement perpendicular to the	
0.98093	10.16667	-10.63333	90.00000	-4.0206	0.0	-0.68313 3.9622 d
1.9619	10.33333	-9.66667	90.00000	-3.8895	0.0	-0.66085 3.8329 d
2.9428	10.50000	-8.70000	90.00000	-3.7593	0.0	-0.63872 3.7046 d
3.9237	10.66667	-7.73333	90.00000	-3.6299	0.0	-0.61674 3.5771 d
4.9046	10.83333	-6.76667	90.00000	-3.5013	0.0	-0.59490 3.4504 d
5.8856	11.00000	-5.80000	90.00000	-3.3735	0.0	-0.57319 3.3245 d
6.8665	11.16667	-4.83333	90.00000	-3.2465	0.0	-0.55160 3.1993 d
7.8474	11.33333	-3.86667	90.00000	-3.1201	0.0	-0.53013 3.0748 d
8.8284	11.50000	-2.90000	90.00000	-2.9944	0.0	-0.50877 2.9509 d
9.8093	11.66667	-1.93333	90.00000	-2.8693	0.0	-0.48752 2.8276 d
10.790	11.83333	-0.96667	90.00000	-2.7448	0.0	-0.46636 2.7049 d
11.771	12.00000	0.00000	90.00000	-2.6208	0.0	-0.44529 2.5827 d
d - Displacements include imported displacements.						

Specific Building Damage Results - Vertical Displacements

Structure: No. 38 | Sub-structure: East Wall

Dist.	Coordinates			Displacements		
	x	y	z	x	y	z
	[m]	[m]	[m]			[mm]
Vertical Offset 1						
0.0	10.00000	-11.60000	90.00000	1.6182	d	
0.98093	10.16667	-10.63333	90.00000	3.0285	d	
1.9619	10.33333	-9.66667	90.00000	2.9309	d	
2.9428	10.50000	-8.70000	90.00000	2.8348	d	
3.9237	10.66667	-7.73333	90.00000	2.7404	d	
4.9046	10.83333	-6.76667	90.00000	2.6479	d	
5.8856	11.00000	-5.80000	90.00000	2.5573	d	
6.8665	11.16667	-4.83333	90.00000	2.4690	d	
7.8474	11.33333	-3.86667	90.00000	2.3830	d	
8.8284	11.50000	-2.90000	90.00000	2.2994	d	
9.8093	11.66667	-1.93333	90.00000	2.2183	d	
10.790	11.83333	-0.96667	90.00000	2.1398	d	
11.771	12.00000	0.00000	90.00000	1.9823	d	
d - Displacements include imported displacements.						

Specific Building Damage Results - All Segments

Structure: No. 38 | Sub-structure: East Wall

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]			[m]	
0.0		1	0.0	2.9384	Sagging	0.034129	-0.0074489	0.030310	268.38E-6	-0.0014381	510.24 0 (Negligible)
		2	2.9384	6.0110	Hogging	171.46E-6	0.0022072	0.0023028	-22.558E-6	97.946E-6	383570. 0 (Negligible)
		3	8.9494	2.8216	Sagging	0.0017809	0.0021566	0.0030931	-21.667E-6	160.54E-6	9680.5 0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

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

Structure: No. 38 | Sub-structure: East Wall

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Max Slope	Max Settlement	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0.0	0.034129	-0.0074489	-0.0014381	3.0266	0.030310	268.38E-6	-0.0014381	383570.	510.24 0	(Negligible)

Specific Building Damage Results - Critical Segments within Each Structure

Structure Name	Parameter	Critical Sub-Structure	Critical Segment	Start	End	Curvature	Max Slope	Max Settlement	Max Tensile Strain	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
						[m]	[m]	[mm]	[%]	[m]	[m]	
No. 38	Max Slope	East Wall	1	0.0	2.9384	Sagging	0.0014381	3.0266	0.030310	-	510.24 0	(Negligible)
	Max Settlement	East Wall	1	0.0	2.9384	Sagging	0.0014381	3.0266	0.030310	-	510.24 0	(Negligible)
	Max Tensile Strain	East Wall	1	0.0	2.9384	Sagging	0.0014381	3.0266	0.030310	-	510.24 0	(Negligible)
	Min Radius of Curvature (Hogging)	East Wall	2	2.9384	8.9494	Hogging	97.946E-6	2.8353	0.0023028	383570.	- 0	(Negligible)
	Min Radius of Curvature (Sagging)	East Wall	1	0.0	2.9384	Sagging	0.0014381	3.0266	0.030310	-	510.24 0	(Negligible)



FAIRHURST

40 Frognal Lane

Long-term Loading, Wall Toe 5mbbl

No. 38

Job No.	Sheet No.	Rev.
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Problem Type

Problem Type : Tunnelling and Embedded Wall Excavations

Displacement Data

Type	Name	Direction of extrusion	Point/Line/Line for extrusion						No. of intervals across extrusion/line	Extrusion depth	No. of intervals along extrusion	Calculate	Surface type for tunnels
			First point			Second point							
			X [m]	Y [m]	Z(level) [m]	X [m]	Y [m]	Z(level) [m]					
Line	No. 38 East	-	10.00000	-11.60000	90.00000	12.00000	0.00000	90.00000		[m]			
									12	-	-	Yes	Surface

Imported Displacements

The following data points and displacements were found in the import file Pdisp Long term Loading to be Imported.csv.

Ref.	Coordinates			Displacements		
	x [m]	y [m]	z [m]	x [mm]	y [mm]	z [mm]
1	-7.50000	0.00000	91.50000	0.00000	0.00000	0.86030
2	-7.50000	1.00000	91.50000	0.00000	0.00000	0.85840
3	-7.50000	2.00000	91.50000	0.00000	0.00000	0.85260
4	-7.50000	3.00000	91.50000	0.00000	0.00000	0.84250
5	-7.50000	4.00000	91.50000	0.00000	0.00000	0.82750
6	-7.50000	5.00000	91.50000	0.00000	0.00000	0.80660
7	-7.50000	6.00000	91.50000	0.00000	0.00000	0.77880
8	-7.50000	7.00000	91.50000	0.00000	0.00000	0.74270
9	-7.50000	8.00000	91.50000	0.00000	0.00000	0.69680
10	-7.50000	9.00000	91.50000	0.00000	0.00000	0.64020
11	-7.50000	10.00000	91.50000	0.00000	0.00000	0.57280
12	-7.50000	11.00000	91.50000	0.00000	0.00000	0.49670
13	-7.50000	12.00000	91.50000	0.00000	0.00000	0.41690
14	-7.50000	13.00000	91.50000	0.00000	0.00000	0.33950
15	-7.50000	14.00000	91.50000	0.00000	0.00000	0.26980
16	-7.50000	15.00000	91.50000	0.00000	0.00000	0.21050
17	-7.50000	0.00000	91.50000	0.00000	0.00000	0.86030
18	-8.42730	0.00000	91.50000	0.00000	0.00000	0.64620
19	-9.35450	0.00000	91.50000	0.00000	0.00000	0.48830
20	-10.28180	0.00000	91.50000	0.00000	0.00000	0.37000
21	-11.20910	0.00000	91.50000	0.00000	0.00000	0.28060
22	-12.13640	0.00000	91.50000	0.00000	0.00000	0.21260
23	-13.06360	0.00000	91.50000	0.00000	0.00000	0.16070
24	-13.99090	0.00000	91.50000	0.00000	0.00000	0.12090
25	-14.91820	0.00000	91.50000	0.00000	0.00000	0.09040
26	-15.84550	0.00000	91.50000	0.00000	0.00000	0.06700
27	-16.77270	0.00000	91.50000	0.00000	0.00000	0.04900
28	-17.70000	0.00000	91.50000	0.00000	0.00000	0.03510
29	-7.50000	15.00000	91.50000	0.00000	0.00000	0.21050
30	-8.42730	15.00000	91.50000	0.00000	0.00000	0.16990
31	-9.35450	15.00000	91.50000	0.00000	0.00000	0.13430
32	-10.28180	15.00000	91.50000	0.00000	0.00000	0.10570
33	-11.20910	15.00000	91.50000	0.00000	0.00000	0.08240
34	-12.13640	15.00000	91.50000	0.00000	0.00000	0.06350
35	-13.06360	15.00000	91.50000	0.00000	0.00000	0.04830
36	-13.99090	15.00000	91.50000	0.00000	0.00000	0.03610
37	-14.91820	15.00000	91.50000	0.00000	0.00000	0.02640
38	-15.84550	15.00000	91.50000	0.00000	0.00000	0.01870
39	-16.77270	15.00000	91.50000	0.00000	0.00000	0.01250
40	-17.70000	15.00000	91.50000	0.00000	0.00000	0.00770
41	10.00000	-1.60000	90.00000	0.00000	0.00000	0.12510 1,2,6
42	10.16670	-10.63330	90.00000	0.00000	0.00000	0.13470 1,2,6
43	10.33330	-9.66670	90.00000	0.00000	0.00000	0.14240 1,2,6
44	10.50000	-8.70000	90.00000	0.00000	0.00000	0.14810 1,2,6
45	10.66670	-7.73330	90.00000	0.00000	0.00000	0.15170 1,2,6
46	10.83330	-6.76670	90.00000	0.00000	0.00000	0.15350 1,2,6
47	11.00000	-5.80000	90.00000	0.00000	0.00000	0.15350 1,2,6
48	11.16670	-4.83330	90.00000	0.00000	0.00000	0.15190 1,2,6
49	11.33330	-3.86670	90.00000	0.00000	0.00000	0.14910 1,2,6
50	11.50000	-2.90000	90.00000	0.00000	0.00000	0.14510 1,2,6
51	11.66670	-1.93330	90.00000	0.00000	0.00000	0.14020 1,2,6
52	11.83330	-0.96670	90.00000	0.00000	0.00000	0.13460 1,2,6
53	12.00000	0.00000	90.00000	0.00000	0.00000	0.12830 1,2,6
54	10.00000	-11.60000	90.00000	0.00000	0.00000	0.12510 1,2,6
55	11.00000	-11.60000	90.00000	0.00000	0.00000	0.09250
56	12.00000	-11.60000	90.00000	0.00000	0.00000	0.06780
57	13.00000	-11.60000	90.00000	0.00000	0.00000	0.04900
58	14.00000	-11.60000	90.00000	0.00000	0.00000	0.03480
59	15.00000	-11.60000	90.00000	0.00000	0.00000	0.02390
60	16.00000	-11.60000	90.00000	0.00000	0.00000	0.01570
61	17.00000	-11.60000	90.00000	0.00000	0.00000	0.00940
62	18.00000	-11.60000	90.00000	0.00000	0.00000	0.00470
63	19.00000	-11.60000	90.00000	0.00000	0.00000	0.00110
64	20.00000	-11.60000	90.00000	0.00000	0.00000	-0.00150
65	21.00000	-11.60000	90.00000	0.00000	0.00000	-0.00350
66	22.00000	-11.60000	90.00000	0.00000	0.00000	-0.00490
67	23.00000	-11.60000	90.00000	0.00000	0.00000	-0.00600
68	24.00000	-11.60000	90.00000	0.00000	0.00000	-0.00670
69	25.00000	-11.60000	90.00000	0.00000	0.00000	-0.00710
70	12.00000	0.00000	90.00000	0.00000	0.00000	0.12830 1,2,6
71	13.00000	0.00000	90.00000	0.00000	0.00000	0.09390
72	14.00000	0.00000	90.00000	0.00000	0.00000	0.06800
73	15.00000	0.00000	90.00000	0.00000	0.00000	0.04850
74	16.00000	0.00000	90.00000	0.00000	0.00000	0.03380
75	17.00000	0.00000	90.00000	0.00000	0.00000	0.02270
76	18.00000	0.00000	90.00000	0.00000	0.00000	0.01440
77	19.00000	0.00000	90.00000	0.00000	0.00000	0.00810
78	20.00000	0.00000	90.00000	0.00000	0.00000	0.00350
79	21.00000	0.00000	90.00000	0.00000	0.00000	0.00000
80	22.00000	0.00000	90.00000	0.00000	0.00000	-0.00250
81	23.00000	0.00000	90.00000	0.00000	0.00000	-0.00440
82	24.00000	0.00000	90.00000	0.00000	0.00000	-0.00570
83	25.00000	0.00000	90.00000	0.00000	0.00000	-0.00660
84	26.00000	0.00000	90.00000	0.00000	0.00000	-0.00720
85	27.00000	0.00000	90.00000	0.00000	0.00000	-0.00760
86	6.50000	-11.60000	91.00000	0.00000	0.00000	0.35240
87	6.79170	-10.63330	91.00000	0.00000	0.00000	0.37310
88	7.08330	-9.66670	91.00000	0.00000	0.00000	0.38390
89	7.37500	-8.70000	91.00000	0.00000	0.00000	0.38570
90	7.66670	-7.73330	91.00000	0.00000	0.00000	0.38030
91	7.95830	-6.76670	91.00000	0.00000	0.00000	0.36940
92	8.25000	-5.80000	91.00000	0.00000	0.00000	0.35460
93	8.54170	-4.83330	91.00000	0.00000	0.00000	0.33700
94	8.83330	-3.86670	91.00000	0.00000	0.00000	0.31770
95	9.12500	-2.90000	91.00000	0.00000	0.00000	0.29740
96	9.41670	-1.93330	91.00000	0.00000	0.00000	0.27670
97	9.70830	-0.96670	91.00000	0.00000	0.00000	0.25580
98	10.00000	0.00000	91.00000	0.00000	0.00000	0.23520
99	10.29170	0.96670	91.00000	0.00000	0.00000	0.21480
100	10.58330	1.93330	91.00000	0.00000	0.00000	0.19490
101	10.87500	2.90000	91.00000	0.00000	0.00000	0.17560
102	11.16670	3.86670	91.00000	0.00000	0.00000	0.15690
103	11.45830	4.83330	91.00000	0.00000	0.00000	0.13890

