CampbellReith
consulting engineers

32 Crediton Hill
London, NW6 1HP

Basement Impact Assessment Audit

For

London Borough of Camden

Project Number: 13693-38
Revision: D1

March 2022

Campbell Reith Hill LLP
15 Bermondsey Square
London
SE1 3UN

T:+44 (0)20 7340 1700
F:+44 (0)20 7340 1777
E:london@campbellreith.com
W:www.campbellreith.com

Document History and Status

Revision	Date	Purpose/Status	File Ref	Author	Check	Review
D1	March 2022	For Comment	KBns-13693-38-180322-32 Crediton Hill.doc	KB	NS	KB

Document Details

Last saved	18/03/2022 09:45
Path	KBns-13693-38-180322-32 Crediton Hill.doc
Author	K Barker
Project Partner	E M Brown, BSc MSc CGeol FGS
Project Number	13693-38
Project Name	32 Crediton Hill, London, NW6 1HP
Planning Reference	2021/5568/P

Contents

Appendix

1.0 NON-TECHNICAL SUMMARY

1.1. CampbellReith was instructed by London Borough of Camden, (LBC) to carry out an audit on the Basement Impact Assessment submitted as part of the Planning Submission documentation for 32 Crediton Hill (planning reference 2021/5568/P). The basement is considered to fall within Category B as defined by the Terms of Reference.

1.2. The Audit reviewed the Basement Impact Assessment (BIA) for potential impact on land stability and local ground and surface water conditions arising from basement development in accordance with LBC's policies and technical procedures.

1.3. CampbellReith was able to access LBC's Planning Portal and gain access to the latest revision of submitted documentation and reviewed it against an agreed audit check list.

1.4. The proposed development comprises a single basement underlying the existing footprint of the dwelling. The basement will be constructed using underpinning techniques and will have a maximum excavation depth of 3.5m.

1.5. The qualifications of the individuals involved in the BIA are in accordance with LBC guidance.

1.6. A site investigation has been undertaken indicating the basement will be constructed within the London Clay Formation. Geotechnical parameters have been provided based on the site investigation.

1.7. It is accepted that the proposed basement will not have a significant impact on the hydrology, hydrogeology or land stability of the area.

1.8. A Ground Movement Assessment and Building Damage Category assessment have been undertaken. A maximum damage category of Burland Category 1 (Very Slight) is estimated for adjacent structures.

1.9. Movement monitoring is recommended and should be agreed as part of the party wall agreement, or any asset protection arrangements required.

1.10. The BIA is considered to meet the requirements of Camden Planning Guidance: Basements.

2.0 INTRODUCTION

2.1. CampbellReith was instructed by London Borough of Camden (LBC) on 09 February 2022 to carry out a Category B audit on the Basement Impact Assessment (BIA) submitted as part of the Planning Submission documentation for 32 Crediton Hill, London, NW6 1HP, planning reference 2021/5568/P.

2.2. The audit was carried out in accordance with the Terms of Reference set by LBC. It reviewed the Basement Impact Assessment for potential impact on land stability and local ground and surface water conditions arising from basement development.

2.3. A BIA is required for all planning applications with basements in Camden in general accordance with policies and technical procedures contained within

- Camden Local Plan 2017 - Policy A5 Basements.
- Camden Planning Guidance (CPG): Basements. January 2021.
- Guidance for Subterranean Development (GSD). Issue 01. November 2010. Ove Arup & Partners.

2.4. The BIA should demonstrate that schemes:

a) maintain the structural stability of the building and neighbouring properties;

b) avoid adversely affecting drainage and run off or causing other damage to the water environment;

c) avoid cumulative impacts upon structural stability or the water environment in the local area;

and evaluate the impacts of the proposed basement considering the issues of hydrology, hydrogeology and land stability via the process described by the GSD and to make recommendations for the detailed design.

