CampbellReith
consulting engineers

28 Charlotte Street, London W1T 2NF

Basement Impact Assessment Audit

For

London Borough of Camden

Project Number: 12336-67

Revision: F1

September 2016

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Planning Reference	2016/1345/P

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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 28 Charlotte Street, London, W1T 2NF (planning reference 2016/1345/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 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 Basement Impact Assessment (BIA) has been carried out by Chelmer Consultancy Services. The qualifications of the individuals who have prepared and reviewed the BIA are in accordance with the requirements of CPG4.

1.5. The site is a six-storey terraced house within the Charlotte Street Conservation Area. Construction is intended to extend the single-storey basement beneath the rear part of 28 Charlotte Street. The rear of the site adjoins both the Crabtree Fields playground and the modern development at No's 7-15 Whitfield Street.

1.6. The site-specific ground investigation consisted of one continuous flight auger borehole and the excavation of two hand dug trial holes. Borehole logs, monitoring results and laboratory test results are presented with the BIA.

1.7. The Construction Method Statement (CMS), compiled by Anderson Consulting Engineers, was provided to CampbellReith separately on 13 July 2016. A revised CMS was received on 2 August 2016 reflecting the revised founding solution.

1.8. A piled foundation solution is proposed, with the existing walls underpinned in a strip underpinning sequence. Schematic and loading details are provided in the Revised Anderson Consulting Engineers report received on 2 August 2016.

1.9. It is accepted that the proposed construction will not have an impact on surrounding roads as the extension is to the rear of the property. Additionally, no railway tunnels are known to pass below or close to the site. A pedestrian right of way is located near the rear of the property, although this has been identified and proposed actions are considered adequate.

1.10. Other infrastructure for cables or communications might be present within the zone of influence of the proposed basement extension, so it is agreed that an appropriate services search should

be undertaken. The potential influence should be investigated should such infrastructure be identified.

1.11. The site and its surrounding are relatively flat and raise no concerns in relation to the overall stability of the slope.

1.12. The site is, and will remain, fully paved. Additionally, no trees will be felled as part of the proposed development. It is accepted that the development will not impact on the wider hydrogeology of the area and is not in an area subject to flooding.

1.13. Groundwater data indicates the groundwater level to be at least 1.0m below the basement slab, and it is therefore agreed that the proposed basement extension is acceptable in relation to groundwater flow. Piles installed at depths below the water table are unlikely to form a barrier and impede groundwater flow.

1.14. Seepages of perched groundwater may occur into the excavations. It is noted that pumping from sumps will be employed if groundwater is encountered. The Made Ground expected at/beneath formation level may be very susceptible to disturbance with the risk of drawing soil into the excavation. Although mitigation measures are proposed, all groundwater control measures should be supervised by an appropriately competent person.

1.15. The GMA predicts damage no worse than Very Slight (Burland Category 1) with mitigation measures proposed in the Cundall Report and Revised Construction Method Statement.

1.16. It is agreed that condition surveys of the neighbouring properties should be commissioned and a programme of monitoring the adjoining structures should be established before the work starts.

1.17. It is accepted that the BIA has identified the potential impacts of the proposed development and describes sufficient mitigation.

2.0 INTRODUCTION

2.1. CampbellReith was instructed by London Borough of Camden (LBC) to carry out a Category B Audit on the Basement Impact Assessment (BIA) submitted as part of the Planning Submission documentation for 28 Charlotte Street, London, W1T 2NF, Camden Reference 2016/1345/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

- Guidance for Subterranean Development (GSD). Issue 01. November 2010. Ove Arup & Partners.
- Camden Planning Guidance (CPG) 4: Basements and Lightwells.
- Camden Development Policy (DP) 27: Basements and Lightwells.
- Camden Development Policy (DP) 23: Water.

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; and,

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 "Conversion of existing single dwelling house to provide 4 self-contained flats, including the enlargement of existing basement, erection of a second floor extension and alterations to rear elevation and roof form."

The Audit Instruction also confirmed that the proposed development is within a Conservation Area, although the building itself is not listed.

2.6. CampbellReith accessed LBC's Planning Portal on 02 June 2016 and gained access to the following relevant documents for audit purposes:

- Basement Impact Assessment Report (BIA) dated April 2016,
- Design and Access Statement,
- Draft Construction Management Plan,
- Daylight and Sunlight Study, and
- Planning application drawings consisting of:

  Existing Plans

  Proposed Plans

  Site Plan

The Construction Method Statement, dated August 2015, was provided to CampbellReith on 13 July 2016.

2.7. Subsequent to the initial audit, supplementary information was received by email on 2 August 2016 and this information is as follows:

- Revised Construction Method Statement,
- Structural Calculations for Proposed Structural Alterations, and
- drawings consisting of:

  Typical section

  Basement Underpin Layout

  Underpin Sequence

The Ground Movement Impact Assessment conducted by Cundall was received by email on 23 August 2016. Pertinent information is presented in Appendix 3.

3.0 BASEMENT IMPACT ASSESSMENT AUDIT CHECK LIST

Item	Yes/No/NA	Comment
Are BIA Author(s) credentials satisfactory?	Yes	BIA Section 1.2.
Is data required by Cl.233 of the GSD presented?	Yes	BIA.
Does the description of the proposed development include all aspects of temporary and permanent works which might impact upon geology, hydrogeology and hydrology?	Yes	BIA Sections 2, 3 4, 5 and 6.
Are suitable plan/maps included?	Yes	BIA and supplementary drawings.
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	BIA Section 7.3.
Hydrogeology Screening: Have appropriate data sources been consulted? Is justification provided for 'No' answers?	Yes	BIA Section 7.2.
Hydrology Screening: Have appropriate data sources been consulted? Is justification provided for 'No' answers?	Yes	BIA Section 7.4.
Is a conceptual model presented?	Yes	BIA Section 10.
Land Stability Scoping Provided? Is scoping consistent with screening outcome?	Yes	BIA Section 8.

Item	Yes/No/NA	Comment
Hydrogeology Scoping Provided? Is scoping consistent with screening outcome?	Yes	BIA Section 8.
Hydrology Scoping Provided? Is scoping consistent with screening outcome?	NA	Not required as there will be no significant change in surface water run-off. Site is already fully paved.
Is factual ground investigation data provided?	Yes	Ground investigation conducted by Chelmer Site Investigations in January 2016 (Dates of January 2015 and September 2015 mentioned in report, incorrectly?).
Is monitoring data presented?	Yes	However, readings were only taken on 28 January 2016 (-4.93m) and 9 February 2016 (-4.77m).
Is the ground investigation informed by a desk study?	Yes	
Has a site walkover been undertaken?	Yes	Friday 12 February 2016.
Is the presence/absence of adjacent or nearby basements confirmed?	Yes	
Is a geotechnical interpretation presented?	Yes	BIA Section 10.
Does the geotechnical interpretation include information on retaining wall design?	Yes	BIA Section 10.
Are reports on other investigations required by screening and scoping presented?	Yes	Site investigation included within BIA.
Are the baseline conditions described, based on the GSD?	Yes	
Do the base line conditions consider adjacent or nearby basements?	Yes	
Is an Impact Assessment provided?	Yes	BIA Section 10.

Item	Yes/No/NA	Comment
Are estimates of ground movement and structural impact presented?	Yes	BIA Section 10.5, 10.6.
Is the Impact Assessment appropriate to the matters identified by screen and scoping?	Yes	Cundall Report.
Has the need for mitigation been considered and are appropriate mitigation methods incorporated in the scheme?	Yes	Revised Construction Method Statement.
Has the need for monitoring during construction been considered?	Yes	BIA Section 10.7.
Have the residual (after mitigation) impacts been clearly identified?	Yes	Revised Construction Method Statement.
Has the scheme demonstrated that the structural stability of the building and neighbouring properties and infrastructure will be maintained?	Yes	Revised Construction Method Statement.
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	Revised Construction Method Statement.
Does report state that damage to surrounding buildings will be no worse than Burland Category 2?	Yes	Cundall GMA Report.
Are non-technical summaries provided?	Yes	BIA Section 11.

4.0 DISCUSSION

4.1. The Basement Impact Assessment (BIA) has been carried out by Chelmer Consultancy Services. The qualifications of the individuals who have prepared and reviewed the BIA are in accordance with the requirements of CPG4. Both authors have previously undertaken assessments of basements in several London Boroughs.

4.2. The existing building is a six-storey terraced house within the Charlotte Street Conservation Area, in the London Borough of Camden. No. 28 is situated on the east side of Charlotte Street, between No. 26 to the south and No. 30 to the north. The rear of the site adjoins both the Crabtree Fields playground and the modern development at No's 7-15 Whitfield Street.

4.3. The proposed basement works will comprise:

- Creation of a single-storey basement beneath the existing open-plan office/studio at the rear of No. 28's lightwell, with a finished floor level (FFL) 0.39m lower than the FFL in the existing basement.
- The existing lower ground floor and lightwell will not be altered.
- Two additional floors will be added above the basement, at 1st and 2nd floor levels.
- A lightwell extending one-storey below ground level will be created across the full width of the rear of the site.
- The existing two-storey high rear wall, including the chimney breast and all three external buttresses, will be taken down and a new wall will be built with large glazed window openings in both this rear wall and the south-east flank wall (at the end of the new lightwell).

4.4. The development at No's 7-15 Whitfield Street includes a lower ground floor approximately 1.15m from the wrap-around buttress at the east corner of No. 28. This floor level is approximately 0.7m below the proposed FFL in No. 28's basement. Additionally, a basement car park, the closest point of which is 3.8m from No. 28's wrap-around buttress, has an FFL approximately 2.9m below that of No. 28's.

4.5. It is stated in the Revised Construction Method Statement (CMS) that the basement is to be built bottom-up with excavation commencing from above the front of the proposed basement through the existing basement progressing towards the rear. A conveyor belt will be set up through the existing basement to convey spoil from the excavation to a skip placed on the road for disposal. In this regard, the management of traffic along Admiral Walk has been proposed to prevent queueing and waiting of vehicles.

4.6. The ground investigation site work was carried out by Chelmer Site Investigations (CSI) in January 2016, and consisted of one continuous flight auger borehole drilled to a depth of 10.0m below ground level and two hand dug trial pits. The site's geology, as found by BH1, was summarised as:

- 0.0 – 5.3m comprised Made Ground.
- 5.3 – 7.7m comprised gravelly sand, considered to be the Lynch Hill Gravel formation.
- 7.7m+ comprised London Clay.

The Revised CMS by Anderson Consulting Engineers indicates that the new basement will be designed to be supported on piles to limit settlements. These will be installed in the Lynch Hill Gravel and London Clay, with depths to be determined during the detailed design stage.

4.7. The formation level of the proposed basement slab (approximately 2.9-2.98m below GL) is expected to comprise silts of the Made Ground. The basement is to be supported on piles at locations presented in the Revised CMS. The construction methodology has been confirmed and the associated impacts assessed in the Revised CMS.

4.8. During the monitoring period groundwater was encountered at 4.93m and 4.77m below GL indicating the groundwater level is likely to be below the FFL for the proposed basement. The piling solution presented is therefore considered appropriate in relation to groundwater.

4.9. It is noted that pumping from sumps will be employed if groundwater is encountered. The Made Ground expected at/beneath formation level may be very susceptible to disturbance. It is therefore critical that the long-term groundwater level be determined as groundwater within granular strata can rapidly and continuously ingress into the excavated basement and result in ground settlement that which may extend beyond the site boundary and affect neighbouring structures.

4.10. In the design of retaining walls, a provisional groundwater level 1m below ground level was proposed in the Revised CMS due to the uncertainty in predicting future groundwater levels. This assumption is considered acceptable.

4.11. Geotechnical parameters for the Made Ground, Sands/Gravels and London Clay material encountered at the site are proposed in the BIA based on the investigation, laboratory results and previous experience. In the natural soils the parameters are considered reasonable. Although the stiffness for the Made Ground is not considered appropriately conservative, based on the piling solution proposed this is not considered to be problematic as the piles will bear in the Lynch Hill Gravels.

4.12. It is acknowledged that there is no concern about slope stability issues in this regard.

4.13. The site is, and will remain, fully paved so there is no change to impermeable area. Additionally, no trees will be felled as part of the proposed development.

4.14. It is accepted that the proposed construction will not have an impact on surrounding roads as the extension is to the rear of the property. Additionally, no railway tunnels are known to pass below or close to the site. A pedestrian right of way is located near the rear of the property, although this has been identified and proposed actions are considered adequate.