Oasys

FAIRHURST

40 Frogнал Lane

Long-term Loading, Wall Toe 5mbbl

No. 38

Job No.

Sheet No.

Rev.

141396

Drg. Ref.

Made by

Date

Checked

JC

10-Feb-2021

Ref.

Coordinates

Displacements

	x [m]	y [m]	z [m]	x [mm]	y [mm]	z [mm]
104	11.75000	5.80000	91.00000	0.00000	0.00000	0.12170
105	12.04170	6.76670	91.00000	0.00000	0.00000	0.10550
106	12.33330	7.73330	91.00000	0.00000	0.00000	0.09020
107	12.62500	8.70000	91.00000	0.00000	0.00000	0.07610
108	12.91670	9.66670	91.00000	0.00000	0.00000	0.06320
109	13.20830	10.63330	91.00000	0.00000	0.00000	0.05170
110	13.50000	11.60000	91.00000	0.00000	0.00000	0.04140

1-Data point coincident with displacement data. Its displacement has been added to those calculated by Xdisp.

2-Data point coincident with horizontal movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.

6-Data point coincident with vertical movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.

Vertical Ground Movement Curves (Excavations)

Curve Name:

Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)]

[0.000,0.000,0.050][2.000,0.000,0.000]

Curve Fitting Method:

Polynomial

Method:

1

x Order:

0

y Order:

0

Polynomial: z =

-2.5E-2x + 5.0E-2

Coeff. of Determination:

1.0

Curve Name:

Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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][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

Method:

4

x Order:

0

y Order:

0

Polynomial: z =

-2.6455E-3x⁴ + 2.8495E-2x³ - 1.0051E-1x² + 1.0569E-1x + 3.8990E-2

Coeff. of Determination:

9.9991E-1

Horizontal Ground Movement Curves (Excavations)

Curve Name:

Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)]

[0.000,0.000,0.081][0.050,0.000,0.076][0.100,0.000,0.072][0.150,0.000,0.067][0.200,0.000,0.063][0.250,0.000,0.059][0.300,0.000,0.056][0.350,0.000,0.052][0.400,0.000,0.049][0.450,0.000,0.045][0.500,0.000,0.043][0.550,0.000,0.040][0.600,0.000,0.037][0.650,0.000,0.034][0.700,0.000,0.032][0.750,0.000,0.029][0.800,0.000,0.027][0.850,0.000,0.024][0.900,0.000,0.022][0.950,0.000,0.020][1.000,0.000,0.018][1.050,0.000,0.016][1.100,0.000,0.014][1.150,0.000,0.012][1.200,0.000,0.011][1.250,0.000,0.009][1.300,0.000,0.007][1.350,0.000,0.005][1.400,0.000,0.004][1.450,0.000,0.002][1.500,0.000,0.000]

Curve Fitting Method:

Polynomial

Method:

3

x Order:

0

y Order:

0

Polynomial: z =

-1.0610E-2x³ + 4.4203E-2x² - 9.6358E-2x + 8.0901E-2

Coeff. of Determination:

1.0000

Curve Name:

Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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

Method:

1

x Order:

0

y Order:

0

Polynomial: z =

-3.75E-2x + 1.50E-1

Coeff. of Determination:

1.00

Polygonal Excavations

Excavation Name:

Pool excavation

Surface level [m]:

90.000

Contribution:

Positive

Enabled:

Yes

Corner

x

y

Base Level

Stiffened

Previous Side

d

p1

p2*

Next Side

d

p1

p2*

[m]

[m]

[m]

[m]

[%]

[%]

[m]

[%]

[%]

1

-4.0000

-11.600

86.500

Yes

0.0

67.000

25.000

0.0

67.000

25.000

2

2.2000

-11.600

86.500

Yes

0.0

67.000

25.000

0.0

67.000

25.000

3

2.2000

11.600

86.500

Yes

0.0

67.000

25.000

0.0

67.000

25.000

4

-4.0000

11.600

86.500

Yes

0.0

67.000

25.000

0.0

67.000

25.000

Side

Corner 1

Corner 2

Ground Movement Curve

x

y

x

y

Vertical

Horizontal

[m]

[m]

[m]

[m]

1

-4.0000

-11.600

2.2000

-11.600

Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))

Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))

2

2.2000

-11.600

2.2000

11.600

Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))

Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))

3

2.2000

11.600

-4.0000

11.600

Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))

Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))

4

-4.0000

11.600

-4.0000

-11.600

Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))

Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))

Excavation Name:

Secant Pile Wall Installation

Surface level [m]:

90.000

Contribution:

Positive

Enabled:

Yes

Corner

x

y

Base Level

Stiffened

Previous Side

d

p1

p2*

Next Side

d

p1

p2*

[m]

[m]

[m]

[m]

[%]

[%]

[m]

[%]

[%]

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X:\a...\141396 Frogнал Lane Long-term Loading Xdisp - Wall Toe 5mbbl (East Wall).xdd

Page 2

Printed 15-Feb-2021

Time 10:44



FAIRHURST

40 Frogmal Lane
Long-term Loading, Wall Toe 5mbbl
No. 38

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Corner	x	y	Base Level	Stiffened	Previous Side		Next Side	
	[m]	[m]	[m]		d	p1	p2*	p2*
					[m]	[%]	[m]	[%]
1	-4.0000	-11.6000	81.500	Yes	0.0	50.000	20.000	0.0
2	2.2000	-11.6000	81.500	Yes	0.0	50.000	20.000	0.0
3	2.2000	11.6000	81.500	Yes	0.0	50.000	20.000	0.0
4	-4.0000	11.6000	81.500	Yes	0.0	50.000	20.000	0.0

Side	Corner 1	Corner 2	Ground Movement Curve	
	x	y	x	y
	[m]	[m]	[m]	[m]
1	-4.0000	-11.600	2.2000	-11.600
2	2.2000	-11.600	2.2000	11.600
3	2.2000	11.600	-4.0000	11.600
4	-4.0000	11.600	-4.0000	-11.600

Vertical	Horizontal
Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))

Damage Category Strains

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

Specific Structures - Geometry

Structure Name	Sub-Structure Name	Displacement Line	Start Distance Along Line	End Distance Along Line	Vertical Offsets from Line for Movement Calculations	Vertical Displacement Limit	Damage Category Strains	Poisson's Ratio	E/G
No. 38	East Wall	No. 38 East	0.00000	11.77100	0.0	0.10000	Burland Strain Limits	0.20000	2.6000

Specific Structures - Bending Parameters

Structure Name	Sub-Structure Name	Height	Default Properties	Hogging		Sagging	
				2nd Moment of Area (per unit width)	Distance of Strain from N.A.	2nd Moment of Area (per unit width)	Distance of Strain from N.A.
No. 38	East Wall	8.0000	Yes	170.67	8.0000	42.667	4.0000

Building Segment Combinations

Structure Name	Sub-Structure Name	Vertical Offset from Line for Vertical Movement Calculations	Segment Start	Length	Curvature	Combined Segment
No structures have segments combined.						

Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Warnings

1 Multiple excavations have been specified. The displacements resulting from these excavations are calculated by summing the displacements resulting from each individual excavation. No account has been taken of the interactions between excavations (e.g. overlapping zones of influence or 'shielding' of one excavation by another).

Errors

None

Displacement and Strain Results

Type/No.	Coordinates			Displacements			Angle of Line
Name	Dist.	x	y	x	y	z	to x Axis
		[m]	[m]	[mm]	[mm]	[mm]	[°]
No. 38 East	Line 1	10.00000	-11.60000	90.00000	-2.4716	0.0	80.218 *
	0.98093	10.16667	-10.63333	90.00000	-4.0206	0.0	80.218 *
	1.9619	10.33333	-9.66667	90.00000	-3.8895	0.0	80.218 *
	2.9428	10.50000	-8.70000	90.00000	-3.7593	0.0	80.218 *
	3.9237	10.66667	-7.73333	90.00000	-3.6299	0.0	80.218 *
	4.9046	10.83333	-6.76667	90.00000	-3.5013	0.0	80.218 *
	5.8856	11.00000	-5.80000	90.00000	-3.3735	0.0	80.218 *
	6.8665	11.16667	-4.83333	90.00000	-3.2465	0.0	80.218 *
	7.8474	11.33333	-3.86667	90.00000	-3.1201	0.0	80.218 *
	8.8284	11.50000	-2.90000	90.00000	-2.9944	0.0	80.218 *
	9.8093	11.66667	-1.93333	90.00000	-2.8693	0.0	80.218 *
	10.790	11.83333	-0.96667	90.00000	-2.7448	0.0	80.218 *
	11.771	12.00000	0.00000	90.00000	-2.6208	0.0	80.218 *

* Result includes imported displacement(s).

Specific Building Damage Results - Horizontal Displacements

Structure: No. 38 | Sub-structure: East Wall

Dist.	Coordinates			Displacements	
	x	y	z	Horizontal displacement along the line	Horizontal displacement perpendicular to line
	[m]	[m]	[m]	[mm]	[mm]
0.0	10.00000	-11.60000	90.00000	-2.4716	0.0

Dist.	Coordinates			Displacements	
	x	y	z	Horizontal displacement along the	Horizontal displacement perpendicular
0.98093	10.16667	-10.63333	90.00000	-4.0206	0.0
1.9619	10.33333	-9.66667	90.00000	-3.8895	0.0
2.9428	10.50000	-8.70000	90.00000	-3.7593	0.0
3.9237	10.66667	-7.73333	90.00000	-3.6299	0.0
4.9046	10.83333	-6.76667	90.00000	-3.5013	0.0
5.8856	11.00000	-5.80000	90.00000	-3.3735	0.0
6.8665	11.16667	-4.83333	90.00000	-3.2465	0.0
7.8474	11.33333	-3.86667	90.00000	-3.1201	0.0
8.8284	11.50000	-2.90000	90.00000	-2.9944	0.0
9.8093	11.66667	-1.93333	90.00000	-2.8693	0.0
10.790	11.83333	-0.96667	90.00000	-2.7448	0.0
11.771	12.00000	0.00000	90.00000	-2.6208	0.0
d - Displacements include imported displacements.					

