A-squared Studio

Harrington Square

Basement Impact Assessment (BIA)

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Project Name	Harrington Square
Project Number	2874
Client	Salboy (Mornington Crescent) Limited
Document Name	Basement Impact Assessment (BIA)

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Contents

Appendices

1. Non-Technical Summary

1.1.1. The site location is at the land adjacent to Hurdwick House, Harrington Square, Camden, London, NW1 2JE, within the London Borough of Camden.

1.1.2. The site is currently occupied by a private car park. The existing buildings near the site comprise a number of 4-5 storey residential properties.

1.1.3. The proposed development works include the construction of a new 5-storey residential apartment building which will be supported by a piled foundation system. A new one-storey basement level is also to be constructed across part of the building footprint. The excavation will be supported by reinforced concrete retaining walls and temporary sheet piling with the potential for some areas of open-cut where feasible.

1.1.4. The following assessments are presented in the current document:

- Screening.
- Scoping.
- Additional evidence/assessments (as required), including:
  - Ground movement assessment (GMA).
  - Architectural and structural drawings.
- Basement Impact Assessment (BIA).

1.1.5. The site is generally flat, with an approximate surrounding ground elevation of +25.0mOD.

1.1.6. Based on a review of BGS data and site-specific ground investigation data, the ground conditions beneath the site are anticipated to comprise:

- Made Ground: to a depth of approximately 2.50 metres below existing ground level (mbgl) comprised of variable anthropogenic deposits.
- London Clay Formation: >22.50m thick firm to stiff brown clay occasionally silty.
- Lambeth Group/Thanet Sand.
- Chalk.

1.1.7. No groundwater has been encountered during the ground investigation works and no interaction with the groundwater is anticipated in the proposed works.

1.1.8. The BIA has assessed land stability, and the impacts of the proposed development on the neighbouring structures will be limited to *Category 1 – Very Slight*, in accordance with the Burland (1995) damage classification scale.

1.1.9. The BIA has concluded that there will be low risk to the development and/or neighbouring properties associated with the risk of land and slope instability.

1.1.10. The BIA has concluded that there is a low risk of groundwater flooding.

2. Introduction

2.1. Overview

2.1.1. This Basement Impact Assessment (BIA) has been prepared by A-squared Studio Engineers Ltd (A-squared) on behalf of Salboy (Mornington Crescent) Limited (hereafter referred to as "the applicant"), in support of an application for Full Planning Permission and Listed Building Consent for the proposed development at the land adjacent to Hurdwick House, Harrington Square, Camden, London, NW1 2JE (herein called the "site").

2.1.2. The purpose of this assessment is to consider the potential effects of the proposed development on the local hydrology, geology, and hydrogeology, and to determine the potential impacts to neighbours and the wider environment.

2.1.3. The location of the proposed development is shown in Figure 2.1.

Approximate site boundary marked in red. Source: Google Earth.

Figure 2.1 Location of the proposed development

2.1.4. The development site is located within the jurisdiction of the London Borough of Camden.

2.1.5. The BIA has followed the approach developed by the London Borough of Camden, which is considered to represent current industry best practice.

2.1.6. The BIA comprises the following elements:

- Screening.
- Scoping.
- Additional evidence/assessments (as required), including:
  - Ground movement assessment (GMA).
  - Architectural and structural drawings.
- Basement Impact Assessment.

2.2. Credentials

2.2.1. The BIA has been reviewed by James Woodcock. James is a Chartered Member of the Institution of Civil Engineers (MICE) with 10 years of industry experience in geotechnical design and construction of ground engineering works. James has attained a Master of Science in Soil Mechanics (MSc DIC) from the Imperial College London.

2.2.2. The BIA has been approved by Tony Suckling. Tony is a Chartered Fellow of the Institution of Civil Engineers (FICE) and a Fellow of the Geological Society (FGS). Tony has a Master of Science (MSc) in Geotechnical Engineering from City University. Tony is a Registered Ground Engineering Professional (RoGEP) with almost 30 years of industry experience in geotechnical design and construction of ground engineering works. Tony has previously held the position of Technical Director for Balfour Beatty Ground Engineering Ltd. Tony has been a past Chairman of the Federation of Piling Specialists Technical Committee and a Board Member of the Deep Foundation Institute Europe. Tony was part of the steering group for CIRIA C760 Guidance on Embedded Retaining Wall Design.

2.3. Sources of Information

2.3.1. The following baseline data has been referenced to complete the BIA in relation to the proposed development:

- *Phase I Geo-Environmental Assessment Report* produced by Renaissance Associated Ltd (Renaissance), dated March 2023 (ref: HAR-REN-00-XX-RP-C-00003).
- Drawings prepared by Renaissance.
- *Factual Report* produced by A2 Site Investigation Limited, dated June 2023 (ref: 33023-A2SI-XX-XX-RP-X-0001-01).
- Public domain geological mapping from British Geological Society Geology of Britain Viewer and Borehole Viewer.
- Camden Planning Guidance – Basements (March 2018).
- Flood map for planning – Environmental Agency.
- LB Camden, Planning Guidance (CPG4) – Basements (March 2018).

2.4. Existing Development

2.4.1. The development site is located at the land adjacent to Hurdwick House, Harrington Square, Camden, London, NW1 2JE. The site area is approximately 0.05 ha.

2.4.2. The site is generally flat with an existing external ground level of approximately +25.0mOD.

2.4.3. The site is currently occupied by a by a private car park, containing hard and soft landscaping.

2.5. Neighbouring Properties and Infrastructure

2.5.1. The site is bounded by a residential apartment building to the south-east, Harrington Square road to the south-west, and terraced housing to the north-west and north-east. A summary of the surrounding land uses and key buildings is presented in Table 2-1.

2.5.2. Underground utilities may be present in the area surrounding the site. Other asset owners with existing underground services that may be impacted by the proposed development include the following:

- London Borough of Camden and the Greater London Authority.
- London Underground Limited (LUL).
- Thames Water Utilities Ltd.
- BT (BT Group Plc) – Telecoms.
- UK Power Networks Ltd – Electricity distribution.
- National Grid Gas Plc – Gas.

2.5.3. Asset protection teams for the assets listed in 2.5.2 will be engaged as the design of the proposed development continues. Where necessary, separate GMAs will be prepared to meet design assurance requirements.

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	1-5 Hurdwick Place terraced housing.	Mornington Crescent tube station. Other commercial premises, including restaurants and retail, and occasional residential use.
South	Hurdwick House - Residential apartment building	Other commercial premises, including restaurants and retail, and occasional residential use.
East	Eversholt Street – terraced mixed commercial and residential use.	Other commercial premises, including restaurants and retail, and occasional residential use. Railway tracks to/from London Euston Station.
West	Harrington Square road and Harrington Square Gardens.	Other commercial premises, including restaurants and retail, and occasional residential use.

2.6. Proposed Development

2.6.1. The proposed development sketches / drawings are included in Appendix A.

2.6.2. The scheme for the proposed development comprises a multi-storey residential building including a single-storey basement across the southern portion of the building footprint. The basement is to be supported by reinforced concrete retaining walls and temporary sheet piles. The building is proposed to be supported by piled foundation.

2.6.3. The location of the proposed basement is indicated in Figure 2.2.

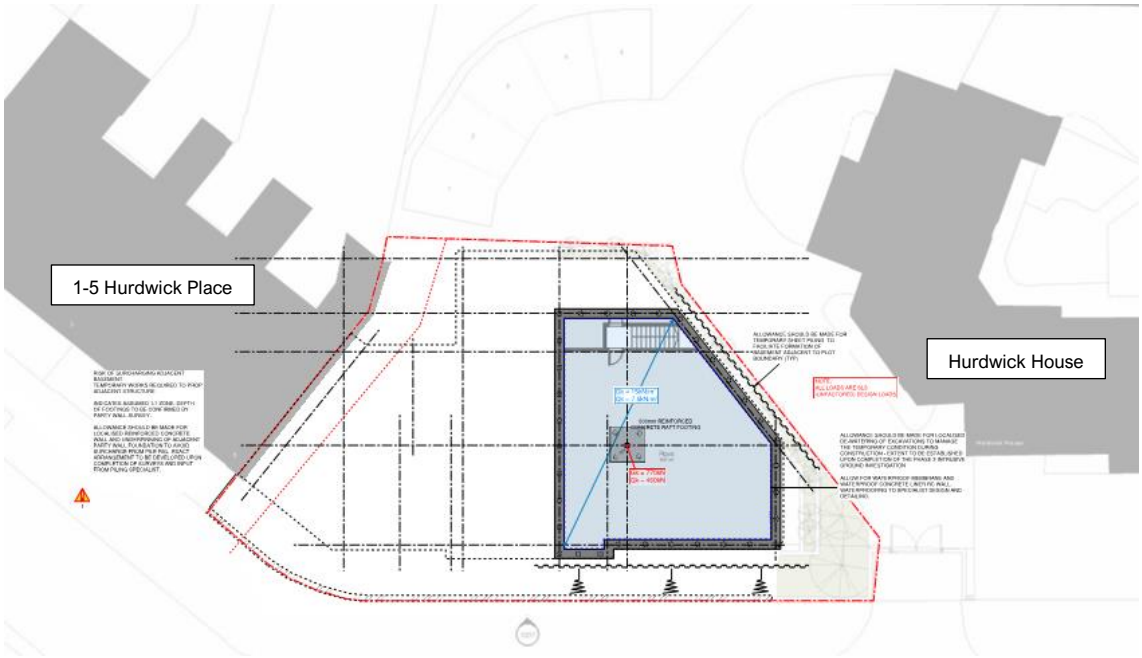


Figure 2.2 Proposed basements location plan

2.6.4. The proposed basement will be constructed at a depth of approximately 4.3mbgl.

2.6.5. The foundation design comprises a pile foundations system.

3. Desk Study

3.1.1. A Phase I Geo-environmental report has been undertaken by Renaissance Limited for the project. The report has been used to inform this BIA.

3.1.2. The Phase I report informs further actions in relation to site investigation and ground contamination risks.

4. Screening

4.1. Subterranean (Groundwater) Flow, Screening Flowchart

Question		Response	Details
1a.	Is the site located directly above an aquifer?	No	The London Clay is classified as an Unproductive stratum.
1b.	Will the proposed basement extend beneath the water table surface?	No	No groundwater has been encountered in the ground investigation and therefore no excavations will extend below the groundwater table.
2.	Is the site within 100m of a watercourse, well (used / disused) or potential spring line?	No	The site is not within 100m of a watercourse, well, or potential spring line.
3.	Will the proposed basement development result in a change in the proportion of the hard surfaced / paved areas?	No	Basement to be formed in existing carpark which is currently covered by hardstanding.
4.	As part of the site drainage, will more surface water (e.g. rainfall and run-off) than at present be discharged to the ground (e.g. via soakaways and / or SUDS)?	No	The proposed development is expected to maintain the existing surface water discharge conditions. SUDs techniques are proposed as part of the scheme, including rainwater harvesting and blue roofs. More details can be found in the Outline Drainage Strategy prepared by Renaissance (ref. HSC-REN-XX-XX-RP-C-00002).
5.	Is the lowest point of the proposed excavation (allowing for any drainage and foundation space under the basement floor) close to, or lower than, the mean water level in any local pond?	No	No ponds are considered local to the site.

4.2. Stability Screening Flow Chart

Question		Response	Details
1.	Does the existing site include slopes, natural or man-made, greater than 7 degrees (approximately 1 in 8)?	No	The site is generally flat.
2.	Will the proposed re-profiling or landscaping at the site change slopes at the property boundary to more than 7 degrees (approximately 1 in 8)?	No	There are no slopes at the existing site and none are proposed.
3.	Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7 degrees (approximately 1 in 8)?	No	Adjacent properties have a similar flat topography to the site.
4.	Is the site within a wider hillside setting in which the general slope is greater than 7 degrees (approximately 1 in 8)?	No	The site is within a generally flat wider area.
5.	Is the London Clay the shallowest strata at the site?	No	BGS information and site-specific ground investigation data show that the site is likely to be underlain by Made Ground over London Clay.
6.	Will any trees be felled as part of the development and/or are any works proposed within any tree protection zones where trees are to be retained?	No	No trees will be felled during development.
7.	Is there a history of seasonal shrink-swell subsidence in the local area and/or evidence of such effects at the site?	No	There is no evidenced history of shrink-swell induced subsidence at the site.
8.	Is the site within 100m of a watercourse or a potential spring line?	No	The site is not within 100m of a watercourse or potential spring line.
9.	Is the site within an area of previously worked ground?	No	The site is not in an area of previously worked ground.
10.	Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	No	The London Clay is classified as an Unproductive stratum. The proposed basement will not extend below the groundwater table. No groundwater was encountered during the ground investigation.
11.	Is the site within 5m of a highway or pedestrian right of way?	Yes	The site is bounded by Hurdwick Place and Harrington Square to the east and a pedestrian pavement.
12.	Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	**Yes**	The proposed basements formation level is approximately 4.3mbgl. For the purpose of conservatism in the ground movement assessment, neighbouring buildings are assumed to be founded at or close to ground level, ignoring any existing basements.
13.	Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	Yes	Th site boundary is within the exclusion zone of a London Underground Limited (LUL) northern line tunnel located to the west of the site. The building footprint does not however overlap with the exclusion zone and proposed foundations will not enter the exclusion zone.

4.3. Surface Water and Flooding Screening Flowchart

Question		Response	Details
1.	As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route?	No	The existing route is expected to be incorporated into the scheme.
2.	Will the proposed basement development result in a change in the proportion of hard surfaced / paved external areas?	No	Basement to be formed in an existing carpark which is currently covered by hardstanding.
3.	Will the proposed basement result in changes to the profile of the inflows (instantaneous and long-term) of surface water being received by adjacent properties or downstream watercourses?	No	The proposed basement is not anticipated to change the surface water discharged from the property.
4.	Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses?	No	No change in surface water quality is anticipated.
5.	Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk from flooding, for example because the proposed basement is below the static water level of nearby surface water feature?	No	Based on the Environment Agency Flood Map, the site is in Flood Zone 1 and has a low probability of flooding. More details can be found in the Flood Risk Assessment prepared by Renaissance (ref. HSC-REN-XX-XX-RP-C-00001)

4.4. Statutory Listed Buildings Screening Flowchart

Question	Response	Details
1. Is the building statutory Listed?	No	There is no existing structure on the site footprint.
2. Is the site located adjacent to or close to a statutory Listed Building?	**Yes**	There is one listed structure within 50m of the site: • Mornington Crescent London Railway Transport Station is a Grade II Listed building located approximately 40m north of the site.

4.5. Non-Technical Summary of Screening Process

4.5.1. The screening process identifies the following issues to be carried forward to scoping for further assessment:

- The proposed basement excavation is adjacent to neighbouring structures and will increase the differential depth of foundations relative to neighbouring properties. The proposed basements formation level is approximately 4.3mbgl.
- There is one listed building within 50m of the site.

4.5.2. The other potential concerns considered within the screening process have been demonstrated to be not applicable or not significant when applied to the proposed development.

5. Scoping

5.1. Stability: Proposed basement excavation is adjacent to neighbouring structures.

Hazards

5.1.1. Deep excavations will be carried out adjacent to neighbouring structures.

Potential Impacts

5.1.2. Collapse of the excavation and associated impact on surrounding assets.

5.1.3. Damage to the buried services due to excessive ground movements.

5.1.4. Damage to neighbouring properties induced by ground movements associated with proposed excavation/construction works.