4.15. Other infrastructure for cables or communications might be present within the zone of influence of the proposed basement extension, so it is agreed that an appropriate services search should be undertaken. The potential influence should be investigated should such infrastructure be identified.

4.16. The BIA notes that the site lies within the Environment Agency's Flood Zone 1, indicating negligible risk of fluvial flooding, and is not at risk of flooding from reservoirs as mapped by the Environment Agency. Additionally, the proposed basement and lightwells will not result in any change in paved surface area because the site is already fully developed with no soft landscaping. Thus, the proposed basement is not expected to cause any adverse effects on surface water run-off characteristics.

4.17. It is accepted that the site is not within the catchment of the ponds on Hampstead Heath, or in the vicinity of any watercourse, rivers, spring lines, or at risk of sea, reservoir, sewer or river flooding.

4.18. Although surface water will continue to be discharged into the mains drainage system, any collected groundwater as a result of construction dewatering that is proposed to be discharged into the public sewers will likely require the prior permission of Thames Water.

4.19. A detailed Ground Movement Assessment was conducted by Cundall and received by CampbellReith on 23 August 2016 and is based on a piled foundation solution. The GMA predicts damage no worse than Very Slight (Burland Category 1). Although this is contrast to Anderson's report that claims "expected settlement damage is zero", mitigation measures are discussed in the Cundall Report and Revised Construction Method Statement.

4.20. It is agreed that condition surveys of the neighbouring properties should be commissioned and a programme of monitoring the adjoining structures should be established before the work starts.

5.0 CONCLUSIONS

5.1. The Building Impact Assessment (BIA) has been carried out by Chelmer Consultancy Services. The qualifications of the individuals who have prepared and reviewed the BIA are in accordance with the requirements of CPG4.

5.2. The site is a six-storey terraced house within the Charlotte Street Conservation Area. Construction is intended to extend the single-storey basement beneath the rear part of 28 Charlotte Street. The rear of the site adjoins both the Crabtree Fields playground and the modern development at No's 7-15 Whitfield Street.

5.3. The BIA has confirmed that the proposed basement will be founded within Made Ground and its foundations will need to be deepened to encounter the Lynch Hill Gravel below. Supporting the basement on piled foundations bearing into the in situ gravels and clays at depth, as proposed in the BIA (Option B) is considered the preferred founding solution. This is now reflected in the Revised Construction Method Statement.

5.4. Groundwater data indicates the groundwater level to be at least 1.0m below the basement slab. It is stated that pumping from sumps will be employed if groundwater is encountered. The Made Ground expected at/beneath formation level may be very susceptible to disturbance with the risk of drawing soil into the excavation, although mitigation measures are proposed.

5.5. It is accepted that the proposed construction will not have an impact on surrounding roads as the extension is to the rear of the property. Additionally, no railway tunnels are known to pass below or close to the site. A pedestrian right of way is located near the rear of the property, although this has been identified and proposed actions are considered adequate.

5.6. It is accepted that the site is not within the catchment of the ponds on Hampstead Heath, or in the vicinity of any watercourse, rivers, spring lines, or at risk of sea, reservoir, sewer or river flooding.

5.7. It is accepted that the development will not impact on the wider hydrogeology of the area and is not in an area subject to flooding.

5.8. The site and its surroundings are relatively flat and raise no concerns in relation to the overall stability of the slope.

5.9. The GMA predicts damage no worse than Very Slight (Burland Category 1) with mitigation measures proposed in the Cundall Report and Revised Construction Method Statement.

5.10. Geotechnical parameters for the natural soils (Sands/Gravels and London Clay) encountered at the site are proposed in the BIA and are considered reasonable, based on the investigation laboratory results and previous experience.

5.11. It is agreed that condition surveys of the neighbouring properties should be commissioned and a programme of monitoring the adjoining structures should be established before the work starts. The movement monitoring strategy should be continued during excavation and construction.

Appendix 1: Residents' Consultation Comments

None

Appendix 2: Audit Query Tracker

Audit Query Tracker

Query No	Subject	Query	Status	Date closed out
1	Stability	Revised CMS required reflecting ground conditions encountered during the site investigation.	Closed	16/09/2016
2	Stability	Revised GMA required reflecting revised CMS and reduced stiffness for Made Ground.	Closed	16/09/2016
3	Hydrogeology	Impact of proposals on groundwater to be confirmed once construction methodology agreed.	Closed	16/09/2016

Appendix 3: Supplementary Supporting Documents

Revised Construction Method Statement by Anderson
Structural Calculations for Proposed Structural Alterations by Anderson
Drawings by Anderson
Ground Movement Impact Assessment by Cundall

CONSTRUCTION METHOD STATEMENT

28 Charlotte Street

Fitzrovia

London

W1T 2NF

METHOD STATEMENT PRODUCED BY:
Anderson Consulting Engineers
One Kingdom Road
Paddington
London
W2 6BD
Tel: 0203 755 5084

PROJECT No: S4444

CONTENTS

1.0 INTRODUCTION

This Construction Method Statement is produced for submission to London Borough of Camden as part of a planning application for works to 28 Charlotte Street, W1T 2NF and should not be used for any other purposes, e.g. construction or Party Wall Awards.

2.0 SCOPE OF WORKS

A new single storey basement is proposed under the rear of the existing property under the study. This will create space for bedrooms to the lower ground floor flat.

3.0 DESCRIPTION OF 28 CHARLOTTE STREET AND ADJOINING PROPERTIES

The front part of the building is a six storey mid-terraced victorian property of masonry construction with timber floors to ground floor and upper levels and timber rafters to form the roof. The property is in a sound condition structurally. The adjoining properties are of similar construction and look to be in sound condition from an external non – intrusive visual examination.

4.0 GEOLOGY AND HYDROLOGY CONDITIONS

The site specific borehole shows made ground to 5.30m below the existing basement floor level.

The new basement will be designed to be supported on piles to limit settlements.

5.0 STRUCTURAL CALCULATIONS

See calculation sheets S4444/ C1a – C9a for calculations to each wall face, showing the assumed loadings and design of underpins. These calculations can be found in the Appendices. Assumptions that were made in these calculations were that the existing wall construction followed the London Building Acts of 1844, found in CIRIA Report 111.

6.0 CONSTRUCTION DRAWINGS

See drawing Nos S4444 / GA01a and D01a in the Appendices for underpinning layout, sequencing and sections to the party walls of the property. This underpin has been taken as the general case on the plans when showing the underpinning areas and sequences.

7.0 CONSTRUCTION SEQUENCE OF THE NEW BASEMENT

1. Excavation will commence from above the front of the proposed basement through the existing basement progressing towards the rear.
2. A conveyor belt will be set up through the existing basement to convey the spoil from the excavation to a skip placed on the road for disposal.
3. The existing ground bearing concrete floor to the rear of the property, above the proposed basement, will be broken out and removed from site.
4. Piles will be installed in the locations shown on drawing No S4444/GA01a.
5. The existing walls will be underpinned in a strip underpinning sequence. See drawing S4444/GA01a, MS01a & MS02a for the construction sequence of a typical underpin strip and underpinning specification in the Appendices.
6. The new retaining walls are to be pinned tight to the underside of existing walls as outlined in the underpinning specification.
7. Continuity reinforcement will be installed between the strips to form a continuous slab and wall.
8. As excavation progresses, any existing foundations discovered will be broken out and removed from site to make way for the new basement construction.
9. After the new basement slab has cured, a drained – cavity layer will be laid to the slab and walls.
10. A layer of insulation will be placed on top of the drained – cavity layer on the slab, and in front of the drained – cavity layer on the walls.
11. Finally a layer of screed will be laid to form the finished basement floor.

8.0 POTENTIAL IMPACT ON 28 CHARLOTTE STREET AND ADJOINING PROPERTIES

The proposed basement under the existing property will be formed using an underpinning method, constructed in sections each no wider than 1000mm, with no adjacent underpins constructed within a 48 hour period. This method of construction reduces the amount of potential ground movement and so minimises the effects of settlement of the adjacent structures.

Expected settlement damage is zero provided an experienced contractor is appointed who undertakes the works using good practice in accordance with the structural design and follows all agreed method statements, installing all necessary temporary vertical and lateral supports required. In practice some settlement is possible but this should be no worse than 'aesthetic', according to the BRE's definition. If these conditions are met, any settlement that occurs is likely to be minimal and is likely to be accommodated in the elasticity of the superstructure. This has been borne out in the vast majority of past projects on similar properties.

The design and construction methodology, as described above, deals with the potential risks and ensures that the excavation and construction of the proposed basement will not affect the structural integrity of the property and adjoining properties.

9.0 SLOPE STABILITY

The site is located on ground that is relatively flat and so slope instability can only be initiated in the temporary condition as the proposed basement is being built. This would be via a collapse of the partially formed underpinning.

This is highly unlikely due to the construction sequence and implementation of temporary works and is covered by the statement above on the impact on adjoining properties.

10.0 POTENTIAL IMPACT ON EXISTING AND SURROUNDING UTILITIES, INFRASTRUCTURE AND MAN – MADE CAVITIES

Any local services on the property's land will be maintained during construction and re – routed if necessary. The exact location of these services will not be known until the works commence. However the impact will be negligible as these services will be maintained. If it is necessary to relocate or divert any utilities, the Contractor and Design Team will be under a statutory obligation to notify the utility owner prior to any works. This will be so that they can assess the impact of the works and grant or refuse their approval. There are no known man – made cavities (e.g. tunnels) in the vicinity of the proposed basement.

11.0 POTENTIAL IMPACT ON DRAINAGE, SEWAGE, SURFACE AND GROUND WATER LEVELS AND FLOWS INCLUDING SUDS

All existing drainage and sewage connections will be maintained throughout the construction works so there will be no impact on these existing systems.

The proposed refurbishment will not alter the current state of the property, which will remain as a mixed use retail and residential building. Therefore there will be no significant change in discharge to the existing drainage and sewage systems.

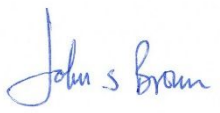
Surface water will not be altered as the proposed works are underground and there will be no change to the external 'hard surfaces'.

The site–specific borehole confirms that the new formation is above the ground water level, thus there will be no impact on ground water flows and levels.

12.0 POTENTIAL IMPACT ON EXISTING AND PROPOSED TREES

The property does not have a garden, therefore no existing trees will be felled during the construction of the proposed basement. In addition, there are no trees protected by Tree Preservation Orders in the vicinity of the proposed basement that will be damaged by the construction works.

Prepared By



John S Brown
IEng. AMIStructE

July 2016

APPENDICES

The following appendices are included with this report.

Appendix A	-	BGS borehole reports
Appendix B	-	Initial Calculation sheets
Appendix C	-	Drawings GA01a & D01a
Appendix D	-	Drawing MS01a-02a
Appendix E	-	Underpinning Specification

APPENDIX A

SITE SPECIFIC BOREHOLE INFORMATION

APPENDIX B

CALCULATION SHEETS

S4444/C1a – C9a

APPENDIX C

DRAWING GA01a & D01a

APPENDIX D

METHOD SEQUENCE MS01a & MS02a

APPENDIX E

UNDERPINNING SPECIFICATION

General Underpinning Specification

1. The walls to the perimeter of the new basement shall be underpinned in reinforced concrete and the underpins shall take the vertical loads from the walls and horizontal loads from the earth.
2. Underpinning bases shall be excavated in short sections not exceeding 1000mm in width. The sequence of the underpinning shall be such that any given underpin will be completed, dry-packed and a minimum period of 48 hours lapsed before an adjacent excavation commenced to form another underpin.
3. In the event that the existing foundations to the wall are found to be unstable, sacrificial steel jacks shall be installed underneath the foundation to prop the bottom few courses of bricks. These steel jacks shall be left in place and shall be incorporated into the concrete stem.
4. In the event that the ground is unstable, lateral propping shall be provided as required to the rear of the excavation and to the sides of the excavated working trench. The front and side faces of the excavation shall be propped using trench sheeting or plywood, timber boards and Acrow props as appropriate. Sacrificial back – shutters shall be used to the rear face of the excavation (i.e. underneath the wall) if required. Cementitious grout will be poured behind the back – shutters to fill up the voids behind the back – shutters.
6. Excavation for an underpin section shall be dug in a day, and the concrete to the base shall be poured by the end of the same day.
7. The concrete to the stem of the underpin shall be poured the following day. This shall be poured up to within 50 – 75mm of the underside of the existing wall foundations.
8. On the following day, the gap between the concrete and the underside of the existing foundation shall be drypacked with C35 concrete using 5 – 10mm coarse aggregate and Conbextra GP admixture by Fosroc UK Ltd in accordance with their instructions.
9. Once the drypack has gained sufficient strength, any protrusions of the footings into our site shall be carefully trimmed back using hand tools to avoid causing any damage to the foundation. The protrusions shall be trimmed back to be flush in-line with the face of the wall above.
10. A minimum of 48 hours shall be allowed before adjacent sections are excavated to form a new underpin.
11. Adjacent underpins shall be connected using T12 dowel bars 800mm long, 400mm embedment each side, at 300mm vertical centres.
12. Concrete cover to reinforcement shall be 35mm for cast against shutter or the top surface of the basement slab, 50mm for cast against blinding and 75mm for cast against earth.
13. Grade of concrete shall be C35 with minimum cement content 300kg/m3, maximum free water to cement ratio 0.60, slump 100mm.