Specific Building Damage Results - Vertical Displacements

Structure: No. 38 | Sub-structure: East Wall

Dist.	Coordinates			Displacements	
	x	y	z	Horizontal displacement along the	Horizontal displacement perpendicular
0.0	10.00000	-11.60000	90.00000	1.9982	d
0.98093	10.16667	-10.63333	90.00000	3.2284	d
1.9619	10.33333	-9.66667	90.00000	3.1391	d
2.9428	10.50000	-8.70000	90.00000	3.0498	d
3.9237	10.66667	-7.73333	90.00000	2.9605	d
4.9046	10.83333	-6.76667	90.00000	2.8715	d
5.8856	11.00000	-5.80000	90.00000	2.7829	d
6.8665	11.16667	-4.83333	90.00000	2.6943	d
7.8474	11.33333	-3.86667	90.00000	2.6080	d
8.8284	11.50000	-2.90000	90.00000	2.5222	d
9.8093	11.66667	-1.93333	90.00000	2.4378	d
10.790	11.83333	-0.96667	90.00000	2.3550	d
11.771	12.00000	0.00000	90.00000	2.4021	d
d - Displacements include imported displacements.					

Specific Building Damage Results - All Segments

Structure: No. 38 | Sub-structure: East Wall

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature	Damage Category	
[m]		[m]	[m]		[%]	[%]	[%]			[m]		
0.0		1	0.0	2.9426	Sagging	0.029895	-0.0074350	0.026261	268.38E-6	-0.0012544	583.21	0
		2	2.9426	8.8284	Hogging	0.0013487	0.0021910	0.0032529	-22.558E-6	91.060E-6	5940.3	0
												(Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

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

Structure: No. 38 | Sub-structure: East Wall

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Max Slope	Max Settlement	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0.0	0.029895	-0.0074350	-0.0012544	3.2283	0.026261	268.38E-6	-0.0012544	5940.3	583.21	0 (Negligible)

Specific Building Damage Results - Critical Segments within Each Structure

Structure Name	Parameter	Critical Sub-Structure	Critical Segment	Start	End	Curvature	Max Slope	Max Settlement	Max Tensile Strain	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
				[m]	[m]			[mm]	[%]	[m]	[m]	
No. 38	Max Slope	East Wall	1	0.0	2.9426	Sagging	0.0012544	3.2283	0.026261	-	583.21	0 (Negligible)
	Max Settlement	East Wall	1	0.0	2.9426	Sagging	0.0012544	3.2283	0.026261	-	583.21	0 (Negligible)
	Max Tensile Strain	East Wall	1	0.0	2.9426	Sagging	0.0012544	3.2283	0.026261	-	583.21	0 (Negligible)
	Min Radius of Curvature (Hogging)	East Wall	2	2.9426	11.771	Hogging	91.060E-6	3.0498	0.0032529	5940.3	-	0 (Negligible)
	Min Radius of Curvature (Sagging)	East Wall	1	0.0	2.9426	Sagging	0.0012544	3.2283	0.026261	-	583.21	0 (Negligible)

Problem Type

Problem Type : Tunnelling and Embedded Wall Excavations

Displacement Data

Type	Name	Direction of extrusion	Point/Line/Line for extrusion						No. of intervals across extrusion/line	Extrusion depth	No. of intervals along extrusion	Calculate	Surface type for tunnels
			First point			Second point							
			X	Y	Z(level)	X	Y	Z(level)					
			[m]	[m]	[m]	[m]	[m]	[m]					
Line	No. 40 West	-	-7.50000	0.00000	91.50000	-7.50000	15.00000	91.50000	15	-	-	Yes	Surface

Imported Displacements

The following data points and displacements were found in the import file Pdisp Short term Unloading to be Imported.csv.

ref.	Coordinates			Displacements		
	x [m]	y [m]	z [m]	x [mm]	y [mm]	z [mm]
1	-7.50000	0.00000	91.50000	0.00000	0.00000	-0.73810
2	-7.50000	1.00000	91.50000	0.00000	0.00000	-0.73690
3	-7.50000	2.00000	91.50000	0.00000	0.00000	-0.73570
4	-7.50000	3.00000	91.50000	0.00000	0.00000	-0.72580
5	-7.50000	4.00000	91.50000	0.00000	0.00000	-0.71350
6	-7.50000	5.00000	91.50000	0.00000	0.00000	-0.69420
7	-7.50000	6.00000	91.50000	0.00000	0.00000	-0.66530
8	-7.50000	7.00000	91.50000	0.00000	0.00000	-0.62330
9	-7.50000	8.00000	91.50000	0.00000	0.00000	-0.56500
10	-7.50000	9.00000	91.50000	0.00000	0.00000	-0.48730
11	-7.50000	10.00000	91.50000	0.00000	0.00000	-0.37660
12	-7.50000	11.00000	91.50000	0.00000	0.00000	-0.25750
13	-7.50000	12.00000	91.50000	0.00000	0.00000	-0.15450
14	-7.50000	13.00000	91.50000	0.00000	0.00000	-0.03940
15	-7.50000	14.00000	91.50000	0.00000	0.00000	0.05940
16	-7.50000	15.00000	91.50000	0.00000	0.00000	0.13690
17	-7.50000	0.00000	91.50000	0.00000	0.00000	-0.73810
18	-8.42730	0.00000	91.50000	0.00000	0.00000	-0.35400
19	-13.35450	0.00000	91.50000	0.00000	0.00000	0.09160
20	-10.28180	0.00000	91.50000	0.00000	0.00000	0.08700
21	-11.20910	0.00000	91.50000	0.00000	0.00000	0.20650
22	-12.13640	0.00000	91.50000	0.00000	0.00000	0.28400
23	-13.06360	0.00000	91.50000	0.00000	0.00000	0.33150
24	-13.99090	0.00000	91.50000	0.00000	0.00000	0.35660
25	-14.91820	0.00000	91.50000	0.00000	0.00000	0.36860
26	-15.84550	0.00000	91.50000	0.00000	0.00000	0.36900
27	-16.77270	0.00000	91.50000	0.00000	0.00000	0.36230
28	-17.70000	0.00000	91.50000	0.00000	0.00000	0.35090
29	-18.62730	15.00000	91.50000	0.00000	0.00000	1.26000
30	-8.42730	0.00000	91.50000	0.00000	0.00000	0.35660
31	-9.35450	15.00000	91.50000	0.00000	0.00000	0.23710
32	-10.28180	15.00000	91.50000	0.00000	0.00000	0.26640
33	-11.20910	15.00000	91.50000	0.00000	0.00000	0.28490
34	-12.13640	15.00000	91.50000	0.00000	0.00000	0.29490
35	-13.06360	15.00000	91.50000	0.00000	0.00000	0.29120
36	-13.99090	15.00000	91.50000	0.00000	0.00000	0.29650
37	-14.91820	15.00000	91.50000	0.00000	0.00000	0.29100
38	-15.84550	15.00000	91.50000	0.00000	0.00000	0.28800
39	-16.77270	15.00000	91.50000	0.00000	0.00000	0.27300
40	-17.70000	15.00000	91.50000	0.00000	0.00000	0.24000
41	10.00000	-11.60000	90.00000	0.00000	0.00000	0.28140
42	10.16670	-10.63330	90.00000	0.00000	0.00000	0.28250
43	10.33330	-9.66670	90.00000	0.00000	0.00000	0.28530
44	10.50000	-8.70000	90.00000	0.00000	0.00000	0.29010
45	10.66670	-7.73330	90.00000	0.00000	0.00000	0.29640
46	10.83330	-6.76670	90.00000	0.00000	0.00000	0.30390
47	11.00000	-5.80000	90.00000	0.00000	0.00000	0.31220
48	11.16670	-4.83330	90.00000	0.00000	0.00000	0.32070
49	11.33330	-3.86670	90.00000	0.00000	0.00000	0.32900
50	11.50000	-2.90000	90.00000	0.00000	0.00000	0.33660
51	11.66670	-1.93330	90.00000	0.00000	0.00000	0.34350
52	11.83330	-0.96670	90.00000	0.00000	0.00000	0.34920
53	12.00000	0.00000	90.00000	0.00000	0.00000	0.35360
54	10.00000	-11.60000	90.00000	0.00000	0.00000	0.28140
55	11.00000	-11.60000	90.00000	0.00000	0.00000	0.31770
56	12.00000	-11.60000	90.00000	0.00000	0.00000	0.31790
57	13.00000	-11.60000	90.00000	0.00000	0.00000	0.31930
58	14.00000	-11.60000	90.00000	0.00000	0.00000	0.31410
59	15.00000	-11.60000	90.00000	0.00000	0.00000	0.30460
60	16.00000	-11.60000	90.00000	0.00000	0.00000	0.29220
61	17.00000	-11.60000	90.00000	0.00000	0.00000	0.27830
62	18.00000	-11.60000	90.00000	0.00000	0.00000	0.26350
63	19.00000	-11.60000	90.00000	0.00000	0.00000	0.24860
64	20.00000	-11.60000	90.00000	0.00000	0.00000	0.23370
65	21.00000	-11.60000	90.00000	0.00000	0.00000	0.21880
66	22.00000	-11.60000	90.00000	0.00000	0.00000	0.20550
67	23.00000	-11.60000	90.00000	0.00000	0.00000	0.19230
68	24.00000	-11.60000	90.00000	0.00000	0.00000	0.17990
69	25.00000	-11.60000	90.00000	0.00000	0.00000	0.16820
70	26.00000	-11.60000	90.00000	0.00000	0.00000	0.15700
71	13.00000	0.00000	90.00000	0.00000	0.00000	0.36780
72	14.00000	0.00000	90.00000	0.00000	0.00000	0.36920
73	15.00000	0.00000	90.00000	0.00000	0.00000	0.36200
74	16.00000	0.00000	90.00000	0.00000	0.00000	0.34940
75	17.00000	0.00000	90.00000	0.00000	0.00000	0.33500
76	18.00000	0.00000	90.00000	0.00000	0.00000	0.31570
77	19.00000	0.00000	90.00000	0.00000	0.00000	0.29720
78	20.00000	0.00000	90.00000	0.00000	0.00000	0.27860
79	21.00000	0.00000	90.00000	0.00000	0.00000	0.26030
80	22.00000	0.00000	90.00000	0.00000	0.00000	0.24280
81	23.00000	0.00000	90.00000	0.00000	0.00000	0.22620
82	24.00000	0.00000	90.00000	0.00000	0.00000	0.21050
83	25.00000	0.00000	90.00000	0.00000	0.00000	0.19520
84	26.00000	0.00000	90.00000	0.00000	0.00000	0.18220
85	27.00000	0.00000	90.00000	0.00000	0.00000	0.16950
86	28.00000	-11.60000	90.00000	0.00000	0.00000	-0.04900
87	6.79170	-10.63330	91.00000	0.00000	0.00000	-0.05030
88	7.08330	-9.66670	91.00000	0.00000	0.00000	-0.04850
89	7.37500	-8.70000	91.00000	0.00000	0.00000	-0.03220
90	7.66670	-7.73330	91.00000	0.00000	0.00000	-0.00540
91	7.95830	-6.76670	91.00000	0.00000	0.00000	0.02220
92	8.25000	-5.80000	91.00000	0.00000	0.00000	0.06540
93	8.54170	-4.83330	91.00000	0.00000	0.00000	0.10340
94	8.83330	-3.86670	91.00000	0.00000	0.00000	0.14050
95	9.12500	-2.90000	91.00000	0.00000	0.00000	0.17130
96	9.41670	-1.93330	91.00000	0.00000	0.00000	0.20070
97	9.70830	-0.96670	91.00000	0.00000	0.00000	0.23530
98	10.00000	0.00000	91.00000	0.00000	0.00000	0.25990
99	10.29170	0.96670	91.00000	0.00000	0.00000	0.28080
100	10.58330	1.93330	91.00000	0.00000	0.00000	0.29810
101	10.87500	2.90000	91.00000	0.00000	0.00000	0.31100
102	11.16670	3.86670	91.00000	0.00000	0.00000	0.32290



FAIRHURST

40 Frogmal Lane

Short-term Basement Excavation (Unloading, Wall Toe 5mbbl)

No. 40

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Ref.	Coordinates			Displacements		
	x [m]	y [m]	z [m]	x [mm]	y [mm]	z [mm]
103	11.45830	4.83330	91.00000	0.00000	0.00000	0.33070
104	11.75000	5.80000	91.00000	0.00000	0.00000	0.33590
105	12.04170	6.76670	91.00000	0.00000	0.00000	0.33840
106	12.33330	7.73330	91.00000	0.00000	0.00000	0.33850
107	12.62500	8.70000	91.00000	0.00000	0.00000	0.33630
108	12.91670	9.66670	91.00000	0.00000	0.00000	0.33190
109	13.20830	10.63330	91.00000	0.00000	0.00000	0.32560
110	13.50000	91.00000	0.00000	0.00000	0.00000	0.31740
1 - Data point coincident with displacement data. Its displacement has been added to those calculated by Xdisp.						
2 - Data point coincident with horizontal movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.						
6 - Data point coincident with vertical movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.						