2.5. LBC's Audit Instruction described the planning proposal as *"Single-storey basement with footprint of existing dwelling."*

2.6. CampbellReith accessed LBC's Planning Portal on the 15th of January 2022 and gained access to the following relevant documents for audit purposes:

- Design & Access Statement by Connect Architecture, dated October 2021.
- Tree Survey Report by Reeves Arboricultural Services Ltd, ref: TSMS140-V1, dated 18 October 2021.

- Basement Impact Assessment by Milvum Engineering Services Ltd, ref: MES/2110/CA002 Rev 02, dated November 2021.
- Construction Method Statement by Davies Maguire Limited, ref: DMAG-2164-CMS-P02 Rev P02, dated 15 December 2021.
- Architectural Drawings by Connect Architecture Ltd:
    - Existing Plans, Elevations & Sections, dated 11 April 2021
    - Location & Block plan: As Existing, dated 11 October 2021.
    - Proposed Basement Plans, Elevations & Sections, dated 11 October 2021.
- E-mail correspondence with Milvum Engineering Services Ltd, dated 17 March 2022.

3.0 BASEMENT IMPACT ASSESSMENT AUDIT CHECK LIST

Item	Yes/No/NA	Comment
Are BIA Author(s) credentials satisfactory?	Yes	Section 2.2 of the BIA.
Is data required by Cl.233 of the GSD presented?	Yes	
Does the description of the proposed development include all aspects of temporary and permanent works which might impact upon geology, hydrogeology and hydrology?	Yes	Section 2.4 of the BIA.
Are suitable plan/maps included?	Yes	All maps to support screening are included in the BIA.
Do the plans/maps show the whole of the relevant area of study and do they show it in sufficient detail?	Yes	
Land Stability Screening: Have appropriate data sources been consulted? Is justification provided for 'No' answers?	Yes	Section 4.2 of the BIA.
Hydrogeology Screening: Have appropriate data sources been consulted? Is justification provided for 'No' answers?	Yes	Section 4.1 of the BIA.
Hydrology Screening: Have appropriate data sources been consulted? Is justification provided for 'No' answers?	Yes	Section 4.3 of the BIA.
Is a conceptual model presented?	Yes	Section 10.2 of the BIA.
Land Stability Scoping Provided? Is scoping consistent with screening outcome?	Yes	Section 5.0 of the BIA.

Item	Yes/No/NA	Comment
Hydrogeology Scoping Provided? Is scoping consistent with screening outcome?	Yes	No items were carried to scoping. However consideration for groundwater management during construction is given in the BIA.
Hydrology Scoping Provided? Is scoping consistent with screening outcome?	NA	No items were carried to scoping.
Is factual ground investigation data provided?	Yes	Section 6.0 of the BIA and Appendices 4 & 5.
Is monitoring data presented?	Yes	Section 6.3 of the BIA
Is the ground investigation informed by a desk study?	Yes	
Has a site walkover been undertaken?	Yes	Section 2.3 of the BIA
Is the presence/absence of adjacent or nearby basements confirmed?	Yes	Section 5.7 of the BIA.
Is a geotechnical interpretation presented?	Yes	Section 7.0 of the BIA. However, clarifications are requested.
Does the geotechnical interpretation include information on retaining wall design?	Yes	Section 7.0 of the BIA. However, clarifications are requested.
Are reports on other investigations required by screening and scoping presented?	Yes	Flood Risk Assessment and Drainage Strategy, GMA, and Construction Method Statement.
Are the baseline conditions described, based on the GSD?	Yes	
Do the base line conditions consider adjacent or nearby basements?	Yes	Section 5.7 of the BIA
Is an Impact Assessment provided?	Yes	Section 13 of the BIA.