Structural Calculations

For

Proposed Structural Alterations
28 Charlotte Street
Fitzrovia
London
W1T 4NF

Anderson Consulting Engineers
One Kingdom Street
Paddington
W2 6BD
0203 755 5084

Project No: S4444

Anderson
Consulting Engineers
One Kingdom Street
Paddington
W2 6BD
0203 755 5084

Project		Job Ref	
28 Charlotte Street, W1T 4NF		S4444	
Drawing Ref	Calculations by	Checked by	Sheet
	JSB		C1a
Part of Structure		Date	
Basement retaining walls		20/08/15	

Loadings (Service Loads)

Flat roof

Dead Loads	
Felt and chippings	0.45 kN/m^2
Boards and joists	0.20 kN/m^2
Ceiling	0.20 kN/m^2
Services	0.15 kN/m^2
Total Dead Load	**1.00 kN/m^2**
Imposed Load	**0.75 kN/m^2**

Pitched Roof

Dead Loads	
Slate and felt	0.30 kN/m^2
Boards and joists	0.25 kN/m^2
Ceiling	0.25 kN/m^2
Services	0.15 kN/m^2
Total Dead Load	**1.00 kN/m^2**
Imposed Load Roof	0.75 kN/m^2
Imposed Load Ceiling	0.25 kN/m^2
Total Imposed Loading	**1.00 kN/m^2**

Timber Floors

Dead Loads	
Boards and joists	0.35 kN/m^2
Ceiling	0.20 kN/m^2
Services	0.25 kN/m^2
Total Dead Load	**0.80 kN/m^2**
Imposed Load	**1.50 kN/m^2**
(Ground Floor retail)	**4.00 kN/m^2**
Partitions	**0.60 kN/m^2**

Walls

215 Brickwork + plaster	**5.30 kN/m^2**
330 Brickwork + Plaster	**7.40 kN/m^2**
Stud partitions	**0.70 kN/m^2**

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	JSB		C2a
Part of Structure		Date	
Basement retaining walls		20/08/15	

Retaining Walls

Design Philosophy – Basement Design

Geology
A site specific borehole revealed made ground below the existing basement floor slab to a depth of 5.30m. The made ground has little inherent strength as shown by the MPT values.

Retaining Wall Design
Retaining walls will be designed using "at rest" pressures to minimise the amount of movement in the walls. This will minimise the risk of damage to this and adjacent structures and when carried out in the correct sequence no structural damage is expected as experienced on many similar projects.

The basement retaining walls have been designed with the following geotechnical design parameters:

SOIL PARAMETERS

Dry soil	= 18 kN/m^3
Water	= 10 kN/m^3
φ	= 28°

The retaining walls, base and basement slab are to be supported on a series of piles around the perimeter of the building and centrally.

Water Table

Borehole test carried out for the project do not show any water present within the basement construction depth.

An assumed accidental case will be assumed of 1.0 m below ground level for design of uplift on the slab and lateral forces on the retaining walls.

Temporary Works

The retaining walls will be designed where possible to be self supporting under soil loading in the construction stage of the project. The underpins will need to be propped during construction to avoid any sliding failure at the base.

In the permanent case the retaining wall bases will be propped by the basement slab therefore the most onerous design case is the temporary condition.

All temporary works to be carried out by the contractor following approval of the temporary works design.

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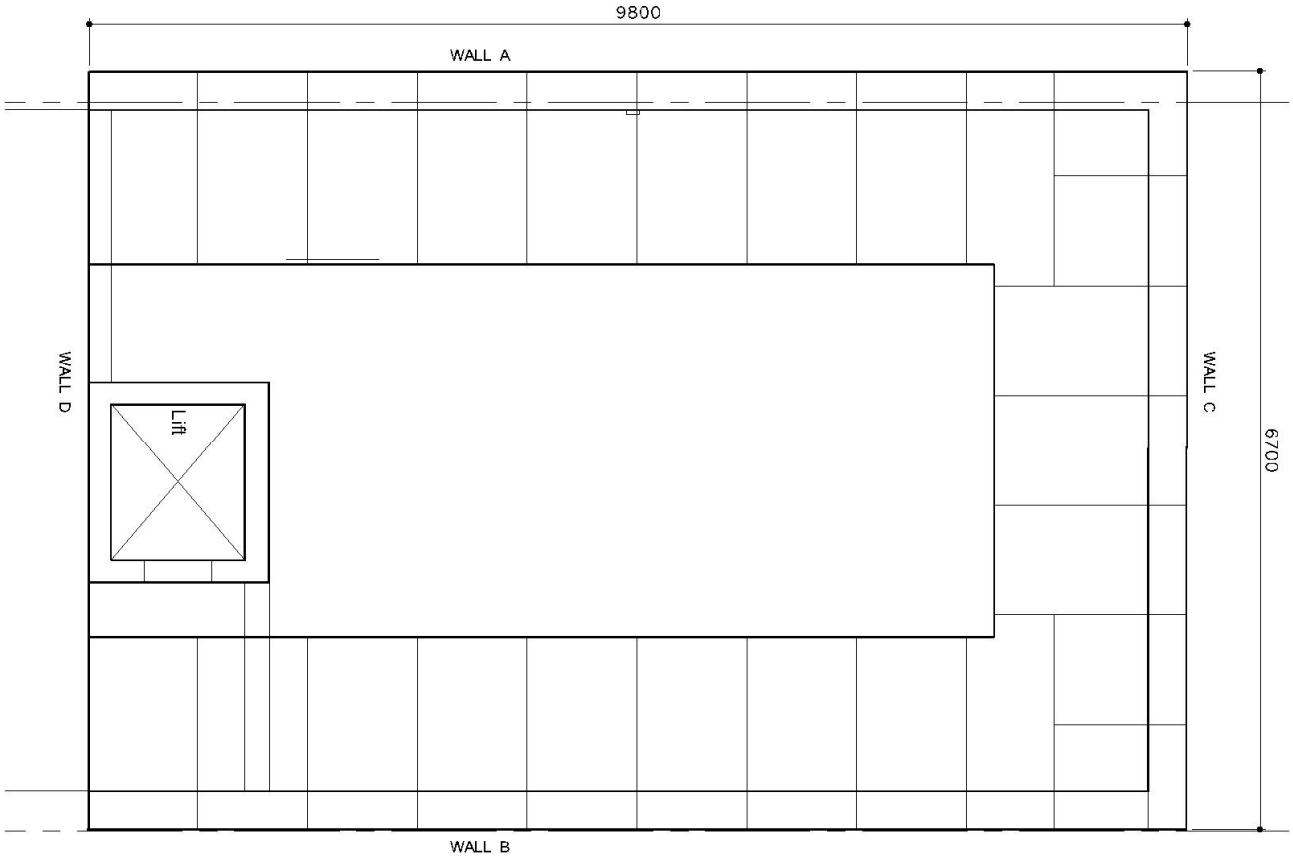
Loadings to perimeter walls

Loads from adjacent floors and roof are included and assumed that a similar extension upwards may be carried out at some time in the future to the adjacent property at N0 30 Charlotte Street.



Reference Plan

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Wall A

Loading

Location	Dead load	Live load	Height/Dist	Dead Load	Live Load	Total load
	kN/m^2	kN/m^2		Gk	Qk	kN/m
Roof	1.00	0.75	6.4	6.4	4.8	11.2
Wall 1st- Roof	5.30	0.00	5.9	31.3	0.0	31.3
2nd Floor	1.40	1.50	6.4	9.0	9.6	18.6
1st Floor	1.40	1.50	6.4	9.0	9.6	18.6
Ground Floor	1.40	1.50	6.4	9.0	9.6	18.6
Wall B - 1st	7.40	0.00	5.8	42.9	0.0	42.9
		Total Service Load		**107.5**	**33.6**	**141.1**
		Total ULS Load		**150.5**	**53.8**	**204.2**

Wall B

Loading

Location	Dead load	Live load	Height/Dist	Dead Load	Live Load	Total load
	kN/m^2	kN/m^2		Gk	Qk	kN/m
Roof	1.00	0.75	3.2	3.2	2.4	5.6
Wall 1st- Roof	5.30	0.00	5.9	31.3	0.0	31.3
2nd Floor	1.40	1.50	3.2	4.5	4.8	9.3
1st Floor	1.40	1.50	3.2	4.5	4.8	9.3
Ground Floor	1.40	1.50	3.2	4.5	4.8	9.3
Wall B - 1st	7.40	0.00	5.8	42.9	0.0	42.9
		Total Service Load		**90.8**	**16.8**	**107.6**
		Total ULS Load		**127.2**	**26.9**	**154.0**

Wall C

Loading

Location	Dead load	Live load	Height/Dist	Dead Load	Live Load	Total load
	kN/m^2	kN/m^2		Gk	Qk	kN/m
Wall Grd - Roof	5.30	0.00	3.0	15.9	0.0	15.9
Wall B- Grd	7.40	1.50	2.7	20.0	4.1	24.0
		Total Service Load		**35.9**	**4.1**	**39.9**
		Total ULS Load		**50.2**	**6.5**	**56.7**

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Wall D

Loading

Location	Dead load	Live load	Height/Dist	Dead Load	Live Load	Total load
	kN/m^2	kN/m^2		Gk	Qk	kN/m
Wall 1st - roof	5.30	0.00	5.2	27.6	0.0	27.6
2nd,3rd 4th Floo	0.80	1.50	13.5	10.8	20.3	31.1
1st Floor	0.80	1.50	4.5	3.6	6.8	10.4
Ground Floor	0.80	4.00	4.5	3.6	18.0	21.6
Wall B- 1st	7.40	0.00	3.5	25.9	0.0	25.9
		Total Service Load		**71.5**	**45.0**	**116.5**
		Total ULS Load		**100.0**	**72.0**	**172.0**
		40% openings in walls				

Total load at slab level

(141.1 + 107.6) x 9.8 + (39.9 +116.5) x 6.7 = 3485 kN

Bearing pressure (not allowing for unbalanced loads) = 3485 / 6.7 x 9.8 = 53 kN/m^2

With the eccentric loads the bearing pressure will be in excess of 90 kN/m^2 which is in excess of the safe bearing pressure for the made ground and potential settlements.