Vertical Ground Movement Curves (Excavations)

Curve Name:	Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)]					
	[0.000,0.000,0.050][2.000,0.000,0.000]					
Curve Fitting Method:	Polynomial					
x Order:	1					
y Order:	0					
Polynomial: z =	-2.5E-2x + 5.0E-2					
Coeff. of Determination:	1.0					

Curve Name:	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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][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 (Excavations)

Curve Name:	Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)]					
	[0.000,0.000,0.081][0.050,0.000,0.076][0.100,0.000,0.072][0.150,0.000,0.067][0.200,0.000,0.063][0.250,0.000,0.059][0.300,0.000,0.056][0.350,0.000,0.052][0.400,0.000,0.049][0.450,0.000,0.045][0.500,0.000,0.043][0.550,0.000,0.040][0.600,0.000,0.037][0.650,0.000,0.034][0.700,0.000,0.032][0.750,0.000,0.029][0.800,0.000,0.027][0.850,0.000,0.024][0.900,0.000,0.022][0.950,0.000,0.020][1.000,0.000,0.018][1.050,0.000,0.016][1.100,0.000,0.014][1.150,0.000,0.012][1.200,0.000,0.011][1.250,0.000,0.009][1.300,0.000,0.007][1.350,0.000,0.005][1.400,0.000,0.004][1.450,0.000,0.002][1.500,0.000,0.000]					
Curve Fitting Method:	Polynomial					
x Order:	3					
y Order:	0					
Polynomial: z =	-1.0610E-2x ³ + 4.4203E-2x ² - 9.6358E-2x + 8.0901E-2					
Coeff. of Determination:	1.0000					

Curve Name:	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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					

Polygonal Excavations

Excavation Name:	Pool excavation					
Surface level [m]:	91.500					
Contribution:	Positive					
Enabled:	Yes					

Corner	x	y	Base Level	Stiffened	Previous Side	Next Side
	[m]	[m]	[m]		d p1 p2* [m] [%]	d p1 p2* [m] [%]
1	-4.0000	-11.600	86.500	Yes	0.0 67.000 25.000	0.0 67.000 25.000
2	2.2000	-11.600	86.500	Yes	0.0 67.000 25.000	0.0 67.000 25.000
3	2.2000	11.600	86.500	Yes	0.0 67.000 25.000	0.0 67.000 25.000
4	-4.0000	11.600	86.500	Yes	0.0 67.000 25.000	0.0 67.000 25.000

Side	Corner 1		Corner 2		Ground Movement Curve	
	x [m]	y [m]	x [m]	y [m]	Vertical	Horizontal
1	-4.0000	-11.600	2.2000	-11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
2	2.2000	-11.600	2.2000	11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
3	2.2000	11.600	-4.0000	11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
4	-4.0000	11.600	-4.0000	-11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))

Excavation Name:	Secant Pile Wall Installation					
Surface level [m]:	91.500					
Contribution:	Positive					
Enabled:	Yes					

Corner	x	y	Base Level	Stiffened	Previous Side	Next Side
					d p1 p2* d p1 p2*	



	[m]	[m]	[m]		[m]	[%]	[%]	[m]	[%]	[%]
1	-4.0000	-11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000
2	2.2000	-11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000
3	2.2000	11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000
4	-4.0000	11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000

Side	Corner 1		Corner 2		Ground Movement Curve					
	x	y	x	y	Vertical		Horizontal			
	[m]	[m]	[m]	[m]						
1	-4.0000	-11.600	2.2000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))		Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))			
2	2.2000	-11.600	2.2000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))		Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))			
3	2.2000	11.600	-4.0000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))		Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))			
4	-4.0000	11.600	-4.0000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))		Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))			

Damage Category Strains

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

Specific Structures - Geometry

Structure Name	Sub-Structure Name	Displacement Line	Start Distance Along Line	End Distance Along Line	Vertical Offsets from Line for Vertical Movement Calculations	Vertical Displacement Limit Sensitivity	Damage Category Strains	Poisson's Ratio	E/G
No. 40	West Wall	No. 40 West	[m]	[m]	[m]	[mm]	Burland Strain Limits	0.20000	2.6000
			0.00000	15.00000	0.0	0.10000			

Specific Structures - Bending Parameters

Structure Name	Sub-Structure Name	Height	Default Properties	Hogging			Sagging		
				2nd Moment of Area (per unit width)	Distance of Strain from N.A.	Distance of N.A. from Edge of Beam in Tension	2nd Moment of Area (per unit width)	Distance of Strain from N.A.	Distance of N.A. from Edge of Beam in Tension
No. 40	West Wall	[m]	12.000 Yes	[m ³]	[m]	[m]	[m ³]	[m]	[m]
				576.00	12.000	12.000	144.00	6.0000	6.0000

Building Segment Combinations

Structure Name	Sub-Structure Name	Vertical Offset from Line for Vertical Movement Calculations	Segment Start	Length	Curvature	Combined Segment
No structures have segments combined.						
		[m]	[m]	[m]		

Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Warnings

- 1 Multiple excavations have been specified. The displacements resulting from these excavations are calculated by summing the displacements resulting from each individual excavation. No account has been taken of the interactions between excavations (e.g. overlapping zones of influence or 'shielding' of one excavation by another).

Errors

None

Displacement and Strain Results

Type/No.	Coordinates				Displacements				Angle of Line to x Axis
	Name	Dist.	x	y	z	x	y	z	
			[m]	[m]	[m]	[mm]	[mm]	[mm]	[°]
No. 40 West	Line 1	[m]	-7.50000	0.00000	91.50000	11.401	0.0	6.2921	90.000 *
	1.0000	-7.50000	1.00000	91.50000	11.401	0.0	7.0314	0.0	-11.401 90.000 *
	2.0000	-7.50000	2.00000	91.50000	11.401	0.0	7.0352	0.0	-11.401 90.000 *
	3.0000	-7.50000	3.00000	91.50000	11.401	0.0	7.0425	0.0	-11.401 90.000 *
	4.0000	-7.50000	4.00000	91.50000	11.401	0.0	7.0548	0.0	-11.401 90.000 *
	5.0000	-7.50000	5.00000	91.50000	11.401	0.0	7.0741	0.0	-11.401 90.000 *
	6.0000	-7.50000	6.00000	91.50000	11.401	0.0	7.1030	0.0	-11.401 90.000 *
	7.0000	-7.50000	7.00000	91.50000	11.401	0.0	7.1450	0.0	-11.401 90.000 *
	8.0000	-7.50000	8.00000	91.50000	11.401	0.0	7.2033	0.0	-11.401 90.000 *
	9.0000	-7.50000	9.00000	91.50000	11.401	0.0	7.2810	0.0	-11.401 90.000 *
	10.000	-7.50000	10.00000	91.50000	11.401	0.0	7.3787	0.0	-11.401 90.000 *
	11.000	-7.50000	11.00000	91.50000	11.401	0.0	7.4928	0.0	-11.401 90.000 *
	12.000	-7.50000	12.00000	91.50000	6.1369	-0.37443	4.1972	-0.37443	-6.1369 90.000 *
	13.000	-7.50000	13.00000	91.50000	4.6230	-1.2245	3.9348	-1.2245	-4.6230 90.000 *
	14.000	-7.50000	14.00000	91.50000	3.3347	-1.8523	3.6804	-1.8523	-3.3347 90.000 *
	15.000	-7.50000	15.00000	91.50000	2.3489	-2.2390	3.5664	-2.2390	-2.3489 90.000 *

* Result includes imported displacement(s).

Specific Building Damage Results - Horizontal Displacements

Structure: No. 40 | Sub-structure: West Wall

Dist.	Coordinates			Displacements	
	x	y	z	Horizontal displacement	Horizontal displacement
				displacement	displacement

						along the Line	perpendicular to Line
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]
0.0	-7.50000	0.00000	91.50000	11.401	0.0	0.0	-11.401 d
1.0000	-7.50000	1.00000	91.50000	11.401	0.0	0.0	-11.401 d
2.0000	-7.50000	2.00000	91.50000	11.401	0.0	0.0	-11.401 d
3.0000	-7.50000	3.00000	91.50000	11.401	0.0	0.0	-11.401 d
4.0000	-7.50000	4.00000	91.50000	11.401	0.0	0.0	-11.401 d
5.0000	-7.50000	5.00000	91.50000	11.401	0.0	0.0	-11.401 d
6.0000	-7.50000	6.00000	91.50000	11.401	0.0	0.0	-11.401 d
7.0000	-7.50000	7.00000	91.50000	11.401	0.0	0.0	-11.401 d
8.0000	-7.50000	8.00000	91.50000	11.401	0.0	0.0	-11.401 d
9.0000	-7.50000	9.00000	91.50000	11.401	0.0	0.0	-11.401 d
10.000	-7.50000	10.00000	91.50000	11.401	0.0	0.0	-11.401 d
11.000	-7.50000	11.00000	91.50000	11.401	0.0	0.0	-11.401 d
12.001	-7.50000	12.00000	91.50000	6.1369	-0.37443	-0.37443	-6.1369 d
13.000	-7.50000	13.00000	91.50000	4.6230	-1.2245	-1.2245	-4.6230 d
14.000	-7.50000	14.00000	91.50000	3.3347	-1.8523	-1.8523	-3.3347 d
15.000	-7.50000	15.00000	91.50000	2.3489	-2.2390	-2.2390	-2.3489 d

d - Displacements include imported displacements.

Specific Building Damage Results - Vertical Displacements

Structure: No. 40 | Sub-structure: West Wall

Dist.	Coordinates			Displacements
[m]	x [m]	y [m]	z [m]	z [mm]

Vertical Offset 1				
0.0	-7.50000	0.00000	91.50000	6.2921 d
1.0000	-7.50000	1.00000	91.50000	7.0314 d
2.0000	-7.50000	2.00000	91.50000	7.0352 d
3.0000	-7.50000	3.00000	91.50000	7.0425 d
4.0000	-7.50000	4.00000	91.50000	7.0548 d
5.0000	-7.50000	5.00000	91.50000	7.0741 d
6.0000	-7.50000	6.00000	91.50000	7.1030 d
7.0000	-7.50000	7.00000	91.50000	7.1450 d
8.0000	-7.50000	8.00000	91.50000	7.2033 d
9.0000	-7.50000	9.00000	91.50000	7.2810 d
10.000	-7.50000	10.00000	91.50000	7.3787 d
11.000	-7.50000	11.00000	91.50000	7.4928 d
12.000	-7.50000	12.00000	91.50000	4.1972 d
13.000	-7.50000	13.00000	91.50000	3.9348 d
14.000	-7.50000	14.00000	91.50000	3.6804 d
15.000	-7.50000	15.00000	91.50000	3.5664 d

d - Displacements include imported displacements.