Item	Yes/No/NA	Comment
Are estimates of ground movement and structural impact presented?	Yes	Section 12 of the BIA.
Is the Impact Assessment appropriate to the matters identified by screening and scoping?	Yes	Section 13 of the BIA.
Has the need for mitigation been considered and are appropriate mitigation methods incorporated in the scheme?	Yes	
Has the need for monitoring during construction been considered?	Yes	Section 13.4 of the BIA.
Have the residual (after mitigation) impacts been clearly identified?	Yes	
Has the scheme demonstrated that the structural stability of the building and neighbouring properties and infrastructure will be maintained?	Yes	Section 12 of the BIA.
Has the scheme avoided adversely affecting drainage and run-off or causing other damage to the water environment?	Yes	
Has the scheme avoided cumulative impacts upon structural stability or the water environment in the local area?	Yes	
Does report state that damage to surrounding buildings will be no worse than Burland Category 1?	Yes	Section 12 of the BIA.
Are non-technical summaries provided?	Yes	

4.0 DISCUSSION

4.1. The Basement Impact Assessment (BIA) has been carried out by MILVUM Engineering Services Ltd and the individuals concerned in its production hold the appropriate qualifications.

4.2. The LBC Instruction to proceed with the audit identified that the basement proposal neither involves, nor is neighbour to, a listed building.

4.3. The proposed development comprises the construction of a single basement below the full footprint of the existing building. The basement will be formed at approximately 3.5m below ground level (bgl) and will be formed using underpinning techniques.

4.4. A site investigation has been carried out at the property and is discussed in Section 6 of the BIA. Three window sample holes to a maximum depth of 6.00m bgl and one hand dug pit to 1.35m bgl were completed. Ground conditions were found to comprise Made Ground over London Clay. The Made Ground layer was found to be between 3.05m and 4.70m thick. Groundwater was not encountered during drilling, however subsequent monitoring visits recorded standing levels at increasingly high levels between 1.39 and 4.13m bgl over the 3 monitoring visits.

4.5. The London Clay was identified as an Unproductive Aquifer, therefore it is accepted that the development will not impact the hydrogeology of the area. The BIA indicates groundwater encountered during the monitoring visits to be perched water. Measures to control water ingress using sump pumping are described in the Construction Method Statement (CMS) and the BIA recommends additional groundwater monitoring to confirm temporary groundwater control measures.

4.6. The screening exercise undertaken for hydrology did not identify any items to be carried forward to the scoping stage. However, the site is identified as being within a Critical Drainage Area and a flood risk assessment and drainage strategy have been undertaken, presented in Section 11 of the BIA. The use of permeable paving and a below ground tank with flow control are recommended for the development, to control surface water run-off rates.

4.7. The site is identified as having a slope of 7° to 10°, however the BIA identifies that this is only at the far end of the garden, some 15m to 20m from the dwelling and proposed basement. This is also shown on the existing section drawings of the property. The BIA states that, as this slope is outside the zone of influence of the proposed basement (calculated to be 14m), the stability of the slope is not considered to be impacted by the basement development. On this basis it is accepted that the proposed basement will not impact the slope stability of the area.

4.8. The CMS identifies the neighbouring property at No. 34 Crediton Hill as having an existing basement, formed in two stages in 2010 (at the rear of the property) and 2014 (below the front

garden and the front of the property) at c. the same level of the proposed basement. The proposed development will share a party wall with this adjacent basement and the CMS indicates that it is unlikely that underpinning will be required below the adjacent basement.

4.9. The CMS provides a proposed underpinning construction sequence and temporary propping details for the basement. The underpins will be constructed in a hit and miss sequence in bays of 1m width, and the basement floor will be suspended to accommodate heave. The underpins will have thickened edges to support the basement floor and retaining walls.

4.10. The hand dug pit carried out at the site extended to 1.35m depth without encountering the base of the existing foundations. Section 12 of the BIA states that records from the construction of the adjacent basement at No. 34 found the building foundation to extend to 3.5m depth along the party wall. The BIA considers it likely that the deep foundations are present at the subject site as well, and that damage to adjacent buildings resulting from the basement construction would therefore be negligible. However, to provide a conservative assessment, foundations have been assumed to be shallow for the purposes of the BIA.