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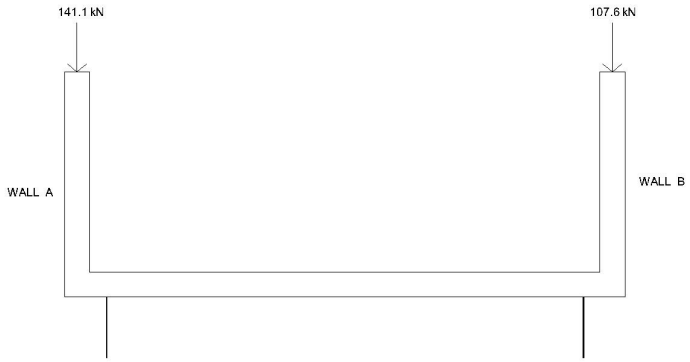
Consider piled foundations

Across the width of the building (between walls A and B)



Slab load + Finishes = 24 x 0.4 = 15.0 kN/m; Imposed load = 1.50 kN/m;
Total load = 141.1 + 107.6 + 16.5 x 6.1 = 350 kN

For a 1.0m strip
Load to LH pile = 141.1 x 6.05 + 16.5 x 5.9 x 2.45 / 5.7 = 192 kN
Load to RH pile = 152 kN

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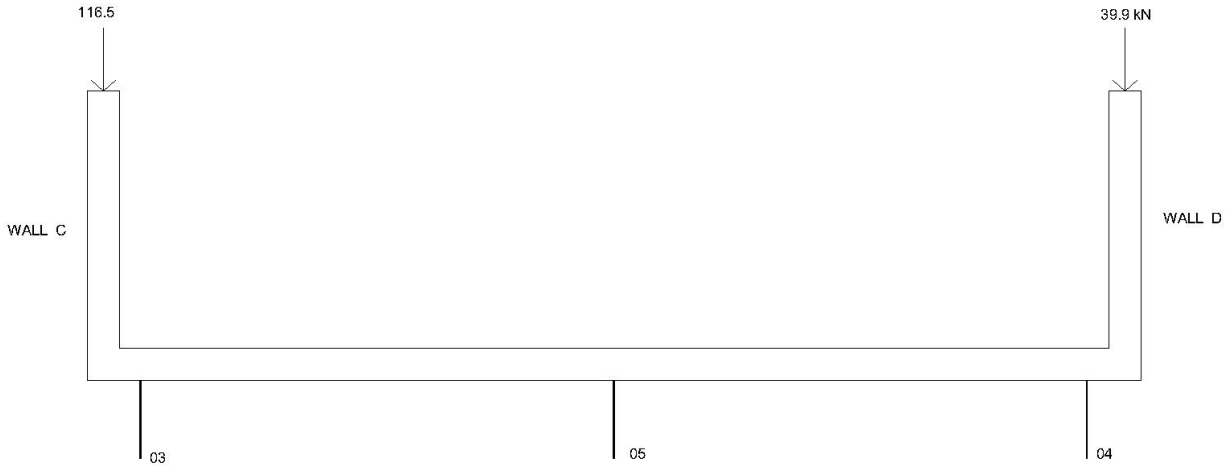
Basement retaining walls		20/08/15	

Along length of building (between walls C and D)



Total load = 318 kN
From continuous slab analysis
Load at

03 = 165 kN
04 = 82 kN
05 = 71 kN

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Basement retaining walls		20/08/15	

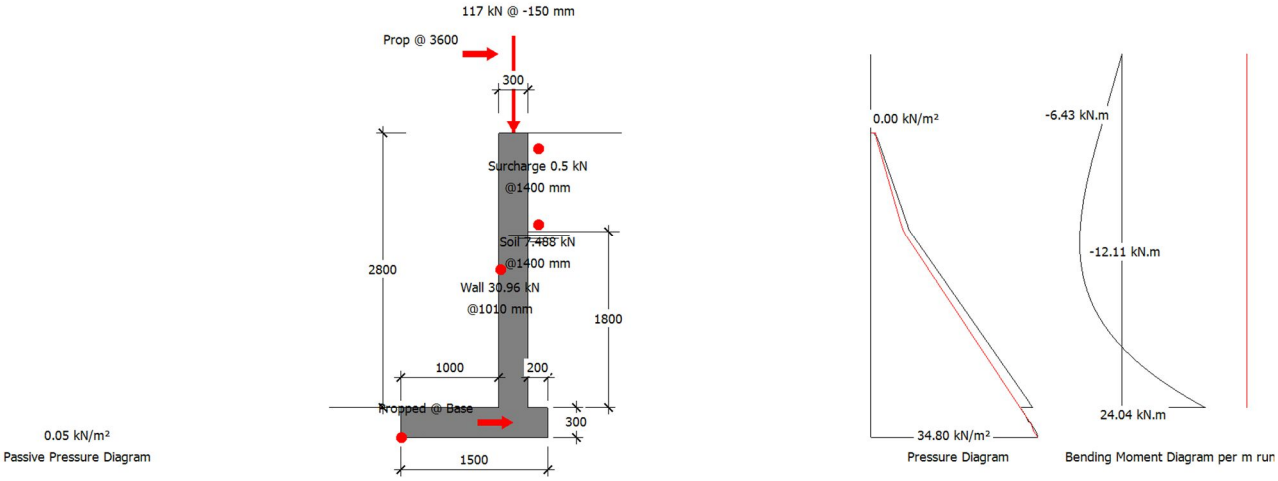
The walls will be designed as a vertical cantilever for the lateral pressure from soil, surcharge loads and water pressure.

Surcharge loads to be taken as 10.0 kN/m^2 or 2.50 kN/m^2 plus water pressure based on the probability that maximum surcharge and flooding are unlikely to occur concurrently.

The bending moment at the base of the wall will be dissipated into the slab. The slab will be supported on the piles.

Typical retaining wall design

Basic RC Retaining Wall
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m^3)	Dry Soil 18.00, Saturated Soil 20.80, Submerged Soil 10.80, Concrete 24.00
Concrete grade	fcu 35 N/mm^2, Permissible tensile stress 0.250 N/mm^2
Concrete covers (mm)	Wall inner cover 75 mm, Wall outer cover 40 mm, Base cover 50 mm
Reinforcement design	fy 460 N/mm^2 designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 2.50 kN/m^2, Water table level 1800 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 3.6 m
Vertical Line Load	117 kN/m @ X -150 mm and Y 0 mm - Load type Dead
† Dimensions	All props are measured from the top of the base Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 200.00 kN/m^2, @ back 200.00 kN/m^2
Back Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(30)/1.2))) = 19.84°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

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Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	1.00 G_{Soil}+1.00 G_{Wall}+1.00 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$
Case 2: Structural Ultimate Design	1.40 G_{Soil}+1.40 G_{Wall}+1.60 Fv_{Heel}+1.00 P_a+1.00 $P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	45.208/195.977	0.231	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+ Rx_{Passive})$	0.000/(56.273+0.000)	0.000	OK
Prop Reactions Case 2 (Service)	42.9 kN @ Base, 4.9 kN @ 3.900 m		

Soil Pressure

Virtual Back (No uplift)	Max(13.811/200, 194.120/200) kN/m²	0.971	OK
Wall Back (No uplift)	Max(21.628/200, 186.302/200) kN/m²	0.932	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\text{Sin}(\phi))$ x $\sqrt{OCR}$ = (1+Sin(25.69)x$\sqrt{1}$		1.43

Prop Reactions

Maximum Prop Reactions (Ultimate)	66.4 kN @ Base, 8.0 kN @ 3.600 m		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2			Steel Prov
Compression Steel Provided (Cover)	Main B10@200 (40 mm) Dist. B10@200 (50 mm)	393 mm²		
Leverarm z=fn(d,b,As,fy,Fcu)	220 mm, 1000 mm, 393 mm², 460 N/mm², 35.0 N/mm²	209 mm		
Mr=fn(above,As',d',x,x/d)	393 mm², 45 mm, 12 mm, 0.06	35.9 kN.m		
Moment Capacity Check (M/Mr)	M 24.0 kN.m, Mr 35.9 kN.m	0.670	OK	
Wall Axail Design (N/Ncap)	N 200.1 kN, Ncap 4200.0 kN	0.048	OK	
Wall Slenderness λ	Leff/tk =1.27x2800.0/300.0	11.9	OK	
Kmin = (Nuz-N)/(Nuz-Nbal)	Min(1.0, 4666.7 - 200.1)/(4666.7 - 1724.6)	1.0		
M_{add}= N.Kmin.h.λ²/2000	200.1x1.0x300.0x11.9²/2000	0.0kN.m		
$(M+Madd)/Mr_{Axial}$	M+Madd 24.1 kN, Mr_{Axail}65.1 kN.m	0.370	OK	
Shear Capacity Check	F 52.5 kN, vc 0.462 N/mm², Fvr 101.7 kN	0.52	OK	

Wall Design (Outer Steel)

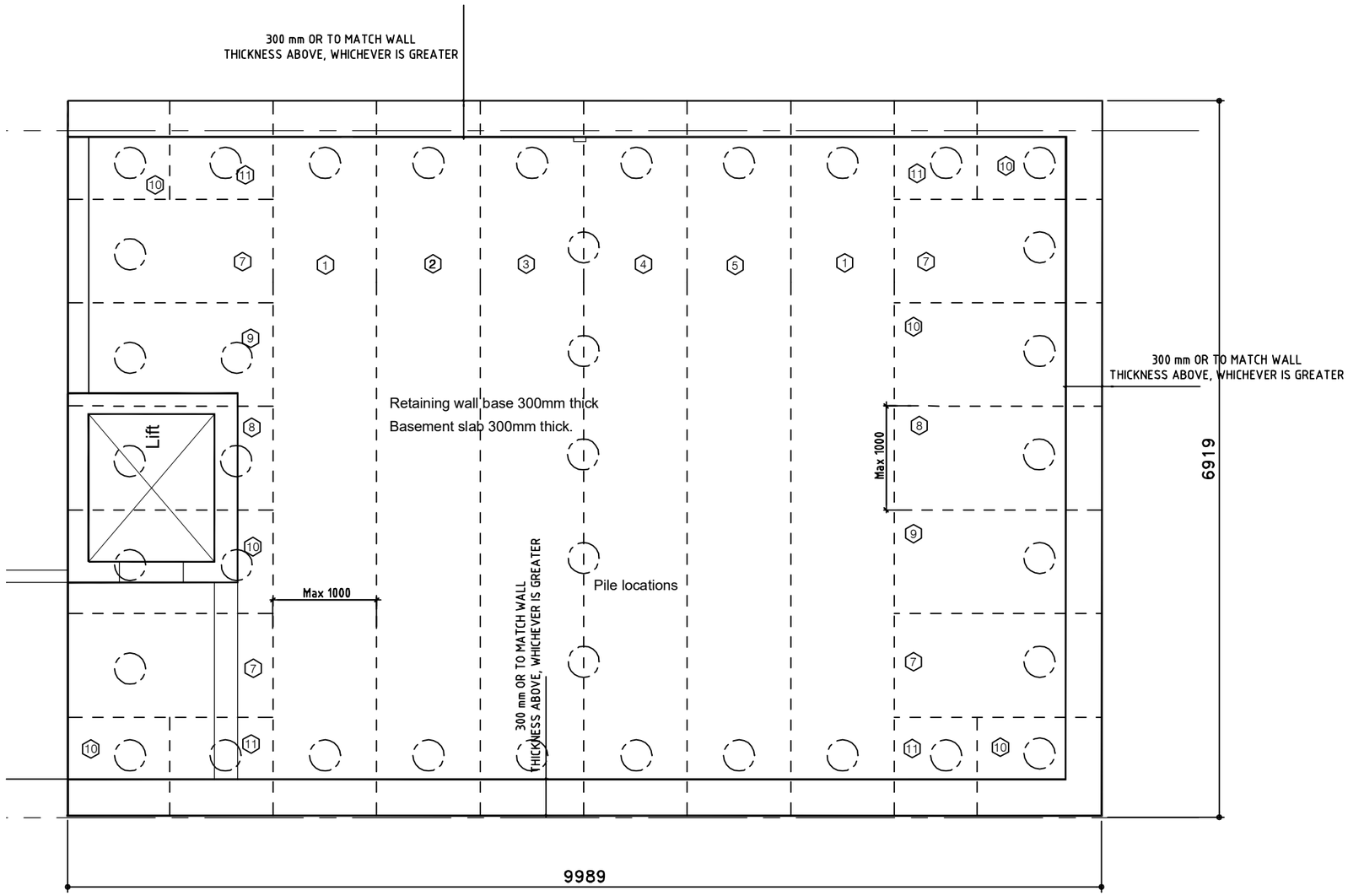
Critical Section	Critical @ 1663 mm from base, Case 2			Steel Prov
Compression Steel Provided (Cover)	Main B10@200 (75 mm) Dist. B10@200 (85 mm)	393 mm²		
Leverarm z=fn(d,b,As,fy,Fcu)	255 mm, 1000 mm, 393 mm², 460 N/mm², 35.0 N/mm²	242 mm		
Mr=fn(above,As',d',x,x/d)	393 mm², 80 mm, 12 mm, 0.05	41.6 kN.m		
Moment Capacity Check (M/Mr)	M 12.1 kN.m, Mr 41.6 kN.m	0.291	OK	
Wall Axail Design (N/Ncap)	N 200.1 kN, Ncap 4200.0 kN	0.048	OK	
Wall Slenderness λ	Leff/tk =1.27x2800.0/300.0	11.9	OK	
Kmin = (Nuz-N)/(Nuz-Nbal)	Min(1.0, 4666.7 - 200.1)/(4666.7 - 2026.3)	1.0		
M_{add}= N.Kmin.h.λ²/2000	200.1x1.0x300.0x11.9²/2000	-3.8kN.m		
$(M+Madd)/Mr_{Axial}$	M+Madd 15.9 kN, Mr_{Axail}76.1 kN.m	0.209	OK	
Shear Capacity Check	F 0.3 kN, vc 0.424 N/mm², Fvr 108.1 kN	0.00	OK	

