A-squared Studio

50 Maresfield Gardens

Buildings Ground Movement Assessment

June 2023

2588-A2S-XX-XX-RP-Y-0001-01

Project Name	50 Maresfield Gardens
Project Number	2588
Client	Webb Yates Engineers Limited
Document Name	Buildings Ground Movement Assessment

A-squared Studio Engineers Ltd
One Westminster Bridge Rd
London, SE1 7XW

020 7620 2868
contact@a2-studio.com
www.a2-studio.com

Prepared by	Checked by	Approved by
Alex Corrigan BEng(Hons)	Hamed Shariff MEng(Hons), CEng, MICE	Alex Nikolic BEng(Hons), MSc, DIC, CEng, MICE, MSt(Cantab)
Engineer	Associate	Director

Document Reference	Status	Notes	Revision	Issued by	Date
2588-A2S-XX-XX-RP-Y-0001-00	Second Issue	Incorporating comments from Webb Yates and planning consultant	01	AC	13/06/2023

Contents

1. Introduction

A-squared Studio Engineers Ltd (A-squared) has been appointed by Webb Yates Engineers Limited (Webb Yates) to undertake a Ground Movement Assessment (GMA) for the redevelopment of 50 Maresfield Gardens, Camden, London, NW3 5RX.

The A-squared scope comprises an assessment of the potential impact of the proposed development works on the various neighbouring building façades, and an assessment of the potential ground movements on the neighbouring / surrounding roads and highways.

1.1. Study Aims & Objectives

A ground movement and impact assessment has been carried out in order to estimate the potential damage induced by the proposed redevelopment works at 50 Maresfield Gardens on neighbouring building façades and ground movements at the surrounding roads and highways.

The proposed development of 50 Maresfield Gardens comprises the demolition of selected internal superstructure elements, the lateral extension of the superstructure, and extension of the basement across the whole building footprint. The proposed basement will be retained by a contiguous piled wall and underpinning the existing ground beams. The basement will extend to a depth of 5.1mbgl (at the formation level of the new ground beams), and 7.6mbgl at the pool area.

The assessment encompasses properties located within the *zone of influence* of the proposed scheme. The GMA assessment is based on *greenfield* ground movements which are unlikely to be exceeded. 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 of ground movements induced by the proposed works on properties adjacent to the development under consideration.
- 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.

2. The Site & Development

2.1. Site Location and Proposed Development

The development site is located at 50 Maresfield Gardens, NW3 5RX as shown in Figure 2.1. The approximate National Grid reference for the site is TQ 26471 85059 and the site footprint covers approximately 0.1 hectares. The approximate ground surface elevation at the site is 81m above Ordnance Datum (mOD) and ground surface levels in the surrounding area fall toward the south.

The development site falls within the administrative boundaries of the London Borough of Camden and currently houses a three-storey residential building with a garden to the rear and a paved area to the front. The current land uses within a 250m radius surrounding the site are given in Table 2.1.

The existing building is anticipated to comprise a load bearing masonry structure with precast concrete floors/timber joist floors. The property underwent a basement and ground floor extension in 2004 and a ground and first floor extension in 2007. The original property and 2007 extension are shown in structural drawings to be supported on ground beams and piled foundations. The 2004 basement comprised contiguous piled retaining walls.

The proposed development comprises the demolition of selected internal superstructure elements, the lateral extension of the superstructure, and extension of the basement across the whole building footprint. The proposed basement will be retained by a contiguous piled wall and underpinning the existing ground beams. The basement will extend to a depth of 5.1mbgl (at the formation level of the new ground beams), and 7.6mbgl at the pool area. The existing ground beams are piled, with a pile length of 19.0m proven by parallel seismic testing. The existing piles are proposed to be cut down, and new ground beams formed at basement level. It is understood that the piles do not have sufficient capacity to support the increase in loading, and so the increment will be taken by the new ground beams working in combination with the piles.

Approximate site boundary marked by red line

Figure 2.1 Location of the proposed development

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	52 Maresfield Gardens – 3-storey detached residential property with private garden.	The site is within a residential area and therefore numerous multi-storey detached residential properties and apartments with private gardens are present up to and beyond 250 m of the site. Within this residential area are the following notable features. Netherhall Gardens (residential street) is approximately 160 m north
South	48 Maresfield Gardens – 2-storey detached residential property with private garden.	Multi-storey detached residential properties and apartments with private gardens along Maresfield Gardens are present up to and beyond 250m south of the site. Within this residential area, notable features include a storage/waste yard associated with 39 Fitzjohn's Avenue (approximately 30 m south), a private wooded area above Belsize Tunnel with air shaft (approximately 40 m south.), Nutley Terrace residential street (approximately 90 m south.) and the Freud History Museum is located (approximately 190 m south).
East	45 Fitzjohn's Avenue – multi-storey detached residential property with private garden. St. Mary's School – School with tennis court and outdoor hard-standing play areas.	Multi-storey detached residential properties and apartments with private gardens are present up to and beyond 250 m east of the site. Within this residential area, notable features include a Fitzjohn's Avenue residential street (approximately 75 m east), Alex Leo Gastrointestinal Surgery (approximately 170 m east) and Gloucester House School (approximately 200 m north-east).
West	Maresfield Gardens – residential street lined with detached and semi-detached multi-storey properties.	Predominantly residential properties (with gardens) to the west, with several schools, student accommodation blocks, commercial buildings and a hotel approximately 210 m west.