Specific Building Damage Results - All Segments

Structure: No. 40 | Sub-structure: West Wall

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]			[m]	
0.0	1	0.0	2.9724	Sagging	0.016231	0.0	0.015979	0.0	-739.30E-6	1086.7	0 (Negligible)
	2	2.9724	6.0496	Hogging	988.09E-6	0.0	972.28E-6	0.0	-97.700E-6	52789.0	0 (Negligible)
	3	9.0221	2.5634	Sagging	0.059642	-0.0085516	0.055754	374.57E-6	0.0032968	1062.2	1 (Very Slight)
	4	11.585	3.4145	Hogging	0.032868	-0.059151	0.024597	850.77E-6	0.0032968	1252.8	0 (Negligible)

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

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

Structure: No. 40 | Sub-structure: West Wall

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Max Slope	Max Settlement	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0.0	0.059642	-0.059151	0.0032968	7.4916	0.055754	850.77E-6	0.0032968	1252.8	1062.2	1 (Very Slight)

Specific Building Damage Results - Critical Segments within Each Structure

Structure Name	Parameter	Critical Sub-Structure	Critical Segment	Start	End	Curvature	Max Slope	Max Settlement	Max Tensile Strain	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
No. 40				[m]	[m]			[mm]	[%]			
	Max Slope	West Wall	3	9.0221	11.585	Sagging	0.0032968	7.4916	0.055754	-	1062.2	1 (Very Slight)
	Max Settlement	West Wall	3	9.0221	11.585	Sagging	0.0032968	7.4916	0.055754	-	1062.2	1 (Very Slight)
	Max Tensile Strain	West Wall	3	9.0221	11.585	Sagging	0.0032968	7.4916	0.055754	-	1062.2	1 (Very Slight)
	Min Radius of Curvature (Hogging)	West Wall	4	11.585	15.000	Hogging	0.0032968	5.5633	0.024597	1252.8	-	0 (Negligible)
	Min Radius of Curvature (Sagging)	West Wall	3	9.0221	11.585	Sagging	0.0032968	7.4916	0.055754	-	1062.2	1 (Very Slight)



Problem Type

Problem Type : Tunnelling and Embedded Wall Excavations

Displacement Data

Type	Name	Direction of extrusion	Point/Line/Line for extrusion						No. of intervals across extrusion/line	Extrusion depth	No. of intervals along extrusion	Calculate	Surface type for tunnels
			First point			Second point							
			X	Y	Z(level)	X	Y	Z(level)					
			[m]	[m]	[m]	[m]	[m]	[m]					
Line	No. 40 West	-	-7.50000	0.00000	91.50000	-7.50000	15.00000	91.50000	15	-	-	Yes	Surface

Imported Displacements

The following data points and displacements were found in the import file Pdisp Short term Loading to be Imported.csv.

Ref.	Coordinates			Displacements			
	x	y	z	x	y	z	
	[m]	[m]	[m]	[mm]	[mm]	[mm]	
1	-7.50000	0.00000	91.50000	0.00000	0.00000	0.17030	1,2,6
2	-7.50000	1.00000	91.50000	0.00000	0.00000	0.17010	1,2,6
3	-7.50000	2.00000	91.50000	0.00000	0.00000	0.16920	1,2,6
4	-7.50000	3.00000	91.50000	0.00000	0.00000	0.16750	1,2,6
5	-7.50000	4.00000	91.50000	0.00000	0.00000	0.16470	1,2,6
6	-7.50000	5.00000	91.50000	0.00000	0.00000	0.16020	1,2,6
7	-7.50000	6.00000	91.50000	0.00000	0.00000	0.15350	1,2,6
8	-7.50000	7.00000	91.50000	0.00000	0.00000	0.14380	1,2,6
9	-7.50000	8.00000	91.50000	0.00000	0.00000	0.13040	1,2,6
10	-7.50000	9.00000	91.50000	0.00000	0.00000	0.11250	1,2,6
11	-7.50000	10.00000	91.50000	0.00000	0.00000	0.08990	1,2,6
12	-7.50000	11.00000	91.50000	0.00000	0.00000	0.06360	1,2,6
13	-7.50000	12.00000	91.50000	0.00000	0.00000	0.03560	1,2,6
14	-7.50000	13.00000	91.50000	0.00000	0.00000	0.00910	1,2,6
15	-7.50000	14.00000	91.50000	0.00000	0.00000	-0.01370	1,2,6
16	-7.50000	15.00000	91.50000	0.00000	0.00000	-0.03160	1,2,6
17	-7.50000	0.00000	91.50000	0.00000	0.00000	0.17030	1,2,6
18	-8.42730	0.00000	91.50000	0.00000	0.00000	0.08170	
19	-9.35450	0.00000	91.50000	0.00000	0.00000	0.02110	
20	-10.28180	0.00000	91.50000	0.00000	0.00000	-0.02010	
21	-11.20910	0.00000	91.50000	0.00000	0.00000	-0.04770	
22	-12.13640	0.00000	91.50000	0.00000	0.00000	-0.06550	
23	-13.06360	0.00000	91.50000	0.00000	0.00000	-0.07650	
24	-13.99090	0.00000	91.50000	0.00000	0.00000	-0.08250	
25	-14.91820	0.00000	91.50000	0.00000	0.00000	-0.08510	
26	-15.84550	0.00000	91.50000	0.00000	0.00000	-0.08520	
27	-16.77270	0.00000	91.50000	0.00000	0.00000	-0.08360	
28	-17.70000	0.00000	91.50000	0.00000	0.00000	-0.08100	
29	-7.50000	15.00000	91.50000	0.00000	0.00000	-0.03160	1,2,6
30	-8.42730	15.00000	91.50000	0.00000	0.00000	-0.04490	
31	-9.35450	15.00000	91.50000	0.00000	0.00000	-0.05470	
32	-10.28180	15.00000	91.50000	0.00000	0.00000	-0.06150	
33	-11.20910	15.00000	91.50000	0.00000	0.00000	-0.06580	
34	-12.13640	15.00000	91.50000	0.00000	0.00000	-0.06810	
35	-13.06360	15.00000	91.50000	0.00000	0.00000	-0.06880	
36	-13.99090	15.00000	91.50000	0.00000	0.00000	-0.06840	
37	-14.91820	15.00000	91.50000	0.00000	0.00000	-0.06720	
38	-15.84550	15.00000	91.50000	0.00000	0.00000	-0.06530	
39	-16.77270	15.00000	91.50000	0.00000	0.00000	-0.06300	
40	-17.70000	15.00000	91.50000	0.00000	0.00000	-0.06040	
41	10.00000	-11.60000	90.00000	0.00000	0.00000	-0.06490	
42	10.16670	-10.63330	90.00000	0.00000	0.00000	-0.06520	
43	10.33330	-9.66670	90.00000	0.00000	0.00000	-0.06590	
44	10.50000	-8.70000	90.00000	0.00000	0.00000	-0.06690	
45	10.66670	-7.73330	90.00000	0.00000	0.00000	-0.06840	
46	10.83330	-6.76670	90.00000	0.00000	0.00000	-0.07010	
47	11.00000	-5.80000	90.00000	0.00000	0.00000	-0.07210	
48	11.16670	-4.83330	90.00000	0.00000	0.00000	-0.07400	
49	11.33330	-3.86670	90.00000	0.00000	0.00000	-0.07590	
50	11.50000	-2.90000	90.00000	0.00000	0.00000	-0.07770	
51	11.66670	-1.93330	90.00000	0.00000	0.00000	-0.07930	
52	11.83330	-0.96670	90.00000	0.00000	0.00000	-0.08060	
53	12.00000	0.00000	90.00000	0.00000	0.00000	-0.08160	
54	10.00000	-11.60000	90.00000	0.00000	0.00000	-0.06490	
55	11.00000	-11.60000	90.00000	0.00000	0.00000	-0.07080	
56	12.00000	-11.60000	90.00000	0.00000	0.00000	-0.07340	
57	13.00000	-11.60000	90.00000	0.00000	0.00000	-0.07370	
58	14.00000	-11.60000	90.00000	0.00000	0.00000	-0.07250	
59	15.00000	-11.60000	90.00000	0.00000	0.00000	-0.07030	
60	16.00000	-11.60000	90.00000	0.00000	0.00000	-0.06740	
61	17.00000	-11.60000	90.00000	0.00000	0.00000	-0.06420	
62	18.00000	-11.60000	90.00000	0.00000	0.00000	-0.06080	
63	19.00000	-11.60000	90.00000	0.00000	0.00000	-0.05740	
64	20.00000	-11.60000	90.00000	0.00000	0.00000	-0.05390	
65	21.00000	-11.60000	90.00000	0.00000	0.00000	-0.05060	
66	22.00000	-11.60000	90.00000	0.00000	0.00000	-0.04740	
67	23.00000	-11.60000	90.00000	0.00000	0.00000	-0.04440	
68	24.00000	-11.60000	90.00000	0.00000	0.00000	-0.04150	
69	25.00000	-11.60000	90.00000	0.00000	0.00000	-0.03880	
70	12.00000	0.00000	90.00000	0.00000	0.00000	-0.08160	
71	13.00000	0.00000	90.00000	0.00000	0.00000	-0.08490	
72	14.00000	0.00000	90.00000	0.00000	0.00000	-0.08520	
73	15.00000	0.00000	90.00000	0.00000	0.00000	-0.08350	
74	16.00000	0.00000	90.00000	0.00000	0.00000	-0.08060	
75	17.00000	0.00000	90.00000	0.00000	0.00000	-0.07700	
76	18.00000	0.00000	90.00000	0.00000	0.00000	-0.07290	
77	19.00000	0.00000	90.00000	0.00000	0.00000	-0.06860	
78	20.00000	0.00000	90.00000	0.00000	0.00000	-0.06430	
79	21.00000	0.00000	90.00000	0.00000	0.00000	-0.06010	
80	22.00000	0.00000	90.00000	0.00000	0.00000	-0.05600	
81	23.00000	0.00000	90.00000	0.00000	0.00000	-0.05220	
82	24.00000	0.00000	90.00000	0.00000	0.00000	-0.04860	
83	25.00000	0.00000	90.00000	0.00000	0.00000	-0.04520	
84	26.00000	0.00000	90.00000	0.00000	0.00000	-0.04200	
85	27.00000	0.00000	90.00000	0.00000	0.00000	-0.03910	
86	6.50000	-11.60000	91.00000	0.00000	0.00000	0.00800	
87	6.79170	-10.63330	91.00000	0.00000	0.00000	0.01160	
88	7.08330	-9.66670	91.00000	0.00000	0.00000	0.01120	
89	7.37500	-8.70000	91.00000	0.00000	0.00000	0.00740	
90	7.66670	-7.73330	91.00000	0.00000	0.00000	0.00120	
91	7.95830	-6.76670	91.00000	0.00000	0.00000	-0.00650	
92	8.25000	-5.80000	91.00000	0.00000	0.00000	-0.01510	
93	8.54170	-4.83330	91.00000	0.00000	0.00000	-0.02390	
94	8.83330	-3.86670	91.00000	0.00000	0.00000	-0.03240	
95	9.12500	-2.90000	91.00000	0.00000	0.00000	-0.04050	
96	9.41670	-1.93330	91.00000	0.00000	0.00000	-0.04780	
97	9.70830	-0.96670	91.00000	0.00000	0.00000	-0.05430	
98	10.00000	0.00000	91.00000	0.00000	0.00000	-0.06000	
99	10.29170	0.96670	91.00000	0.00000	0.00000	-0.06480	
100	10.58330	1.93330	91.00000	0.00000	0.00000	-0.06880	
101	10.87500	2.90000	91.00000	0.00000	0.00000	-0.07200	
102	11.16670	3.86670	91.00000	0.00000	0.00000	-0.07450	