Base Top Steel Design

Steel Provided (Cover)	Main B10@200 (50 mm) Dist. B10@200 (60 mm)	393 mm²	OK
Compression Steel Provided (Cover)	Main B10@200 (50 mm) Dist. B10@200 (60 mm)	393 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	245 mm, 1000 mm, 393 mm², 460 N/mm², 35 N/mm²	233 mm	
Mr=fn(above,As',d',x,x/d)	393 mm², 55 mm, 12 mm, 0.05	39.9 kN.m	
Moment Capacity Check (M/Mr)	M 0.0 kN.m, Mr 39.9 kN.m	0.000	OK
Shear Capacity Check	F 0.0 kN, vc 0.434 N/mm², Fvr 106.4 kN	0.00	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main B10@200 (50 mm) Dist. B10@200 (60 mm)	393 mm²	OK
Compression Steel Provided (Cover)	Main B10@200 (50 mm) Dist. B10@200 (60 mm)	393 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	245 mm, 1000 mm, 393 mm², 460 N/mm², 35 N/mm²	233 mm	
Mr=fn(above,As',d',x,x/d)	393 mm², 55 mm, 12 mm, 0.05	39.9 kN.m	
Moment Capacity Check (M/Mr)	M 36.4 kN.m, Mr 39.9 kN.m	0.912	OK
Shear Capacity Check	F 97.9 kN, vc 0.434 N/mm², Fvr 106.4 kN	0.92	OK



FOUNDATION PLAN

REV	DATE	BY	DETAILS OF REVISION
F			
E			
D			
C			
B			
A	28.07.16	JW	Methodology amended

PROJECT
28 Charlotte Street
London
W1T 4NF

PROJECT NO.
S4444

DRAWING NO.
GA01

REVISION
A

TITLE
Basement Underpin Layout

DRAWN BY
JW

DATE
August 2015

SCALE
1:50@A3

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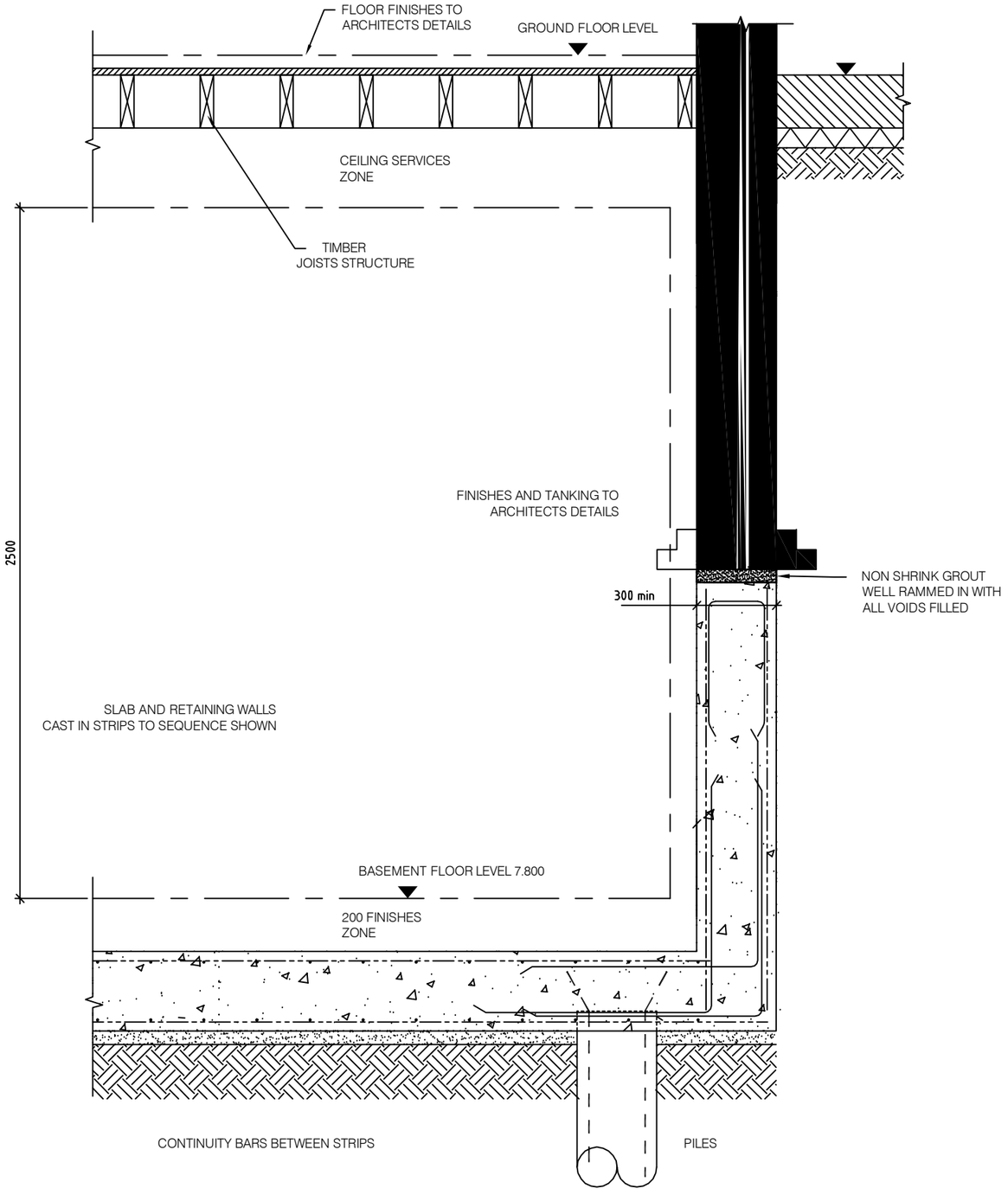

TYPICAL SECTION THROUGH RETAINING WALL

REV	DATE	BY	DETAILS OF REVISION
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Typical Section

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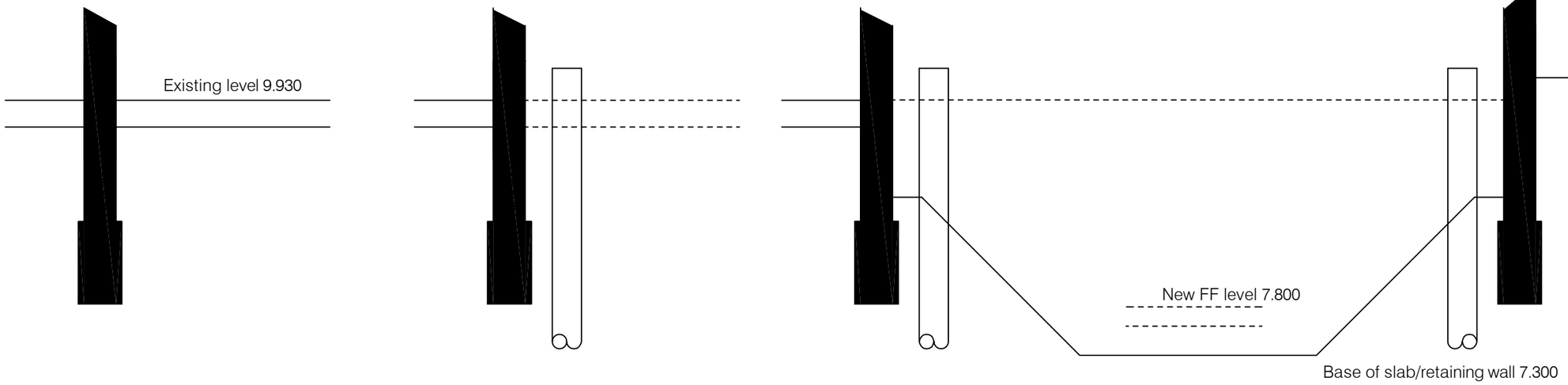
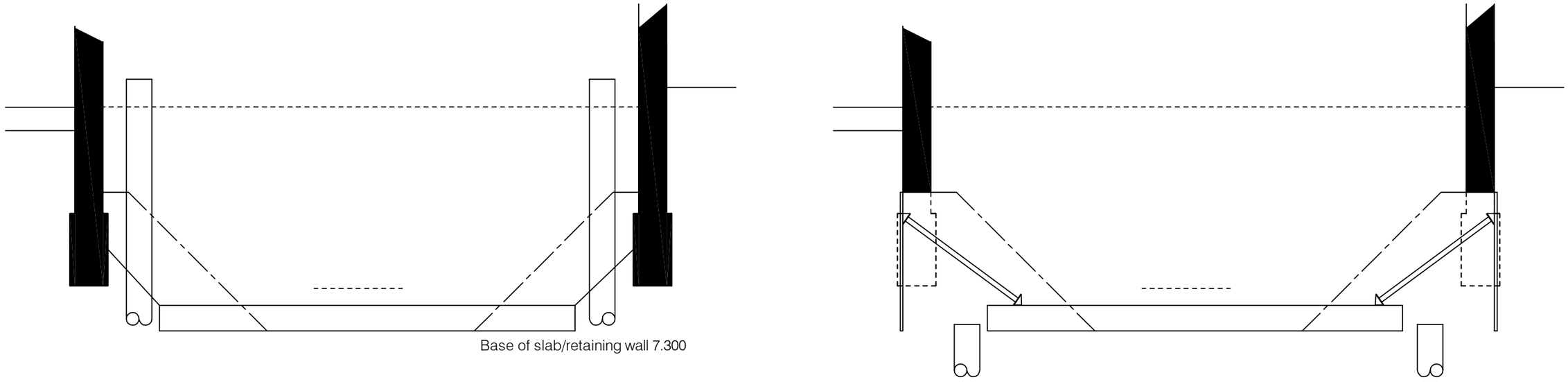


STAGE 0
EXISTING CONDITION

STAGE 1
REMOVE SLAB AND INSTALL PILES

STAGE 2
GENERAL REDUCED LEVEL



STAGE 3
REMOVE 1.0 m STRIP, CAST SLAB UP TO PILE

STAGE 4
REDUCE PILE, REMOVE FOUNDATION BRICKWORK , PROP SOIL FACE IF REQUIRED

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TITLE
Underpin Sequence

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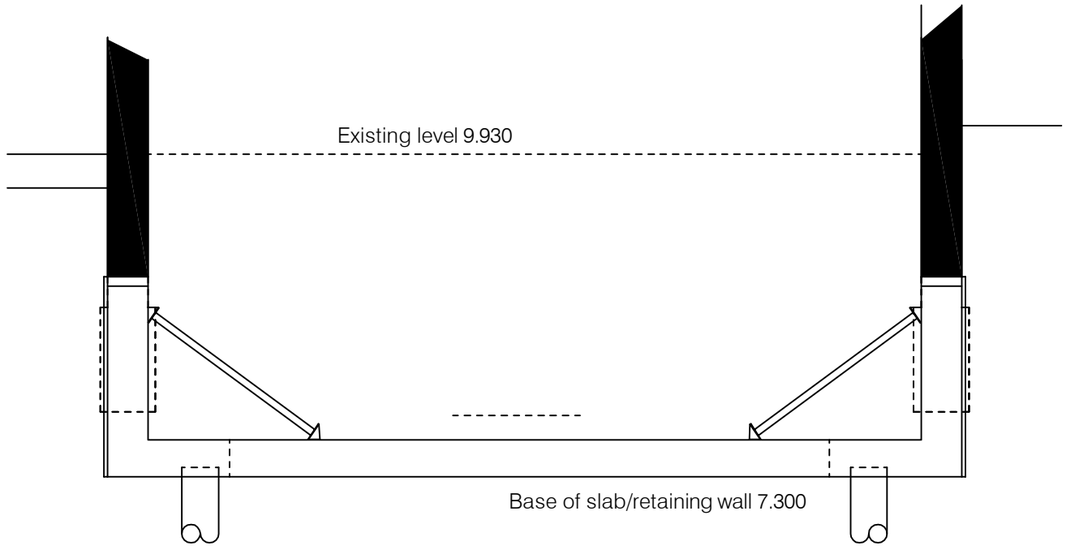

STAGE 5
CAST REMAINING BASE THEN STEM,

STAGE 6
DRYPACK TO EXISTING WALL, REPEAT FOR OTHER STRIPS AS SEQUENCE

NOTE: ANY DRAINAGE BELOW THE SLAB TO BE INSTALLED WITH EACH STRIP

REV	DATE	BY	DETAILS OF REVISION
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28 Charlotte Street, London

Impact Assessment for Proposed Underpinning Works

For: Anderson Consulting Engineers

Job No: 1013857

Doc Ref: 1013857.RPT.GL.001

Latest Revision: -

Date: 19/08/2016

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Project Name:	28 Charlotte Street, London
Client:	Anderson Consulting Engineers
Report Title:	Impact Assessment for Proposed Underpinning Works
Job Number:	1013857

Document Revision History

Revision Ref	Issue Date	Purpose of issue / description of revision

Document Validation (latest issue)

22/08/2016	22/08/2016	Recoverable Signature
X	X	X
Principal author	Checked by	Verified by
Signed by: Schoor, Jesse	Signed by: Spears, James	Signed by: k.mcqee@cundall.com

CUNDALL

Contents

CUNDALL

Figures

Tables

Appendices

CUNDALL

1. Introduction

1.1 Context

Cundall Johnston & Partners LLP (Cundall) has been appointed by Anderson Consulting Engineers (ACE) to provide geotechnical engineering advice relating to the formation of a single level of basement at 28 Charlotte Street, London. The development site forms part of a terraced apartment block and impacts to adjoining structures will need to be evaluated in accordance with Camden Planning Guidance on Basements and Lightwells (CPG4).