3. Ground Conditions

Site-specific ground investigation was undertaken by A2 Site Investigation Limited (A2SI) between 16th – 22nd December 2022 and on 13th January 2023. Following the ground investigation, the ground conditions on site were found to comprise the following (in order of succession):

- Made Ground – Soft dark brown gravelly slightly sandy silty clay.
- Claygate Member – Soft yellowish brown mottled grey slightly sandy silty clay.
- London Clay Formation – Firm to stiff, slightly micaceous dark grey slightly sandy silty clay.

The data from the ground investigation were used to derive geotechnical parameters for the site which have been used in the analysis of this GMA. The geotechnical parameters are given in Table 3.1. Note that the Claygate Member and London Clay Formation were found to be geotechnically similar, and so have been treated as a homogenous layer for design purposes. For more information see the Interpretive Report produced by A2SI (ref. 26822-A2SI-XX-XX-RP-Y-0003-00) dated March 2023.

Table 3.1 Geotechnical parameters adopted for the analysis

Stratum	Elevation (mOD)	Thickness (m)	Undrained Young's Modulus, E_u [2](MPa)	Drained Young's Modulus, E' [2](MPa)	Poisson's ratio
Made Ground	+81.0	1.3	-	10.0	v' = 0.2
London Clay	+79.7	Not Proven	7.2 + 2.1z[4]	9.0 + 2.6z[4]	v_u = 0.5 v' = 0.2

1. Ground model based on site specific ground investigation data in the vicinity of the site. This data has been interpreted specifically for the scope of the GMA presented herein.
2. Stiffness data (E_u and E') has been evaluated empirically from in-situ testing data taking into consideration the nature of the geotechnical/soil-structure interaction mechanisms and level of anticipated strain within the soil mass.
3. Rigid boundary was assumed at -42.3 mOD / 38.7 mbgl for analytical purposes. The London Clay Formation is expected to be >90.0m in thickness based on a review of surrounding BGS borehole data.
4. z refers to the depth in metres below the top of the London Clay formation. Lower bound stiffness values have been adopted for GMA purposes only.

4. Impact Assessment Methodology

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 basement excavations will induce ground movements arising from the overburden removal and installation of the proposed retention system. The permanent condition loading will partially reinstate a portion of the removed overburden, yielding settlements across the foundation system. The induced ground movements will extend over a given zone of influence surrounding the building/excavation footprint.

A series of three-dimensional models of the proposed scheme have been developed in Oasys PDisp/XDisp 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. Demolition and basement excavation (short-term).

A2. Demolition, basement excavation, and application of the proposed building loading (long-term).

Group B – CIRIA-based ground movements

B1. Installation of contiguous wall and underpins and basement excavation.

B2. Installation of contiguous wall and underpins, basement excavation, and application of the proposed building loading (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 overburden removal unloading and reloading processes. The modelled excavation footprint has been simplified for the purpose of the analysis.

The demolition unloading pressures have been calculated based on the provided loading / unloading information. Excavation unloading pressures have been modelled at the basement formation level representing the removal of a maximum of 5.23m of overburden to form the basement level as shown in Figure 4.1. Note that the maximum excavation depth has been taken as the bottom of the ground beams to model a worst case for the purposes of the GMA. The underside of the basement slab will be at 4.5mbgl.

The modelled building loading has been based on information provided by Webb Yates. It is understood that the existing piles to be cut down do not have sufficient capacity to support the increase in loading, and so the load increment will be taken by the new ground beams, formed at +75.88mOD. The loading onto the contiguous piled wall has been idealised into an equivalent spread loading at +72.32mOD. The building loading pressures idealised in PDisp are shown in Figure 4.2.

