A2 Site Investigation

15 Fitzroy Road

Building Damage Ground Movement Assessment

September 2022

22022-A2SI-XX-XX-RP-Y-0005-00

Project Name	15 Fitzroy Road
Project Number	22022
Client	Kate & Mark Waites
Document Name	Building Damage Ground Movement Assessment

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Appendices

1. Introduction

A2 Site Investigation Limited (A2SI) has been engaged by BC Structural Design Limited (BC Structural) on behalf of Kate Waites to prepare a ground movement assessment (GMA) for the proposed development at 15 Fitzroy Road, London (herein referred to as the 'site').

1.1. Study Aims and Objectives

A ground movement and impact assessment has been carried out in order to estimate the potential damage induced by the proposed redevelopment at 15 Fitzroy Road on the neighbouring properties.

The scheme includes deepening of the existing lower ground floor, demolition and reconstruction of the two-storey outrigger at the rear of the property, and removal of selected internal walls. The lower ground floor will be deepened by 0.7m.

The assessment encompasses properties located within the *zone of influence* of the proposed scheme. The GMA is based on *greenfield* ground movements and *unlikely to be exceeded* ground movements. The adopted assessment methodology provides a robust and conservative assessment representative of current industry best practice, as detailed in Section 4.

The assessment carried out and described herein aims to:

- Assess the impact on ground movements induced by the proposed works on adjacent properties.
- Inform Party Wall awards.
- Provide performance criteria and inform aspects of substructure construction and design.

This report provides a detailed description of the:

- Site and proposed development.
- Modelling parameters and input.
- Analyses and results.

1.2. Information Sources

The principal sources of information, which have informed the assessments presented herein, include the following:

- Current design information/data and drawings (available at the time of undertaking the GMA), provided by the project design team.
- *Structural Engineers Report*, prepared by BC Structural Design Limited. Reference J207-S-RP-0001 dated August 2022.
- 15 Fitzroy Road *Phase I Desk Study*, prepared by A2 Site Investigation Limited. Reference: 22022-A2SI-XX-XX-RP-Y-0001-00 dated September 2022.
- 15 Fitzroy Road *Factual Report*, prepared by A2 Site Investigation Limited. Reference: 22022-A2SI-XX-XX-RP-X-0002-00 dated September 2022.
- Existing Foundation Loads, prepared by BC Structural Design Limited. Reference: J207-BC-SK-0002 dated July 2022.
- Proposed Foundation Loads, prepared by BC Structural Design Limited. Reference: J207-BC-SK-0003 dated July 2022.

Information available in the public domain:

- British Geological Survey online database (various sources).
- Google Earth Pro.

2. The Site and Proposed Development

2.1. Development Location and Current Site Use

The development site is located at 15 Fitzroy Road, London NW1 8TU, as shown in Figure 2.1. The approximate National Grid reference for the site is 528140, 184010 and the site footprint covers approximately 0.02 hectares. In line with the nearest spot levels the approximate ground surface elevation at the site is 33.0m above Ordnance Datum (mOD) and ground surface levels in the surrounding area rise towards the west and northwest. The development site falls within the administrative boundaries of the London Borough of Camden and currently includes a four-storey residential building including a single-level lower ground floor over the entire building footprint.

The current land uses within a 250m radius surrounding the site are summarised in Table 2.1.

Figure 2.1 Location of the proposed development (red line reflects the site boundary used for this assessment)

Table 2.1 Surrounding land uses summary

Bearing from Site	Features directly adjacent to the site boundary	Other identified land uses and key structures
North	Residential premises with gardens – 13 Fitzroy Road	Railway tracks (leading from Euston Station) are present approximately 150m to the north – northeast.
South	Residential premises with gardens – 17 Fitzroy Road	Notable features south of the site include Chalcot Road approximately 30m south and Regents Canal 220m to the southeast. In addition, the Princess of Wales public house and Primrose Hill Park are located approximately 15m and 250m southwest respectively.
East	Residential premises with gardens – 6A Egbert Street	Egbert Street (cul-de-sac) is approximately 50m to the southeast. Notable features beyond the cul-de-sac include railway lines and Regents Canal located 200m and 250m east respectively. Beyond the railway lines is a large superstore 250m to the northeast

Bearing from Site	Features directly adjacent to the site boundary	Other identified land uses and key structures
West	Fitzroy Road (single carriage way)	Residential premises with gardens approximately 25m from site. A large area of soft landscaping named ‘Chalcot Square Gardens’ is approximately 100m to the northwest of the site.

2.2. Site History and Current Condition

A review of the historical maps shows that the site has historically comprised a terraced residential building with a rear garden since 1871. Prior to that based on an 1851 map, the site was an empty plot of land.

2.3. Proposed Scheme

The scheme for the proposed development comprises internal reconfiguration including deepening the existing lower ground floor by 0.7m, demolition and reconstruction of the existing two-storey outrigger at the rear, and removal of selected lower ground floor walls. The new outrigger will comprise steel frame and timber joist construction. Section views of the proposed development are shown in Figure 2.2. The extent of the lower ground floor to be deepened is shown in Figure 2.3. The front façade and Party Walls will be retained and underpinning as part of the deepening works, and the current footprint of the building will remain largely unchanged, aside from a slight extension due to the new outrigger. The proposed development will remain as a residential home.