1.2 Objectives and Scope of Assessment

The report summarises potential ground movements resulting from the formation of a single level of basement at 28 Charlotte Street and evaluates the impact of these movements on adjacent structures at 30 and 32 Charlotte Street.

It should be noted that the Local Authority may require submission of a 'basement impact assessment' in connection with the proposed development, and that this report, in itself, will be insufficient for satisfying this requirement.

This report does not consider the stability of existing foundations during the excavation and underpinning works.

1.3 References

This report has been prepared (in part) using information from the following sources:

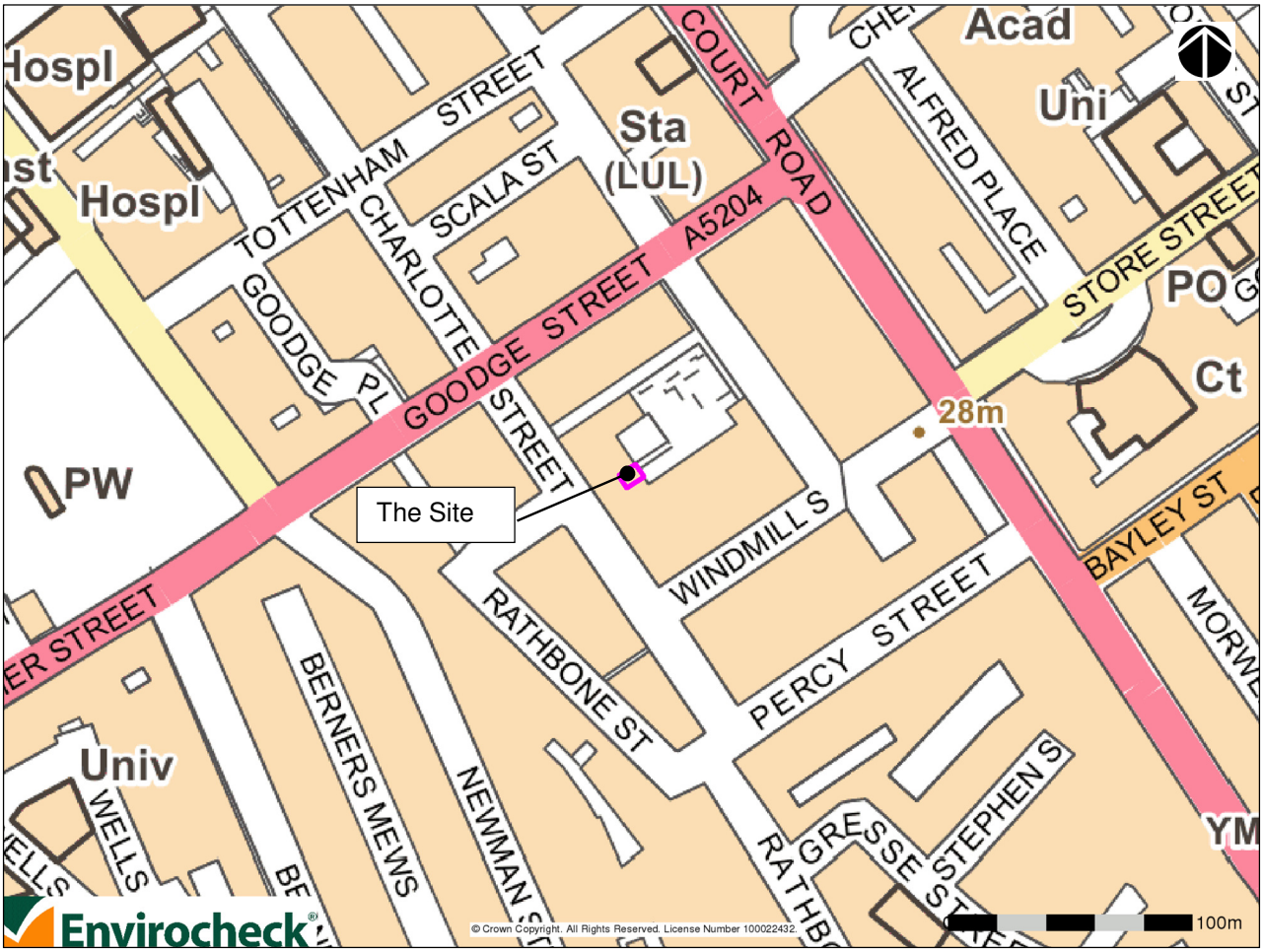
- ACE (2016) Construction Method Statement for 28 Charlotte Street, Fitzrovia, London, WIT 2NF.
- Burland (1996) Prediction of ground movements and assessment of risk of building damage due to bored tunnelling , Geotechnical Aspects of Underground Construction in Soft Ground, ISBN 9054108568.
- Chelmer (2016) Factual Report on Ground Investigation at 28 Charlotte Street, London, Report Reference FACT/6262-REV1.
- ITA/AITES (2007) Settlement Induced by Tunnelling in Soft Ground, Tunnelling and Underground Space Technology, Volume 22, Pages 119-149.

2. The Site

2.1 Site Location

The site is located at the rear of 28 Charlotte Street, London. A site location plan is presented as Figure 1.

Figure 1 – Site Location Plan

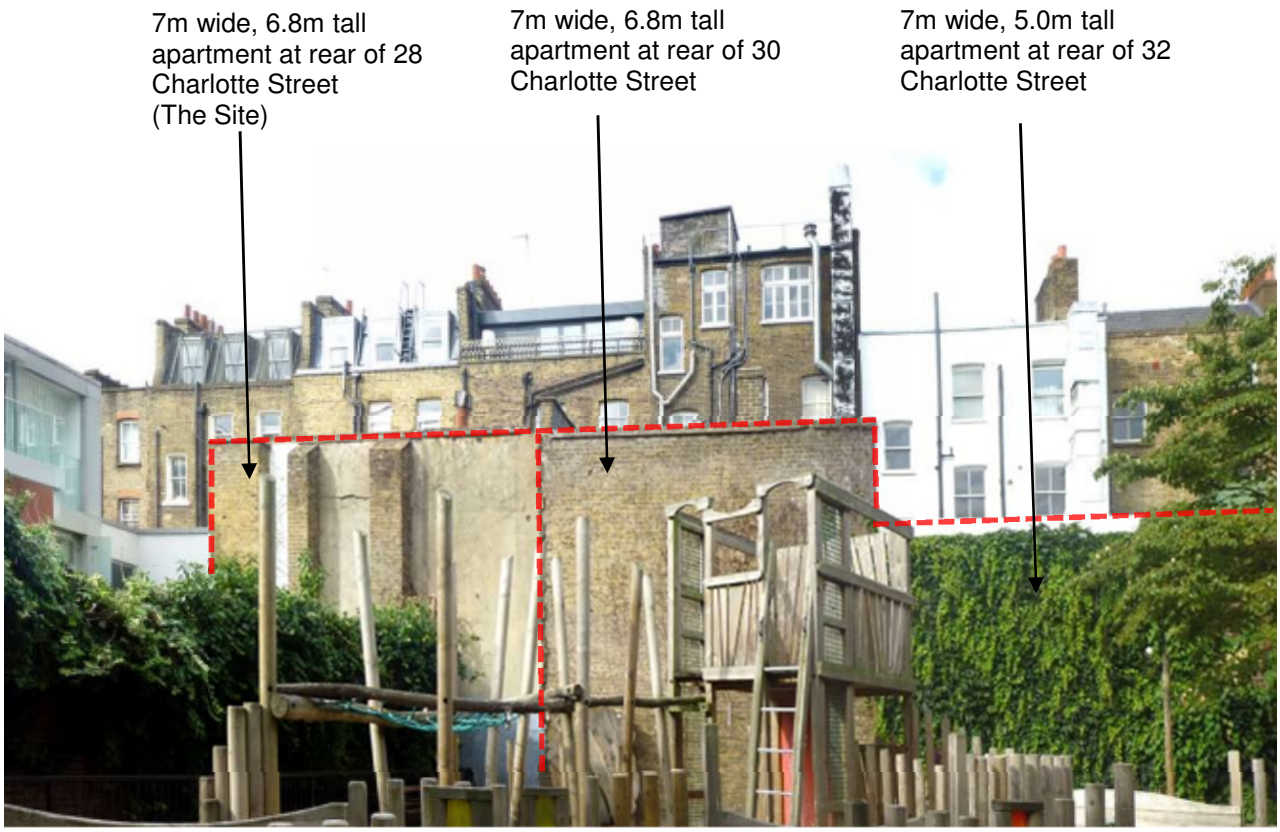


2.2 Site Description

The site comprises a two-storey apartment at the rear of a terraced apartment block. The building measures approximately 7m x 10m in plan and is approximately 6.8m in height. The building is adjoined to two similar structures at 30 and 32 Charlotte Street.

A rear view of the site and adjoining apartments is presented as Figure 2.

Figure 2 – Rear View of Site Looking West



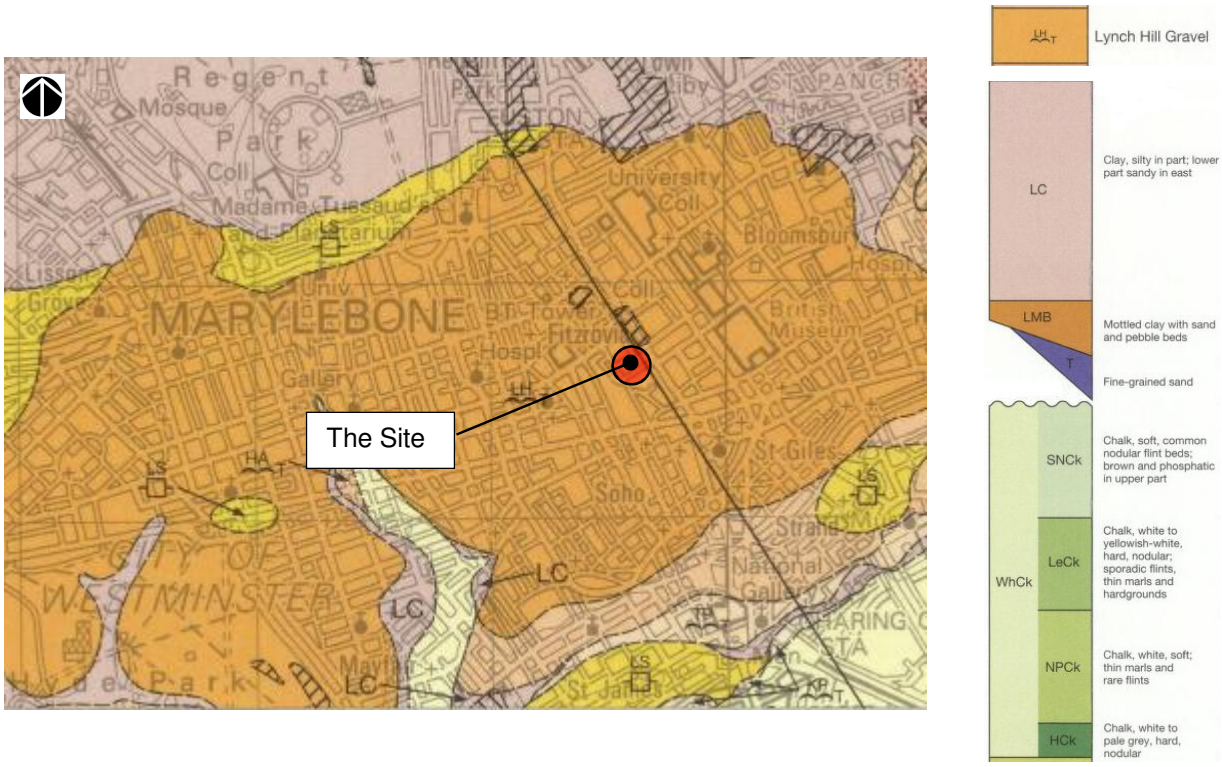
2.3 Ground Conditions

Sheet 256 of the British Geological Survey (England & Wales, Solid & Drift Edition) indicates the site to be underlain by a downward sequence comprising:

- Lynch Hill Gravel.
- London Clay (LC).
- Lambeth Group (LMB).
- Thanet Sand (T).
- White Chalk Subgroup (WhCk)

An extract of the BGS map is presented as Figure 3.