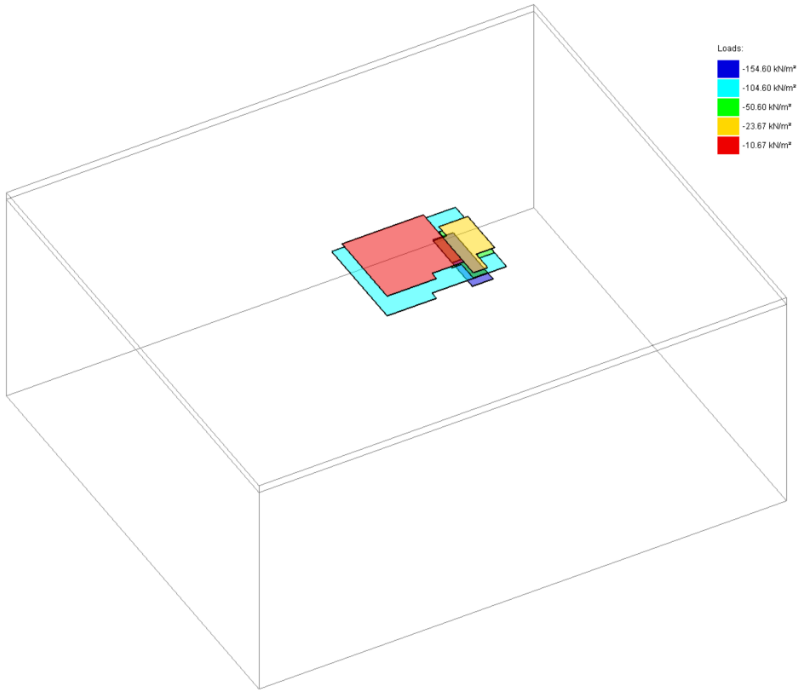

Figure 4.1 Unloading pressures modelled in PDisp - demolition and excavation

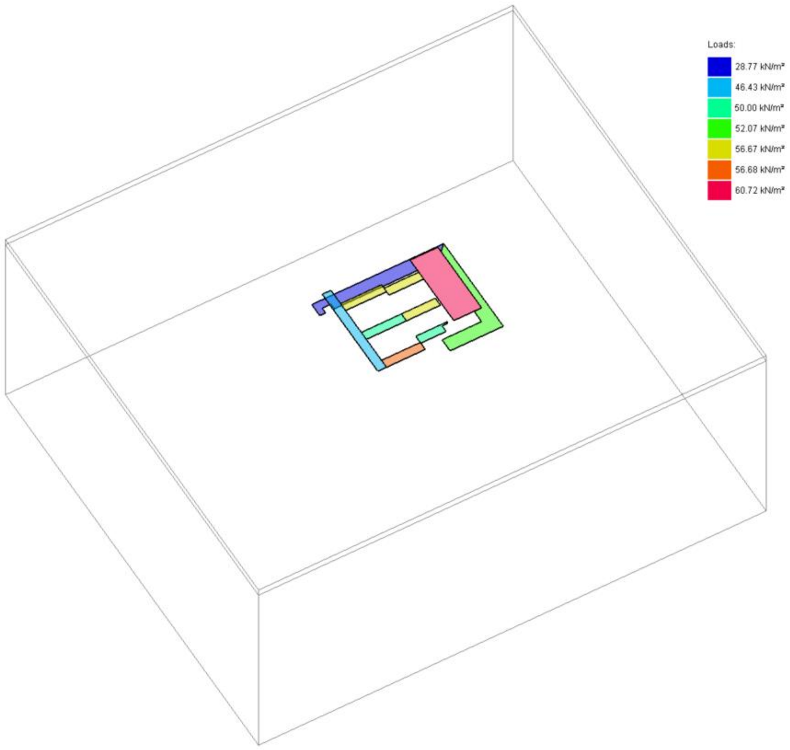

Figure 4.2 Structural loading modelled in PDisp

The Group B assessments adopt the normalised ground displacement curves reported in CIRIA C760. In addition to the effects arising from the basement excavation, the ground movement effects associated with the installation of the contiguous retaining wall and underpinning have been considered. The following CIRIA C760 normalised ground movement curves were adopted to assess ground movements due to retention system installation and excavation works:

- *Contiguous pile wall installation*: Installation of contiguous bored pile wall in stiff clay.

- *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 contiguous retaining walls have been assessed as 10.0m in length, and the underpins are formed at 5.1mbgl based on drawings prepared by Webb Yates.

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.

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 construction sequencing and scheme design, the engineer should thoroughly review the discrepancy and evaluate any potential impacts on ground movements and adjacent utilities. If necessary, the GMA results should be re-evaluated. It is critical that the permanent and temporary works designs are carried out in a coordinated manner, with the aim to ensure that such design elements are in alignment with the assumptions/findings of the GMA and overall design intent.

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 assumed the Contractor will produce a detailed temporary works design, construction methodology and controls which will be presented within a Basement Construction Plan (BCP) as part of the detailed design, in accordance with the assumptions of the GMA.

In the B2 assessment, the CIRIA ground movements are combined with the long-term settlements induced by the loading redistribution (evaluated in PDisp).

The two sets of analyses enabled the evaluation of an envelope of damage classification results, with the worst-case results presented herein. The 3D representative geometry as modelled in XDisp is presented in Figure 4.3.

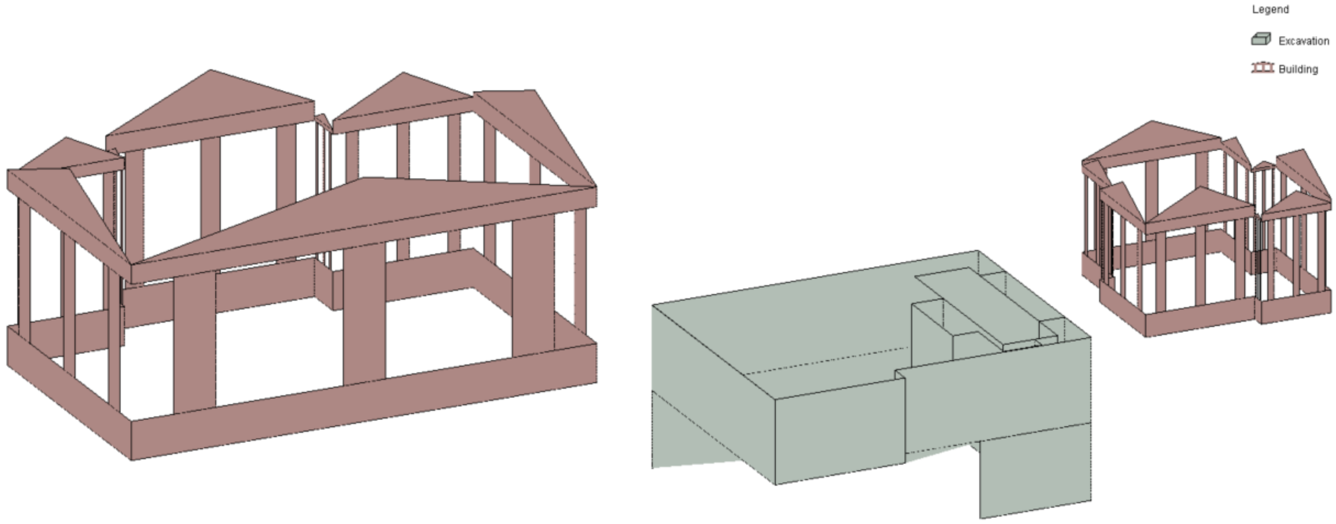

Figure 4.3 Three-dimensional modelled geometry in XDisp

4.2. Buildings 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 4.4 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 basements (covering the key deformation mechanisms). In total, 18 facades of the neighbouring buildings were considered for the current study, and these are grouped together in the following manner.

