# THE STUDIO HOUSE
# 1 HAMPSTEAD HILL GARDENS, LONDON NW3 2PH

## GROUND MOVEMENT ASSESSMENT

**FOR**

## *CARMI KORINE*

June 2018

**Our Ref:** HLEI64102/GMA/001R

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*This report has been prepared in the RPS Group Quality Management System to British Standard EN ISO 9001:2008*

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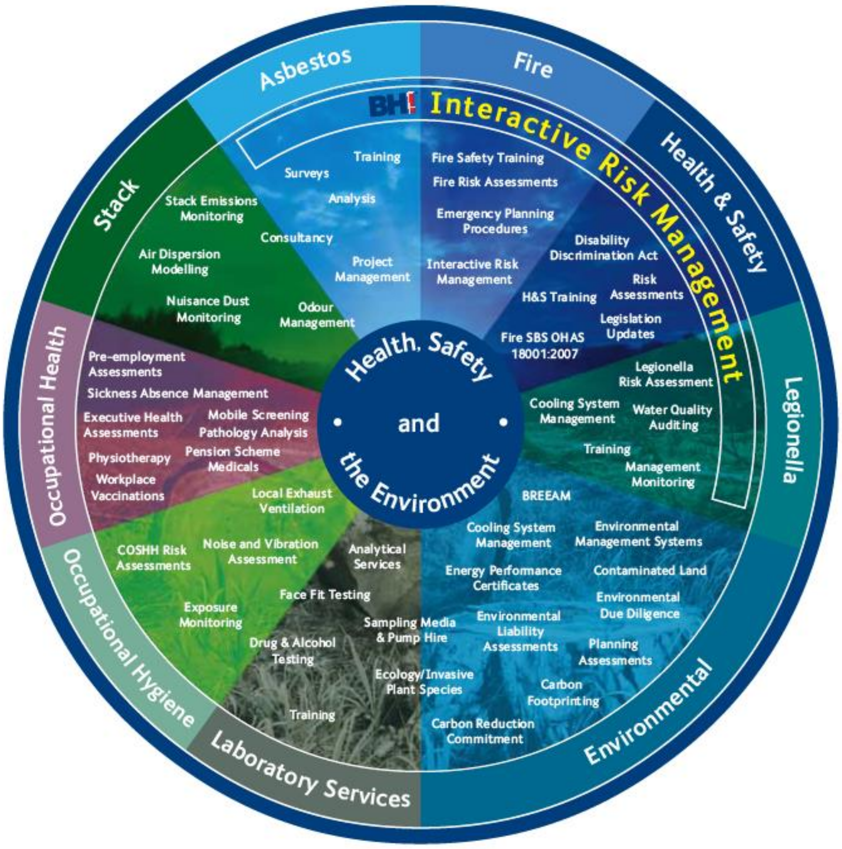

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# EXECUTIVE SUMMARY

*RPS Health, Safety & Environment (RPS) was commissioned by Carmi Korine to undertake a Ground Movement Assessment, relating to the proposed construction of a single level basement beneath the Studio House, 1 Hampstead Hill Gardens, London NW3 2PH. The assessment was required to identify the potential impact of soil movements caused by the basement construction to neighbouring buildings and the Transport for London (TfL) railway tunnels to the south. This report presents an assessment of the anticipated ground movements caused by the proposed basement construction.*

# 1 INTRODUCTION

## 1.1 Preamble

A Basement Impact Assessment (BIA) was previously undertaken by RPS for the proposed basement works in March 2017 (reference HLEI50381-001R) to satisfy the requirements of the Camden Council's Local Planning Authority (LPA). The BIA included a geotechnical site investigation within the footprint of the proposed basement. The BIA report should be read in conjunction with the current report.

RPS Health, Safety & Environment (RPS) was commissioned by *Cami Korine* to undertake a Ground Movement Assessment for the proposed redevelopment at the Studio House, 1 Hampstead Hill Gardens, London NW4 EPH comprising the construction of a single storey basement.

The Ground Movement Assessment was requested by the LPA to determine the potential impact of the ground movements caused by the construction of the proposed basement and extension of the building on neighbouring structures.

## 1.2 Objectives

The principal objectives of this assessment were as follows:

- To assess the potential for ground excavations undertaken as part of the development to result in ground movements that could influence neighbouring buildings and public highways; and
- To produce movement calculations for the various phases of the demolition, excavation and construction and to assess the potential damage categories that may apply to the impacted buildings in accordance with CIRIA document C580 or C760 as appropriate.

## 1.3 Limitations

The work undertaken does not include assessment of the impacts of constructed related ground movements on utilities located near the site. The assessment assumes a good standard of design and construction and isn't intended to assess the impacts of other construction related activities or cumulative construction related impacts from any nearby activities.

The report has been based on information provided by others in regards to building design and construction. If the plans or design of the building are changed prior to construction, in particular relation to foundation or retaining wall design, extent of ground excavation and load then an update should be undertaken to this ground movement assessment report.

The report has not been prepared to meet any specific requirements stipulated by TfL with regards to their assets that comprise the Northern line running tunnels and the Overground rail running tunnels.

### 1.4 Legislation and Guidance

This report has been produced in general accordance with:

- *National Planning Policy Framework (2012);*
- *Camden Planning Guidance, London Borough of Camden, CPG4 Basements and Lightwells*
- *(2013);British Standard requirements for the 'protection of below ground structures against water from the ground - Code of Practice' (ref. BS8102: 2009);*
- *British Standard requirements for the 'Investigation of potentially contaminated sites - Code of practice' (ref. BS10175:2011);*
- British Standard requirements for the *'Code of practice for ground investigations' (ref. BS5930:2015)*;
- CIRIA Report C580, Construction Industry Research and Information Association, Embedded retaining walls – guidance for economic design (2003);
- CIRIA Report 143, Construction Industry Research and Information Association, The Standard Penetration Test (SPT): Methods and use (1995); and
- CIRIA Report C760, Guidance on Embedded Retaining Wall Design (2017).