FAIRHURST

40 Frogнал Lane

Short-term Loading, Wall Toe 5mbbl

No. 40

Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Ref.	Coordinates		Displacements			
	x [m]	y [m]	z [m]	x [mm]	y [mm]	z [mm]
103	11.45830	4.83330	91.00000	0.00000	0.00000	-0.07630
104	11.75000	5.80000	91.00000	0.00000	0.00000	-0.07750
105	12.04170	6.76670	91.00000	0.00000	0.00000	-0.07810
106	12.33330	7.73330	91.00000	0.00000	0.00000	-0.07810
107	12.62500	8.70000	91.00000	0.00000	0.00000	-0.07760
108	12.91670	9.66670	91.00000	0.00000	0.00000	-0.07660
109	13.20830	10.63330	91.00000	0.00000	0.00000	-0.07510
110	13.50000	11.60000	91.00000	0.00000	0.00000	-0.07320
1 - Data point coincident with displacement data. Its displacement has been added to those calculated by Xdisp.						
2 - Data point coincident with horizontal movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.						
6 - Data point coincident with vertical movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.						
Vertical Ground Movement Curves (Excavations)						
Curve Name:	Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)]					
	[0.000,0.000,0.050][2.000,0.000,0.000]					
Curve Fitting Method:	Polynomial					
x Order:	1					
y Order:	0					
Polynomial: z =	-2.5E-2x + 5.0E-2					
Coeff. of Determination:	1.0					
Curve Name:	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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][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 (Excavations)						
Curve Name:	Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)]					
	[0.000,0.000,0.081][0.050,0.000,0.076][0.100,0.000,0.072][0.150,0.000,0.067][0.200,0.000,0.063][0.250,0.000,0.059][0.300,0.000,0.056][0.350,0.000,0.052][0.400,0.000,0.049][0.450,0.000,0.045][0.500,0.000,0.043][0.550,0.000,0.040][0.600,0.000,0.037][0.650,0.000,0.034][0.700,0.000,0.032][0.750,0.000,0.029][0.800,0.000,0.027][0.850,0.000,0.024][0.900,0.000,0.022][0.950,0.000,0.020][1.000,0.000,0.018][1.050,0.000,0.016][1.100,0.000,0.014][1.150,0.000,0.012][1.200,0.000,0.011][1.250,0.000,0.009][1.300,0.000,0.007][1.350,0.000,0.005][1.400,0.000,0.004][1.450,0.000,0.002][1.500,0.000,0.000]					
Curve Fitting Method:	Polynomial					
x Order:	3					
y Order:	0					
Polynomial: z =	-1.0610E-2x ³ + 4.4203E-2x ² - 9.6358E-2x + 8.0901E-2					
Coeff. of Determination:	1.0000					
Curve Name:	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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					
Polygonal Excavations						
Excavation Name:	Pool excavation					
Surface Level [m]:	91.500					
Contribution:	Positive					
Enabled:	Yes					
Corner	x	y	Base Level	Stiffened	Previous Side	Next Side
	[m]	[m]	[m]		d p1 p2*	d p1 p2*
					[m] [%]	[m] [%]
1	-4.0000	-11.600	86.500	Yes	0.0 67.000 25.000	0.0 67.000 25.000
2	2.2000	-11.600	86.500	Yes	0.0 67.000 25.000	0.0 67.000 25.000
3	2.2000	11.600	86.500	Yes	0.0 67.000 25.000	0.0 67.000 25.000
4	-4.0000	11.600	86.500	Yes	0.0 67.000 25.000	0.0 67.000 25.000
Side	Corner 1		Corner 2		Ground Movement Curve	
	x	y	x	y	Vertical	Horizontal
	[m]	[m]	[m]	[m]		
1	-4.0000	-11.600	2.2000	-11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
2	2.2000	-11.600	2.2000	11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
3	2.2000	11.600	-4.0000	11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
4	-4.0000	11.600	-4.0000	-11.600	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b))	Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))
Excavation Name:	Secant Pile Wall Installation					
Surface Level [m]:	91.500					
Contribution:	Positive					
Enabled:	Yes					
Corner	x	y	Base Level	Stiffened	Previous Side	Next Side
					d p1 p2*	d p1 p2*

40 Frogнал Lane
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No. 40

	[m]	[m]	[m]		[m]	[%]	[%]	[m]	[%]	[%]
1	-4.0000	-11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000
2	2.2000	-11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000
3	2.2000	11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000
4	-4.0000	11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000

Side	Corner 1		Corner 2		Vertical		Ground Movement Curve		Horizontal	
	x	y	x	y						
	[m]	[m]	[m]	[m]						
1	-4.0000	-11.600	2.2000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))		Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))			
2	2.2000	-11.600	2.2000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))		Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))			
3	2.2000	11.600	-4.0000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))		Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))			
4	-4.0000	11.600	-4.0000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))		Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))			

Damage Category Strains

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

Specific Structures - Geometry

Structure Name	Sub-Structure Name	Displacement Line	Start Distance Along Line	End Distance Along Line	Vertical Offsets from Line for Vertical Movement Calculations	Vertical Displacement Limit Sensitivity	Damage Category Strains	Poisson's Ratio	E/G
No. 40	West Wall	No. 40 West	[m]	[m]	[m]	[mm]	Burland Strain Limits	0.20000	2.6000
			0.00000	15.00000	0.0	0.10000			

Specific Structures - Bending Parameters

Structure Name	Sub-Structure Name	Height	Default Properties	Hogging		Sagging	
				2nd Moment of Area (per unit width)	Distance of Bending Strain from N.A.	2nd Moment of Area (per unit width)	Distance of Bending Strain from N.A.
No. 40	West Wall	[m]	Yes	[m³]	[m]	[m³]	[m]
		12.000		576.00	12.000	144.00	6.0000

Building Segment Combinations

Structure Name	Sub-Structure Name	Vertical Offset from Line for Vertical Movement Calculations	Segment Start	Length	Curvature	Combined Segment
No structures have segments combined.						
		[m]	[m]	[m]		

Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Warnings

- 1 Multiple excavations have been specified. The displacements resulting from these excavations are calculated by summing the displacements resulting from each individual excavation. No account has been taken of the interactions between excavations (e.g. overlapping zones of influence or 'shielding' of one excavation by another).

Errors

None

Displacement and Strain Results

Type/No.	Coordinates				Displacements				Angle of Line to x Axis
	Name	Dist.	x	y	z	x	y	z	
			[m]	[m]	[m]	[mm]	[mm]	[mm]	[°]
No. 40 West	Line 1	[m]	-7.50000	0.00000	91.50000	11.401	0.0	8.1089	90.000 *
	1.0000	-7.50000	1.00000	91.50000	11.401	0.0	7.9384	0.0	-11.401 90.000 *
	2.0000	-7.50000	2.00000	91.50000	11.401	0.0	7.9375	0.0	-11.401 90.000 *
	3.0000	-7.50000	3.00000	91.50000	11.401	0.0	7.9358	0.0	-11.401 90.000 *
	4.0000	-7.50000	4.00000	91.50000	11.401	0.0	7.9330	0.0	-11.401 90.000 *
	5.0000	-7.50000	5.00000	91.50000	11.401	0.0	7.9285	0.0	-11.401 90.000 *
	6.0000	-7.50000	6.00000	91.50000	11.401	0.0	7.9218	0.0	-11.401 90.000 *
	7.0000	-7.50000	7.00000	91.50000	11.401	0.0	7.9121	0.0	-11.401 90.000 *
	8.0000	-7.50000	8.00000	91.50000	11.401	0.0	7.8987	0.0	-11.401 90.000 *
	9.0000	-7.50000	9.00000	91.50000	11.401	0.0	7.8808	0.0	-11.401 90.000 *
	10.000	-7.50000	10.00000	91.50000	11.401	0.0	7.8582	0.0	-11.401 90.000 *
	11.000	-7.50000	11.00000	91.50000	11.401	0.0	7.8319	0.0	-11.401 90.000 *
	12.000	-7.50000	12.00000	91.50000	6.1369	-0.37443	4.3873	-0.37443	-6.1369 90.000 *
	13.000	-7.50000	13.00000	91.50000	4.6230	-1.2245	3.9833	-1.2245	-4.6230 90.000 *
	14.000	-7.50000	14.00000	91.50000	3.3347	-1.8523	3.6073	-1.8523	-3.3347 90.000 *
	15.000	-7.50000	15.00000	91.50000	2.3489	-2.2390	3.2294	-2.2390	-2.3489 90.000 *

* Result includes imported displacement(s).

Specific Building Damage Results - Horizontal Displacements

Structure: No. 40 | Sub-structure: West Wall

Dist.	Coordinates			Displacements	
	x	y	z	Horizontal displacement	Horizontal displacement
				displacement	displacement

					along the Line		perpendicular to Line		
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	
0.0	-7.50000	0.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
1.0000	-7.50000	1.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
2.0000	-7.50000	2.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
3.0000	-7.50000	3.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
4.0000	-7.50000	4.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
5.0000	-7.50000	5.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
6.0000	-7.50000	6.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
7.0000	-7.50000	7.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
8.0000	-7.50000	8.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
9.0000	-7.50000	9.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
10.000	-7.50000	10.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
11.000	-7.50000	11.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
12.000	-7.50000	12.00000	91.50000	6.1369	-0.37443	-0.37443	-6.1369	d	
13.000	-7.50000	13.00000	91.50000	4.6230	-1.2245	-1.2245	-4.6230	d	
14.000	-7.50000	14.00000	91.50000	3.3347	-1.8523	-1.8523	-3.3347	d	
15.000	-7.50000	15.00000	91.50000	2.3489	-2.2390	-2.2390	-2.3489	d	
d - Displacements include imported displacements.									

Specific Building Damage Results - Vertical Displacements

Structure: No. 40 | Sub-structure: West Wall

Dist.	Coordinates			Displacements	
	x	y	z	z	
[m]	[m]	[m]	[m]	[mm]	
Vertical Offset 1					
0.0	-7.50000	0.00000	91.50000	8.1089	d
1.0000	-7.50000	1.00000	91.50000	7.9384	d
2.0000	-7.50000	2.00000	91.50000	7.9375	d
3.0000	-7.50000	3.00000	91.50000	7.9358	d
4.0000	-7.50000	4.00000	91.50000	7.9330	d
5.0000	-7.50000	5.00000	91.50000	7.9285	d
6.0000	-7.50000	6.00000	91.50000	7.9218	d
7.0000	-7.50000	7.00000	91.50000	7.9121	d
8.0000	-7.50000	8.00000	91.50000	7.8987	d
9.0000	-7.50000	9.00000	91.50000	7.8808	d
10.000	-7.50000	10.00000	91.50000	7.8582	d
11.000	-7.50000	11.00000	91.50000	7.8319	d
12.000	-7.50000	12.00000	91.50000	4.3873	d
13.000	-7.50000	13.00000	91.50000	3.9833	d
14.000	-7.50000	14.00000	91.50000	3.6073	d
15.000	-7.50000	15.00000	91.50000	3.2294	d
d - Displacements include imported displacements.					

Specific Building Damage Results - All Segments

Structure: No. 40 | Sub-structure: West Wall

Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]			[m]	
0.0	1	0.0	2.9726	Hogging	0.0037428		0.0	0.0037282	0.0	170.50E-6	4712.5 0 (Negligible)
	2	2.9726	8.6124	Sagging	0.021667	-0.0025434	0.018589	374.57E-6	0.0034459	1055.1 0 (Negligible)	
	3	11.585	2.7974	Hogging	0.038499	-0.063670	0.028674	850.77E-6	0.0034459	1291.5 0 (Negligible)	
	4	14.382	0.61754	None	0.0	-0.038666	0.0077332	386.81E-6	378.05E-6	108890. 0 (Negligible)	

Tensile horizontal strains are +ve, compressive horizontal strains are -ve.

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

Structure: No. 40 | Sub-structure: West Wall

Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Max Slope	Max Settlement	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0.0	0.038499	-0.063670	0.0034459	8.1089	0.028674	850.77E-6	0.0034459	1291.5	1055.1 0 (Negligible)	

Specific Building Damage Results - Critical Segments within Each Structure

Structure Name	Parameter	Critical Sub-Structure	Critical Segment	Start	End	Curvature	Max Slope	Max Settlement	Max Tensile Strain	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
No. 40	Max Slope	West Wall		2	2.9726	11.585	Sagging	0.0034459	7.9358	0.018589	- 1055.1 0 (Negligible)	
	Max Settlement	West Wall		1	0.0	2.9726	Hogging	170.50E-6	8.1089	0.0037282	4712.5 - 0 (Negligible)	
	Max Tensile Strain	West Wall		3	11.585	14.382	Hogging	0.0034459	5.8167	0.028674	1291.5 - 0 (Negligible)	
	Min Radius of Curvature (Hogging)	West Wall		3	11.585	14.382	Hogging	0.0034459	5.8167	0.028674	1291.5 - 0 (Negligible)	
	Min Radius of Curvature (Sagging)	West Wall		2	2.9726	11.585	Sagging	0.0034459	7.9358	0.018589	- 1055.1 0 (Negligible)	



Job No.	Sheet No.	Rev.
141396		
Drg. Ref.		
Made by JC	Date 10-Feb-2021	Checked

Problem Type

Problem Type : Tunnelling and Embedded Wall Excavations

Displacement Data

Type	Name	Direction of extrusion	Point/Line/Line for extrusion						No. of intervals across extrusion/line	Extrusion depth	No. of intervals along extrusion	Calculate	Surface type for tunnels
			First point			Second point							
			X	Y	Z(level)	X	Y	Z(level)					
			[m]	[m]	[m]	[m]	[m]	[m]					
Line	No. 40 West	-	-7.50000	0.00000	91.50000	-7.50000	15.00000	91.50000	15	-	-	Yes	Surface

Imported Displacements

The following data points and displacements were found in the import file Pdisp Long term Loading to be Imported.csv.