- 48.MG.01-10 – 48 Maresfield Gardens
- 52.MG.01-08 – 52 Maresfield Gardens

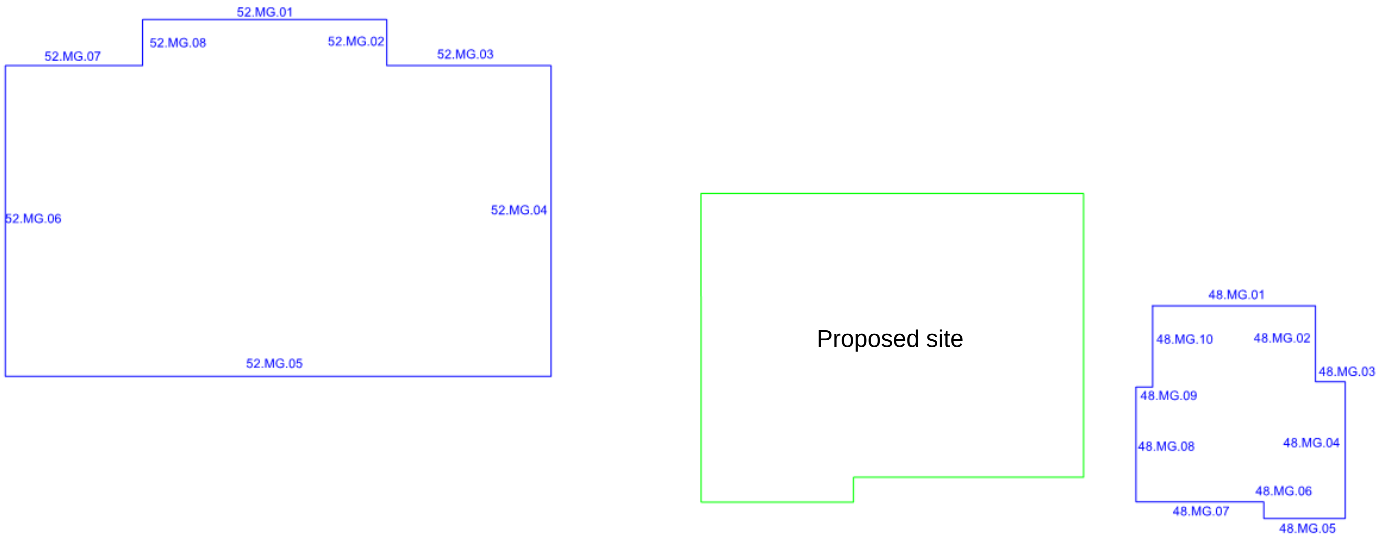

Figure 4.4 Nomenclature for each neighbouring building facade

Each wall has been assumed to behave as an equivalent beam subject to 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 ∆/L and horizontal extension mechanisms estimated from the analyses. The assessment considers the well-established Burland (1997) damage classification method, as presented and summarised in Figure 4.5 and Figure 4.6. 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).

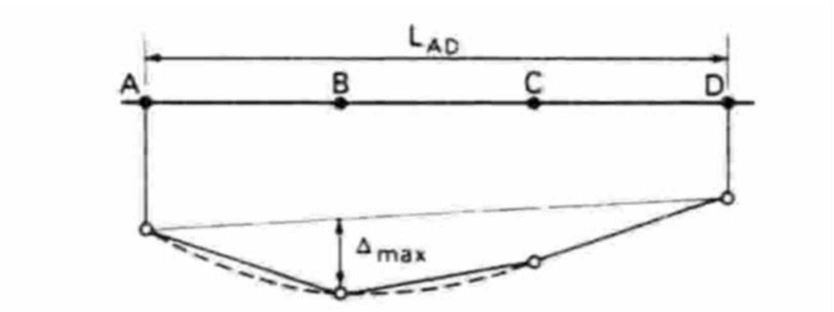

Figure 4.5 Definition of relative deflection Δ and defelction ratio Δ/L

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 classificaton – relationship between catergory of damage and limiting strain ε_{lim}

5. Results

5.1. Building Damage Impact Assessment

The results of the assessment indicate that all facades will fall within or under damage Category 1 – Very Slight throughout the construction works. The results of the assessment are presented in Table 5.1. Any facades which fall into Category 0 – Negligible in all analysis scenarios are omitted from the table. Figure 5.1 and Figure 5.2 depict the vertical displacements induced by the proposed basement excavation and structural loading from PDisp respectively. Figure 5.3, Figure 5.4, Figure 5.5, and Figure 5.6 show vertical and horizontal displacements calculated using CIRIA C760 data sets for the B1 and B2 assessments using XDisp.