4.11. Section 12 of the BIA presents a Ground Movement Assessment (GMA) for the proposed basement. The GMA uses CIRIA C760 guidance to predict the magnitude of ground movement due to underpinning. It should be noted that, whilst the CIRIA approach is intended for embedded retaining walls, we accept that the predicted ground movements are within the range typically anticipated for underpinning techniques carried out with good control of workmanship.

4.12. Section 12.3 of the BIA describes the anticipated ground movement generated by the proposed basement. The GMA ignores the depth of the existing footings and considers underpinning and excavation depths from ground level. This is considered to be a suitably conservative model. A maximum horizontal ground movement of 9mm and a maximum vertical ground movement of 7mm are predicted for the basement.

4.13. Section 12.4 of the BIA provides a list of the structures considered to be within the potential zone of influence of the proposed basement. The adjacent footway and sensitive utilities therein are also identified and considered in the assessment. Ground movements between 2mm and 4mm are identified as impacting the footway and utilities, and the BIA concludes that this magnitude of movement will have a negligible impact.

4.14. A building damage assessment has been undertaken for the sensitive structures identified, using XDisp software, which is based on the ground movement curves presented in CIRIA C760. In acknowledgement of the limitations of using CIRIA C760 to model ground movements due to underpinning, the XDisp input data equates the underpin installation to that of a contiguous pile wall 8m deep. This analogue results in comparable movement to those described in Section

12.3 of the BIA. The results of the XDisp assessment indicates that damage associated with the predicted ground movements does not exceed Burland Category 1 (Very Slight).

4.15. The BIA indicates that at formation level (c. 3.50m bgl) the London Clay can provide a bearing capacity of c. 100kPa. However, based on the site investigation data, it is understood that Made Ground may locally extend deeper than this, as it was encountered to a maximum depth of 4.70m bgl during the site investigation. Correspondence with Milvum Engineering Services Ltd (MES), presented in Appendix 3 of this audit report, indicates that locally deeper excavation and underpinning, extending greater than 3.50m, will occur if Made Ground is encountered at underpin formation level.

4.16. Underpinning to greater depths than 3.50m is typically undertaken in two stages, with associated ground movements also typically expected to occur at each stage of underpinning. The GMA considers only a single lift of underpinning with a maximum excavation depth of 3.50m. Clarification from MES (provided in Appendix 3) indicates that, as the existing foundation was proven to extend to at least 1.35m depth, any local deepening of the underpinning would still not exceed the depth of a single lift of underpinning of 3.50m.

4.17. The BIA recommends that a structural movement monitoring plan be set out at design stage and agreed as part of any Party Wall award or asset protection agreement, to monitor adjacent structures for movement.

5.0 CONCLUSIONS

5.1. The qualifications of the individuals involved in the BIA are in accordance with LBC guidance.

5.2. The proposed basement will be constructed using underpinning techniques and the basement will not exceed the footprint of the existing building.

5.3. A site investigation has been undertaken indicating the basement will be constructed within the London Clay Formation. Geotechnical parameters have been provided based on the site investigation.

5.4. Screening and scoping assessments are presented, supported by desk study information.

5.5. It is accepted that the proposed basement will not have a significant impact on the hydrology, hydrogeology or land stability of the area.

5.6. A Ground Movement Assessment has been carried out and predicts maximum horizontal ground movement of 9mm and vertical movement of 7mm.

5.7. A Building Damage Category assessment has been undertaken and identifies a maximum damage category of Burland Category 1 (Very Slight) for adjacent structures.

5.8. Movement monitoring is recommended and should be agreed as part of the party wall agreement, or any asset protection arrangements required.