Mitigating Factors

5.1.5. Localised temporary propping should be considered in to reduce the risk of adversely affecting the neighbouring properties and any surrounding third-party assets due to excessive ground movements.

5.1.6. Several basements of similar depth and scale have been successfully constructed throughout London within similar geological conditions and urban settings.

5.1.7. The proposed construction sequence will be driven by limiting ground movements and keeping the potential damage to the neighbouring structures to Burland (1995) *Category 1 – Very Slight*.

Assessments and Further Actions

5.1.8. Design of the retaining structures shall be carried out by an appropriately experienced and qualified specialist / engineer / ground engineering contractor in accordance with relevant Eurocodes / British Standards, Codes of Practice, and industry standards. The design shall allow for appropriate surcharging behind the retaining walls to accurately reflect the type and intensity of traffic and building loads.

5.1.9. A ground movement assessment has been carried out to determine the impact of proposed excavation works on the neighbouring properties, discussed in Section 8.2. The assessment predicts a maximum damage classification of *Category 1 – Very Slight* for the neighbouring properties, in accordance with the Burland (1995) damage classification scale.

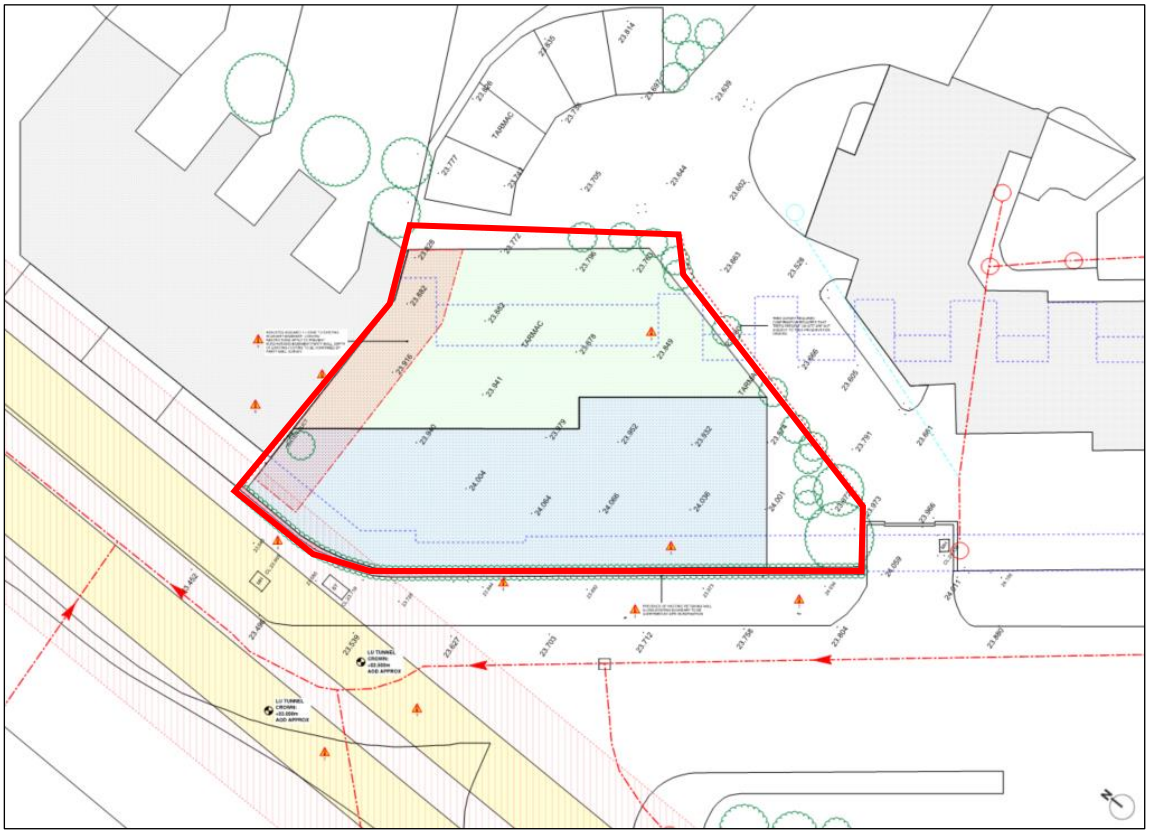
5.1.10. Additional ground movement assessments will be performed as required to determine the impact of the proposed excavation works on any buried utilities and other third-party assets surrounding the site. These assessments will confirm the predicted impact of the development in accordance with performance limits set by the relevant third-party asset protection teams.

5.1.11. Appropriate ground movement monitoring should be implemented during construction to assess the performance of the earth retention system (baseline monitoring pre-commencement of the works should be carried out to determine any potential existing movement trends).

5.2. Stability: The site is located over (or within the exclusion zone of) a tunnel.

Hazards

5.2.1. Piling works and excavations will be carried out in proximity to two LUL northern line tunnels. The location of these in relation to the proposed development in presented in Figure 5.1.



Approximate site boundary marked in red. LUL tunnels marked in yellow. Exclusion zone marked in hatched red.

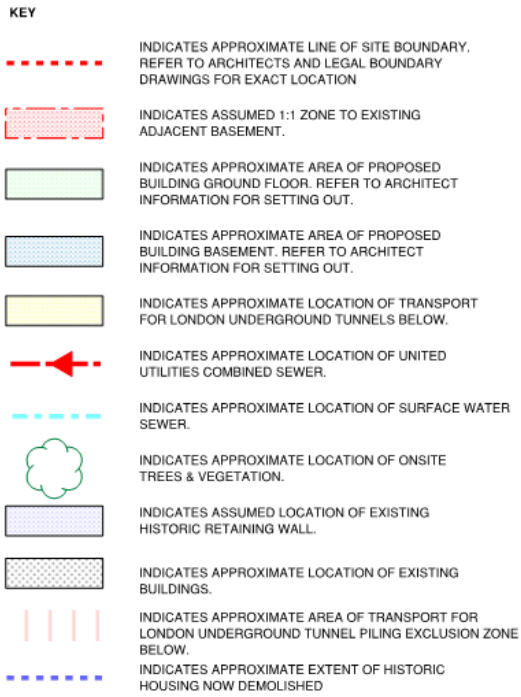


Figure 5.1 Northern line tunnels in proximity to site.

Potential Impacts

5.2.2. Damage to the tunnel due to excessive ground movements.

Mitigating Factors

5.2.3. No piling to be carried out in the exclusion zone.

5.2.4. The footprint of the proposed building and associated loading does not breach the exclusion zone.

Assessments and Further Actions

5.2.5. A ground movement assessment has been carried out to determine the impact of proposed development works on the two nearby LUL northern line tunnels, discussed in Section 7. The impact has been found to be within acceptable criteria.

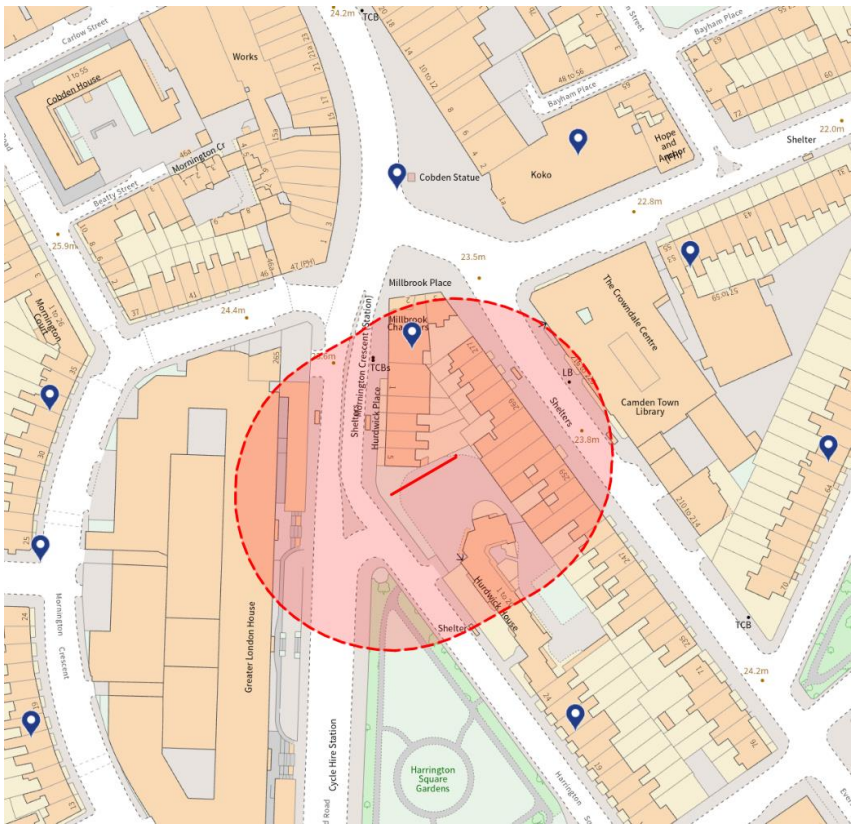
5.2.6. Appropriate ground movement monitoring should be implemented during construction to assess the performance of the earth retention system (baseline monitoring pre-commencement of the works should be carried out to determine any potential existing movement trends).

5.3. Statutory Listed Buildings: The site is located adjacent or close to a statutory Listed Building.

Hazards

5.3.1. There is one building within 50m of the site:

- Mornington Crescent London Railway Transport Station is a Grade II Listed building located approximately 40m north of the site. The location of this is presented in Figure 5.2.



Source: Historic England

Figure 5.2 Listed buildings within 50m of the site

Potential Impacts

5.3.2. Collapse of the excavation and associated impact on surrounding assets.

5.3.3. The proposed development will likely increase the differential foundation depths with neighbouring properties. Ground movements arising due to construction and excavation activities may damage these properties.

Mitigating Factors

5.3.4. Localised temporary propping should be considered in to reduce the risk of adversely affecting the neighbouring properties and any surrounding third-party assets due to excessive ground movements.

5.3.5. Several basements of similar depth and scale have been successfully constructed throughout London within similar geological conditions and urban settings.

5.3.6. The proposed construction sequence will be driven by limiting ground movements and keeping the potential damage to the neighbouring structures to Burland (1995) *Category 1 – Very Slight*.

5.3.7. The design of the retaining walls shall be carried out by an appropriately experienced and qualified specialist / engineer / ground engineering contractor in accordance with relevant Eurocodes / British Standards, Codes of Practice, and industry standards. The design shall allow for appropriate surcharging behind the retaining walls to accurately reflect the type and intensity of traffic and building loads.

5.3.8. Appropriate ground movement monitoring should be implemented during construction to assess the performance of the earth retention system (baseline monitoring pre-commencement of the works should be carried out to determine any potential existing movement trends).

6. Site Investigation

6.1.1. A site-specific ground investigation has been undertaken at the site as presented in *A2 Site Investigation, Harrington Square Factual Report, ref. 33023-A2SI-XX-XX-RP-X-0001-01*.

6.1.2. At this stage, based on the anticipated ground model and desk-based review, it is not considered likely that the ground conditions would render the current proposals non-viable from a construction or stability perspective.

7. Additional Assessments

7.1. Northern Line Ground Movement Assessment

7.1.1. A ground movement assessment has been conducted to determine the impact of the proposed works on the LUL Northern Line assets to the west.

7.1.2. The impact of the construction works associated with the Harrington Square development has been assessed using the Oasys PDisp and XDisp software package, in general accordance with thresholds set by the LUL asset protection team. The Oasys PDisp and XDisp assessment simulates full greenfield conditions, where the impact of any structural stiffness from the proposed development and tunnel lining are not considered.

7.1.3. The tunnel deformations induced by ground movements have been assessed in the short- and long-term conditions accounting for time-dependent ground movements and load redistribution.

7.1.4. Soil parameters have been selected based on site specific ground investigation data.

7.1.5. The modelled locations of the Northern Line tunnels have been modelled based on archive and as-built information provided by LUL.

7.1.6. Whilst the asset protection team has not set specific criteria to be satisfied, the induced displacements, radii of curvature and radial distortions of all tunnels are within generally adopted criteria for similar assessments

8. Construction Methodology / Engineer Statements

8.1. Outline Temporary and Permanent Works Proposals

8.1.1. It is proposed at this stage to construct the basements using temporary sheet piling to form cast in situ reinforced concrete retaining walls with the potential for some areas of open-cut where feasible.

8.1.2. Standard means and methods of excavation are expected to be suitable to excavate the basement, based upon the anticipated ground conditions.

8.1.3. The basement excavation will be restrained by new cast in situ reinforced concrete walls and temporary sheet pile walls. The final arrangement is subject to ongoing design development.

8.1.4. Design of the retaining walls shall be carried out in accordance with the relevant Eurocodes, non-conflicting codes of practice, and associated design best practice.

8.2. Ground Movement and Damage Impact Assessment

8.2.1. A GMA has been carried out in accordance with CIRIA C760 and takes into account the construction methodology and site-specific ground and groundwater conditions.

8.2.2. All structures / properties within the zone of influence of the proposed development have been assessed.

8.2.3. The following assumptions have been made within the GMA:

- The buildings included in the GMA are assumed to be founded at the ground surface.
- The walls of these properties/buildings are assumed to behave as equivalent beams.
- The stiffness of the structures have no impact on the ground movements (i.e. greenfield movements are used to determine damage).

8.2.4. The ground movements resulting from the works comprise deformations arising from the following mechanisms:

- Installation of the reinforced concrete retaining walls and temporary sheet piling.
- Bulk excavation works.
- Ground heave and settlements due to unloading / loading.

8.2.5. The following structures were assessed, having been identified as falling within the zone of influence of the proposed development:

- 5 Hurdwick Place
- Hurdwick House

8.2.6. In accordance with the Burland Scale, the potential damage impacts are assessed not to be greater than *Category 1 – Very Slight.*

8.2.7. The following mitigation measures are proposed to ensure ground movements and impact on adjacent assets remain within acceptable limits:

- Design of the retaining wall and temporary propping measures shall be carried out in accordance with the relevant Eurocodes, non-conflicting codes of practice, and associated design best practice.

- Retaining wall construction to be performed by an experienced ground engineering contractor.
- Frequent monitoring of neighbouring properties to be carried out during excavation, to validate ground movement predictions against reality.
- Development of a monitoring-trigger-action plan that identifies trigger levels, responsible personnel and actions to be followed in the event of a trigger level exceedance.
- Incorporating stiff, high level propping into the temporary works design of the basement excavation, so as to provide a high stiffness earth retention system. Design details regarding minimum wall flexural stiffness, prop stiffness and arrangement, shall be defined as part of detailed design development and will take cognisance of the results of the scheme GMAs.
- Designated areas for stacking and storing materials behind the retaining wall should be identified. These should be located away from sensitive structures. The design of the retaining wall should incorporate an appropriate surcharge load to the rear of the wall, to capture effects of stacking and storing materials, vehicle traffic, etc.

8.2.8. An additional scheme GMA has been performed in order to review the impact of the scheme on LUL assets at an early stage of the design development. This assessment should be reviewed post-planning and further refined based on the ongoing scheme development, prior to issue to the relevant asset protection teams.