Ref.	Coordinates			Displacements			
	x	y	z	x	y	z	
	[m]	[m]	[m]	[mm]	[mm]	[mm]	
1	-7.50000	0.00000	91.50000	0.00000	0.00000	0.86030	1,2,6
2	-7.50000	1.00000	91.50000	0.00000	0.00000	0.85840	1,2,6
3	-7.50000	2.00000	91.50000	0.00000	0.00000	0.85260	1,2,6
4	-7.50000	3.00000	91.50000	0.00000	0.00000	0.84250	1,2,6
5	-7.50000	4.00000	91.50000	0.00000	0.00000	0.82750	1,2,6
6	-7.50000	5.00000	91.50000	0.00000	0.00000	0.80660	1,2,6
7	-7.50000	6.00000	91.50000	0.00000	0.00000	0.77880	1,2,6
8	-7.50000	7.00000	91.50000	0.00000	0.00000	0.74270	1,2,6
9	-7.50000	8.00000	91.50000	0.00000	0.00000	0.69680	1,2,6
10	-7.50000	9.00000	91.50000	0.00000	0.00000	0.64020	1,2,6
11	-7.50000	10.00000	91.50000	0.00000	0.00000	0.57280	1,2,6
12	-7.50000	11.00000	91.50000	0.00000	0.00000	0.49670	1,2,6
13	-7.50000	12.00000	91.50000	0.00000	0.00000	0.41690	1,2,6
14	-7.50000	13.00000	91.50000	0.00000	0.00000	0.33950	1,2,6
15	-7.50000	14.00000	91.50000	0.00000	0.00000	0.26980	1,2,6
16	-7.50000	15.00000	91.50000	0.00000	0.00000	0.21050	1,2,6
17	-7.50000	0.00000	91.50000	0.00000	0.00000	0.86030	1,2,6
18	-8.42730	0.00000	91.50000	0.00000	0.00000	0.64620	
19	-9.35450	0.00000	91.50000	0.00000	0.00000	0.48830	
20	-10.28180	0.00000	91.50000	0.00000	0.00000	0.37000	
21	-11.20910	0.00000	91.50000	0.00000	0.00000	0.28060	
22	-12.13640	0.00000	91.50000	0.00000	0.00000	0.21260	
23	-13.06360	0.00000	91.50000	0.00000	0.00000	0.16070	
24	-13.99090	0.00000	91.50000	0.00000	0.00000	0.12090	
25	-14.91820	0.00000	91.50000	0.00000	0.00000	0.09040	
26	-15.84550	0.00000	91.50000	0.00000	0.00000	0.06700	
27	-16.77270	0.00000	91.50000	0.00000	0.00000	0.04900	
28	-17.70000	0.00000	91.50000	0.00000	0.00000	0.03510	
29	-7.50000	15.00000	91.50000	0.00000	0.00000	0.21050	1,2,6
30	-8.42730	15.00000	91.50000	0.00000	0.00000	0.16900	
31	-9.35450	15.00000	91.50000	0.00000	0.00000	0.13430	
32	-10.28180	15.00000	91.50000	0.00000	0.00000	0.10570	
33	-11.20910	15.00000	91.50000	0.00000	0.00000	0.08240	
34	-12.13640	15.00000	91.50000	0.00000	0.00000	0.06350	
35	-13.06360	15.00000	91.50000	0.00000	0.00000	0.04830	
36	-13.99090	15.00000	91.50000	0.00000	0.00000	0.03610	
37	-14.91820	15.00000	91.50000	0.00000	0.00000	0.02640	
38	-15.84550	15.00000	91.50000	0.00000	0.00000	0.01870	
39	-16.77270	15.00000	91.50000	0.00000	0.00000	0.01250	
40	-17.70000	15.00000	91.50000	0.00000	0.00000	0.00770	
41	10.00000	-11.60000	90.00000	0.00000	0.00000	0.12510	
42	10.16670	-10.63330	90.00000	0.00000	0.00000	0.13470	
43	10.33330	-9.66670	90.00000	0.00000	0.00000	0.14240	
44	10.50000	-8.70000	90.00000	0.00000	0.00000	0.14810	
45	10.66670	-7.73330	90.00000	0.00000	0.00000	0.15170	
46	10.83330	-6.76670	90.00000	0.00000	0.00000	0.15350	
47	11.00000	-5.80000	90.00000	0.00000	0.00000	0.15350	
48	11.16670	-4.83330	90.00000	0.00000	0.00000	0.15190	
49	11.33330	-3.86670	90.00000	0.00000	0.00000	0.14910	
50	11.50000	-2.90000	90.00000	0.00000	0.00000	0.14510	
51	11.66670	-1.93330	90.00000	0.00000	0.00000	0.14020	
52	11.83330	-0.96670	90.00000	0.00000	0.00000	0.13460	
53	12.00000	0.00000	90.00000	0.00000	0.00000	0.12930	
54	10.00000	-11.60000	90.00000	0.00000	0.00000	0.12510	
55	11.00000	-11.60000	90.00000	0.00000	0.00000	0.09250	
56	12.00000	-11.60000	90.00000	0.00000	0.00000	0.06780	
57	13.00000	-11.60000	90.00000	0.00000	0.00000	0.04900	
58	14.00000	-11.60000	90.00000	0.00000	0.00000	0.03480	
59	15.00000	-11.60000	90.00000	0.00000	0.00000	0.02390	
60	16.00000	-11.60000	90.00000	0.00000	0.00000	0.01570	
61	17.00000	-11.60000	90.00000	0.00000	0.00000	0.00940	
62	18.00000	-11.60000	90.00000	0.00000	0.00000	0.00470	
63	19.00000	-11.60000	90.00000	0.00000	0.00000	0.00110	
64	20.00000	-11.60000	90.00000	0.00000	0.00000	-0.00150	
65	21.00000	-11.60000	90.00000	0.00000	0.00000	-0.00350	
66	22.00000	-11.60000	90.00000	0.00000	0.00000	-0.00490	
67	23.00000	-11.60000	90.00000	0.00000	0.00000	-0.00600	
68	24.00000	-11.60000	90.00000	0.00000	0.00000	-0.00670	
69	25.00000	-11.60000	90.00000	0.00000	0.00000	-0.00710	
70	12.00000	0.00000	90.00000	0.00000	0.00000	0.12830	
71	13.00000	0.00000	90.00000	0.00000	0.00000	0.09390	
72	14.00000	0.00000	90.00000	0.00000	0.00000	0.06800	
73	15.00000	0.00000	90.00000	0.00000	0.00000	0.04850	
74	16.00000	0.00000	90.00000	0.00000	0.00000	0.03380	
75	17.00000	0.00000	90.00000	0.00000	0.00000	0.02270	
76	18.00000	0.00000	90.00000	0.00000	0.00000	0.01440	
77	19.00000	0.00000	90.00000	0.00000	0.00000	0.00810	
78	20.00000	0.00000	90.00000	0.00000	0.00000	0.00350	
79	21.00000	0.00000	90.00000	0.00000	0.00000	0.00000	
80	22.00000	0.00000	90.00000	0.00000	0.00000	-0.00250	
81	23.00000	0.00000	90.00000	0.00000	0.00000	-0.00440	
82	24.00000	0.00000	90.00000	0.00000	0.00000	-0.00570	
83	25.00000	0.00000	90.00000	0.00000	0.00000	-0.00660	
84	26.00000	0.00000	90.00000	0.00000	0.00000	-0.00720	
85	27.00000	0.00000	90.00000	0.00000	0.00000	-0.00760	
86	6.50000	-11.60000	91.00000	0.00000	0.00000	0.35240	
87	6.79170	-10.63330	91.00000	0.00000	0.00000	0.37310	
88	7.08330	-9.66670	91.00000	0.00000	0.00000	0.38390	
89	7.37500	-8.70000	91.00000	0.00000	0.00000	0.38570	
90	7.66670	-7.73330	91.00000	0.00000	0.00000	0.38030	
91	7.95830	-6.76670	91.00000	0.00000	0.00000	0.36940	
92	8.25000	-5.80000	91.00000	0.00000	0.00000	0.35460	
93	8.54170	-4.83330	91.00000	0.00000	0.00000	0.33700	
94	8.83330	-3.86670	91.00000	0.00000	0.00000	0.31770	
95	9.12500	-2.90000	91.00000	0.00000	0.00000	0.29740	
96	9.41670	-1.93330	91.00000	0.00000	0.00000	0.27670	
97	9.70830	-0.96670	91.00000	0.00000	0.00000	0.25580	
98	10.00000	0.00000	91.00000	0.00000	0.00000	0.23520	
99	10.29170	0.96670	91.00000	0.00000	0.00000	0.21480	
100	10.58330	1.93330	91.00000	0.00000	0.00000	0.19490	
101	10.87500	2.90000	91.00000	0.00000	0.00000	0.17560	
102	11.16670	3.86670	91.00000	0.00000	0.00000	0.15690	

Oasys

FAIRHURST

40 Frogнал Lane

Long-term Loading, Wall Toe 5mbbl

No. 40

Job No.

Sheet No.

Rev.

141396

Drg. Ref.

Made by

Date

Checked

JC

10-Feb-2021

Ref.

Coordinates

Displacements

x

y

z

x

y

z

[m]

[m]

[m]

[mm]

[mm]

[mm]

103 11.45830 4.83330 91.00000 0.00000 0.00000 0.13890

104 11.75000 5.80000 91.00000 0.00000 0.00000 0.12170

105 12.04170 6.76670 91.00000 0.00000 0.00000 0.10550

106 12.33330 7.73330 91.00000 0.00000 0.00000 0.09020

107 12.62500 8.70000 91.00000 0.00000 0.00000 0.07610

108 12.91670 9.66670 91.00000 0.00000 0.00000 0.06320

109 13.20830 10.63330 91.00000 0.00000 0.00000 0.05170

110 13.50000 11.60000 91.00000 0.00000 0.00000 0.04140

1 - Data point coincident with displacement data. Its displacement has been added to those calculated by Xdisp.

2 - Data point coincident with horizontal movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.

6 - Data point coincident with vertical movement calculation point for a specific building. Its displacement has been added before performing building damage calculations.

Vertical Ground Movement Curves (Excavations)

Curve Name:

Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)]

[0.000,0.000,0.050][2.000,0.000,0.000]

Curve Fitting

Polynomial

Method:

1

x Order:

0

y Order:

0

Polynomial: z =

-2.5E-2x + 5.0E-2

Coeff. of

1.0

Determination:

Curve Name:

Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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][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

Polynomial

Method:

4

x Order:

0

y Order:

0

Polynomial: z =

-2.6455E-3x⁴ + 2.8495E-2x³ - 1.0051E-1x² + 1.0569E-1x + 3.8990E-2

Coeff. of

9.9991E-1

Determination:

Horizontal Ground Movement Curves (Excavations)

Curve Name:

Installation of secant bored pile wall in stiff clay (CIRIA 580 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) (%)]

[0.000,0.000,0.081][0.050,0.000,0.076][0.100,0.000,0.072][0.150,0.000,0.067][0.200,0.000,0.063][0.250,0.000,0.059][0.300,0.000,0.056][0.350,0.000,0.052][0.400,0.000,0.049][0.450,0.000,0.045][0.500,0.000,0.043][0.550,0.000,0.040][0.600,0.000,0.037][0.650,0.000,0.034][0.700,0.000,0.032][0.750,0.000,0.029][0.800,0.000,0.027][0.850,0.000,0.024][0.900,0.000,0.022][0.950,0.000,0.020][1.000,0.000,0.018][1.050,0.000,0.016][1.100,0.000,0.014][1.150,0.000,0.012][1.200,0.000,0.011][1.250,0.000,0.009][1.300,0.000,0.007][1.350,0.000,0.005][1.400,0.000,0.004][1.450,0.000,0.002][1.500,0.000,0.000]

Curve Fitting

Polynomial

Method:

3

x Order:

0

y Order:

0

Polynomial: z =

-1.0610E-2x³ + 4.4203E-2x² - 9.6358E-2x + 8.0901E-2

Coeff. of

1.0000

Determination:

Curve Name:

Excavation in front of high stiffness wall in stiff clay (CIRIA 580 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

Polynomial

Method:

1

x Order:

0

y Order:

0

Polynomial: z =

-3.75E-2x + 1.50E-1

Coeff. of

1.00

Determination:

Polygonal Excavations

Excavation Name:

Pool excavation

Surface level [m]:

91.500

Contribution:

Positive

Enabled:

Yes

Corner

x

y

Base Level

Stiffened

Previous Side

Next Side

[m]

[m]

[m]

d

p1

p2*

d

p1

p2*

[m]

[m]

[m]

[m]

[m]

[m]

[m]

[m]

[m]

1 -4.0000 -11.600 86.500 Yes 0.0 67.000 25.000 0.0 67.000 25.000

2 2.2000 -11.600 86.500 Yes 0.0 67.000 25.000 0.0 67.000 25.000

3 2.2000 11.600 86.500 Yes 0.0 67.000 25.000 0.0 67.000 25.000

4 -4.0000 11.600 86.500 Yes 0.0 67.000 25.000 0.0 67.000 25.000

Side

Corner 1

Corner 2

Ground Movement Curve

x

y

x

y

Vertical

Horizontal

[m]

[m]

[m]

[m]

1 -4.0000 -11.600 2.2000 -11.600 Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b)) Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))

2 2.2000 -11.600 2.2000 11.600 Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b)) Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))

3 2.2000 11.600 -4.0000 11.600 Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b)) Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))

4 -4.0000 11.600 -4.0000 -11.600 Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(b)) Excavation in front of high stiffness wall in stiff clay (CIRIA 580 Fig. 2.11(a))

Excavation Name:

Secant Pile Wall Installation

Surface level [m]:

91.500

Contribution:

Positive

Enabled:

Yes

Corner

x

y

Base Level

Stiffened

Previous Side

Next Side

d

p1

p2*

d

p1

p2*

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X:\a...\141396 Frogнал Lane Long-term Loading Xdisp - Wall Toe 5mbbl (West Wall).xdd

Page 2

Printed 15-Feb-2021

Time 10:52

40 Frognal Lane

Long-term Loading, Wall Toe 5mbbl

No. 40

	[m]	[m]	[m]		[m]	[°]	[°]	[m]	[°]	[°]
1	-4.0000	-11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000
2	2.2000	-11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000
3	2.2000	11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000
4	4.2000	11.600	81.500	Yes	0.0	50.000	20.000	0.0	50.000	20.000

Side	Corner 1		Corner 2		Ground Movement Curve	
	x [m]	y [m]	x [m]	y [m]	Vertical	Horizontal
1	-4.0000	-11.600	2.2000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
2	2.2000	-11.600	2.2000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
3	2.2000	11.600	-4.0000	11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))
4	-4.0000	11.600	-4.0000	-11.600	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(b))	Installation of secant bored pile wall in stiff clay (CIRIA 580 Fig. 2.8(a))

Damage Category Strains

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

Specific Structures - Geometry

Structure Name	Sub-Structure Name	Displacement Line	Start Distance Along Line	End Distance Along Line	Vertical Offsets from Line for Vertical Movement Calculations	Vertical Displacement Limit Sensitivity	Damage Category	Strains	Poisson's Ratio	E/G
No. 40	West Wall	No. 40 West	[m] 0.00000	[m] 15.00000	[m] 0.0	[mm] 0.10000	Burland	Strain Limits	0.20000	2.60000

Specific Structures - Bending Parameters

Structure Name	Sub-Structure Name	Height	Default Properties	Hogging			Sagging		
				2nd Moment of Area (per unit width)	Distance of Bending Strain from N.A.	Distance of N.A. from Edge of Beam in Tension	2nd Moment of Area (per unit width)	Distance of Bending Strain from N.A.	Distance of N.A. from Edge of Beam in Tension
No. 40	West Wall	12.000	Yes	m^4 576.00	m 12.000	m 12.000	m^4 144.00	m 6.0000	m 6.0000

Building Segment Combinations

Structure Name	Sub-Structure Name	Vertical Offset from Line for Vertical Movement Calculations	Segment Start	Length	Curvature	Combined Segment
No structures have segments combined.						

Utility Strain Calculation Options

Neglect beneficial contribution of axial strains : No

Warnings

1 Multiple excavations have been specified. The displacements resulting from these excavations are calculated by summing the displacements resulting from each individual excavation. No account has been taken of the interactions between excavations (e.g. overlapping zones of influence or 'shielding' of one excavation by another).

Errors

None

Displacement and Strain Results

Type/No.		Coordinates			Displacements					Angle of Line	
Name	Dist.	x	y	z	x	y	z	Horizontal displacement along Line	Horizontal displacement perpendicular to Line	to x Axis	
No. 40	[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	[°]	
West	Line 1	-7.50000	0.00000	91.50000	11.401	0.0	9.4889	0.0	-11.401	90.000 *	
	1.0000	-7.50000	1.00000	91.50000	11.401	0.0	8.6267	0.0	-11.401	90.000 *	
	2.0000	-7.50000	2.00000	91.50000	11.401	0.0	8.6209	0.0	-11.401	90.000 *	
	3.0000	-7.50000	3.00000	91.50000	11.401	0.0	8.6108	0.0	-11.401	90.000 *	
	4.0000	-7.50000	4.00000	91.50000	11.401	0.0	8.5958	0.0	-11.401	90.000 *	
	5.0000	-7.50000	5.00000	91.50000	11.401	0.0	8.5749	0.0	-11.401	90.000 *	
	6.0000	-7.50000	6.00000	91.50000	11.401	0.0	8.5471	0.0	-11.401	90.000 *	
	7.0000	-7.50000	7.00000	91.50000	11.401	0.0	8.5110	0.0	-11.401	90.000 *	
	8.0000	-7.50000	8.00000	91.50000	11.401	0.0	8.4651	0.0	-11.401	90.000 *	
	9.0000	-7.50000	9.00000	91.50000	11.401	0.0	8.4085	0.0	-11.401	90.000 *	
	10.000	-7.50000	10.00000	91.50000	11.401	0.0	8.3411	0.0	-11.401	90.000 *	
	11.000	-7.50000	11.00000	91.50000	11.401	0.0	8.2650	0.0	-11.401	90.000 *	
	12.000	-7.50000	12.00000	91.50000	6.1369	-0.37443	4.7686	-0.37443	-6.1369	90.000 *	
	13.000	-7.50000	13.00000	91.50000	4.6230	-1.2245	4.3137	-1.2245	-4.6230	90.000 *	
	14.000	-7.50000	14.00000	91.50000	3.3347	-1.852	3.8908	-1.8523	-3.3447	90.000 *	
	15.000	-7.50000	15.00000	91.50000	2.3489	-2.2390	3.7136	-2.2390	-2.3489	90.000 *	

* Result includes imported displacement(s).

Specific Building Damage Results - Horizontal Displacements

Structure: No. 40 | Sub-structure: West Wall

[illegible]

					along the Line		perpendicular to Line		
[m]	[m]	[m]	[m]	[mm]	[mm]	[mm]	[mm]	[mm]	
0.0	-7.50000	0.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
1.0000	-7.50000	1.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
2.0000	-7.50000	2.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
3.0000	-7.50000	3.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
4.0000	-7.50000	4.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
5.0000	-7.50000	5.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
6.0000	-7.50000	6.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
7.0000	-7.50000	7.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
8.0000	-7.50000	8.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
9.0000	-7.50000	9.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
10.000	-7.50000	10.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
11.000	-7.50000	11.00000	91.50000	11.401	0.0	0.0	0.0	-11.401	d
12.001	-7.50000	12.00000	91.50000	6.1369	-0.37443	-0.37443	-6.1369	-6.1369	d
13.000	-7.50000	13.00000	91.50000	4.6230	-1.2245	-1.2245	-4.6230	-4.6230	d
14.000	-7.50000	14.00000	91.50000	3.3347	-1.8523	-1.8523	-3.3347	-3.3347	d
15.000	-7.50000	15.00000	91.50000	2.3489	-2.2390	-2.2390	-2.3489	-2.3489	d
d - Displacements include imported displacements.									

Specific Building Damage Results - Vertical Displacements						
Structure: No. 40 Sub-structure: West Wall						
Dist.	Coordinates			Displacements		
	x [m]	y [m]	z [m]	z [mm]		
Vertical Offset 1						
0.0	-7.50000	0.00000	91.50000	9.4889	d	
1.0000	-7.50000	1.00000	91.50000	8.6267	d	
2.0000	-7.50000	2.00000	91.50000	8.6209	d	
3.0000	-7.50000	3.00000	91.50000	8.6108	d	
4.0000	-7.50000	4.00000	91.50000	8.5958	d	
5.0000	-7.50000	5.00000	91.50000	8.5749	d	
6.0000	-7.50000	6.00000	91.50000	8.5471	d	
7.0000	-7.50000	7.00000	91.50000	8.5110	d	
8.0000	-7.50000	8.00000	91.50000	8.4651	d	
9.0000	-7.50000	9.00000	91.50000	8.4085	d	
10.000	-7.50000	10.00000	91.50000	8.3411	d	
11.000	-7.50000	11.00000	91.50000	8.2650	d	
12.000	-7.50000	12.00000	91.50000	4.7686	d	
13.000	-7.50000	13.00000	91.50000	4.3137	d	
14.000	-7.50000	14.00000	91.50000	3.8908	d	
15.000	-7.50000	15.00000	91.50000	3.7136	d	
d - Displacements include imported displacements.						

Specific Building Damage Results - All Segments											
Structure: No. 40 Sub-structure: West Wall											
Vertical Offset from Line for Vertical Movement Calculations	Segment	Start	Length	Curvature	Deflection Ratio	Average Horizontal Strain	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature	Damage Category
[m]		[m]	[m]		[%]	[%]	[%]			[m]	
0.0	1	0.0	2.9768	Hogging	0.018910	0.0	0.018836	0.0	862.20E-6	933.21	0 (Negligible)
	2	2.9768	8.6084	Sagging	0.021826	-0.0025454	0.018734	374.57E-6	0.0034977	1052.7	0 (Negligible)
	3	11.585	3.4148	Hogging	0.033498	-0.059150	0.025024	850.77E-6	0.0034977	1192.4	0 (Negligible)
Tensile horizontal strains are +ve, compressive horizontal strains are -ve.											

Specific Building Damage Results - Critical Values for All Segments within Each Sub-Structure										
Structure: No. 40 Sub-structure: West Wall										
Vertical Offset from Line for Vertical Movement Calculations	Deflection Ratio	Average Horizontal Strain	Max Slope	Max Settlement	Max Tensile Strain	Max Gradient of Horizontal Displacement Curve	Max Gradient of Vertical Displacement Curve	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
[m]	[%]	[%]		[mm]	[%]			[m]	[m]	
0.0	0.033498	-0.059150	0.0034977	9.4889	0.025024	850.77E-6	0.0034977	933.21	1052.7	0 (Negligible)

Specific Building Damage Results - Critical Segments within Each Structure												
Structure Name	Parameter	Critical Sub-structure	Critical Segment	Start	End	Curvature	Max Slope	Max Settlement	Max Tensile Strain	Min Radius of Curvature (Hogging)	Min Radius of Curvature (Sagging)	Damage Category
No. 40				[m]	[m]			[mm]	[%]	[m]	[m]	
	Max Slope	West Wall		2	2.9768	11.585	Sagging	0.0034977	8.6110	0.018734	-	1052.7 0 (Negligible)
	Max Settlement	West Wall		1	0.0	2.9768	Hogging	862.20E-6	9.4889	0.018836	933.21	- 0 (Negligible)
	Max Tensile Strain	West Wall		3	11.585	15.000	Hogging	0.0034977	6.2188	0.025024	1192.4	- 0 (Negligible)
	Min Radius of Curvature (Hogging)	West Wall		1	0.0	2.9768	Hogging	862.20E-6	9.4889	0.018836	933.21	- 0 (Negligible)
	Min Radius of Curvature (Sagging)	West Wall		2	2.9768	11.585	Sagging	0.0034977	8.6110	0.018734	-	1052.7 0 (Negligible)

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