Figure 3 – Extract of BGS Sheet 256



A ground investigation was undertaken in connection with the proposed development in January 2016. These works are reported in Chelmer (2016) and confirm the published geology to be accurate. Further details of the precise soil stratigraphy encountered during the works are presented as Table 1.

Chelmer (2016) suggests groundwater to be located at 5.3m depth. This depth coincides with the top of the locally occurring Lynch Hill Gravel and is below the anticipated depth of basement excavation

Table 1 – Ground Investigation Results

Stratum	Description	Depth to Top of Stratum (m)	Stratum Thickness (m)
Made Ground	Variable silty gravelly SAND to sandy gravelly SILT containing frequent to occasional brick, slate, and concrete fragments	0.0	5.3
Lynch Hill Gravel	Silty gravelly SAND	5.3	2.4
London Clay	Very stiff, silty CLAY	7.7	Not proven

3. Assumed Construction Sequence

Details of the proposed basement construction sequence are provided in ACE (2016) and summarised as follows:

Stage 1: Break out existing ground floor slab and install load bearing piles from working platform level of +9.93m Site Datum (SD).

Stage 2: Excavate down to +7.3m SD at centre of basement area. Earthen berms are to be left in place at basement perimeter.

Stage 3: Cast ground floor slab at centre of basement area.

Stage 4: Partially remove earthen berms from basement perimeter and form underpinning to existing footings using a one-metre bay width. Propping to be applied to excavated face, as required.

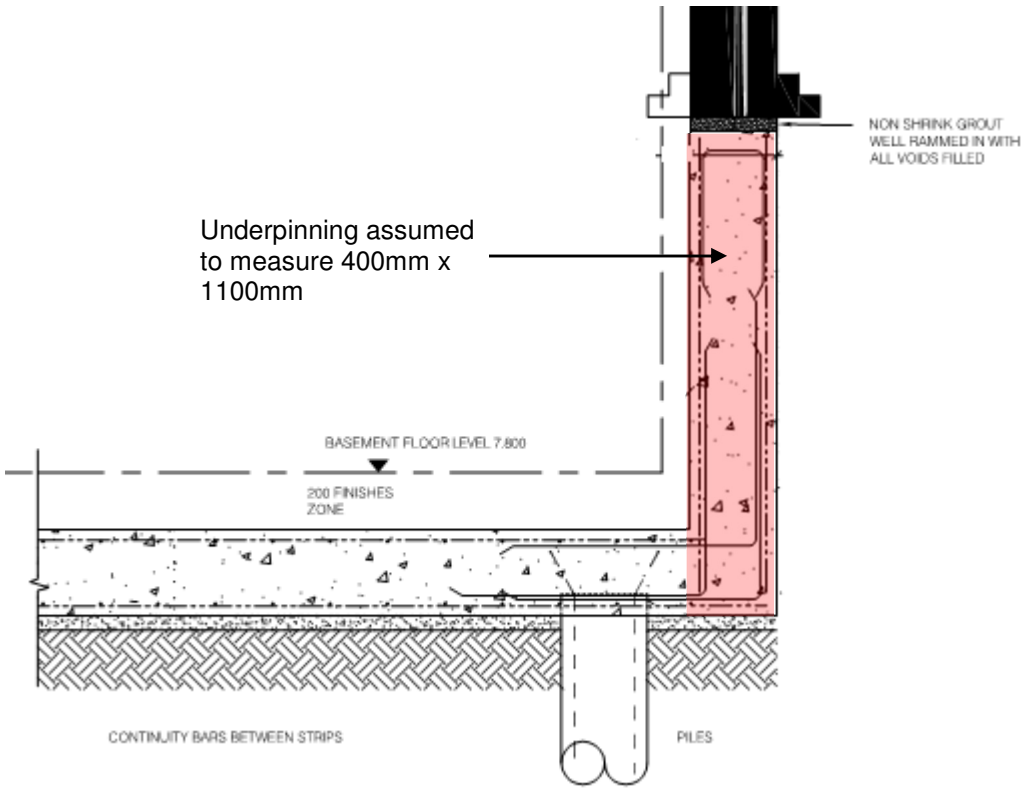
Stage 5: Apply dry packing to underpinnings and extend ground floor slab to basement perimeter.

Stage 6: Repeat Stages 4 through 5 for each bay width. It is assumed that bays will be underpinned in a "1, 3, 5, 2, 4," sequence.

Indicative details of the basement extent and underpinning are presented as Figures 4 and 5, respectively.

Figure 4 – Cross Section through Proposed Basement

Figure 5 – Indicative Underpinning Detail



4. Method of Analysis

4.1 Ground Movement

In the absence of published case histories, it is assumed that the underpinning works will be similar to tunnelling, in that some soil volume loss will be experienced within the zone of excavation, and that this volume loss will result in horizontal and vertical movement of the overlying soils. It is assumed that the soil volume loss will be limited to 1 %, which is in keeping with the maximum allowable soil volume loss typically specified for tunnelling in granular soil. Refer to ITA/AITES (2007) for further details.

4.2 Impacts to Existing Structures

Impacts of ground movement on existing structures have been evaluated in accordance with Burland (1996). This methodology likens masonry structures to an equivalent beam and classifies damage according to limiting tensile strain (see Table 2).

Table 2 – Burland Damage Classification

Damage Category	Normal Degree of Severity	Limiting Tensile Strain (%)	Typical Damage Manifestation
0	Negligible	0.05	Hairline cracks less than about 0.1mm
1	Very slight	0.075	Fine cracks which are easily treated during normal decoration works. Crack widths are typically between 0.1 and 1.0mm
2	Slight	0.15	Cracks easily filled, with redecoration likely to be required. Exterior cracking may be visible, with doors and windows sticking slightly. Crack widths are typically between 1 and 5mm
3	Moderate	0.3	Cracks may require cutting out and replacement. Doors and windows likely to stick and site services likely to be interrupted. Crack widths typically between 5 and 15mm
4	Severe to very severe	>0.3	Extensive repairs required, with crack widths in excess of 15mm

5. Analysis Results

The analysis results are presented as Appendix A and summarised as Table 3.

Table 3 – Analysis Results

Parameter	Result
Vertical ground movement	6mm
Horizontal ground movement	2mm
Limiting tensile strain in ‘sagging’ zone	0.057 %
Limiting tensile strain in ‘hogging’ zone	0.051 %

Based upon the above, the underpinning works are anticipated to result in Category 1 damage to the adjoining buildings. This damage classification is described as being ‘very slight’ in nature and typically results in crack widths of up to 1.0mm.

6. Conclusions and Recommendations

6.1 Conclusions

The proposed underpinning works are likely to result in 6mm of vertical movement and 2mm of horizontal movement at existing foundation level. This movement is likely to result in Category 1 damage to adjacent structures. This damage classification is described as being 'very slight' in nature and typically results in crack widths of less than 1.0mm. This category of damage is expected to be easily repaired during the course of normal re-decoration works.

6.2 Recommendations

It is recommended that adjacent buildings be subject to visual inspection surveys immediately prior to and upon completion of works and that vertical movement of existing foundations be monitored on a routine basis. Suggested trigger levels and contingency actions for the vertical movement monitoring are presented as Table 4.

Table 4 – Trigger Levels and Contingency Actions for Foundation Movement Monitoring

Trigger Level	Vertical Movement Corresponding to Trigger Level	Contingency Actions
Amber	6mm	• Review method of working and assess possibility of further movement occurring • Increase frequency of monitoring • Undertake visual condition survey of affected area
Red	10mm	• Stop work in affected area • Undertake visual condition survey of affected area

Notwithstanding the analysis results described herein, it is suggested that the following maximum damage criteria be incorporated into the underpinning works contract:

- Settlement of any adjacent foundation shall be limited to 10mm; and
- Damage to any adjacent structure shall be limited to Burland Category 1. This damage classification is described as 'very slight' and is typically associated with crack widths of between 0.1 and 1.0mm.

APPENDIX A

CALCULATIONS

CUNDALL

JOB NUMBER / FILE	CALCULATION NUMBER	DRAWING REFERENCE
1013857	—	—

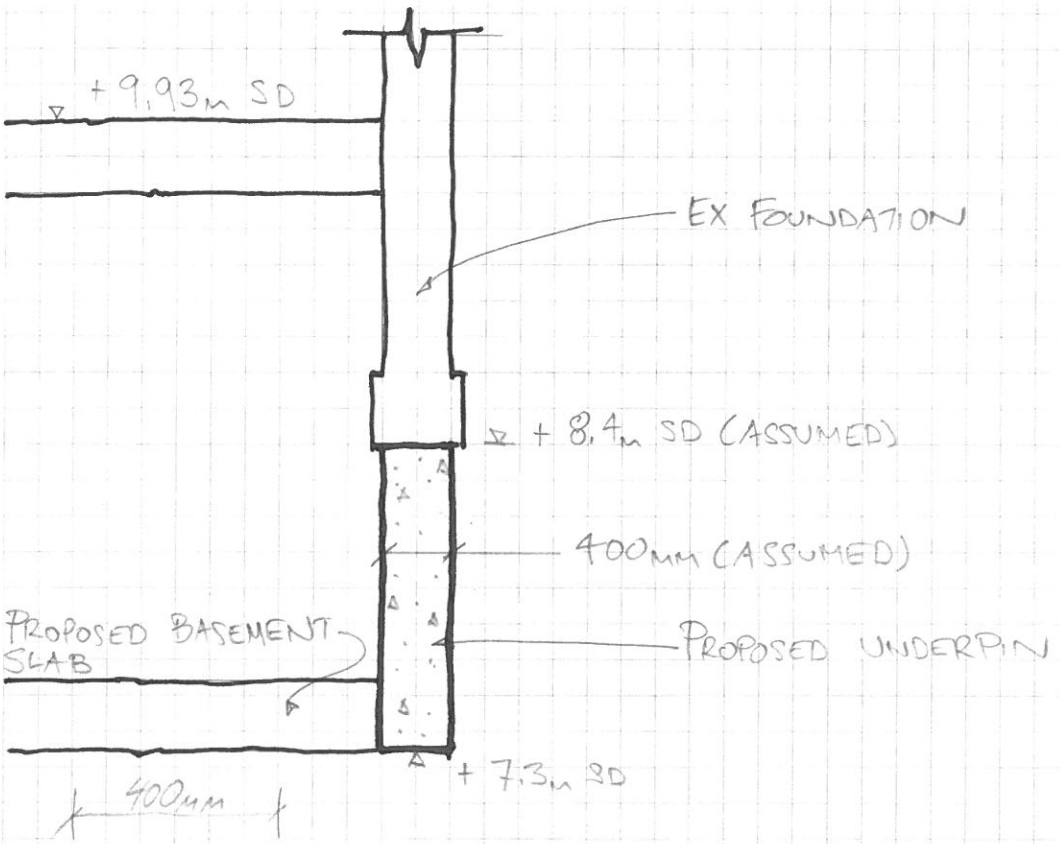
JOB TITLE: 28 CHARLOTTE STREET

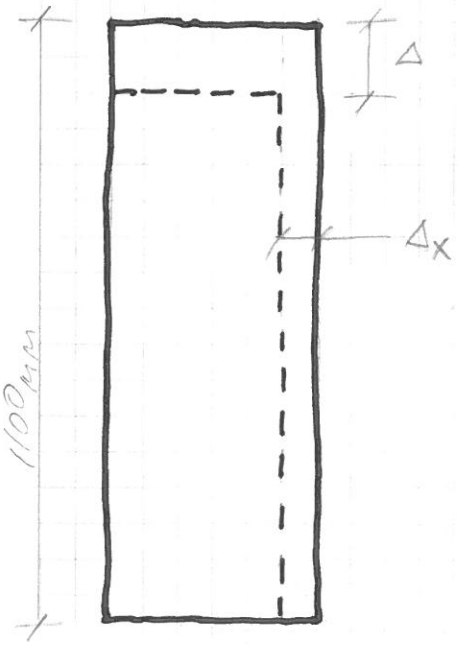
CALCULATION: IMPACT ASSESSMENT FOR GROUND MOVEMENT