5.9. The BIA is considered to meet the requirements of Camden Planning Guidance: Basements.

Appendix 1: Residents' Consultation Comment

None

Appendix 2: Audit Query Tracker

None

Appendix 3: Supplementary Supporting Documents

E-mail correspondence

XDisp input data

32 Crediton HillCorrado Candian to nicolasimonini 17/03/2022 12:51
Cc camdenaudit

0 Attachment

image001.png

Dear Nico,

Further to our discussion in regard to the potential depth of foundations, specifically with reference to Sections 7.2, 12.3 and 12.5 and with reference to the CMS:

Where Made Ground is encountered deeper than the intended formation level, the underpin excavation will be extended into the natural strata (London Clay) and filled with mass concrete, with the stem bases formed in RC concrete at intended formation level. Based on the observation on site, which indicate existing foundations are >1.35m bgl, even if Made Ground is encountered to the maximum depth observed in the site investigation (of 4.70m bgl), then underpinning is achievable within a single lift. The GMA presented, including the sensitivity analyses undertaken, allows for the local deepening of foundations as described above and the levels of movement and resultant impacts to neighbours will remain within the range predicted.

The observations at the adjoining No. 34 Crediton Hill, as per Section 12.1, are noted with original foundations being very deep; given that the properties are adjoining in the same terrace constructed at the same time, foundation arrangements at both properties are likely to be very similar, and as such excavations to form retaining walls are likely to be reduced compared to the full depth of excavations considered in the GMA. Therefore the GMA is considered to be reasonably conservative and over estimate the magnitude of movement and impacts resulting from the proposals.

Note that in all cases the bulk excavation will not be required to be depended beyond the formation level stated.

We trust the above addresses your query. Please do not hesitate to contact us further, if required.

Kind Regards.
Corrado

Corrado Candian
Chartered Engineer (CEng MICE)

+44 207 193 8810
ccandian@milvumgroup.com

Milvum Engineering Services Ltd

71-75 Shelton Street, London WC2H 9JQ

Titles

Job No.:
Job Title: 32 Crediton Hill
Sub-title: GMA for basement excavation
Calculation Heading:
Initials: GF
Checker:
Date Saved: 25-Oct-2021
Date Checked:
Notes: Basement
Excavation depth = 3.5m
Contig wall = 8m

Outbuilding
Excavation depth = 2.5m
Contig wall = 6m
File Name: 32CH_XDisp_3.5m-no 34CH_00_GF.xdd
File Path: C:\Users\gkite\32CH\XDisp\Excavation 3.5m-Inst8m\Outputs

History

Date	Time	By	Notes
12-Oct-2021	16:54	gkite	New
12-Oct-2021	19:36	gkite	
13-Oct-2021	14:48	gkite	
25-Oct-2021	09:31	gkite	

Displacement Lines

Ref.	Name	x1 [m]	y1 [m]	z1 [m]	x2 [m]	y2 [m]	z2 [m]	Intervals [No.]	Surface type for tunnels	Interpolate imported displacements	Calculate
1	19CH_a	-37.21000	14.30000	100.00000	-37.46000	5.97000	100.00000	8	Surface	Yes	Yes
2	19CH_b	-37.46000	5.97000	100.00000	-25.68000	5.62000	100.00000	11	Surface	Yes	Yes
3	19CH_c	-25.68000	5.62000	100.00000	-25.42000	13.95000	100.00000	8	Surface	Yes	Yes
4	19CH_d	-25.42000	13.95000	100.00000	-37.21000	14.30000	100.00000	11	Surface	Yes	Yes
5	17CH_a	-34.19000	3.90000	100.00000	-34.67000	-4.86000	100.00000	8	Surface	Yes	Yes
6	17CH_b	-34.67000	-4.86000	100.00000	-22.42000	-5.53000	100.00000	12	Surface	Yes	Yes
7	17CH_c	-22.42000	-5.53000	100.00000	-21.94000	3.23000	100.00000	8	Surface	Yes	Yes
8	17CH_d	-21.94000	3.23000	100.00000	-34.19000	3.90000	100.00000	12	Surface	Yes	Yes
9	15CH_a	-34.67000	-4.86000	100.00000	-35.12000	-13.06000	100.00000	8	Surface	Yes	Yes
10	15CH_b	-35.12000	-13.06000	100.00000	-22.86000	-13.73000	100.00000	12	Surface	Yes	Yes
11	15CH_c	-22.86000	-13.73000	100.00000	-22.42000	-5.53000	100.00000	8	Surface	Yes	Yes
12	30CH_a	3.27000	-2.43000	100.00000	3.33000	-11.11000	100.00000	8	Surface	Yes	Yes
13	30CH_b	3.33000	-11.11000	100.00000	16.93000	-11.14000	100.00000	13	Surface	Yes	Yes
14	30CH_c	16.93000	-11.14000	100.00000	17.24000	-2.73000	100.00000	8	Surface	Yes	Yes
15	30CH_d	17.24000	-2.73000	100.00000	3.27000	-2.43000	100.00000	13	Surface	Yes	Yes