Table 5.1 Facade damage categories

Façade Reference	Analysis Scenario			
	A1	A2	B1	B2
48.MG.01	Category 0 – Negligible	Category 0 – Negligible	Category 1 – Very Slight	Category 1 – Very Slight
48.MG.03	Category 0 – Negligible	Category 0 – Negligible	Category 0 – Negligible	Category 1 – Very Slight
48.MG.03	Category 0 – Negligible	Category 0 – Negligible	Category 1 – Very Slight	Category 1 – Very Slight

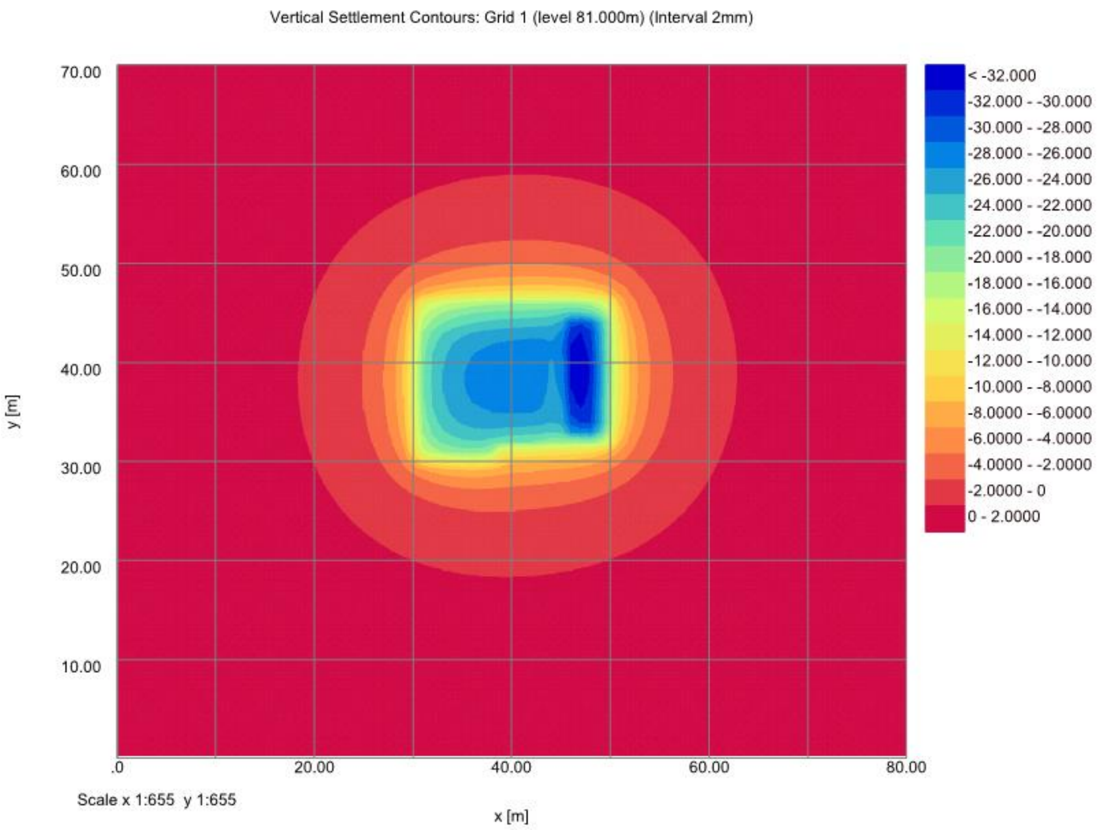

Figure 5.1 A1 – short-term unloading vertical displacement plot

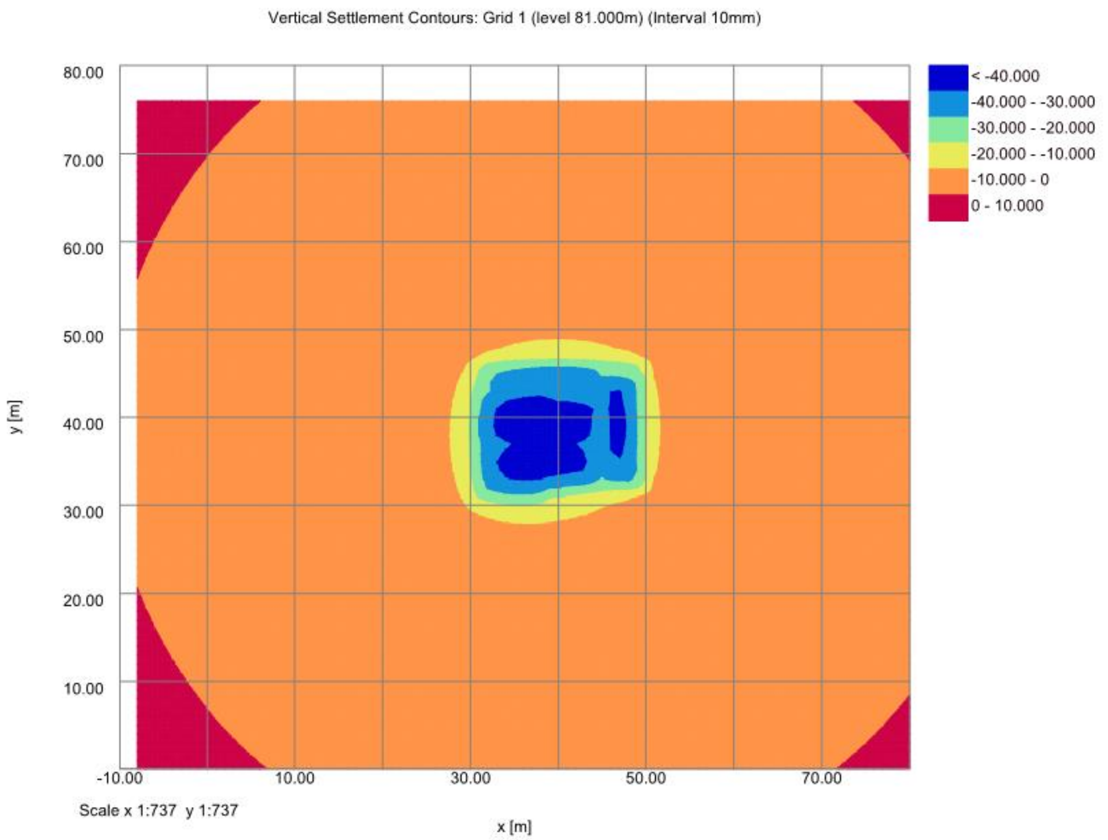

Figure 5.2 A2 – long-term loading vertical displacement plot

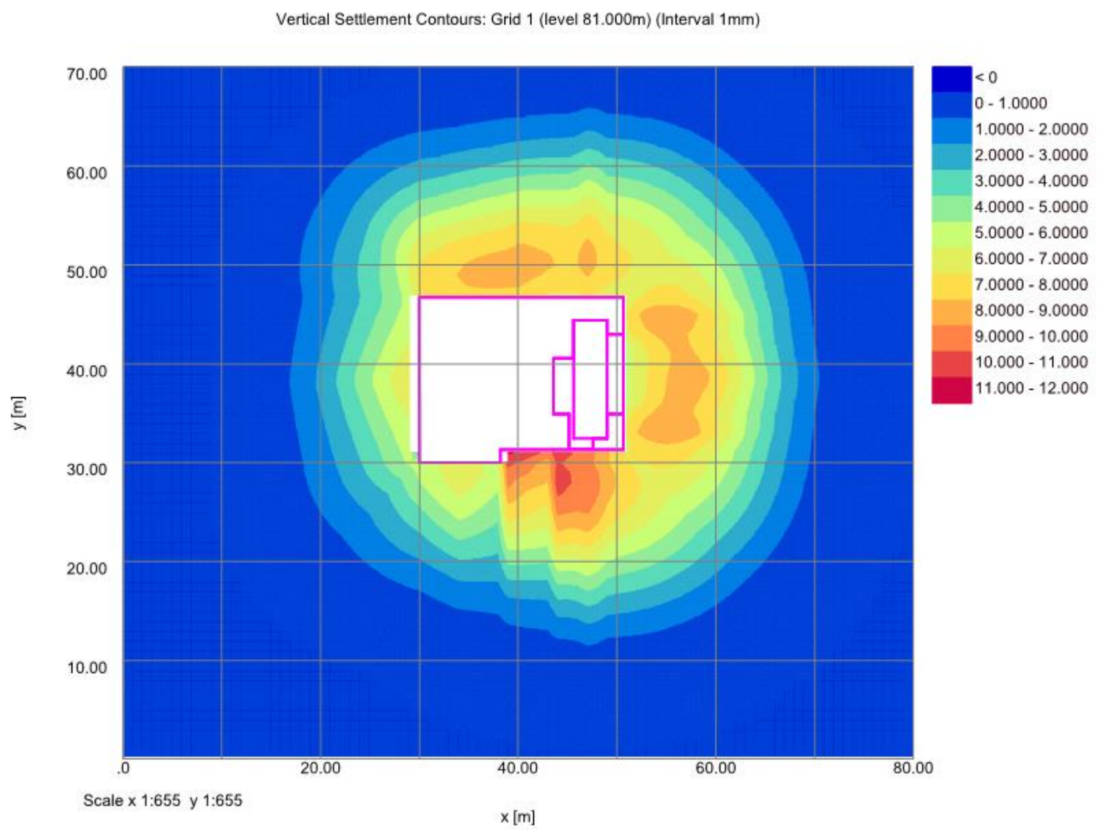