8.3. Control of Construction Works

8.3.1. Following the selection of a Principal Contractor, a Construction Method Statement should be developed, which will cover the items outlined in this section in detail.

8.3.2. Work method statements and logistics strategies shall be developed for the main stages of the construction works, outlining the means and methods of safely carrying out the works. Key risks and associated mitigation measures shall also be detailed.

8.3.3. Details of all temporary works required should be developed to ensure that structural stability is maintained throughout the demolition and excavation works.

8.3.4. Construction traffic management plans and environmental considerations for the site, including site waste management and noise / vibration / dust mitigation, should also be developed.

8.3.5. A detailed structural monitoring strategy should also be developed to control construction works and maintain movements / damage impacts that are within the predicted limits and tolerances. This should include the following:

- A structural monitoring layout plan of instrumentation / survey points / critical sections.
- Programme / frequency of monitoring.
- Trigger values derived for each of the structures within the zone of influence of the proposed works.
- Contingency actions and project team lines of responsibility.

9. Basement Impact Assessment

9.1. General

9.1.1. The Conceptual Site Model (CSM) is described below:

- The proven ground conditions of the site generally comprise Made Ground to a depth of approximately 2.6mbgl overlying London Clay.
- The site and the general surrounding areas are relatively flat.
- No groundwater has been encountered during the ground investigation and it is therefore not anticipated to be present beneath the site. Finite perched bodies of perched groundwater may be present within the Made Ground.
- The site is currently occupied by a by a private car park, containing hard and soft landscaping.
- The scheme for the proposed development comprises a multi-storey residential building including a single-storey basement across the southern portion of the building footprint. The basement is to be supported partially by a reinforced concrete retaining wall and temporary sheet piles. The building is proposed to be supported by piled foundation.
- The excavations will be undertaken using temporary sheet piling to form cast in situ reinforced concrete retaining walls with the potential for some areas of open-cut where feasible.
- For the purpose of the ground movement assessment undertaken as part of this study, all neighbouring buildings have conservatively been assumed to be founded near surface.
- The proposed development may result in limited impact/cosmetic damage to the neighbouring buildings. Any potential damage will be mitigated by appropriate construction means and methods (such as temporary propping/shoring, controlled excavation operations and robust underpinning proposals).
- The site is bounded by Harrington Square to the south-west. The road is at a minimum distance of approximately 5.3m from the proposed basement.
- Thames Water and other near surface utilities/assets may be present in the area surrounding the site. The potential impact of the development proposals on these assets will be reviewed as part of design development.

9.2. Land Stability / Slope Stability

9.2.1. It is assumed that all new substructure elements will be founded on the London Clay formation, which are considered to be a suitable founding stratum.

9.2.2. A GMA has concluded that ground movements caused by excavation and construction of the proposed development will be limited. The upper bound damage category for existing on site and surrounding structures within the zone of influence of the proposed development has been assessed as *Category 1 – Very Slight,* in accordance with the Burland damage classification scale.

9.2.3. The BIA has concluded that the risks to the adjacent properties is limited and will be mitigated in a reasonable fashion as part of design development.

9.3. Hydrology and Groundwater Flooding

9.3.1. The BIA has concluded that there is a low risk of groundwater flooding due to the proposed development.

9.4. Hydrology, Surface Water Flooding and Sewer Flooding

9.4.1. The BIA has concluded that there are little potential impacts to the wider hydrological environment. Subject to final scheme surface water drainage design and Flood Risk Assessments.

Appendix A: Proposed Development Drawings

GENERAL NOTES:

1. REFER TO DRAWING HSC-REN-XX-ZZ-DR-S-00010 FOR GENERAL NOTES AND REINFORCEMENT ESTIMATES

HEALTH & SAFETY NOTES:

1 RISK OF SURCHARGING ADJACENT MASONRY RETAINING WALL AND UNDERPINNING DUE TO SITE ACCESS FOR PILING AND FOUNDATION CONSTRUCTION. WORKING AND EXCLUSION ZONE ADJACENT TO BASEMENT WALL AND ASSOCIATED TEMPORARY WORKS IS TO BE DEVELOPED BY THE MAIN CONTRACTOR AND THEIR TEMPORARY WORKS DESIGNER

2 RISK OF STRIKING SERVICES DURING PILING WORKS. UTILITY MAPS AND REDUCED LEVELS DIGS REQUIRED TO DETERMINE LOCATION OF ALL SERVICES PRIOR TO PILING

HIGHWAYS RETAINING STRUCTURE

HIGHWAY RETAINING WALL TO RESIST A SURCHARGE LOAD OF 15kN/m² IN LINE WITH BS EN 1997-1:2004+A1:2013

ALLOWANCE WITHIN THE PROGRAMME SHOULD BE MADE FOR ENGAGEMENT WITH HIGHWAYS AUTHORITY AND AIP PROCESS UPON CONCLUSION OF AGREED BASEMENT CONSTRUCTION METHOD.

BASEMENT TANKING

WATER PROOFING TO SPECIALIST DESIGN AND DETAIL.
TO INTERNAL AREAS ALLOW FOR CAT 3 BASEMENT PROTECTION TO BS8102 TO BE CONFIRMED BY ARCHITECT
EXTERNAL AREAS ALLOW FOR CAT 1 BASEMENT PROTECTION TO BS8102 TO BE CONFIRMED BY ARCHITECT

BELOW GROUND DRAINAGE

CONNECTION TO PUBLIC SEWER NOT YET ASCERTAINED. ADDITIONAL CCTV DRAINAGE SURVEYS REQUIRED.
ALLOW FOR PACKAGE PUMPING STATION PER BASEMENT UNIT TO SUPPLIERS DESIGN AND DETAIL

FOUNDATIONS SIZES AND BEARING PRESSURE

THE UPPER RAFT IS BASED ON FOUNDING IN UNDISTURBED CLAY ABOVE THE GROUND WATER TABLE WITH AN ALLOWABLE BEARING PRESSURE OF 150kN/m². THE CONTRACTOR TO UNDERTAKE THE WORKS AND MANAGE THE GROUNDWATER IN A MANNER THAT DOES NOT DISTURB THE NATURAL FOUNDING STRATA AND COMPROMISE THE BEARING STRATA.

DETAILED UTILITIES INVESTIGATIONS

ALLOWANCE SHOULD BE MADE FOR THE DETAILED INVESTIGATIONS TO ESTABLISH THE POSITION AND EXTENT OF STATUTORY UTILITIES IN AND AROUND THE SITE. A CONTINGENT ALLOWANCE SHOULD BE CONSIDERED AT THIS STAGE FOR POTENTIAL WORKS TO MANAGE DIVERSIONS OR ISOLATION OF REDUNDANT SERVICES THAT SERVICE THE SITE.

PILES ARE ASSUMED 300mm DIAMETER, SPACED AT 3x PILE DIAMETER WITH A WORKING LOAD CAPACITY OF 200kN AND PILE LENGTH OF 15m, TBC BY PILE DESIGNER AND SUBJECT TO DETAILED GROUND MOVEMENT ASSESSMENT.

RISK OF SURCHARGING ADJACENT BASEMENT.
TEMPORARY WORKS REQUIRED TO PROP ADJACENT STRUCTURE.

INDICATES ASSUMED 1:1 ZONE. DEPTH OF FOOTINGS TO BE CONFIRMED BY PARTY WALL SURVEY.

ALLOWANCE SHOULD BE MADE FOR LOCALISED REINFORCED CONCRETE WALL AND UNDERPINNING OF ADJACENT PARTY WALL FOUNDATION TO AVOID SURCHARGE FROM PILE RIG. EXACT ARRANGEMENT TO BE DEVELOPED UPON COMPLETION OF SURVEYS AND INPUT FROM PILING SPECIALIST.

1

ALLOWANCE SHOULD BE MADE FOR TEMPORARY SHEET PILING TO FACILIATE FORMATION OF BASEMENT ADJACENT TO PLOT BOUNDARY (TYP)

NOTE:
ALL LOADS ARE SLS (UNFACTORED) DESIGN LOADS

Gk = 15kN/m²
Qk = 7.5kN/m²

500mm REINFORCED CONCRETE RAFT FOOTING

Plant
105 m²

Gk = 770kN
Qk = 460kN

ALLOWANCE SHOULD BE MADE FOR LOCALISED DE-WATERING OF EXCAVATIONS TO MANAGE THE TEMPORARY CONDITION DURING CONSTRUCTION - EXTENT TO BE ESTABLISHED UPON COMPLETION OF THE PHASE 2 INTRUSIVE GROUND INVESTIGATION

ALLOW FOR WATERPROOF MEMBRANE AND WATERPROOF CONCRETE LINER RC WALL. WATERPROOFING TO SPECIALIST DESIGN AND DETAILING.

Hurdwick House

Harrington Square

Harrington Square Gardens

0201

DESIGN LOADING MARKUP
03.08.23

Rev:	Description:	Date:	By:	Chkd:
P03	UPDATED PROPOSALS - DRAFT SCHEME	11.07.23	EM	AI
P02	UPDATED ARCHITECTURAL PROPOSALS	14.06.23	EM	AI
P01	STAGE 2	31.03.23	EM	AI

renaissance
Renaissance Associates Ltd
Carvers Warehouse
77 Dale Street
Manchester
M1 2HG

Project:
HARRINGTON SQUARE CAMDEN

Drawing Title:
BASEMENT PLAN

Status:
DRAFT

Size:	Date:	Drawn by:	Designed by:	Checked by:
A1	MAR '23	EM	EM	AI

Scale: 1:100 | Project No: 2202-03

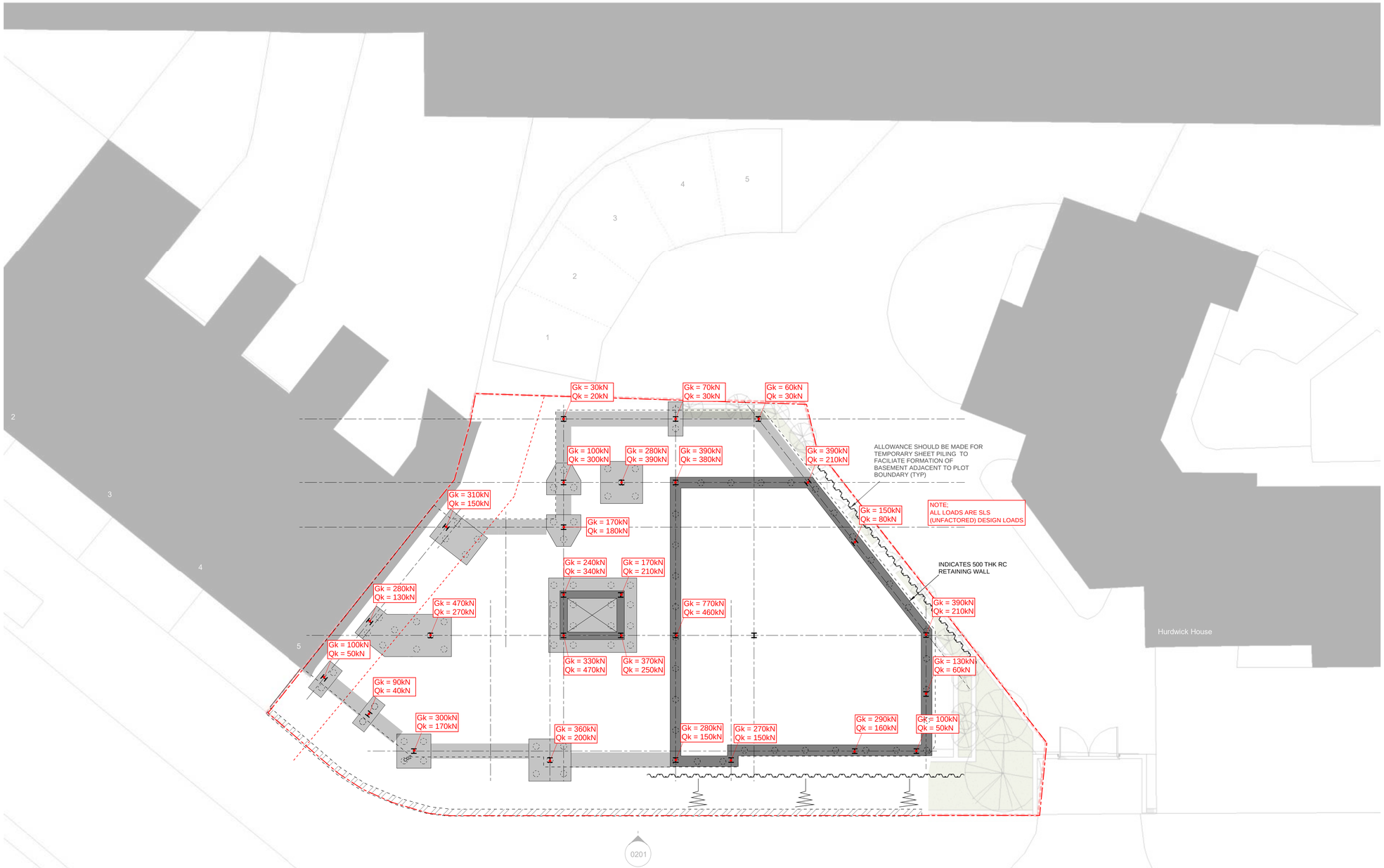
Project: Originator: Volume: Level: Type: Role: Category/Number: Rev:

HSC-REN-XX-B1-DR-S-01080 P03

RIBA STAGE 2

THESE DRAWINGS ARE INTENDED TO COMMUNICATE THE CONCEPT DESIGN FOR THE STRUCTURAL FRAME FOR THE PROPOSED BUILDING AND ARE APPROPRIATE FOR RIBA STAGE 2 (CONCEPT DESIGN). ALL STRUCTURAL SIZES ARE INDICATIVE ONLY AND TO ASSIST WITH HIGH LEVEL COSTING BY THE PROJECT QUANTITY SURVEYOR AND CONTRACTOR. ALL STRUCTURAL SIZES AND REINFORCEMENT RATES ARE INDICATIVE AT THIS STAGE AND ARE SUBJECT TO CHANGE AS THE DESIGN DEVELOPS THROUGH RIBA STAGE 3 (SPATIAL CO-ORDINATION) AND STAGE 4 (TECHNICAL DESIGN).

A DESIGN CONTINGENCY OF 15-20% IS RECOMMENDED TO ALLOW FOR DESIGN DEVELOPMENT DURING RIBA STAGE 2, 3 AND STAGE 4 (TECHNICAL DESIGN) AND TO REFLECT INPUT FROM CONTRACTOR DESIGNED PACKAGES.