Displacement Grids

Ref.	Name	Extrusion: Direction	Base line start: X [m]	Base line start: Y [m]	Base line start: Z(level) [m]	Base line end: X [m]	Base line end: Y [m]	Base line end: Z(level) [m]	Base line: Intervals [No.]	Extrusion: Distance [m]	Extrusion: Intervals [No.]	Surface type for tunnels	Calculate
1	1	Global X	-50.00000	-50.00000	100.00000	-	50.00000	100.00000	100	100.00000	100	Surface	Yes

Polygonal Excavations

Ref. 1
Excavation Name: Basement excavation
Surface level [m]: 100.00
Contribution: Positive

Corner	x [m]	y [m]	Base Level [m]	Arc Enabled	Stiffened	Prev. Side: d [m]	Prev. Side: p1 [%]	Prev. Side: p2* [%]	Next Side: d [m]	Next Side: p1 [%]	Next Side: p2* [%]
1	1.7700	7.9100	96.500	Yes	No	-	-	-	-	-	-
2	1.7500	-0.37000	96.500	Yes	No	-	-	-	-	-	-
3	14.580	-0.37000	96.500	Yes	No	-	-	-	-	-	-
4	14.580	7.9100	96.500	Yes	No	-	-	-	-	-	-

Side	x1	y1	x2	y2	G.M. Curve: Vertical	G.M. Curve: Horizontal

	[m]	[m]	[m]	[m]		
1	1.7700	7.9100	1.7500	-0.37000	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(a))
2	1.7500	-0.37000	14.580	-0.37000	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(a))
3	14.580	-0.37000	14.580	7.9100	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(a))
4	14.580	7.9100	1.7700	7.9100	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(a))

Ref. **2**
Excavation Name: **Basement installation**
Surface level [m]: 100.00
Contribution: Positive

Corner	x [m]	y [m]	Base Level [m]	Arc Enabled	Stiffened	Prev. Side: d [m]	Prev. Side: p1 [%]	Prev. Side: p2* [%]	Next Side: d [m]	Next Side: p1 [%]	Next Side: p2* [%]
1	1.7700	7.9100	92.000	Yes	No	-	-	-	-	-	-
2	1.7500	-0.37000	92.000	Yes	No	-	-	-	-	-	-
3	14.580	-0.37000	92.000	Yes	No	-	-	-	-	-	-
4	14.580	7.9100	92.000	Yes	No	-	-	-	-	-	-

Side	x1 [m]	y1 [m]	x2 [m]	y2 [m]	G.M. Curve: Vertical	G.M. Curve: Horizontal
1	1.7700	7.9100	1.7500	-0.37000	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(a))
2	1.7500	-0.37000	14.580	-0.37000	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(a))
3	14.580	-0.37000	14.580	7.9100	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(a))
4	14.580	7.9100	1.7700	7.9100	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(a))

Ref. **3**
Excavation Name: **Outbuilding excavation**
Surface level [m]: 100.00
Contribution: Positive