Figure 5.3 B1 – application of CIRIA curves vertical displacement plot

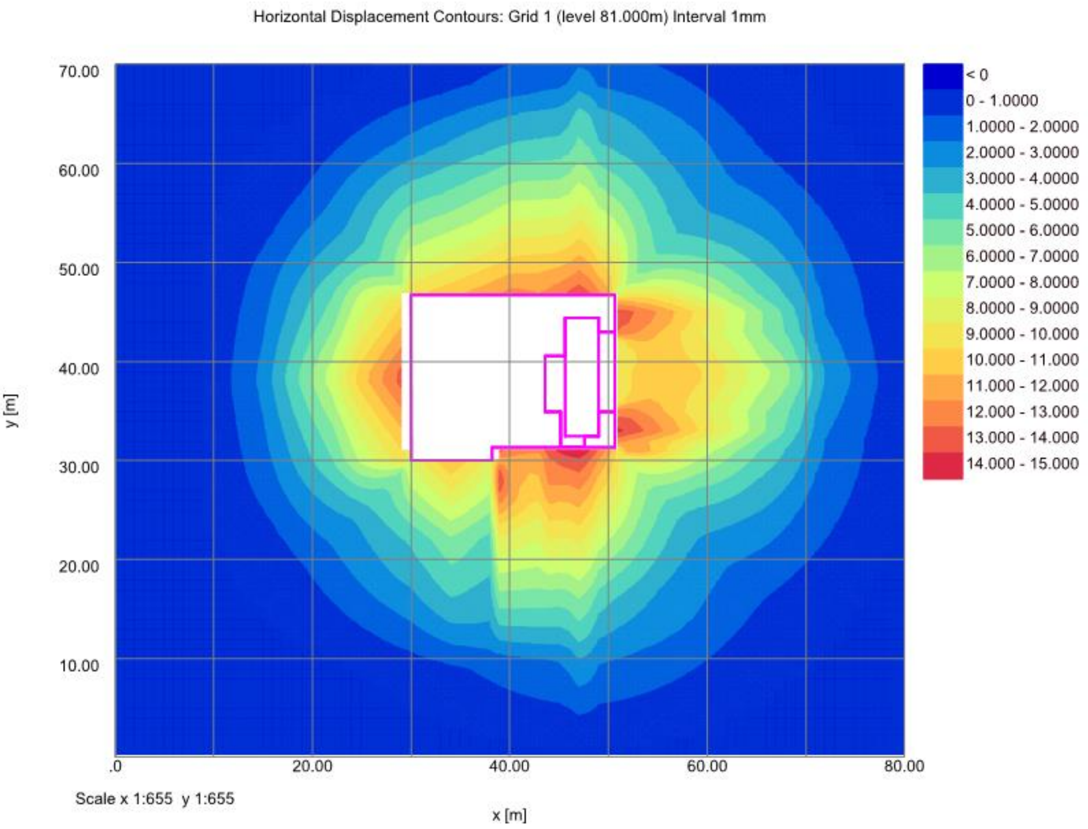

Figure 5.4 B1 – application of CIRIA curves horizontal displacement plot

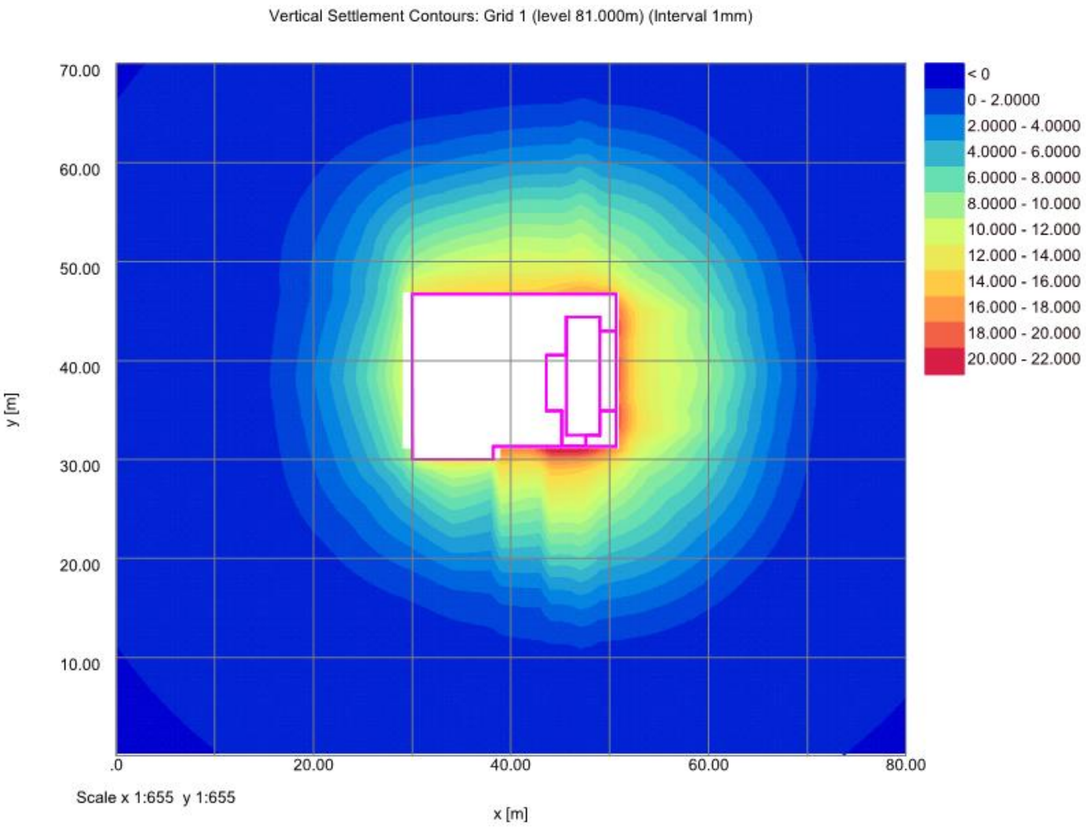

Figure 5.5 B2 – application of CIRIA curves and long-term building loading vertical dispacement plot