GENERAL NOTES:

1. REFER TO DRAWING HSC-REN-XX-ZZ-DR-S-00010 FOR GENERAL NOTES AND REINFORCEMENT ESTIMATES

HEALTH & SAFETY NOTES:

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HARRINGTON SQUARE CAMDEN

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FOUNDATION PLAN

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DRAFT

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Scale: 1:100 | Project No: 2202-03

Project: Originator: Volume: Level: Type: Role: Category/Number: Rev:

HSC-REN-XX-B1-DR-S-01090 P03

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Appendix B: Ground Movement and Damage Impact Assessment

A-squared Studio

Harrington Square

Ground Movement Assessment (Neighbouring Buildings)

September 2023

2874-A2S-XX-XX-RP-Y-0002-02

Project Name	Harrington Square
Project Number	2874
Client	Salboy (Mornington Crescent) Limited
Document Name	Ground Movement Assessment (Neighbouring Buildings)

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Engineer	Principal Engineer	Director

Document Reference	Status	Notes	Revision	Issued by	Date
2874-A2S-XX-XX-RP-Y-0002-00	First Issue	-	00	NH	01.09.23
2874-A2S-XX-XX-RP-Y-0002-01	Second Issue	Minor amendments	01	NH	04.09.23
2874-A2S-XX-XX-RP-Y-0002-02	Third Issue	Revised foundation level	02	NH	11.09.23

Contents

Appendices

1. Introduction

A-Squared Studio Engineers has been appointed by Salboy (Mornington Crescent) Limited to undertake a Ground Movement Assessment (GMA) for the proposed development at the land adjacent to Hurdwick House, Harrington Square, Camden, London, NW1 2JE (herein called the 'site'). The scope comprises an assessment of the potential impact of ground movement imposed by the development on the neighbouring buildings located at 5 Hurdwick Place and Hurdwick House.

1.1. Study Aims and Objectives

A ground movement and impact assessment has been carried out to estimate the potential impact of the proposed development construction works at Harrington Square on the neighbouring buildings located north and south of the site. The proposed scheme comprises the construction of a multi-storey residential building including the excavation of a single-storey basement level over part of the footprint and the installation of reinforced concrete retaining walls and temporary sheet piling in order to support the excavation.

The GMA study provides an estimate of greenfield ground movements, which are unlikely to be exceeded. The adopted methodology provides a robust and conservative assessment, representative of the current industry best practice as detailed in Section 5.

The assessment carried out and described herein aims to:

- Assess the impact of ground movements induced by the proposed works on the buildings directly neighbouring the site (5 Hurdwick Place and Hurdwick House).

This report provides a detailed description of the:

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

2. The Site and Development

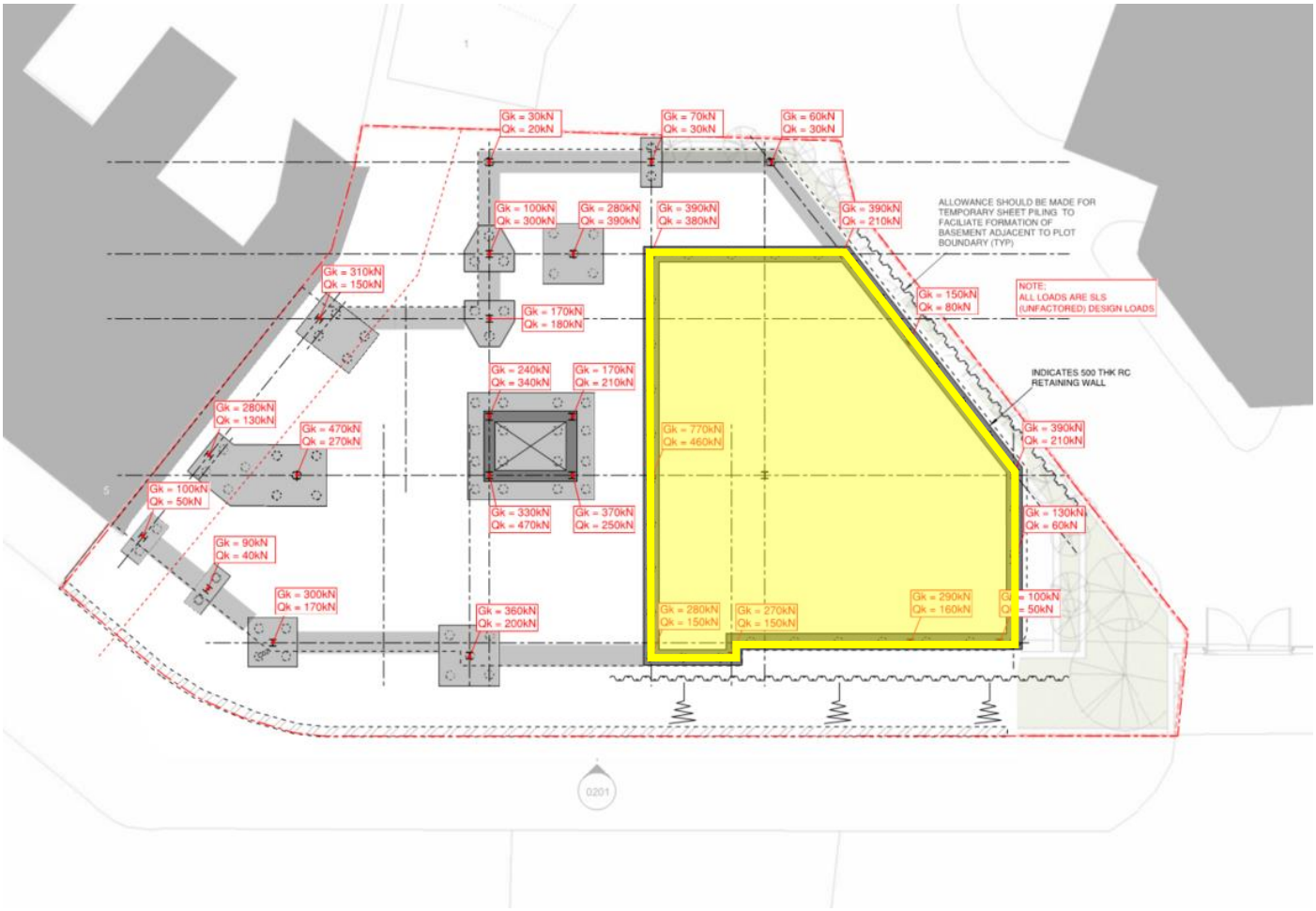
The proposed development is located at the land adjacent to Hurdwick House, Harrington Square, Camden, London, NW1 2JE (see Figure 2.1). The site is currently occupied by a private car park with soft landscaping. The proposed scheme comprises the construction of a multi-storey residential building including the excavation of a single-storey basement level (over part of the footprint of the structure). The excavation will be supported by reinforced concrete retaining walls and temporary sheet piling. The new structure will be founded on piled foundations. The site is bounded by two neighbouring buildings; 5 Hurdwick Place to the north-west and Hurdwick House to the south-east.

Key dimensions and levels assumed in the analysis, based on the information provided by Renaissance Associates Ltd (Renaissance) and are outlined in the following.

- The proposed basement formation level is +20.425mOD, based on a 500mm thick basement slab.
- The piled foundations have an assumed toe level of +9.00mOD for both the ground floor and basement level.
- A proposed load of 6300kN at basement level and 6960kN at ground floor level has been assumed. The arrangement of the proposed basement footprint in relation to the proposed building is presented in Figure 2.2.

Approximate site boundary marked in red. Source: Google Earth.

Figure 2.1 Location of the proposed development



Site boundary marked in red. Basement footprint outlined in yellow

Figure 2.2 Proposed basement arrangement

3. Neighbouring Buildings

A number of adjacent properties lie within the zone of influence of the ground movement induced by the development, as shown in Figure 3.1 and detailed in Section 2. The site is bounded by two neighbouring buildings; 5 Hurdwick Place to the north-west and Hurdwick House to the south-east.

5 Hurdwick Place is a five-storey residential terraced building. Hurdwick House is a four-storey residential apartment building.

As the maximum ground movements occur at ground level, for the sake of conservatism any existing basements (e.g. the semi-basement at 5 Hurdwick Place) have been ignored and it is assumed that all assessed buildings are founded at ground level. Greenfield movements have conservatively been used to determine impacts.

Approximate site boundary marked in red. Source: Google Earth.

Figure 3.1 Plan of neighbouring buildings

4. Ground Model

The ground model and soil parameters adopted as part of this study presented herein are based on site-specific ground investigation undertaken in June 2023 as presented in the *Factual Report* by A2 Site Investigation Limited (ref: 33023-A2SI-XX-XX-RP-X-0001-01). An interpretation of the findings of the ground investigation is presented in the A2 Site Investigation Geotechnical Interpretive Report (ref. 33023-A2SI-XX-XX-RP-Y-0002-00). This is summarised in Table 4.1.

Table 4.1 Ground model and geotechnical parameters

Stratum	Top of stratum (mOD)	Thickness (m)	Unit Weight, γ_b (kN/m^3)	Undrained Young's Modulus, E_u (kPa)	Drained Young's Modulus, E' (kPa)
Made Ground	24.70	2.50	19	-	14,000
London Clay	22.20	22.50	20	26,000 + 3,600z[1]	20,800 + 2,900z[1]

1. z refers to depth below top of stratum

5. Impact Assessment Methodology

The impact assessment has been carried out using the commercially available software programs Oasys PDisp and XDisp.

Ground movement will occur due to the excavation of a new basement level installation of reinforced concrete retaining walls and temporary sheet piling to support the excavation and subsequent associated loading of the proposed structure. These works will cause settlements across the footprint of the load and over a given zone of influence surrounding the footprint.

The analysis strategy can be summarised as follows:

1. Model the short-term excavation unloading effects in Oasys PDisp.
2. Model the excavation and associated wall installation in Oasys XDisp.
3. Model the long-term proposed loading on-site in Oasys PDisp.
4. Calculate greenfield ground movements at the adjacent building locations for critical combinations of ground movements.
5. Carry out a damage assessment for the adjacent structures using Oasys Xdisp, following the well-established Burland damage assessment methodology.

A uniform value of 83kPa has been used to model the proposed unloading resulting from ground excavation, derived from the soil unit weight presented in Section 4 (i.e. an excavation depth of 4.3mbgl).

To simulate the proposed building construction in Oasys PDisp, the loads have been applied using the "equivalent raft" approach (i.e. as a uniformly distributed load at a level equivalent to two-thirds the foundation pile-toe depth, with a 1H-in-4V lateral load spread). This approach results in applied pressures of 19.4kPa at +13.5mOD and 47.9kPa at +12.8mOD for the ground floor and basement respectively.

The Xdisp analysis used to assess the ground movements resulting from the proposed excavation and installation of the retaining wall in the two properties, used the following curves adopted from CIRIA C760:

- *Reinforced Concrete Retaining Wall and Sheet Pile Wall installation:* Installation of contiguous bored pile wall in stiff clay.
- *Excavation to formation*: Excavation in front of a high stiffness wall in stiff clay.

The contiguous bored pile wall CIRIA C760 installation curves are considered to be a conservative assumption to estimate the ground movements associated with the installation of sheet pile walls and reinforced concrete retaining walls. The modelled wall has an assumed toe level of +16.000mOD. It has been assumed that temporary sheet piling will be used along the full perimeter of the basement.

Two models have been analysed examining the impact of key combinations of the different sources of ground movement. These are:

1. Short-term heave resulting from excavation of the proposed basement.
2. Long-term settlement due to wall installation, basement excavation and structural loading.

Indicative views of the PDisp and XDisp models are presented in Figure 5.1 and Figure 5.2 respectively.

The neighbouring buildings have been analysed as representative walls situated along their perimeters. The walls have been assumed to behave as elastic beams subject to bending/shear and axial elongation mechanisms, for the purpose of the damage assessment. The buildings are assumed to be in good condition with no existing damage. A wall height of 14m for both 5 Hurdwick Place and Hurdwick House has been assumed.

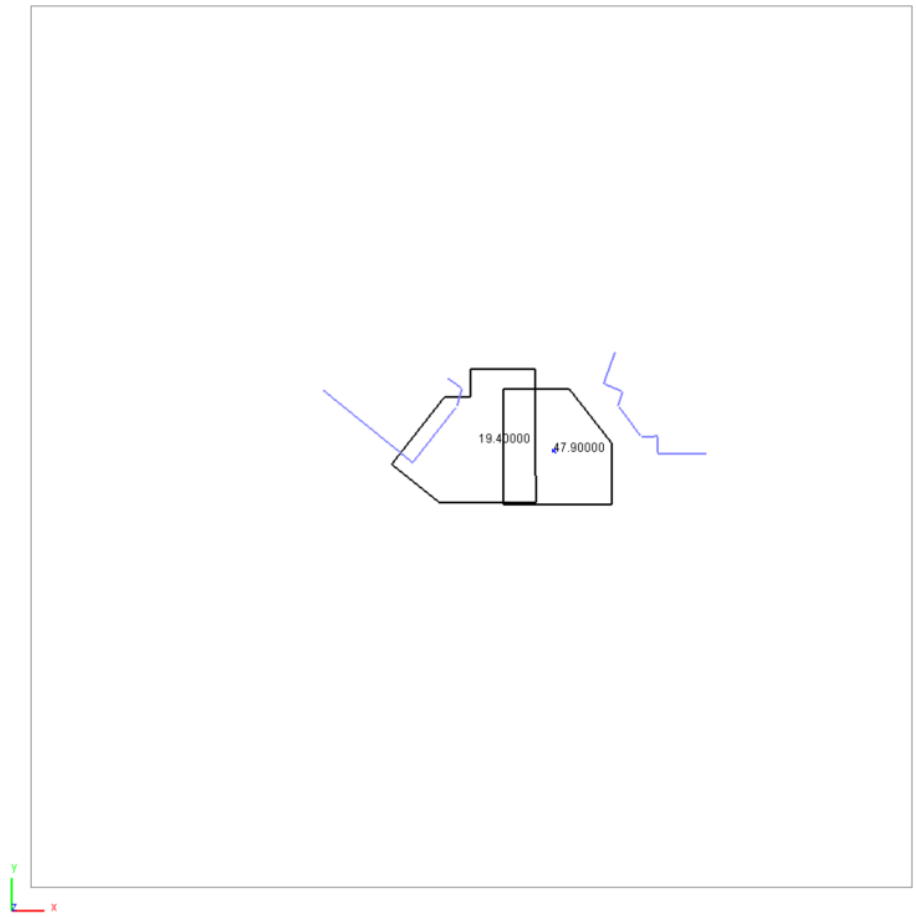


Figure 5.1 PDisp model (loading). Location of adjacent structures indicated by blue lines.

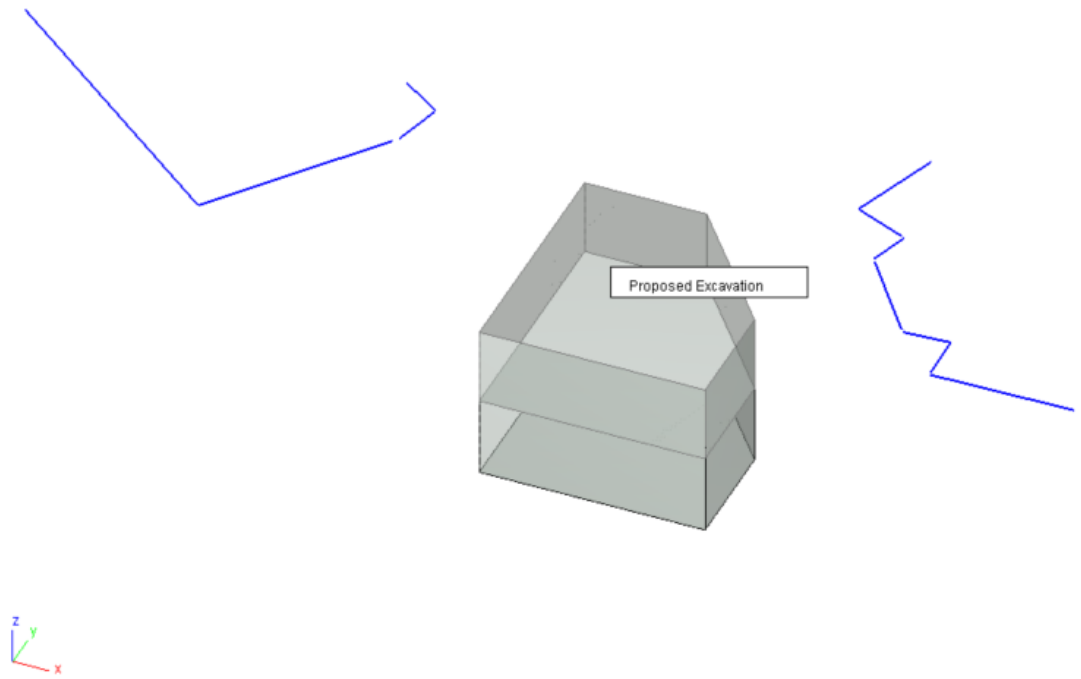


Figure 5.2 XDisp model (excavation) . Location of adjacent structures indicated by blue lines.