Corner	x [m]	y [m]	Base Level [m]	Arc Enabled	Stiffened	Prev. Side: d [m]	Prev. Side: p1 [%]	Prev. Side: p2* [%]	Next Side: d [m]	Next Side: p1 [%]	Next Side: p2* [%]
1	31.540	7.3000	97.500	Yes	No	-	-	-	-	-	-
2	31.540	0.19000	97.500	Yes	No	-	-	-	-	-	-
3	36.610	0.19000	97.500	Yes	No	-	-	-	-	-	-
4	36.610	7.3000	97.500	Yes	No	-	-	-	-	-	-

Side	x1 [m]	y1 [m]	x2 [m]	y2 [m]	G.M. Curve: Vertical	G.M. Curve: Horizontal
1	31.540	7.3000	31.540	0.19000	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(a))
2	31.540	0.19000	36.610	0.19000	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(a))
3	36.610	0.19000	36.610	7.3000	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(a))
4	36.610	7.3000	31.540	7.3000	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(b))	Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(a))

Ref. **4**
Excavation Name: **Outbuilding installation**
Surface level [m]: 100.00
Contribution: Positive

Corner	x [m]	y [m]	Base Level [m]	Arc Enabled	Stiffened	Prev. Side: d [m]	Prev. Side: p1 [%]	Prev. Side: p2* [%]	Next Side: d [m]	Next Side: p1 [%]	Next Side: p2* [%]
1	31.540	7.3000	94.000	Yes	No	-	-	-	-	-	-

Corner	x [m]	y [m]	Base Level [m]	Arc Enabled	Stiffened	Prev. Side: d [m]	Prev. Side: p1 [%]	Prev. Side: p2* [%]	Next Side: d [m]	Next Side: p1 [%]	Next Side: p2* [%]
2	31.540	0.19000	94.000	Yes	No	-	-	-	-	-	-
3	36.610	0.19000	94.000	Yes	No	-	-	-	-	-	-
4	36.610	7.3000	94.000	Yes	No	-	-	-	-	-	-

Side	x1 [m]	y1 [m]	x2 [m]	y2 [m]	G.M. Curve: Vertical	G.M. Curve: Horizontal
1	31.540	7.3000	31.540	0.19000	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(a))
2	31.540	0.19000	36.610	0.19000	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(a))
3	36.610	0.19000	36.610	7.3000	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(a))
4	36.610	7.3000	31.540	7.3000	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(b))	Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(a))

Circular Excavations

Vertical Ground Movement Curves

Curve Name: **Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(b))**
Coordinates: [Distance from wall / wall depth or max. excavation depth (x), Depth / wall depth or max. excavation depth (y), Settlement / wall depth or max. excavation depth (z)(%)]

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

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

Curve Name: **Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(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

Curve Name: **Inst. of contiguous bored pile wall in stiff clay (CIRIA C760 Fig. 6.8(a))**
Coordinates: [Distance from wall / wall depth or max. excavation depth (x), Depth / wall depth or max. excavation depth (y), Horizontal movement / wall depth or max. excavation depth (z)(%)]
[0.000,0.000,0.041][0.050,0.000,0.038][0.100,0.000,0.036][0.150,0.000,0.034]
[0.200,0.000,0.032][0.250,0.000,0.030][0.300,0.000,0.029][0.350,0.000,0.027]
[0.400,0.000,0.025][0.450,0.000,0.023][0.500,0.000,0.022][0.550,0.000,0.020]
[0.600,0.000,0.019][0.650,0.000,0.018][0.700,0.000,0.016][0.750,0.000,0.015]
[0.800,0.000,0.014][0.850,0.000,0.013][0.900,0.000,0.011][0.950,0.000,0.010]
[1.000,0.000,0.009][1.050,0.000,0.008][1.100,0.000,0.007][1.150,0.000,0.006]
[1.200,0.000,0.005][1.250,0.000,0.004][1.300,0.000,0.004][1.350,0.000,0.003]
[1.400,0.000,0.002][1.450,0.000,0.001][1.500,0.000,0.000]
Curve Fitting Method: Polynomial
x Order: 3
y Order: 0
Polynomial: z = $-4.2486E-3x^3 + 1.9096E-2x^2 - 4.6221E-2x + 4.0729E-2$
Coeff. of Determination: 1.0000