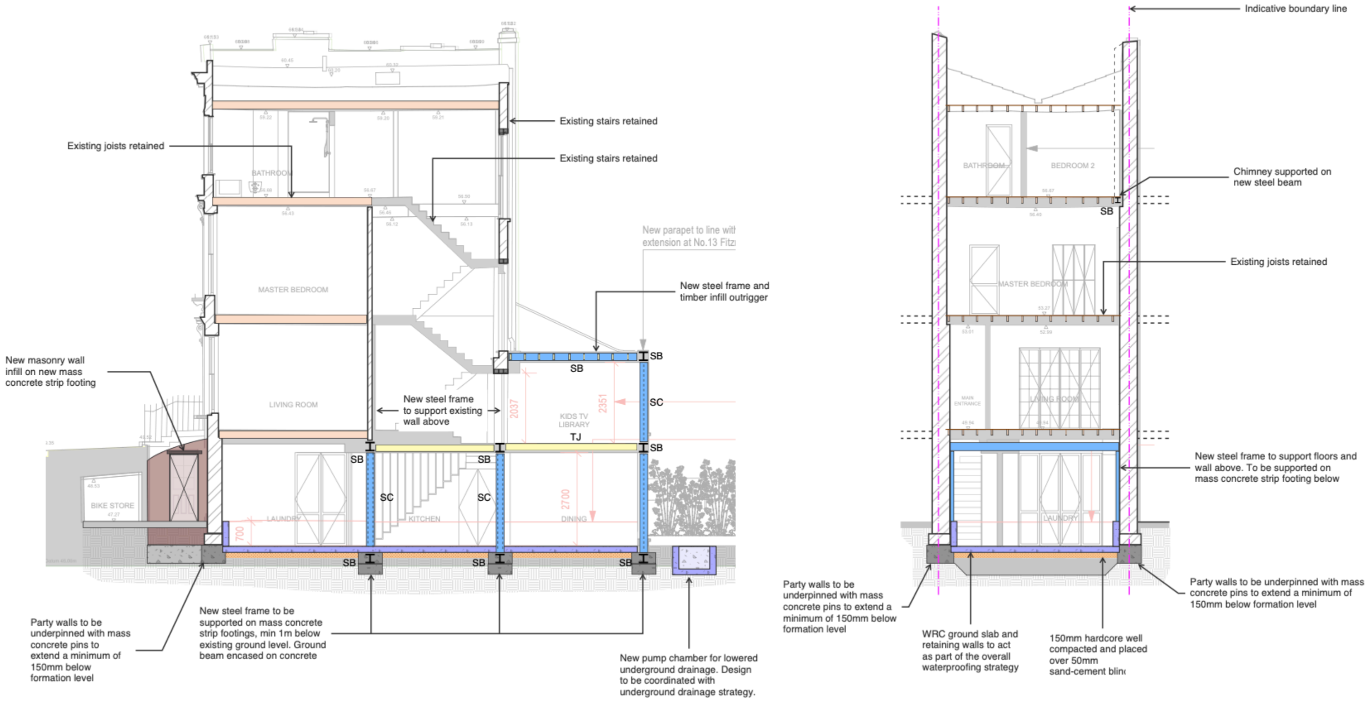


Figure 2.2 Section views of the proposed development

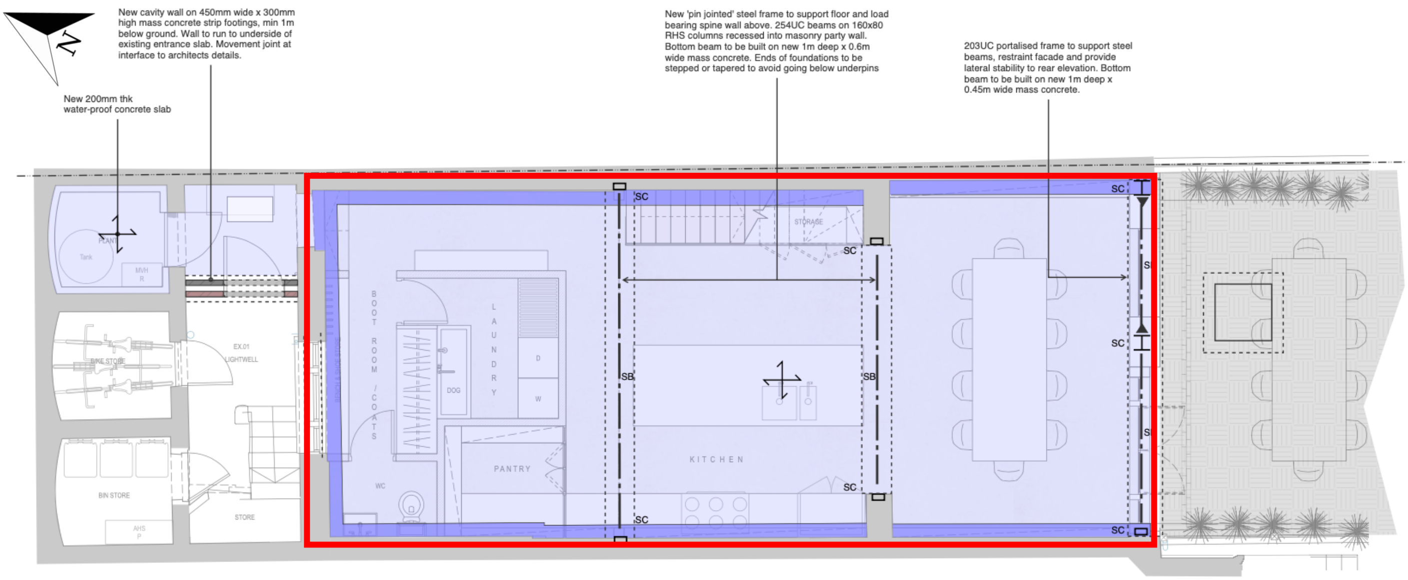


Figure 2.3 Lower ground floor general arrangement showing extent of lower ground floor to be deepened (marked in red)

3. Geology

Site specific ground investigation works have been carried out on the project site. The information contained in this section has been obtained from the ground investigation carried out in August 2022 together with the desk-based review of the site.

The ground conditions were found to comprise the following (in order of succession):

- Made Ground – Variable anthropogenic deposits.
- London Clay Formation – Soft to firm very closely fissured light brown mottled light grey silty CLAY.

The above include the strata of engineering interest and significance, taking cognisance of the scale of the proposed development and zone of influence. The stratigraphic profile and geotechnical parameters used for the assessment are provided in Table 3.1.

Table 3.1 Ground model and geotechnical parameters adopted for the ground movement assessment

Stratum	Top of stratum (mOD)	Thickness (m)	Undrained Young's Modulus, E_u [2] (MPa)	Drained Young's Modulus, E' [2] (MPa)
Made Ground	33.0[4]	3.0	-	10.0
London Clay (1)	30.0	3.0	27.0	21.6
London Clay (2)	27.0	9.0[3]	50.0	40.0

1. The ground model and geotechnical parameters have been derived solely for the purposes of this assessment.
2. The stiffness data (E_u and E') has been evaluated empirically taking into consideration the nature of the geotechnical/soil-structure interaction mechanisms and level of anticipated strain within the soil mass.
3. *Rigid boundary* assumed at approximately 18.0mOD for analytical purposes.
4. Top of Made Ground stratum taken at street level, approximated based on spot levels on publicly available OS maps.

4. Impact Assessment Evaluation

4.1. Assessment Details

The assessment has been undertaken using proprietary spreadsheets and the commercially available software Oasys PDisp and XDisp, which consider the three-dimensional ground movement field induced by the proposed excavation works.

Ground movements will arise as a result of various mechanisms, which are mobilised as part of the construction works for the proposed scheme. The demolition of the existing outrigger and excavation process will induce ground movements arising from the overburden removal. The transfer of the building loading to lower strata by the underpins will partially reinstate a portion of the removed overburden, yielding settlements across areas the foundation system. The induced ground movements will extend over a given zone of influence surrounding the building/basement footprint.