REV	CALCULATION BY	DATE	CHECKED BY	VERIFIED BY
0	JMS	19 AUG 16	JAS	—
1				
2				

CALCULATION DETAIL:

ESTIMATE VERTICAL FOUNDATION MOVEMENT DUE TO UNDERPINNING WORKS





* ASSUME THAT UNDERPINNING WILL RESULT IN 1% VOLUME LOSS
* UNDERPINNING WIDTH = 400mm
* UNDERPINNING HEIGHT = 1100mm

$\therefore h = 2.75w$

$\therefore (w)(2.75) = (0.99)(1100)(400)$

$2.75w^2 = 435{,}600$

$w = 398\text{mm}$

$\therefore \Delta = 1100 - (2.75)(398) = 5.5\text{mm}$ ($\pm 6.0\text{mm}$)

$\Delta x = 400 - 398 = 2.0\text{mm}$

CUNDALL

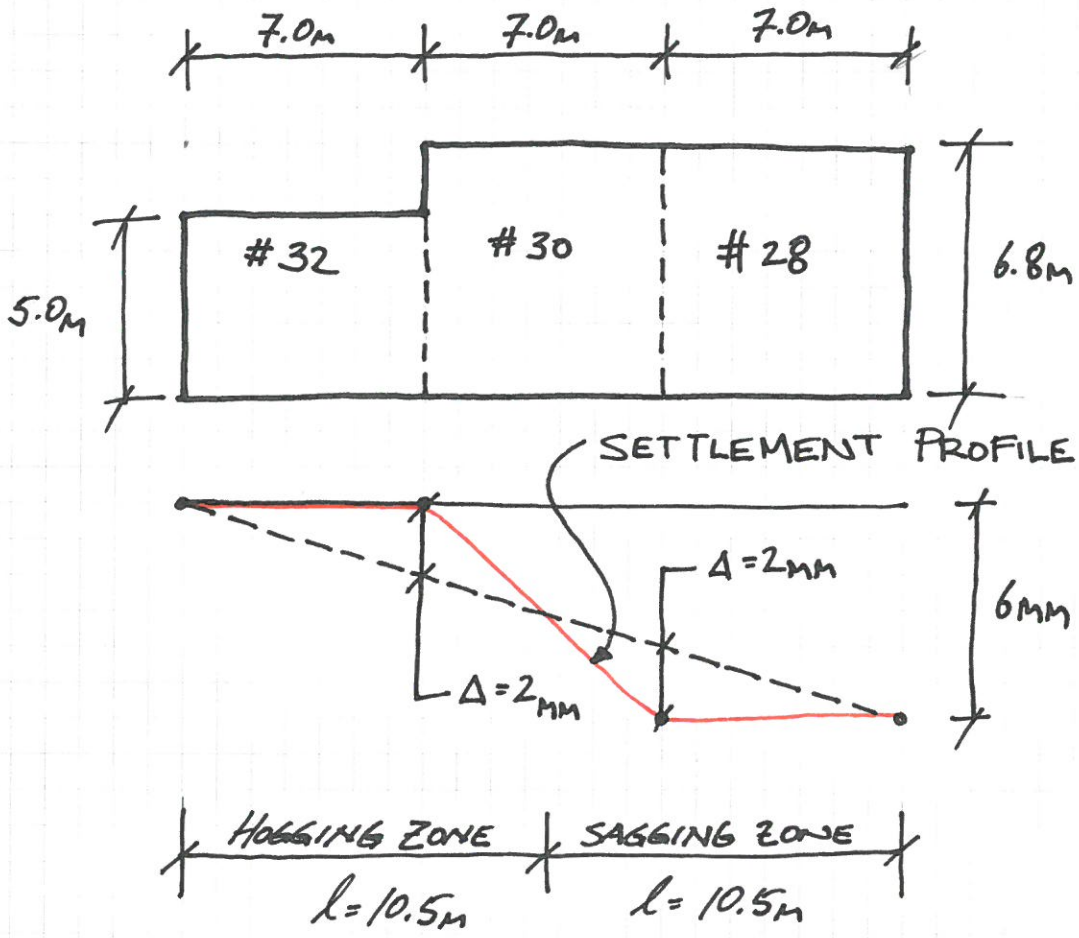
JOB NUMBER / FILE	CALCULATION NUMBER	DRAWING REFERENCE
1013857	–	–

JOB TITLE: 28 CHARLOTTE STREET

CALCULATION: IMPACT ASSESSMENT FOR GROUND MOVEMENT

REV	CALCULATION BY	DATE	CHECKED BY	VERIFIED BY
0				
1				
2				

CALCULATION DETAIL:



FROM BURLAND + WROTH (1974):

$$\frac{\Delta}{l} = \left\{ \frac{l}{12t} + \frac{3IE}{2tlHG} \right\} \varepsilon_b \text{ ; AND}$$

$$\frac{\Delta}{l} = \left\{ 1 + \frac{Hl^2G}{18IE} \right\} \varepsilon_d$$

CUNDALL

JOB NUMBER / FILE	CALCULATION NUMBER	DRAWING REFERENCE
1013857		

JOB TITLE	REV	CALCULATION BY	DATE	CHECKED BY	VERIFIED BY
28 CHARLOTTE STREET	0				
CALCULATION	1				
IMPACT ASSESSMENT FOR GROUND MOVEMENT	2				

CALCULATION DETAIL:

WHERE:

H = BUILDING HEIGHT

= 6.8m IN SAGGING ZONE

= 5.9m IN HOGGING ZONE

l = BUILDING LENGTH

= 10.5m FOR BOTH SAGGING + HOGGING ZONES

$\frac{E}{G}$ = 2.6 (CONSTANT)

I = SECOND MOMENT OF INERTIA

= $\frac{H^3}{12}$ IN SAGGING ZONE

= $\frac{H^3}{3}$ IN HOGGING ZONE

t = FURTHEST DISTANCE FROM NEUTRAL AXIS TO EDGE OF EQUIVALENT BEAM

= $\frac{H}{2}$ IN SAGGING ZONE

= H IN HOGGING ZONE

CUNDALL

JOB NUMBER / FILE	CALCULATION NUMBER	DRAWING REFERENCE
1013857		

JOB TITLE: 28 CHARLOTTE STREET

CALCULATION: IMPACT ASSESMENT FOR GROUND MOVEMENT

REV	CALCULATION BY	DATE	CHECKED BY	VERIFIED BY
0				
1				
2				

CALCULATION DETAIL:

* FROM BURLAND + WROTH (1974):

LIMITING TENSILE STRAIN IS THE GREATEST OF:

① $\varepsilon_{bt} = \varepsilon_h + \varepsilon_b$; AND

② $\varepsilon_{dt} = 0.35\varepsilon_h + \sqrt{(0.65\varepsilon_h)^2 + \varepsilon_d^2}$

* ASSUME THAT HORIZONTAL STRAIN (ε_h) = $\frac{\Delta x}{7.0_m}$

$= \frac{2mm}{7,000mm}$

$= 0.00029$

$= 0.029\%$

FOR SAGGING ZONE

$I = \frac{H^3}{12} = \frac{(6.8)^3}{12} = 26.2m^3$

$t = \frac{H}{2} = \frac{6.8}{2} = 3.4m$

$l = 10.5m$

$\Delta = 2mm$

$\therefore \frac{0.002}{10.5} = \left\{ \frac{10.5}{12(3.4)} + \frac{3(26.2)(2.6)}{2(3.4)(10.5)(6.8)} \right\} \varepsilon_b$

$\frac{0.002}{10.5} = \{0.257 + 0.421\} \varepsilon_b$

$\varepsilon_b = 0.00028$

$= 0.028\%$

CUNDALL

JOB NUMBER / FILE:	CALCULATION NUMBER:	DRAWING REFERENCE:
1013857		

JOB TITLE: 28 CHARLOTTE STREET

CALCULATION: IMPACT ASSESSMENT FOR GROUND MOVEMENT

REV.	CALCULATION BY	DATE	CHECKED BY	VERIFIED BY:
0				
1				
2				

CALCULATION DETAIL:

$$\frac{0.002}{10.5} = \left\{ 1 + \frac{(6.8)(10.5)^2}{18(26.2)(2.6)} \right\} \varepsilon_d$$

$$\frac{0.002}{10.5} = \{ 1 + 0.61 \} \varepsilon_d$$

$$\varepsilon_d = 0.00012$$

$$= 0.012\%$$

$$\varepsilon_{bt} = \varepsilon_h + \varepsilon_b$$

$$= 0.029 + 0.028$$

$$= 0.057\%$$

$$\varepsilon_{dt} = 0.35\varepsilon_h + \sqrt{(0.65\varepsilon_h)^2 + \varepsilon_d^2}$$

$$= 0.35(0.029) + \sqrt{[(0.65)(0.029)]^2 + 0.012^2}$$

$$\varepsilon_{dt} = 0.032\%$$

% LIMITING TENSILE STRAIN = 0.057%. THIS CORRESPONDS TO DAMAGE CATEGORY 1

CUNDALL

JOB NUMBER / FILE:	CALCULATION NUMBER:	DRAWING REFERENCE:
1013857		

JOB TITLE: 28 CHARLOTTE STREET

CALCULATION: IMPACT ASSESSMENT FOR GROUND MOVEMENT

REV:	CALCULATION BY:	DATE:	CHECKED BY:	VERIFIED BY:
0				
1				
2				

CALCULATION DETAIL:

FOR HOGGING ZONE

$H = 5.9m$

$I = \frac{H^3}{3} = \frac{(5.9)^3}{3} = 68.5$

$L = H = 5.9m$

$l = 10.5m$

$\Delta = 2.0mm$

$$\frac{0.002}{10.5} = \left\{ \frac{10.5}{12(5.9)} + \frac{3(68.5)(2.6)}{2(5.9)(10.5)(5.9)} \right\} \varepsilon_b$$

$$\frac{0.002}{10.5} = \{ 0.149 + 0.731 \} \varepsilon_b$$

$\varepsilon_b = 0.00022$

$= 0.022\%$

$$\frac{0.002}{10.5} = \left\{ 1 + \frac{(5.9)(10.5)^2}{1.0(68.5)(2.6)} \right\} \varepsilon_d$$

$$\frac{0.002}{10.5} = \{ 1 + 0.203 \} \varepsilon_d$$

$\varepsilon_d = 0.00016$

$= 0.016\%$

CUNDALL

JOB NUMBER / FILE	CALCULATION NUMBER	DRAWING REFERENCE
1013857		

JOB TITLE: 28 CHARLOTTE STREET

CALCULATION: IMPACT ASSESIMENT FOR GROUND MOVEMENT

REV	CALCULATION BY	DATE	CHECKED BY	VERIFIED BY
0				
1				
2				

CALCULATION DETAIL:

$$\varepsilon_{bt} = \varepsilon_h + \varepsilon_b$$

$$= 0.029 + 0.022$$

$$= 0.051\ \%$$

$$\varepsilon_{dt} = 0.35\varepsilon_h + \sqrt{(0.65\varepsilon_h)^2 + \varepsilon_d^2}$$

$$= 0.35(0.029) + \sqrt{[0.65(0.029)]^2 + 0.016^2}$$

$$\varepsilon_{dt} = 0.035\ \%$$

∴ LIMITING TENSILE STRAIN FOR HOGGING ZONE IS 0.051% THIS CORRESPONDS TO CLASS 1 DAMAGE

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