Curve Name: **Exc. in front of high stiffness wall in stiff clay (CIRIA C760 Fig. 6.15(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

Side	x1 [m]	y1 [m]	x2 [m]	y2 [m]	G.M. Curve: Vertical	G.M. Curve: Horizontal

Polynomial: z = -3.75E-2x + 1.50E-1
Coeff. of Determination: 1.00

Damage Category Strains

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

Specific Buildings - Geometry

Ref.	Building Name	Sub-Building Name	Displacement Line	Distance Along Line: Start [m]	Distance Along Line: End [m]	Vertical Offsets from Line for Vertical Movement Calculations [m]	Vertical Displacement Limit Sensitivity [mm]	Damage Category Strains	Poisson's Ratio	E/G
1	19CH_1		19CH_a	0.00000	8.33000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
2	19CH_2		19CH_b	0.00000	11.78000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
3	19CH_3		19CH_c	0.00000	8.33000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
4	19CH_4		19CH_d	0.00000	11.79000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
5	17CH_1		17CH_a	0.00000	8.77000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
6	17CH_2		17CH_b	0.00000	12.26000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
7	17CH_3		17CH_c	0.00000	8.77000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
8	17CH_4		17CH_d	0.00000	12.26000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
9	15CH_1		15CH_a	0.00000	8.21000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
10	15CH_2		15CH_b	0.00000	12.27000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
11	15CH_3		15CH_c	0.00000	8.21000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
12	30CH_1		30CH_a	0.00000	8.68000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
13	30CH_2		30CH_b	0.00000	13.60000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
14	30CH_3		30CH_c	0.00000	8.41000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000
15	30CH_4		30CH_d	0.00000	13.97000	0.0	0.10000	Burland Strain Limits	0.20000	2.6000

Specific Buildings - Bending Parameters

Ref.	Building Name	Sub-Building Name	Height [m]	Default	Hogging: 2nd Mom. of Area (per unit width) [m³]	Hogging: Dist. of Bending Strain from N.A. [m]	Hogging: Dist. of N.A. from Edge of Beam in Tension [m]	Sagging: 2nd Mom. of Area (per unit width) [m³]	Sagging: Dist. of Bending Strain from N.A. [m]	Sagging: Dist. of N.A. from Edge of Beam in Tension [m]
1	19CH_1		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
2	19CH_2		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
3	19CH_3		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
4	19CH_4		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
5	17CH_1		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
6	17CH_2		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
7	17CH_3		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
8	17CH_4		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
9	15CH_1		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
10	15CH_2		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
11	15CH_3		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
12	30CH_1		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
13	30CH_2		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
14	30CH_3		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000
15	30CH_4		11.000	Yes	443.67	11.000	11.000	110.92	5.5000	5.5000

London

15 Bermondsey Square
London
SE1 3UN

T: +44 (0)20 7340 1700
E: london@campbellreith.com

Birmingham

Chantry House
High Street, Coleshill
Birmingham B46 3BP

T: +44 (0)1675 467 484
E: birmingham@campbellreith.com

Surrey

Raven House
29 Linkfield Lane, Redhill
Surrey RH1 1SS

T: +44 (0)1737 784 500
E: surrey@campbellreith.com

Manchester

No. 1 Marsden Street
Manchester
M2 1HW

T: +44 (0)161 819 3060
E: manchester@campbellreith.com

Bristol

Unit 5.03,
HERE,
470 Bath Road,
Bristol BS4 3AP

T: +44 (0)117 916 1066
E: bristol@campbellreith.com