A series of three-dimensional models of the proposed scheme have been developed in Oasys XDisp/PDisp software and combined by means of superposition in order to enable ground movement assessments to be carried out representing the various construction stages. The ground movement displacement fields were separated in two groups (A & B) based on the approach followed, as detailed below:

Group A – Unloading/Loading ground movements

A1. Outrigger demolition and excavation (short-term).
A2. Outrigger demolition, excavation and building loading transfer (long-term).

Group B – CIRIA-based ground movements

B1. Underpin installation and excavation (short-term).
B2. Underpin installation and excavation and building loading transfer (long-term).

The Group A assessments are based on *greenfield* ground movements evaluated from linear half space (PDisp) analyses and focus on vertical ground movements induced by the unloading/re-loading processes. The PDisp model geometry is presented in Figure 4.3.

The demolition and proposed loading pressures have been determined from load take down information provided by BC Structural (included in Appendix A) and have been applied as uniformly distributed unloading and loading pressures, as shown in Figure 4.1 and Figure 4.2. For modelling purposes, all footings are assumed to be 0.5m wide.

The excavation unloading pressure has been modelled as an unloading pressure of 14kPa applied at the excavation formation level (equating to the removal of 0.7m of soil).

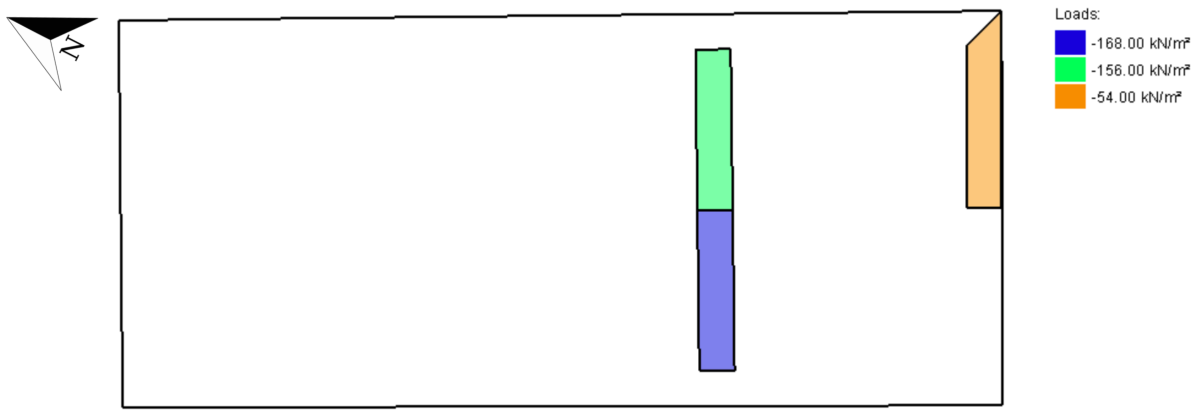


Figure 4.1 Modelled demolition unloading patches

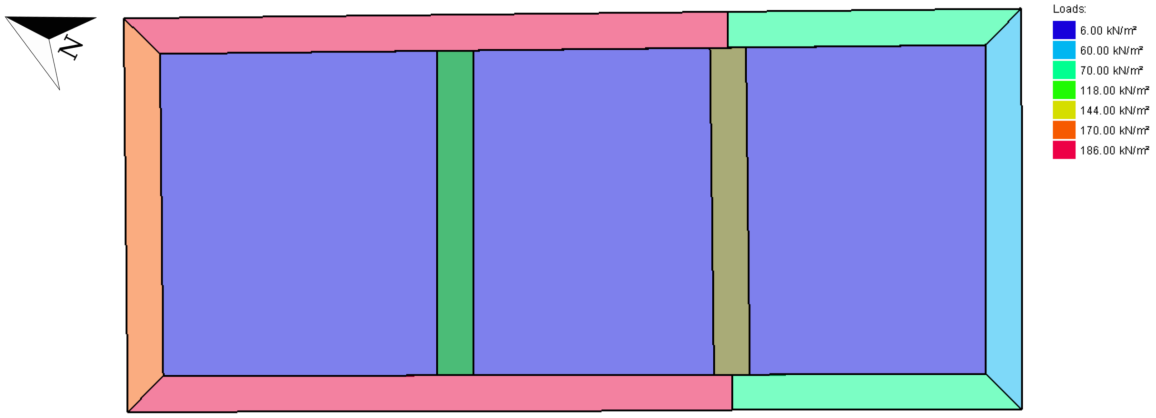


Figure 4.2 Modelled building loading patches

The Group B assessments adopt the normalised ground displacement curves reported in CIRIA C760 to assess the impact of retention system installation works and the excavation. The following CIRIA C760 normalised ground movement curves were adopted to assess ground movements due to retention system installation and excavation works:

- *Underpin installation*: Installation of planar diaphragm wall in stiff clay.
- *Excavation to formation*: Excavation in front of a high stiffness wall in stiff clay.

The empirical data set for diaphragm wall installation is not strictly compatible with the construction technologies adopted in underpinning. However, it is assessed that the ground movement mechanisms are reasonably well-matched and, in lieu of better empirical relationships, the diaphragm wall curves are considered to provide a satisfactory and conservative approximation.