6. Impact Assessment Results

The ground settlement contours in the short-term and long-term analyses are presented in Figure 6.1 and Figure 6.2 respectively.

The building damage assessment results estimate that there will be 'Negligible' damage to most of the modelled representative walls for the neighbouring buildings, with the exception of two Hurdwick House walls, which are estimated to have 'Very Slight' damage. The results of the building damage assessment carried out in XDisp are detailed in Table 6.1.

The displacement graphs for each wall analysed are presented in Appendix A. A summary of the Burland building damage categories is presented in Figure 6.3. The Burland damage assessment considers the maximum tensile strain induced by both horizontal and vertical movement.

It is assumed that the excavation will be supported by means of temporary propping. It is recommended that any proposed temporary propping remains in place until the permanent floor slabs are installed in order to effectively limit the ground movements.

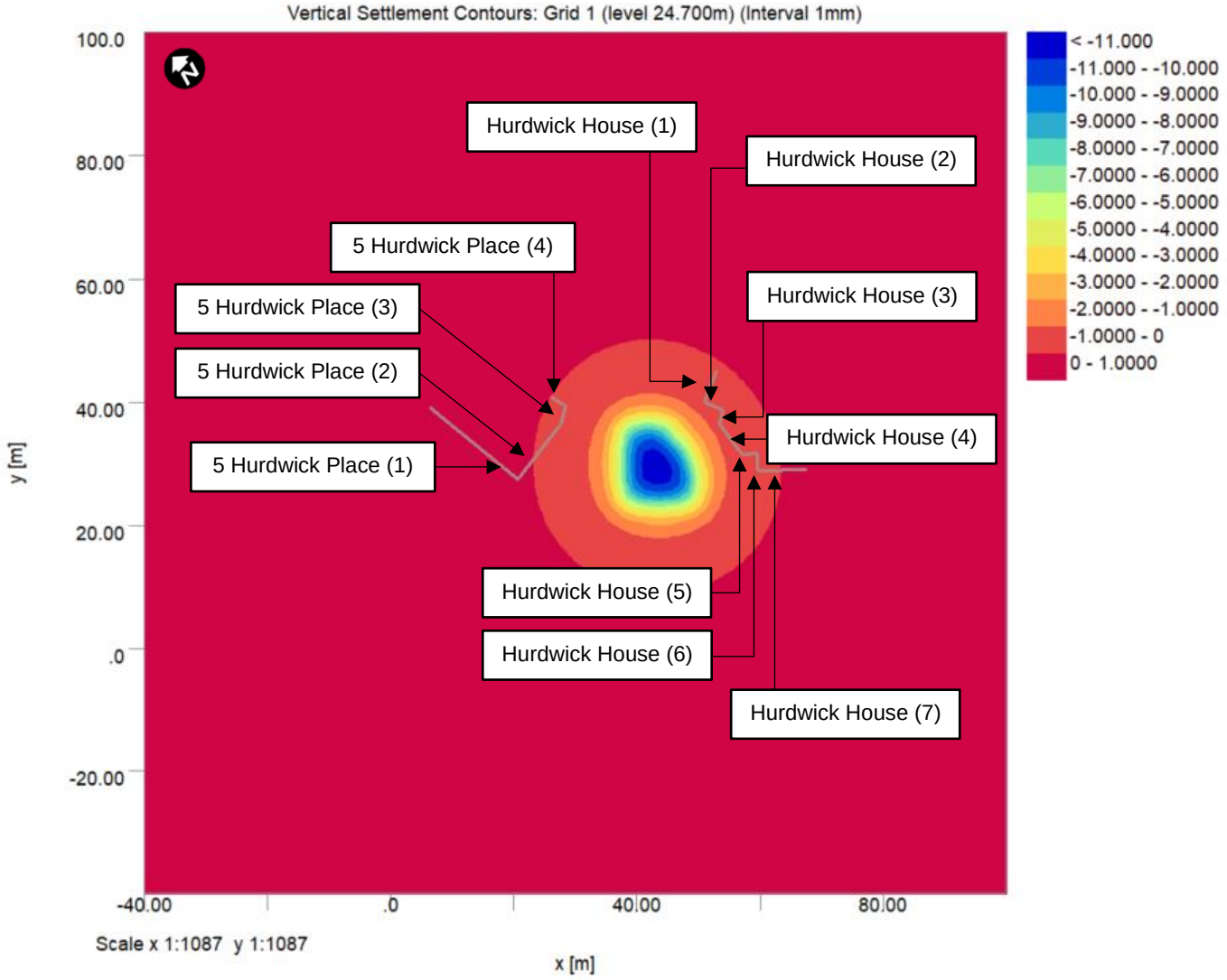


Figure 6.1 Short-term settlement results

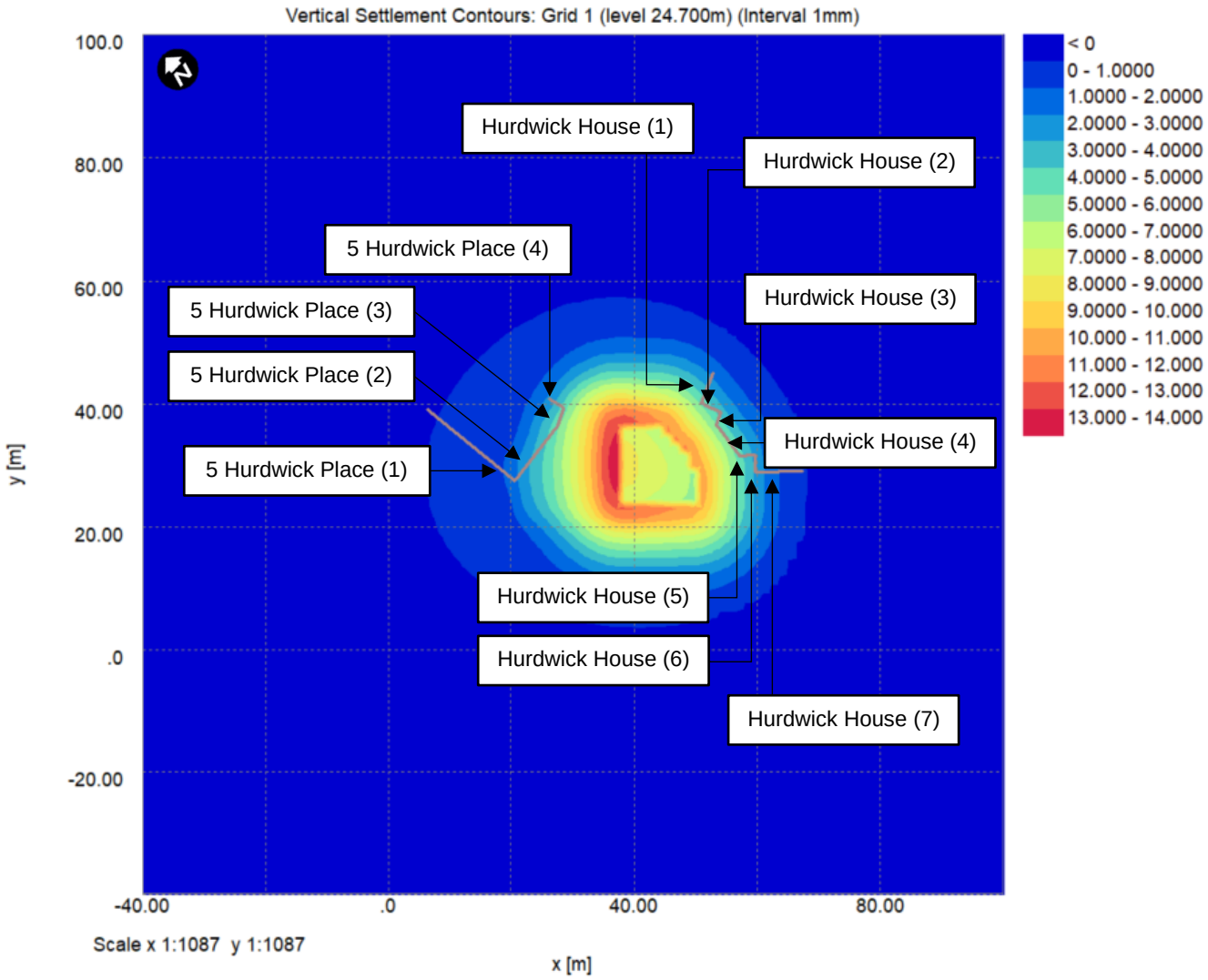


Figure 6.2 Long-term settlement results

Table 6.1 Building Damage Assessment results summary

	Wall	Maximum Settlement (mm)	Maximum Tensile Strain (%)	Damage Category
Short-term	5 Hurdwick Place (1)	<0.1	<0.01	Category 0 – *Negligible*
	5 Hurdwick Place (2)	0.2	<0.01	Category 0 – *Negligible*
	5 Hurdwick Place (3)	0.2	<0.01	Category 0 – *Negligible*
	5 Hurdwick Place (4)	0.1	<0.01	Category 0 – *Negligible*
	Hurdwick House (1)	0.5	<0.01	Category 0 – *Negligible*
	Hurdwick House (2)	0.5	<0.01	Category 0 – *Negligible*

	Wall	Maximum Settlement (mm)	Maximum Tensile Strain (%)	Damage Category
	Hurdwick House (3)	0.6	<0.01	Category 0 – *Negligible*
	Hurdwick House (4)	0.6	<0.01	Category 0 – *Negligible*
	Hurdwick House (5)	0.4	<0.01	Category 0 – *Negligible*
	Hurdwick House (6)	0.2	<0.01	Category 0 – *Negligible*
	Hurdwick House (7)	0.2	<0.01	Category 0 – *Negligible*
Long-term	5 Hurdwick Place (1)	1.6	<0.01	Category 0 – *Negligible*
	5 Hurdwick Place (2)	4.7	0.02	Category 0 – *Negligible*
	5 Hurdwick Place (3)	4.8	<0.01	Category 0 – *Negligible*
	5 Hurdwick Place (4)	4.3	0.04	Category 0 – *Negligible*
	Hurdwick House (1)	4.7	0.04	Category 0 – *Negligible*
	Hurdwick House (2)	4.6	0.01	Category 0 – *Negligible*
	Hurdwick House (3)	5.0	0.04	Category 0 – *Negligible*
	Hurdwick House (4)	5.0	0.01	Category 0 – *Negligible*
	Hurdwick House (5)	4.4	0.05	Category 1 – *Very Slight*
	Hurdwick House (6)	2.8	<0.01	Category 0 – *Negligible*
	Hurdwick House (7)	2.8	0.05	Category 1 – *Very Slight*

Building / Structure Damage Risk Classification (Burland (1997))

Damage Category	Category of damage	Description of typical damage* (Ease of repair is underlined)	Approx. crack width* (mm)	Limiting tensile strain (%)
0	Negligible	Hairline cracks	< 0.1	< 0.05
1	Very Slight	Fine cracks that can easily be treated during normal decoration. Perhaps isolated slight fracture in buildings. Cracks in external brickwork visible on inspection.	< 1	0.05 - 0.075
2	Slight	Cracks easily filled. Redecorating probably required. Several slight fractures showing inside of building. Cracks are visible externally and some repointing may be required externally to ensure weather tightness. 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. Weather tightness 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 door frames distorted, floor sloping noticeably. Walls leaning and 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 job involving partial or complete rebuilding. Beams lose bearing, walls lean badly and require shoring. Windows broken due to distortion. Danger of instability.	Usually > 25 but depends on number of cracks.	-

Figure 6.3 Burland building damage classification

7. Conclusions and Recommendations

A-Squared Studio Engineers Ltd has been appointed by Salboy (Mornington Crescent) Limited to undertake a Ground Movement Assessment (GMA) for the proposed development at the land adjacent to Hurdwick House, Harrington Square, Camden, London, NW1 2JE. The scope comprises an assessment of the potential impact of ground movement imposed by the development on the neighbouring buildings located at 5 Hurdwick Place and Hurdwick House.

The proposed works can generally be described as the construction of a multi-storey residential building including the excavation of a single-storey basement level and the installation of reinforced concrete retaining walls and temporary sheet piling in order to support the excavation.

The proposed development construction operations comprise three stages: wall installation, bulk excavation and proposed building construction (long-term loading). The impact of the various construction stage has been reviewed, evaluating the effects of unloading/loading using PDisp and simulating the excavation and wall installation induced ground movement fields using empirical CIRIA curves in XDisp.

The impact assessment has been carried out with Oasys software PDisp and XDisp. The damage has been assessed along representative walls situated along the perimeter of each building. The existing buildings are assumed to be in good condition with no existing damage. The assumptions made as part of this assessment should be reviewed based on the contractor's proposed scheme.

The building damage assessment results estimate that there will be 'Negligible' damage to most of the neighbouring buildings, with the exception of two Hurdwick House walls, which are estimated to have 'Very Slight' damage. This level of impact is considered to be acceptable.

It is assumed that the excavation will be supported by means of temporary propping, as required. It is recommended that any proposed temporary propping remains in place until the permanent floor slabs are installed in order to effectively limit the ground movements.