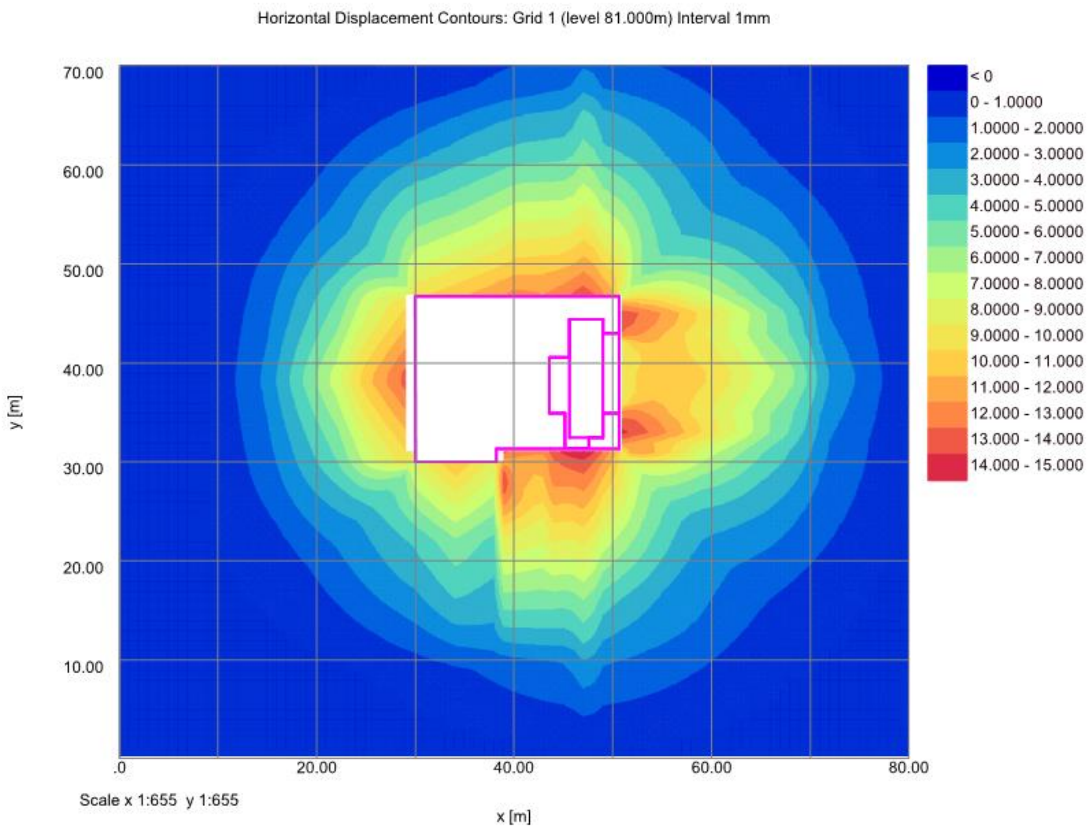

Figure 5.6 B2 – application of CIRIA curves and long-term building loading horizontal displacement plot

5.2. Impact on Adjacent Roads and Highways

An assessment of the impact that the proposed development will have on the adjacent roads has been carried out. The assessment included Maresfield Gardens, with assessments taken at its closest position to the site boundary. The maximum displacements expected along Maresfield Gardens is 2mm both horizontally and vertically.

5.3. Basement Excavation Criteria

A maximum horizontal and vertical movements of 15mm and 22mm, respectively, at the top of the retention system are expected to be induced by the proposed development. The results of the analysis show that all building fall within acceptable damage classifications if the ground movements caused by the proposed development are limited to the values presented in Table 5.2.

Table 5.2 Limiting ground movement values for the project at various constrution stages

Stage	Maximum Cumulative Ground Movement (mm)	
	Vertical	Horizontal
Installation of contiguous pile wall and underpinning	5	5
Excavation	8	15
Long-Term	22	15

Movements at top of retention system.

It is recommended that ground movement / earth retention system design and construction movement criteria are developed based on the results presented herein. This will enable the design of the retaining wall and any required temporary propping measures to be undertaken in a holistic fashion, ensuring ground movements are limited to no greater than that presented herein.

Specific wall/façade deflection limits and trigger levels may also be developed as part of the scheme monitoring regime. Such limits and trigger levels should be coordinated with the scheme monitoring specification and monitoring action plan / emergency preparedness plan.

6. Conclusions and Closing Remarks

The interaction between the proposed 50 Maresfield Gardens 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 comprises the demolition of some internal superstructure elements, the lateral extension of superstructure, and extension of the basement across the whole building footprint. The proposed basement will be retained by a contiguous piled wall and underpinning the existing ground beams. The basement will extend to a depth of 5.1mbgl (at the formation level of the new ground beams), and 7.6mbgl at the pool area.

The impact of the various construction stages has been reviewed on the basis of two alternative methods, i.e. evaluating the effects of unloading / overburden removal using PDisp and simulating the excavation-induced ground movement fields using empirical CIRIA curves in XDisp. In the latter case, a contiguous wall solution (during the installation of the retaining wall) and underpinning have been considered, utilising the CIRIA C760 ground movement curves for excavation in front of 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 construction methodology. Both short-term (undrained) and long-term (drained) conditions have been assessed by adopting the relevant soil stiffness parameters for each case.

In order to best limit ground movements in proximity to sensitive neighbouring buildings, due consideration may be given to suitable means and methods of construction. For example, reducing the extent of temporary excavations during earth removal operations in close proximity to buildings considered to be at most risk of damage.

The results from the GMA (denoting the evaluated damage categorisation in accordance with the Burland criteria described herein) considering neighbouring properties are presented in Section 4. It is observed that the maximum damage classification for the neighbouring properties is Category 1 – Very Slight.

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

During the design of the embedded retaining walls and temporary propping measures, deflection performance criteria for these design elements should be derived on the basis of the results presented herein to ensure that the maximum damage classification of Category 1 – Very Slight is not breached.

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.

An assessment of the impact of the proposed development on the adjacent roads and highways has been undertaken. The maximum vertical and horizontal movements of Maresfield Gardens are estimated to be 2mm both vertically and horizontally.

A-squared Studio

A-squared Studio Engineers Ltd
One Westminster Bridge Rd
London, SE1 7XW

020 7620 2868
contact@a2-studio.com
www.a2-studio.com