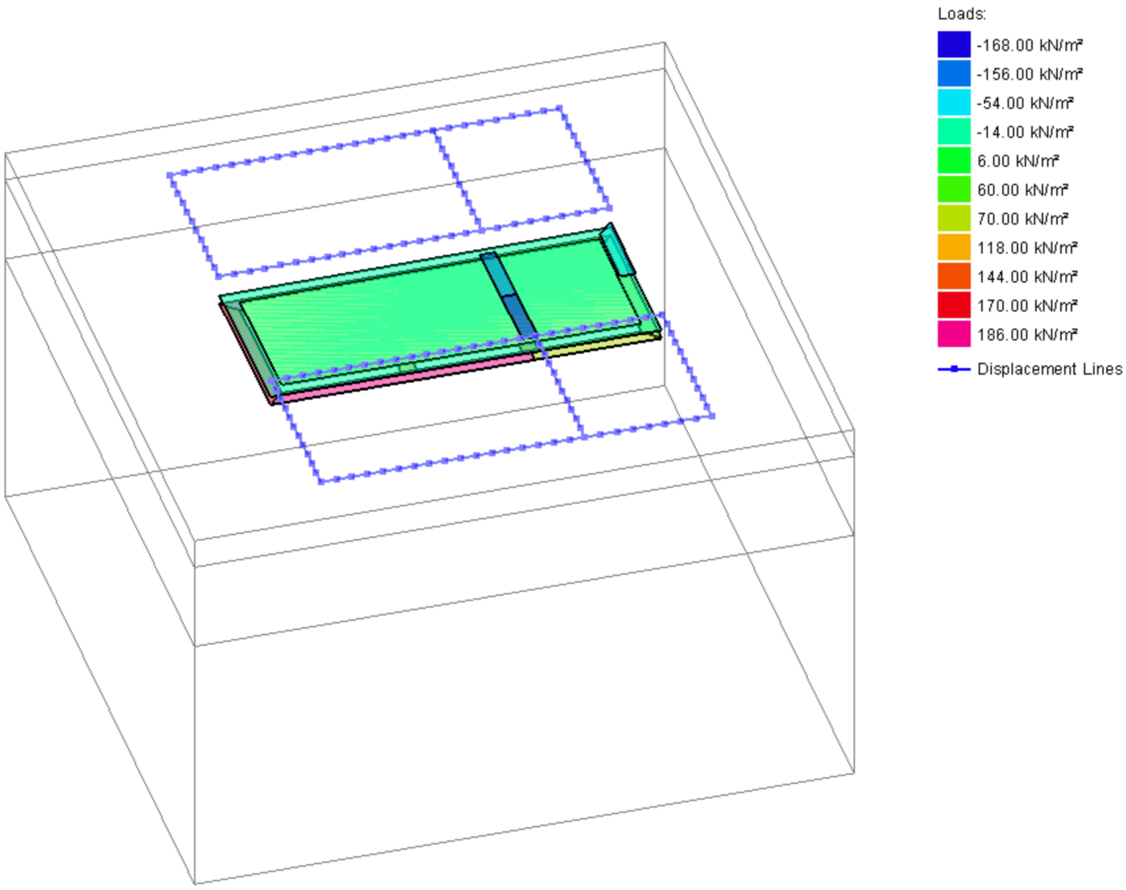


Figure 4.3 Oasys PDisp model geometry (example long-term scenario - A2)

The two groups of analyses enabled the production of an envelope of damage classification results – with the worst-case results presented herein. A representative geometry has been adopted for defining the excavation/installation geometry implemented in the 3D modelling efforts. An indicative plot of the analytical model is presented below in Figure 4.4 showing the excavation area and the adjacent properties included in the damage assessment.

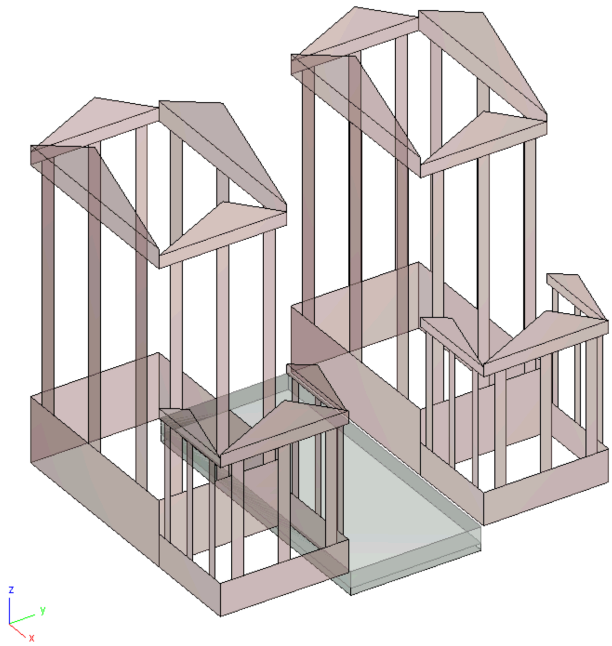


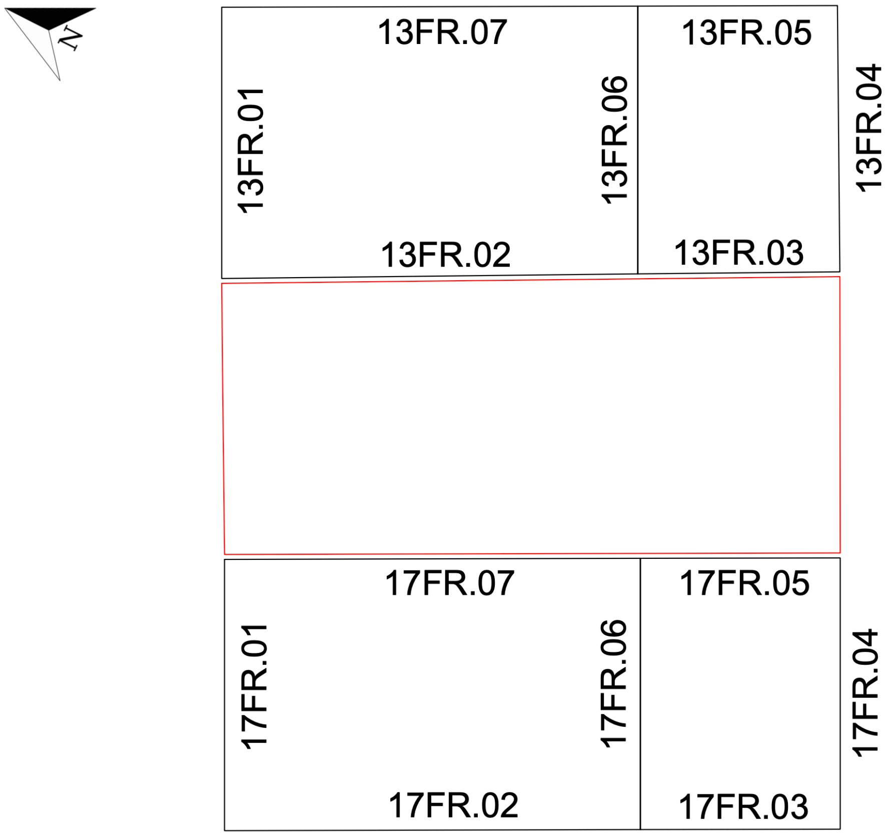
Figure 4.4 Indicative plot of three-dimensional analytical model using the Oasys XDisp software suite (soil removed for clarity of presentation)

4.2. Impact Assessment

4.2.1. General

The potential impact/damage induced on primary façade/wall elements of the buildings surrounding the proposed scheme have been evaluated on the basis of the calculated ground movement fields. The masonry walls of concern are shown in Figure 4.5, including the wall nomenclature/reference system adopted. The arrangement is based on the currently available survey information and presents an array of masonry façades running both perpendicular and parallel to the proposed basement (covering the key deformation mechanisms). In total, 14 façades of the neighbouring buildings were considered for the current study, and these are grouped in the following manner:

- 13FR.01 – 13FR.07: 13 Fitzroy Road.
- 17FR.01 – 17FR.07: 17 Fitzroy Road.