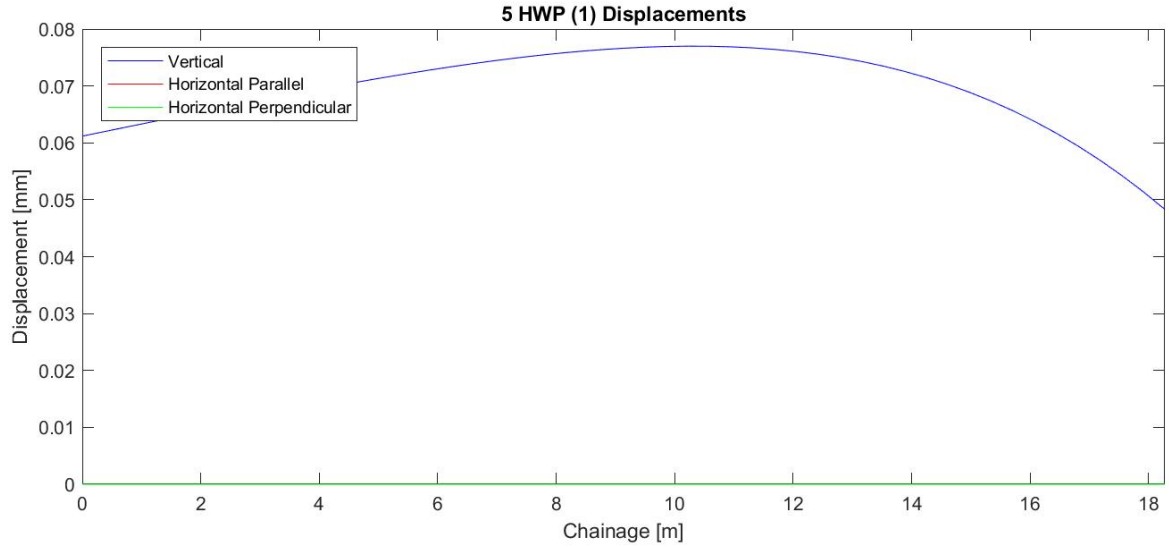
It is worth noting that the predicted movements are likely to be conservative, in view of the greenfield nature of the predicted movements, the relatively cautious assumptions in relation to the ground model and the simplifications in the analysis software.

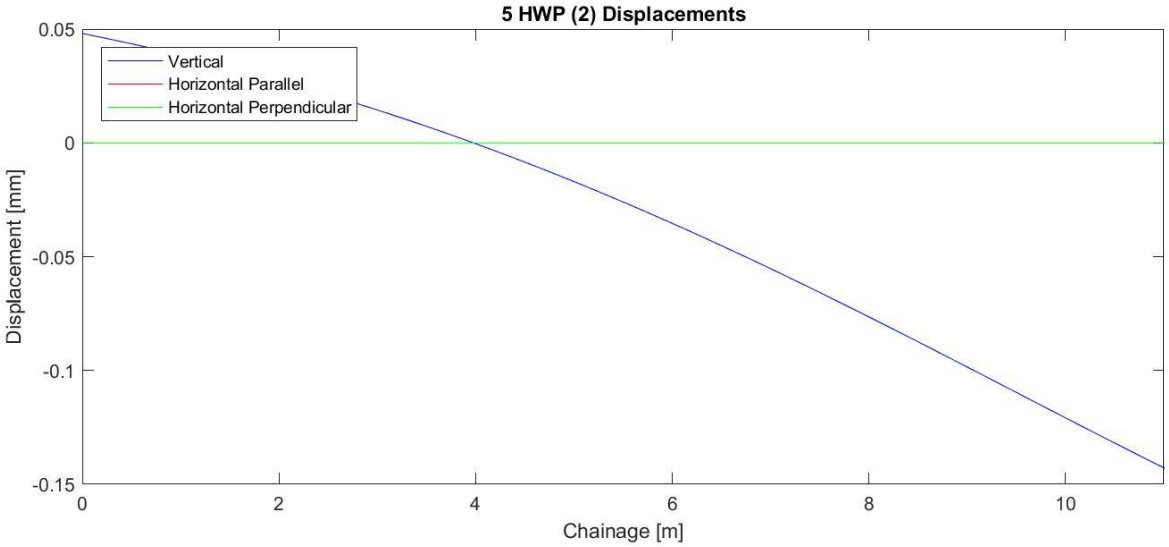
It is recommended that this report is reviewed and understood in full by the project team and major stakeholders. Where significant changes are made to items such as construction sequencing and scheme design, the engineer should thoroughly review the discrepancy and evaluate any potential impacts on ground movements and adjacent structures. This is particularly relevant in relation to any temporary works/sequencing adopted as part of the initial enabling works phase (potentially involving excavation/filling earthworks to form working platforms, etc) and with regards to plant loading during construction. If necessary, the GMA results should be re-evaluated, including these temporary works items.

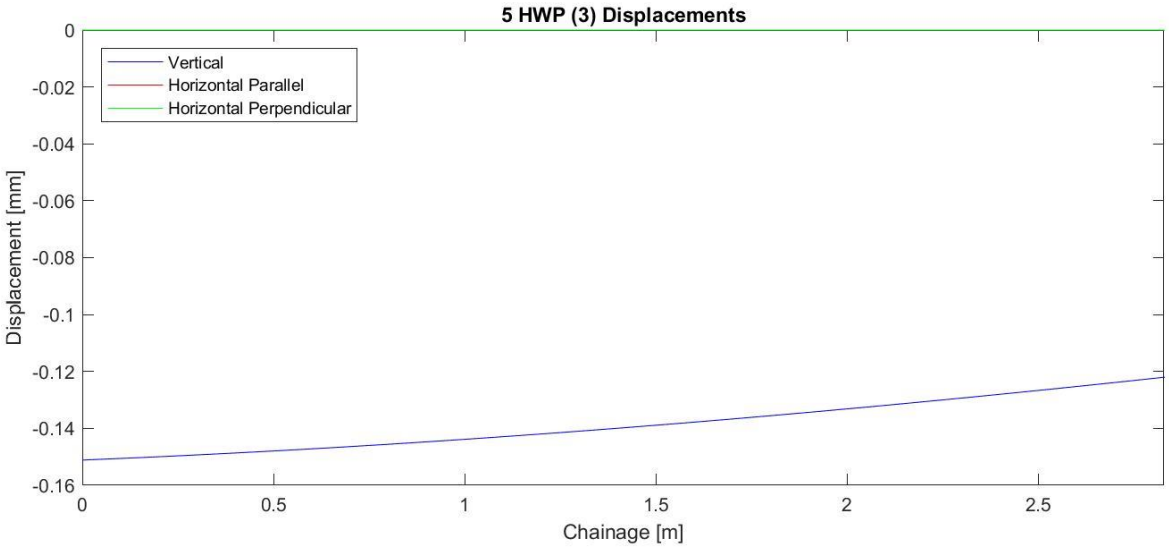
It is critical that the permanent and temporary works designs are carried out in a coordinated manner, with the aim to ensure that such design elements are in alignment with the assumptions/findings of the GMA and overall design intent. The assessment presented herein is dependent and reliant on the works being undertaken by an experienced contractor, high quality workmanship, and appropriate supervision of construction means and methods by experienced personnel.

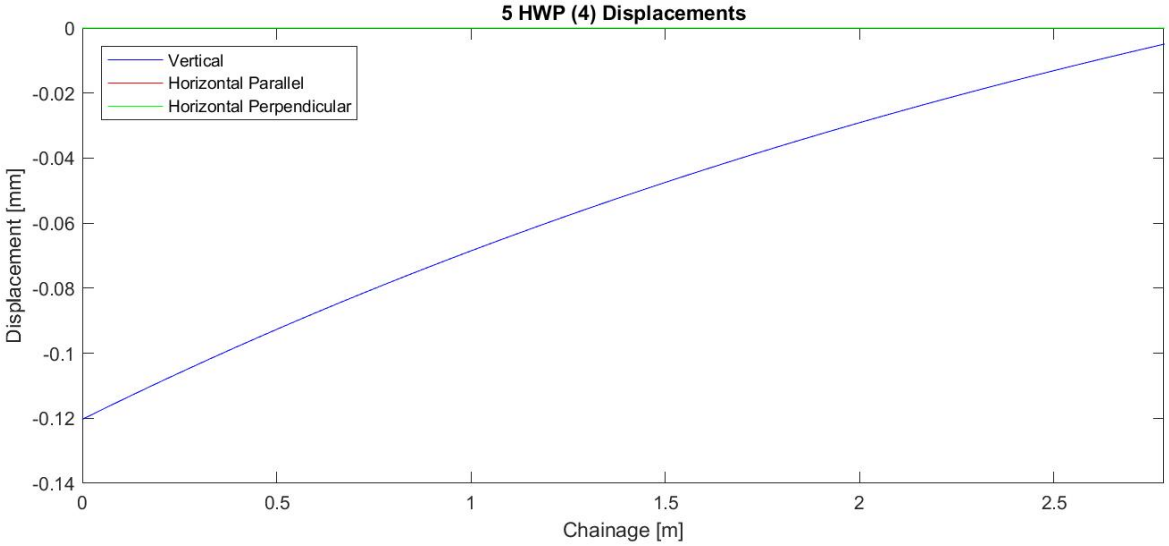
Appendix A: Building Displacement Profiles