Basement footprint marked in red

Figure 4.5 Simplified scheme and nomenclature for each building façade/masonry wall element

Each wall has been assumed to behave as an equivalent beam subject to a bending and extension/compression deformation mechanism, based on the evaluated greenfield ground movement, as outlined previously.

Tensile strains induced within the building masonry walls have been evaluated based on the deflection ratios Δ/L and horizontal extension mechanisms estimated from the analyses. The assessment considers the well-established Burland (1997) damage classification method, as presented and summarized in Figure 4.6 and Figure 4.7. This method involves a relatively simple but robust means of assessment, which is widely adopted and is considered to comprise an industry standard/best practice basis for impact assessments of this typology.

Potential damage categories are directly related to the tensile strains induced by the proposed construction stages, arising from a combination of direct tension and bending induced tension mechanisms. The evaluated damage categories correspond to an *unlikely to be exceeded* scenario (on the basis of the data sets adopted and greenfield assumptions).

Category of damage	Description of typical damage (ease of repair is underlined)	Approximate crack width (mm)	Limiting tensile strain ε_{lim} (per cent)
0 Negligible	Hairline cracks of less than about 0.1 mm are classed as negligible.	< 0.1	0.0–0.05
1 Very slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in building. Cracks in external brickwork visible on inspection.	< 1	0.05–0.075
2 Slight	Cracks easily filled. Redecoration probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weathertightness. Doors and windows may stick slightly.	< 5	0.075–0.15
3 Moderate	The cracks require some opening up and can be patched by a mason. Recurrent cracks can be masked by suitable linings. Repointing of external brickwork and possibly a small amount of brickwork to be replaced. Doors and windows sticking. Service pipes may fracture. Weathertightness often impaired.	5–15 or a number of cracks > 3	0.15–0.3
4 Severe	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Windows and frames distorted, floor sloping noticeably. Walls leaning or bulging noticeably, some loss of bearing in beams. Service pipes disrupted.	15–25 but also depends on number of cracks	> 0.3
5 Very severe	This requires a major repair involving partial or complete rebuilding. Beams lose bearings, walls lean badly and require shoring. Windows broken with distortion. Danger of instability.	usually > 25 but depends on number of cracks.	

Figure 4.6 Building damage classification, after Burland et al. 1977, Boscardin and Cording 1989 and Burland 2001 - relationship between category of damage and limiting strain ε_{lim}

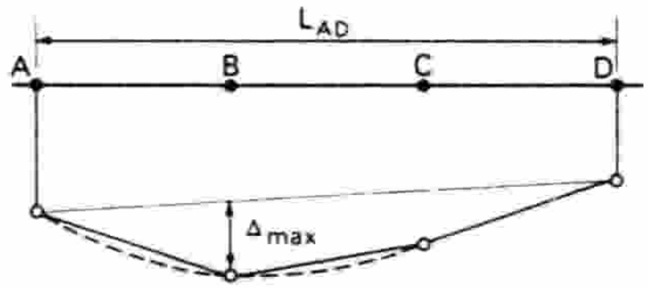


Figure 4.7 Definition of relative deflection Δ and deflection ratio Δ/L

4.2.2. Results

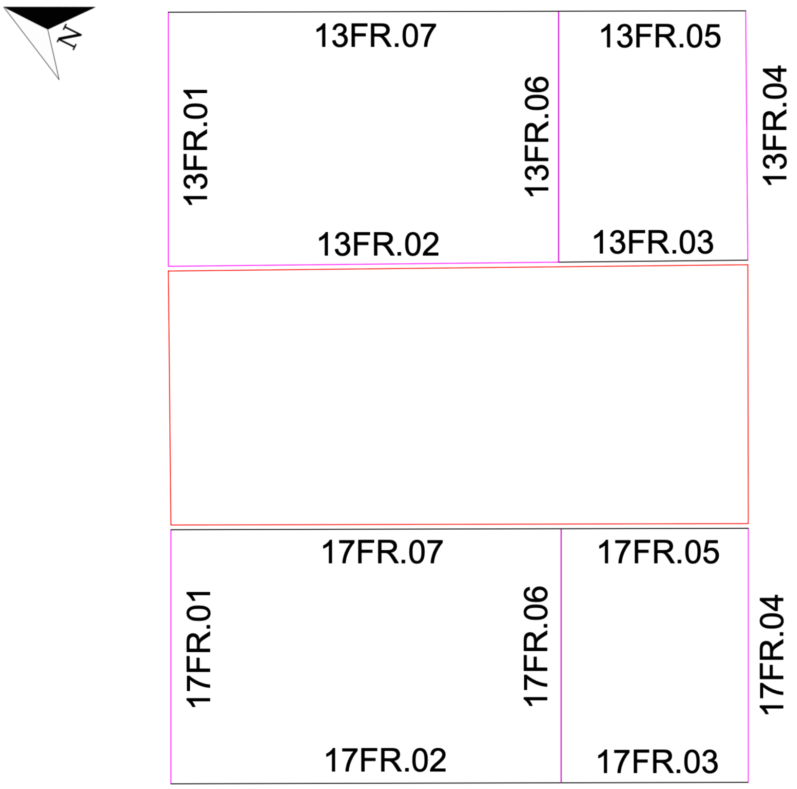
The results of the assessment are presented in Table 4.1. Note that the results presented in this table represent the worst case resulting from all analysis runs. Damage category results are presented in Figure 4.8 for the affected façades. Figure 4.9 and Figure 4.10 depict the vertical and horizontal displacements the ground movement respectively, induced by long term structural loadings, the secant pile wall installation and basement excavation calculated as per CIRIA 760 installation of contiguous bored pile wall in stiff clay and CIRIA 760 excavation in front of high stiffness wall in stiff clay (assessment B2).