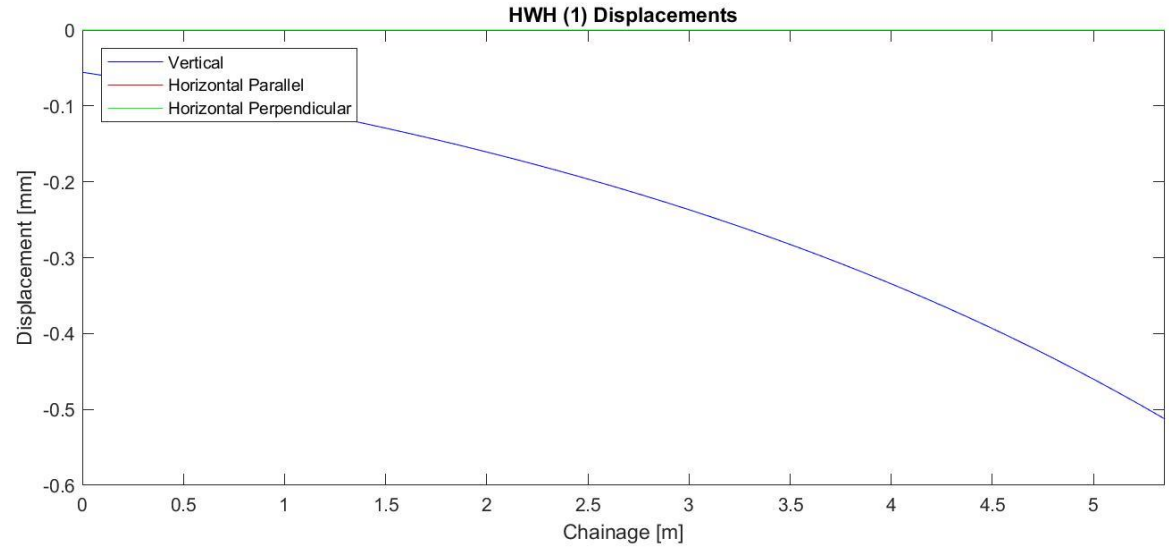
Short-term

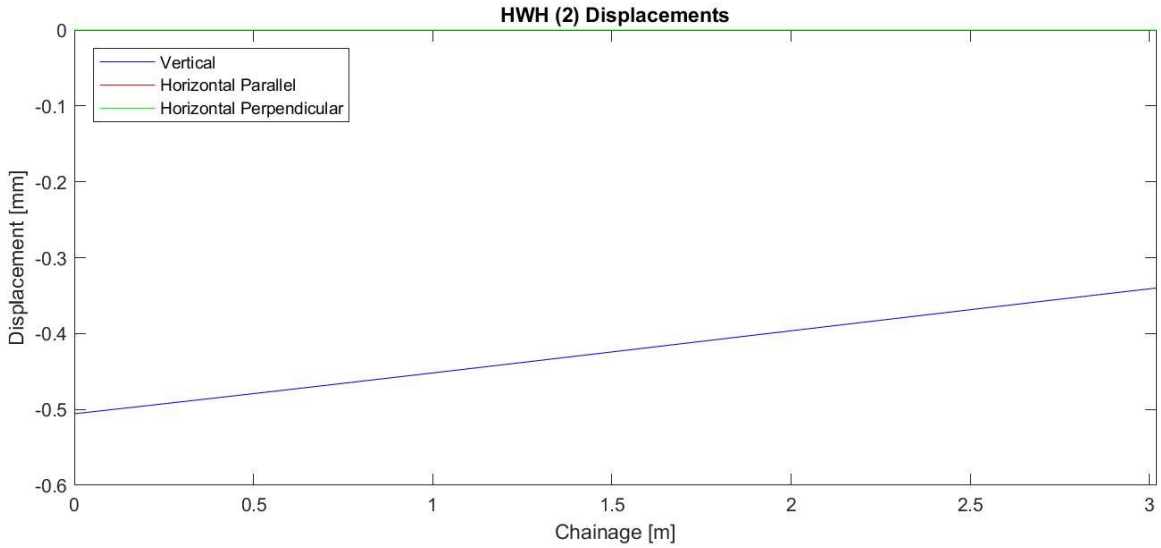


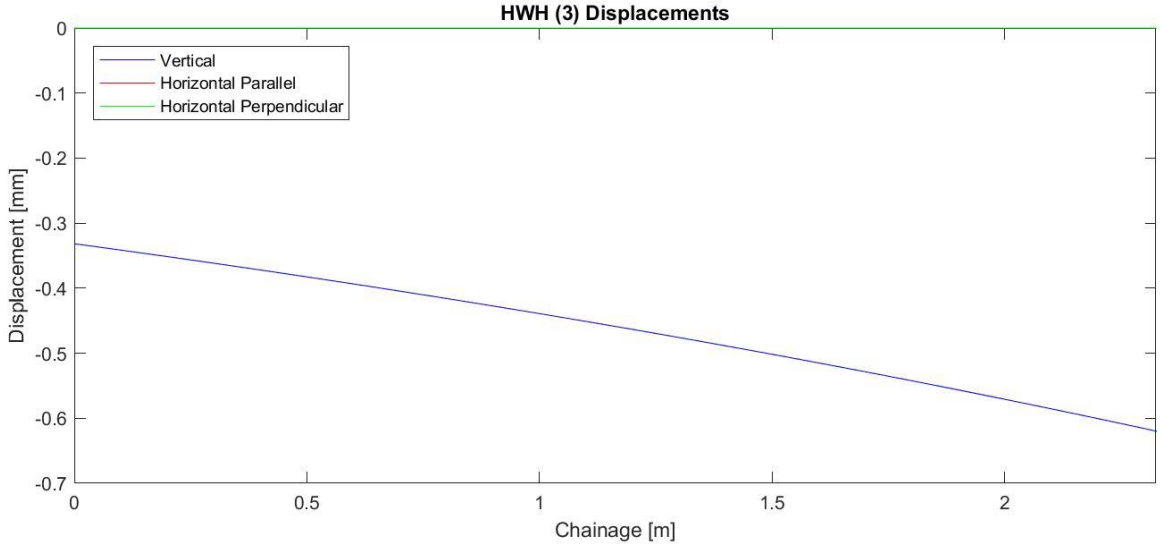


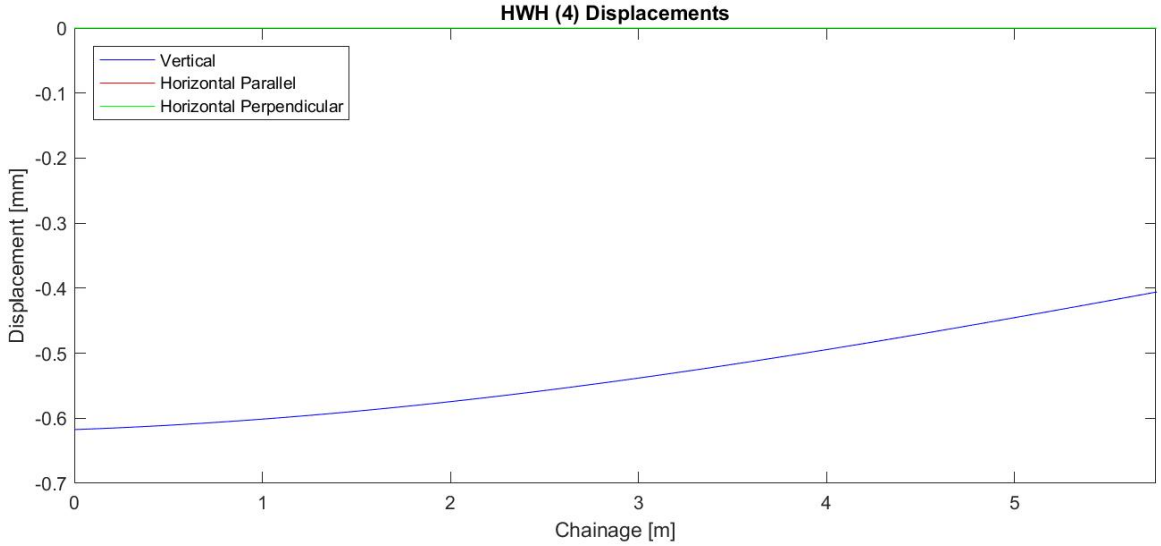

5 HWP (3) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]

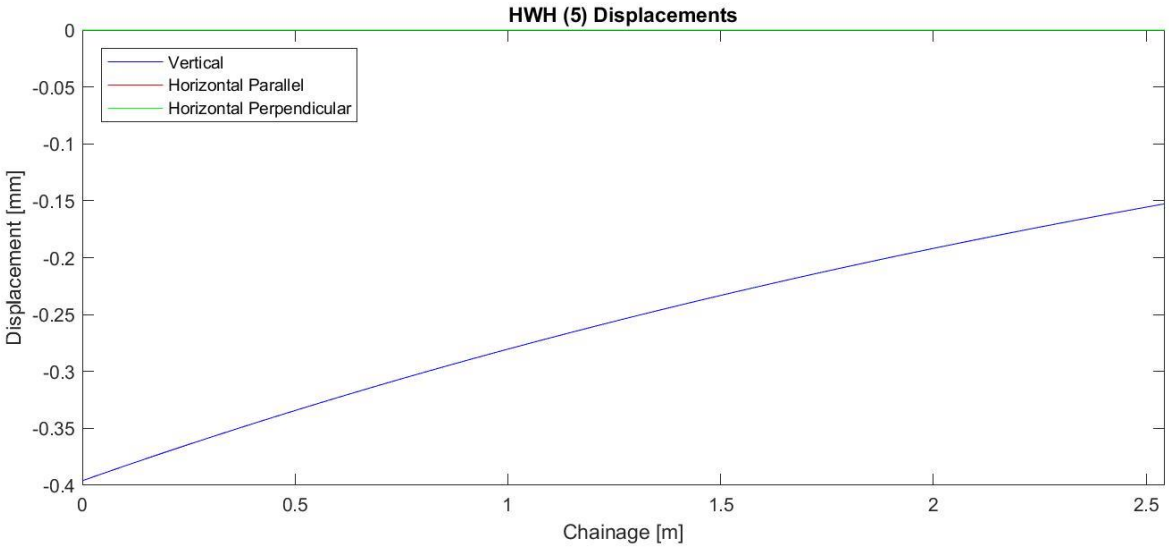

5 HWP (4) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]

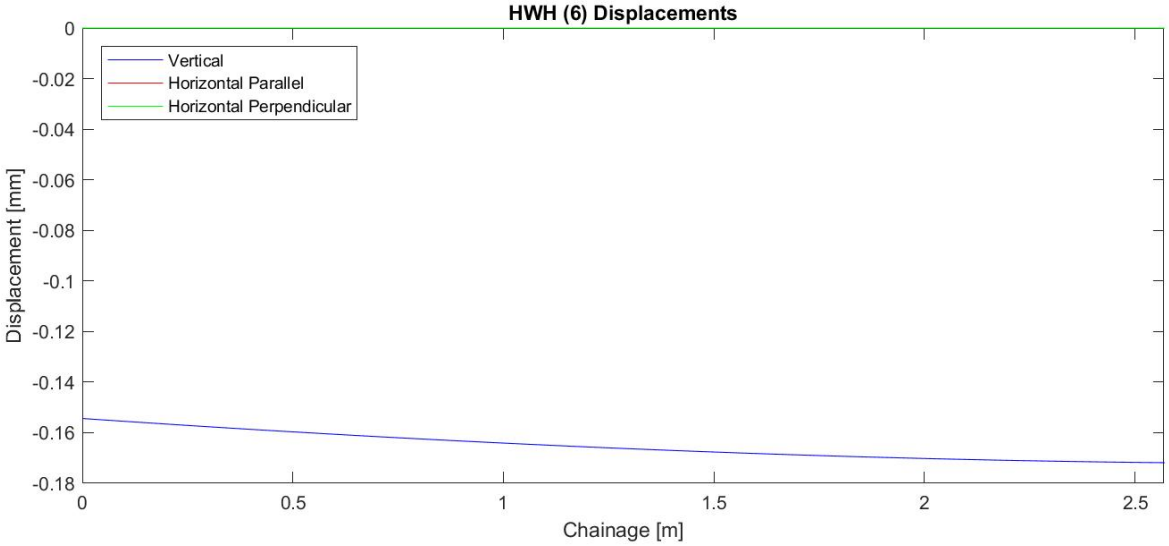

HWH (1) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]

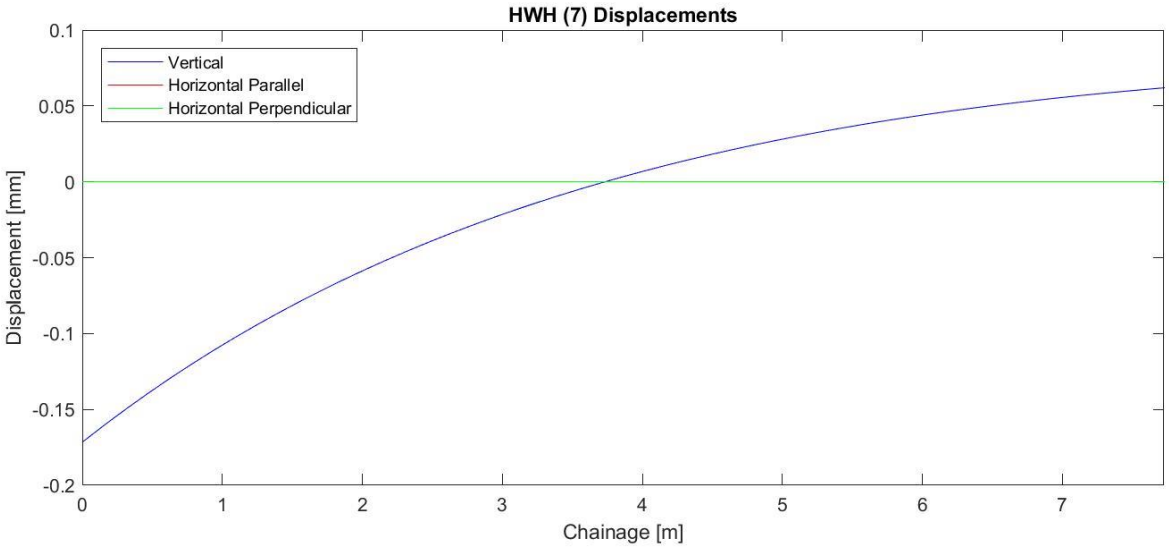

HWH (2) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
0
0.5
1
1.5
2
2.5
3


HWH (3) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
0
0.5
1
1.5
2

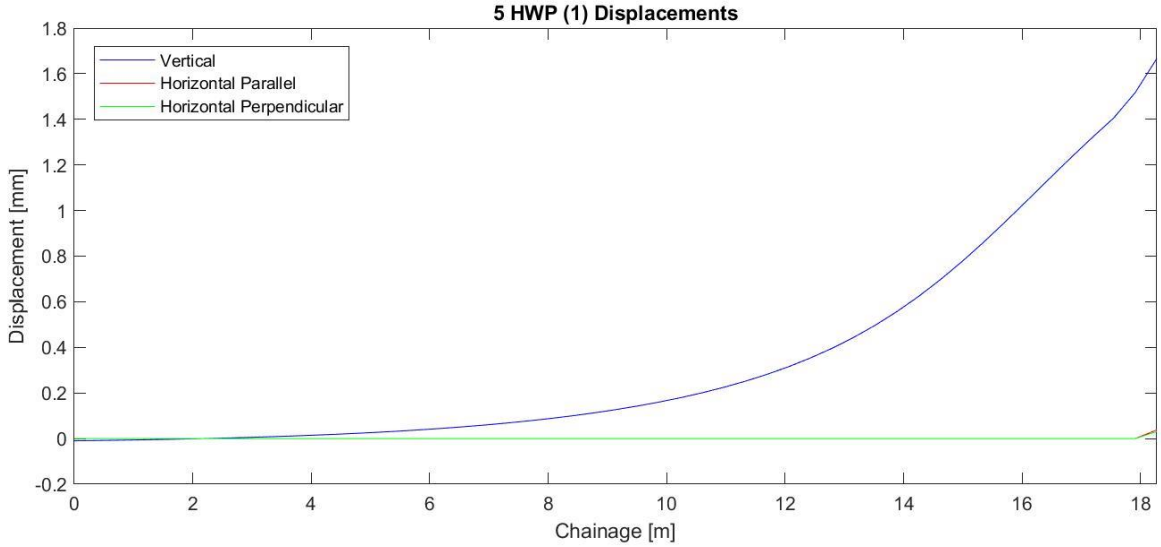

HWH (4) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
0
1
2
3
4
5

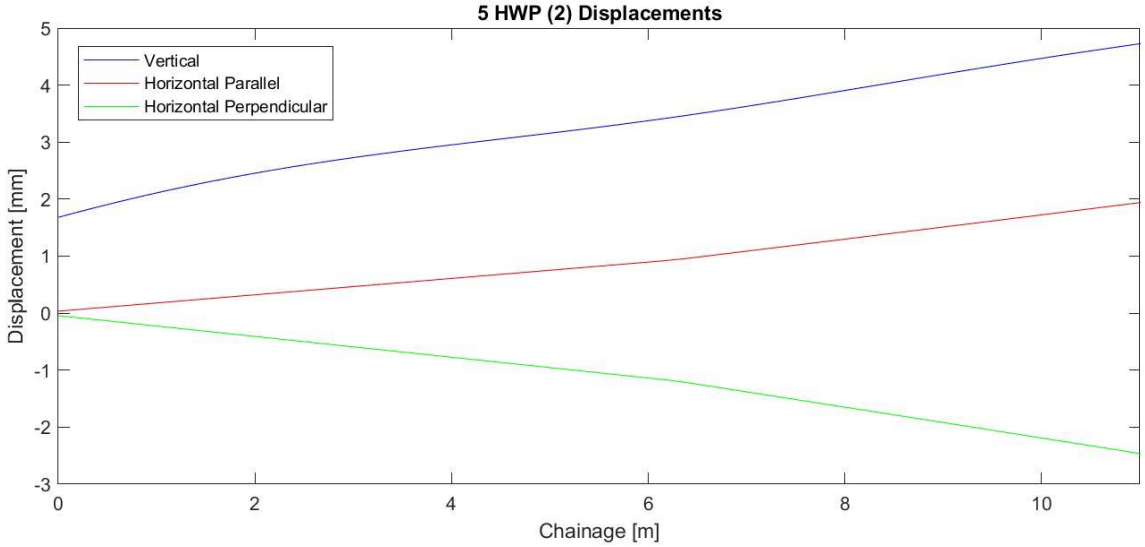

HWH (5) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
0
0.5
1
1.5
2
2.5

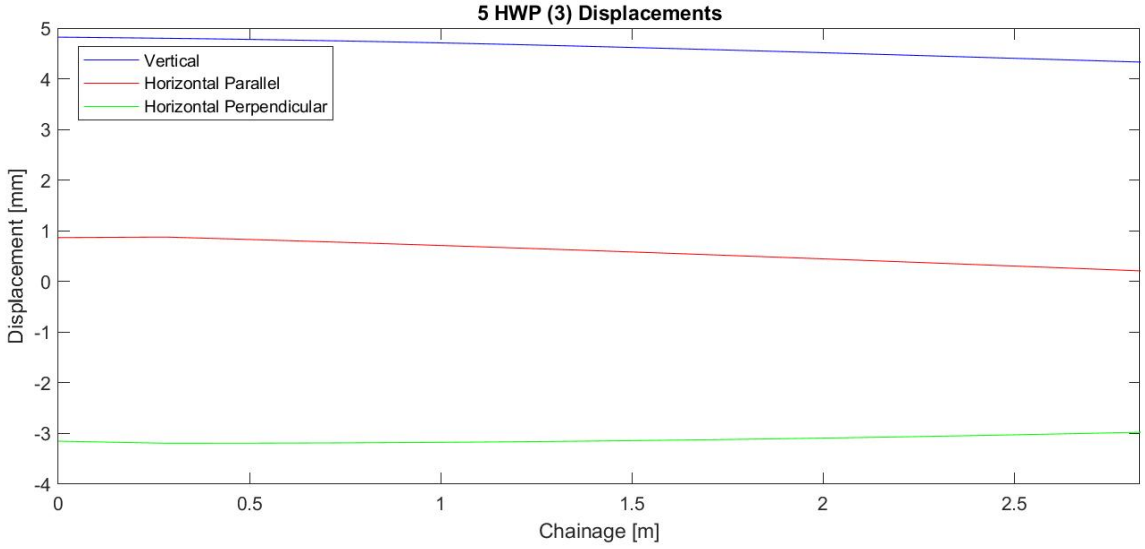

HWH (6) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
-0.16
-0.18
0
0.5
1
1.5
2
2.5