Table 4.1 Evaluated damage categories from XDisp

Façade Reference	Analysis Scenario			
	A1	A2	B1	B2
13FR.01	Category 0 – Negligible	Category 1 – Very Slight	Category 0 – Negligible	Category 0 – Negligible
13FR.02	Category 0 – Negligible	Category 0 – Negligible	Category 1 – Very Slight	Category 1 – Very Slight
13FR.04	Category 0 – Negligible	Category 0 – Negligible	Category 1 – Very Slight	Category 0 – Negligible
13FR.06	Category 0 – Negligible	Category 0 – Negligible	Category 1 – Very Slight	Category 1 – Very Slight
17FR.01	Category 0 – Negligible	Category 0 – Negligible	Category 1 – Very Slight	Category 0 – Negligible
17FR.04	Category 0 – Negligible	Category 0 – Negligible	Category 1 – Very Slight	Category 0 – Negligible
17FR.06	Category 0 – Negligible	Category 0 – Negligible	Category 1 – Very Slight	Category 1 – Very Slight

Only façades exceeding *Category 0 – Negligible* in any scenario are presented.

Refer to Figure 4.8 for building/wall nomenclature



Purple – Category 1 (Very Slight). All remaining facades – Category 0 (Negligible)

Figure 4.8 Affected façades after all scenarios

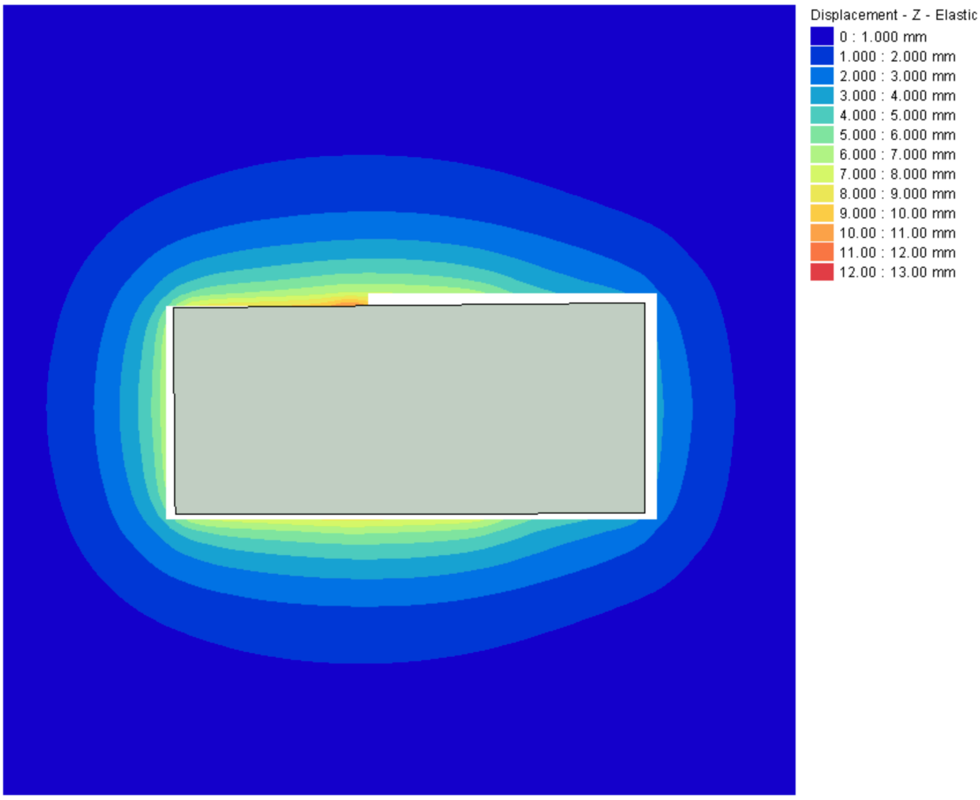


Figure 4.9 Resultant XDisp vertical displacement contours for scenario B2 - Underpin installation and excavation (CIRIA C760) + building loading

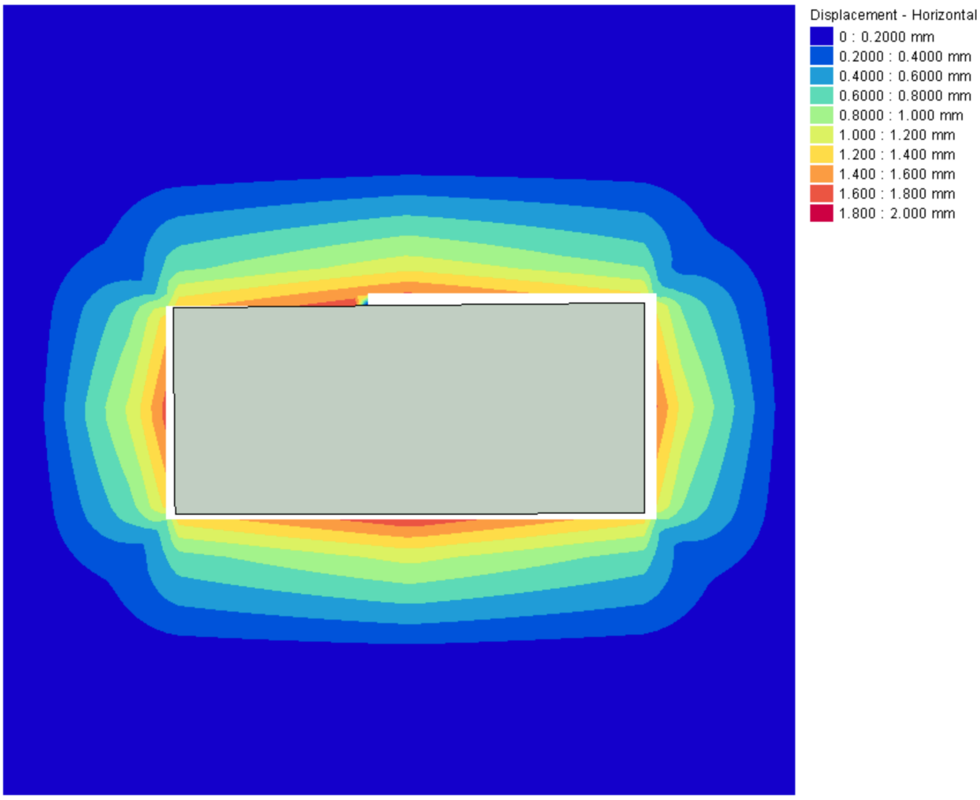


Figure 4.10 Resultant XDisp horizontal displacement contours for scenario B2 - Underpin installation and excavation (CIRIA C760) + building loading

4.2.3. Basement Excavation Criteria

The results of this analysis show that all buildings will fall within the acceptable damage classification (i.e. not exceeding Category 1 – Very Slight), if the ground movements caused by the wall installation, excavation and scheme construction are limited to the values presented in Table 4.2.

Table 4.2 Limiting ground movement values at the top of the retention system at various construction stages

Stage	Maximum Cumulative Ground Movement (mm)	
	Vertical	Horizontal
Underpin Installation	5	2
Excavation	5	2
Long-Term	8	2

Movements correspond to the top of the secant wall. Detailed trigger levels to be developed as part of monitoring proposals.

It is also noted that the GMA will be supplemented by a project-specific monitoring regime and Action Plan, which will delineate lines of responsibility, trigger levels in accordance with those presented in this GMA and appropriate mitigation measures.

5. Conclusion

The interaction between the proposed 15 Fitzroy Road development and the neighbouring properties within the zone of influence of the scheme has been reviewed as part of the GMA study presented herein.

The proposed development construction operations comprise a series of stages, including demolition of the existing outrigger at the back of the property, installation of underpins, bulk excavation to deepen the lower ground floor, and construction of a new outrigger. The impact of the various stages of construction have been reviewed on the basis of two alternative methods: evaluating the effects of unloading/overburden removal using Pdisp; and simulating the excavation induced ground movements using empirical CIRIA curves in XDisp. In the latter case, a propped retaining wall solution (during the temporary works stage) has been considered, utilising the CIRIA C760 ground movement curves for high stiffness walls in stiff clay.

These two different scenarios have been considered in order to bind the potential ground movements arising from excavation operations (i.e. maximum potential heave and settlement respectively). This strategy ensures a robust evaluation of potential impact in light of the bespoke, intricate and workmanship-dependent basement construction methodology. Both short-term (undrained) and long-term (drained) conditions have been assessed by adopting the relevant soil stiffness parameters for each case.

The results from the GMA analyses are presented in Table 4.1 (denoting the evaluated damage categorisation in accordance with the Burland criteria described herein). It is observed that the maximum potential damage classification for the neighbouring properties is Category 1 – Very Slight. The deflections predicted by the GMA should be considered to be the maximum acceptable in order to ensure the Very Slight damage category. It is noted that the predicted ground movements, the associated wall tensile strains, and the level of damage categorisation are considered to be moderately conservative in view of the relatively cautious data selection and *greenfield* nature of the assessment undertaken.

It is noted that the GMA will be supplemented by a project-specific monitoring regime and Action Plan, which will delineate lines of responsibility, trigger levels in accordance with those presented in this GMA and appropriate mitigation measures. The assessment presented herein is dependent and reliant on the works being undertaken by an experienced contractor, high quality workmanship and appropriate supervision of construction means and methods by experienced personnel.

It is recommended that this report is reviewed and understood in full by the project team and major stakeholders. Where significant changes are made to items such as the construction sequencing, temporary propping arrangements and scheme design, the engineer should thoroughly review the discrepancy and evaluate any potential impacts on ground movement and building damage. If necessary, the building damage categories should be re-evaluated.

It is critical that the permanent and temporary works designs are carried out in a coordinated manner between performance specified elements and substructure contractors, with the aim to ensure that such design elements are in alignment with the assumptions/findings of the GMA and overall design intent.

Appendix A: Selected Supporting Information

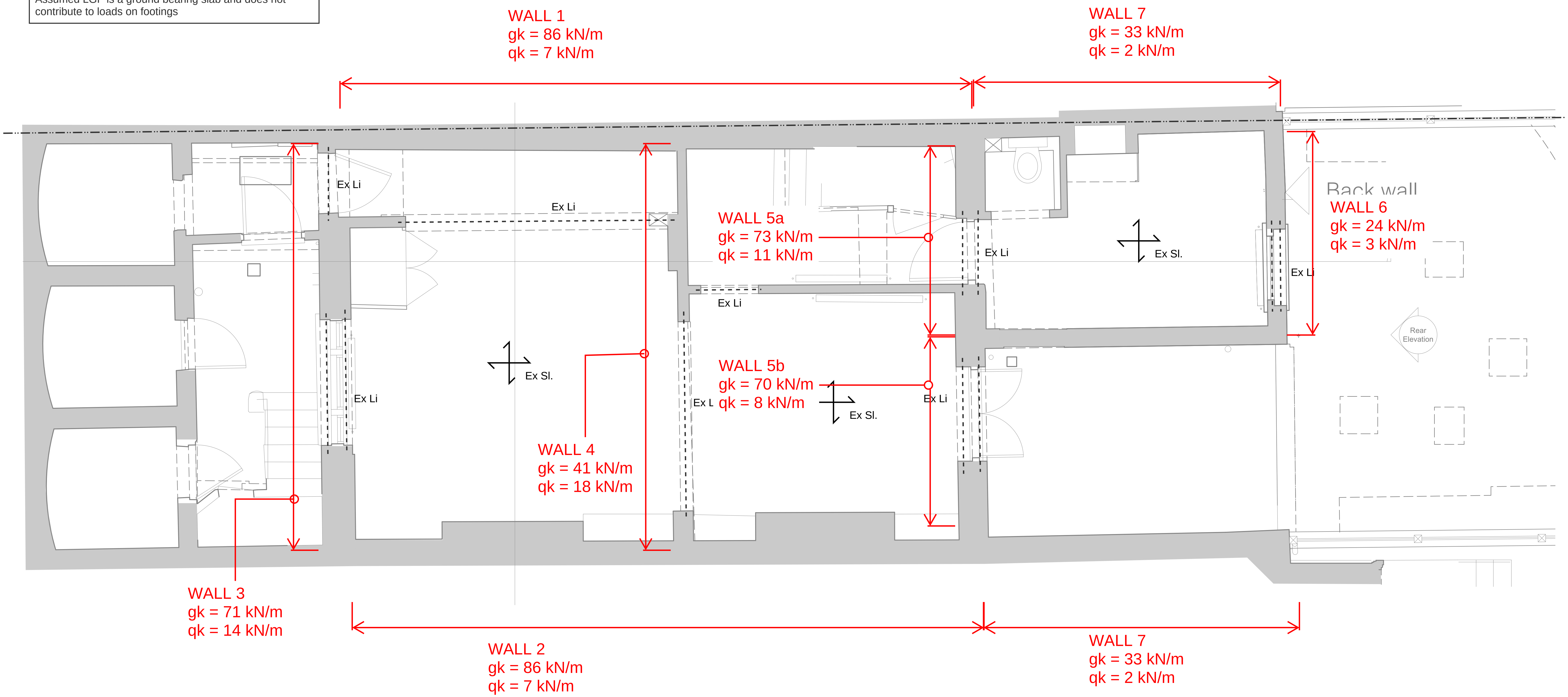
Existing loads are based on assumptions on the structural arrangement and footings. TBC following site investigations

All existing footings assumed to be corbelled masonry strip footings.