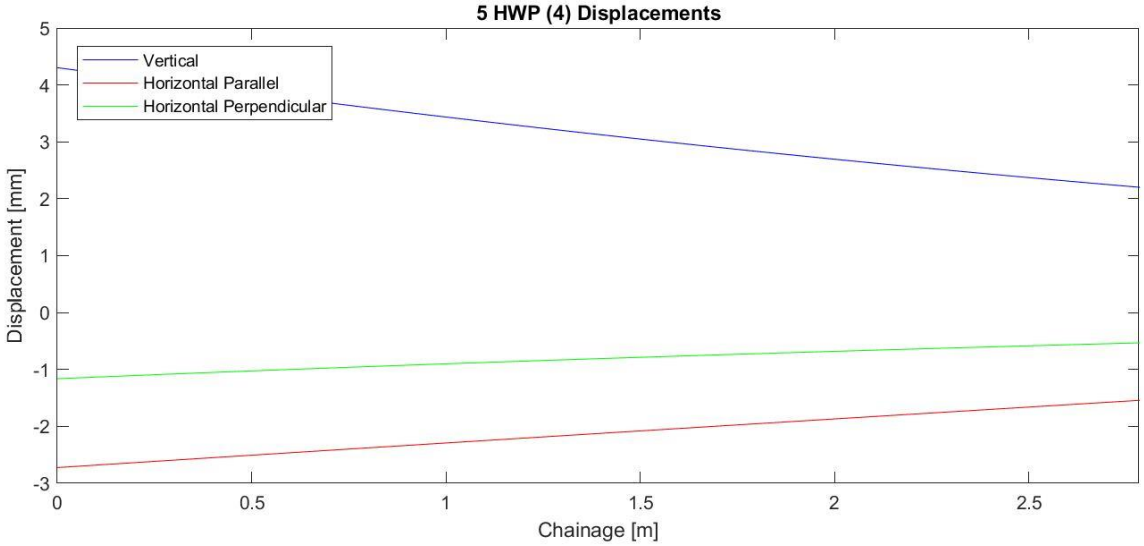

HWH (7) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
0
1
2
3
4
5
6
7

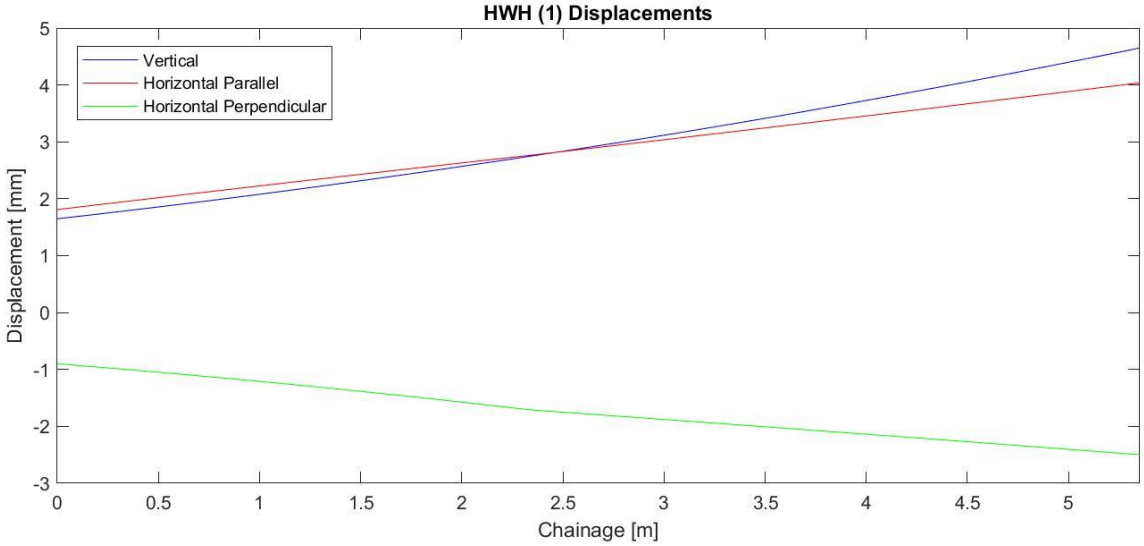
Long-term

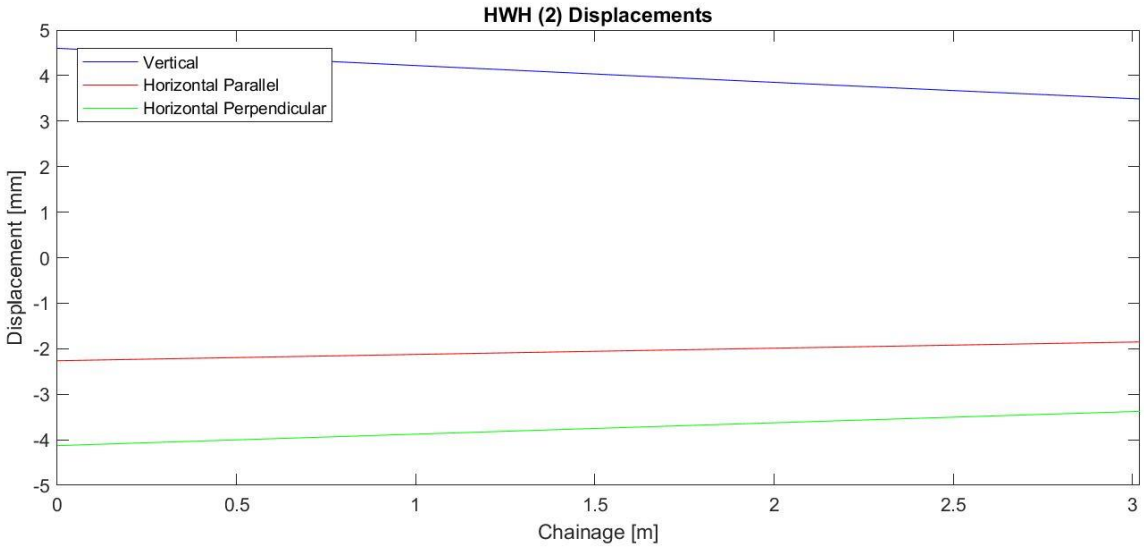

5 HWP (1) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]

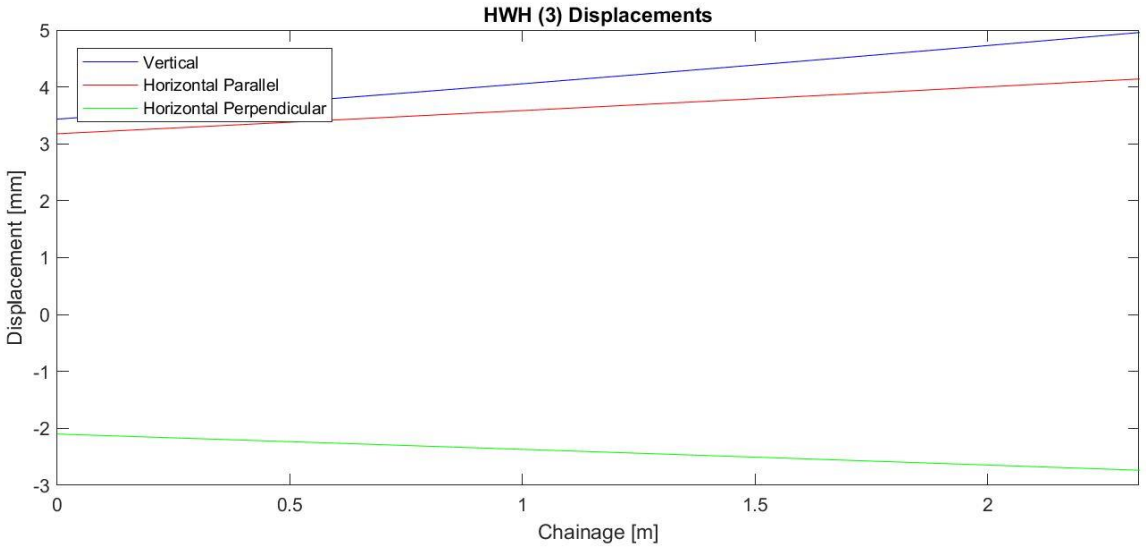

5 HWP (2) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]

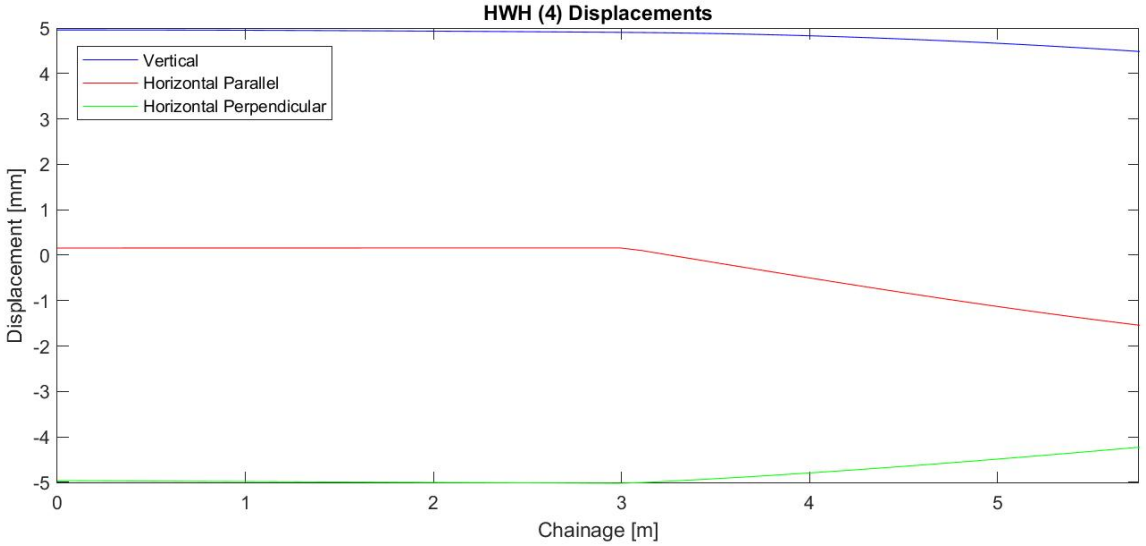

5 HWP (3) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]

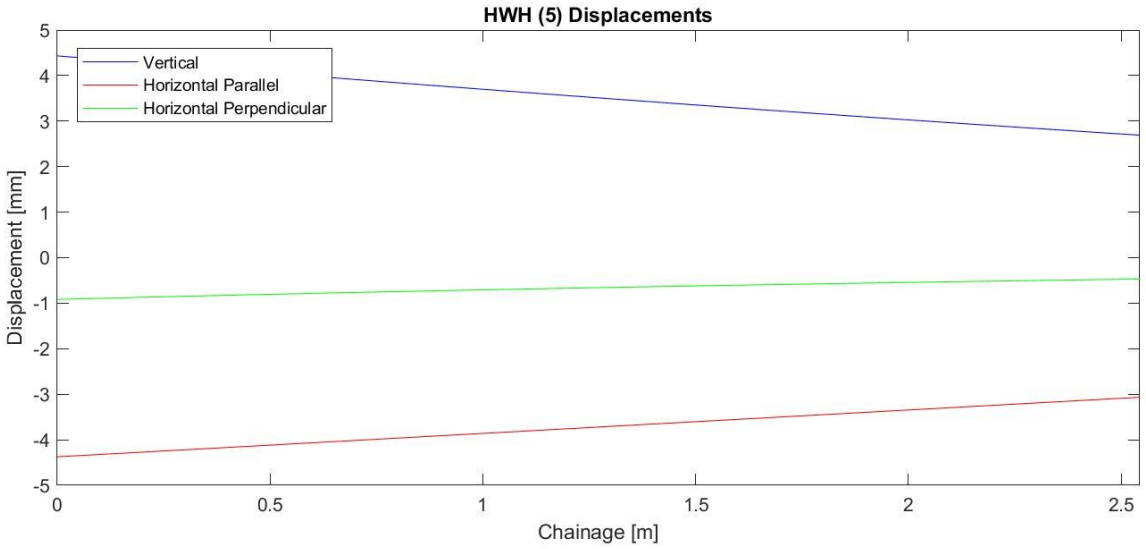

5 HWP (4) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]

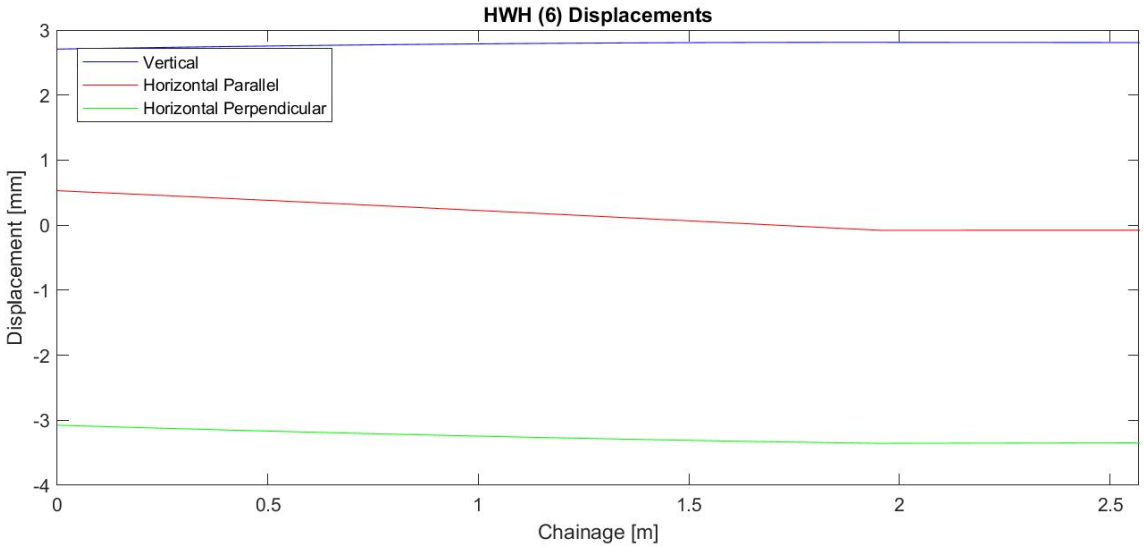

HWH (1) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]

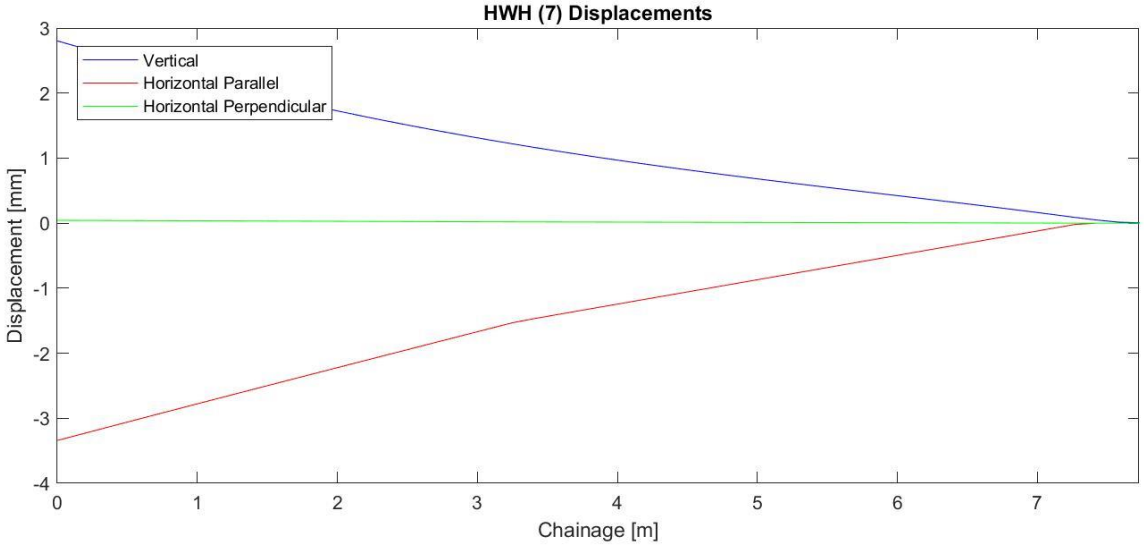

HWH (2) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]


HWH (3) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]


HWH (4) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]


HWH (5) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]


HWH (6) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]
3
2
1
0
-1
-2
-3
-4
0
0.5
1
1.5
2
2.5


HWH (7) Displacements
Vertical
Horizontal Parallel
Horizontal Perpendicular
Displacement [mm]
Chainage [m]
3
2
1
0
-1
-2
-3
-4
0
1
2
3
4
5
6
7

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