Imposed load reduction assumed

Assumed LGF is a ground bearing slab and does not contribute to loads on footings

Existing Loading Plan



Existing Lower Ground Floor Plan

BC STRUCTURAL DESIGN

Alex@BCStructural.co.uk
Dylan@BCStructural.co.uk

Project: **15 Fitzroy Road**

Drawing Number: **J207-BC-SK-0002**

Issued: **07.22**

Drawn by: **DJC**

Drawing Title: **Existing Foundation Loads**

Rev: **P1**

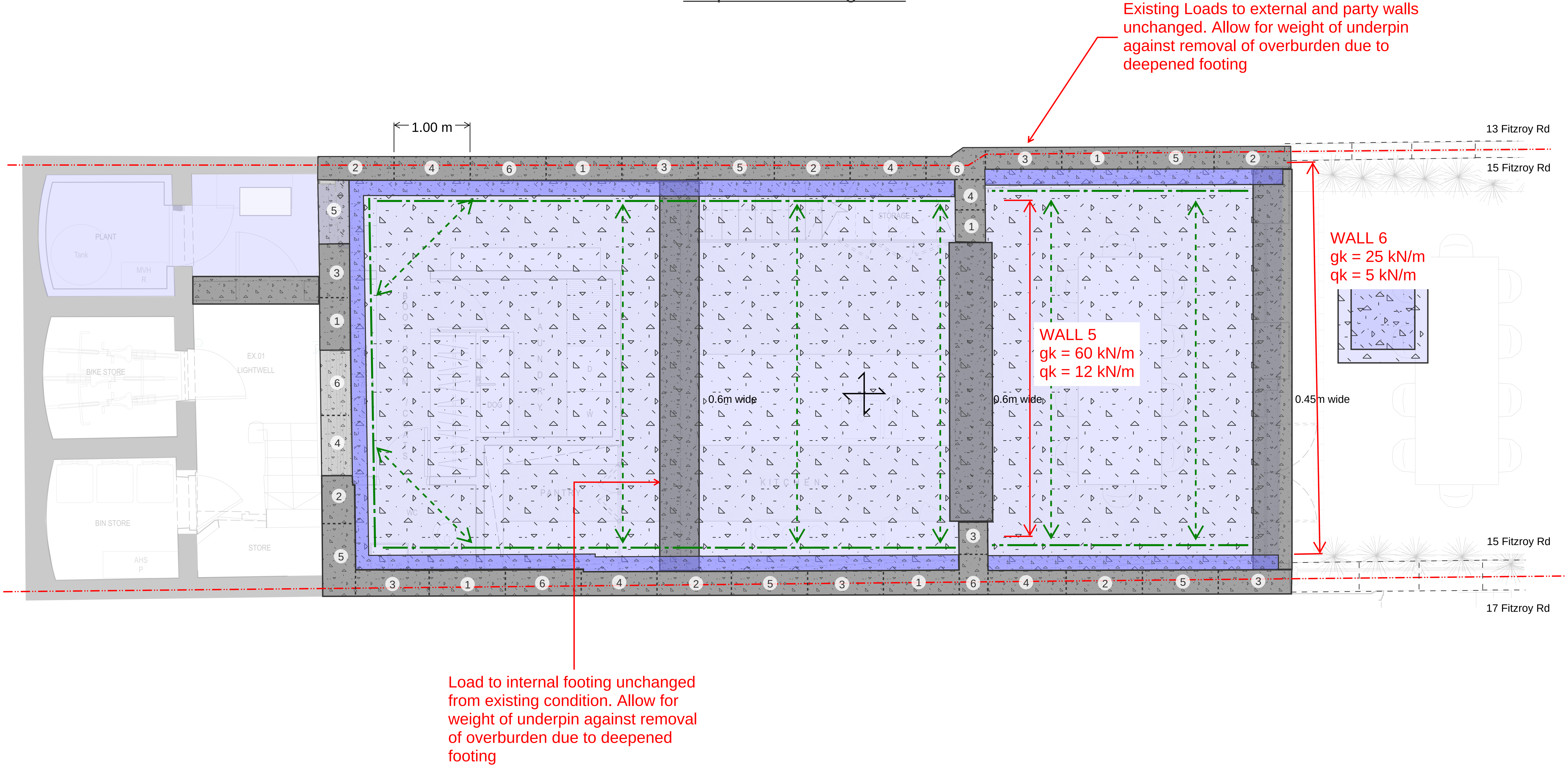
Scale: **NTS**

General Notes:
1. All setting out by Architect
2. Do not scale from these drawings
3. All dimensions to be checked on site by contractor
4. Drawing to be read in conjunction with general notes drawing
5. Where discrepancy occurs between specification and drawing, Engineer to be notified immediately
6. Temporary words design, method statement and construction sequence to be determined by contractor
7. Where discrepancy occurs between drawings and findings on site, Engineer to be notified immediately

Imposed load reduction assumed

Assumed new ground bearing slab does not contribute to loads on footings

Proposed Loading Plan



Proposed Foundation Plan

BC STRUCTURAL DESIGN

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Dylan@BCStructural.co.uk

Project: **15 Fitzroy Road**

Drawing Number: **J207-BC-SK-0003**

Issued: **08.22**

Drawn by: **DJC**

Drawing Title: **Proposed Foundation Loads**

Rev: **P2**

Scale: **NTS**

Work in Progress

Abreviations
TJ"x" - Timber Joists
TB"x" - Timber Beam
TC"x" - Timber Column
TW"x" - Timber Wall
SB"x" - Steel Beam
SC"x" - Steel Column
L"x" - Lintel over
PS"x" - Concrete padstone
CU - Column Under

Notes:
1. Do not scale from these drawings
2. All dimensions to be checked on site by contractor
3. Drawing to be read in conjunction with general notes drawing
4. Where discrepancy occurs between specification and drawing, Engineer to be notified immediately
5. Temporary words design, method statement and construction sequence to be determined by contractor
6. Where discrepancy occurs between drawings and findings on site, Engineer to be notified immediately
7. Contractor may allow for splicing of steelwork to aid erection if necessary, final design by contractor, to be coordinated with BC Structural Design.
8. Refer to architects details for fire protection of all elements
9. All foundations assumed to be founded a minimum of 1.0m BGL on natural undisturbed ground – to be checked by Building Control or an Approved Inspector – assumed bearing capacity – 100kN/m2. If adjacent to existing foundation, excavation to be stepped at 45degrees to avoid undermining. Foundations to be 450mm deep MC and a minimum of 450mm wide UNO.
10. All setting out to Architects information

A2 Site Investigation

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