# 2 THE DEVELOPMENT SITE

## 2.1 Site Location & Description

The site is located in the London Borough of Camden at National Grid Reference 526950, 185503. A site location plan is provided as an extract from drawing 525/1/1.1000 and is presented as Figure 1.

The proposed development comprises a single-level basement beneath the northern portion of the existing two storey apartment and which will extend beneath the existing conservatory on the northern side and beyond the eastern outer wall of the building to form a light well. Proposed basement, ground and first floor plans for the development are provided as extracts from Nick Leith-Smith Architecture and Design Drawings 525/A/1.1001-1003 as Figures 2 to 4 of this report.

## 2.2 Ground Conditions

### 2.2.1 Topography

The ground surface within the site is generally flat at an approximate elevation of 77.25m AOD.

### 2.2.2 Geology and Hydrogeology

Based on the *RPS Phase 2 Environmental and Geotechnical Site Investigation* (reference HLEI50381-001R), British Geological Survey (BGS) online maps (1:50,000-scale) and the Environment Agency (EA) Groundwater Vulnerability mapping (1:100,000-scale), the stratigraphic sequence is indicated to be Topsoil overlying the London Clay Formation. The geological sequence underlying the site is summarised in **Table 1** below.

**Table 1: Encountered Strata**

| Strata | Depth to Top of Strata m bgl (m AOD) | Aquifer Classification |
|---|---|---|
| Topsoil | GL (77.25) | N/A |
| London Clay Formation | 0.40 (76.85) | Unproductive Stratum |

A previous intrusive site investigation was undertaken as part of the BIA which comprised the drilling of one cable percussion borehole (BH1) to a depth of approximately 10.00m below ground level, the installation of a groundwater monitoring well in the borehole and the excavation of a hand dug foundation inspection pit adjacent to the southern party wall within the apartment. The investigation indicated the following ground conditions.

**London Clay Formation**

The London Clay Formation was encountered beneath a limited thickness of topsoil at a depth of approximately 0.40m bgl (76.85m AOD). The London Clay Formation was encountered as orange brown and grey mottled slightly silty clay to a depth of approximately 5.90m bgl (71.35m AOD), at which point the stratum comprised dark brown-grey very closely fissured clay to the base of the borehole at 10.00m bgl.

Atterberg Limit testing was undertaken on four soil samples collected from the London Clay Formation at depths ranging from approximately 1.50m to 9.00m bgl (68.25m to 75.75m AOD). This testing was undertaken to determine values for Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI). The results for LL were 71% to 78%. The results for PL were 30% to 32%. The results for PI were 41% to 46%. This is indicative of a very high plasticity clay. In accordance with the NHBC Technical Standard, Section 4.3, Building near trees, modified plasticity index values indicate that these samples have a high volume change potential. The natural moisture contents of these samples ranged from 34% to 37%.

Four SPT results obtained from within the London Clay Formation at depths ranging from approximately 1.00m bgl to 8.00m bgl (69.25m to 76.25m AOD) gave results ranging from N = 11 to N = 19 with the SPT results increasing with depth.

Approximate undrained shear strengths were calculated from SPT results using the correlation by Stroud:

$$Cu = f_1 \times N$$

Where, a conservative value for $f_1 = 4.5$.

The SPT results generally increased with depth and correspond approximately to undrained shear strength values of 50kN/$m^2$ to greater than 86kN/$m^2$ which is indicative of a medium, ranging to a high strength cohesive material.

Two quick undrained triaxial compression tests undertaken on samples collected from the London Clay Formation at depths of approximately 6.50m and 9.50m bgl (67.75m and 70.75m AOD) gave results of 77kN/$m^2$ and 168kN/$m^2$ respectively. These are indicative of a high strength material. The results of triaxial tests were higher than those derived from the SPT's. The natural moisture contents of the samples were both 29%. Bulk density was 1.89Mg/$m^3$ and 1.91Mg/$m^3$. Dry density was 1.46Mg/$m^3$ and 1.48Mg/$m^3$.

A single consolidated Undrained Triaxial test was undertaken on a sample collected from the London Clay Formation at a depth of approximately 2.00m bgl (75.25m AOD), giving a result of 11.2kN/$m^2$ for effective cohesion. The natural moisture content of this sample was 29%.

One oedometer consolidation test was undertaken on a sample collected from the London Clay Formation at a depth of approximately 4.00m bgl (73.25m AOD). Between a pressure range of 100kN/m$^2$ to 200kN/m$^2$, a coefficient of compression ($m_v$) value of 0.187m$^2$/MN was obtained. This is indicative of a medium compressibility material.

**Groundwater**

Groundwater was not encountered during the SI works. Groundwater was encountered at a depth of approximately 1.97m bgl (75.28m AOD) during a subsequent monitoring visit to site on 4$^{th}$ August 2017. It is considered that this is representative of perched water within sandy horizons or claystone bands in the London Clay Formation.

## 2.3 Existing Land use and Buildings

The development area currently comprises a two storey apartment at the northern end, which is part of a four storey, six-apartment masonry conversion. A garden and a residential garage are located to the northwest of the apartment building.

## 2.4 Neighbouring buildings

Two buildings surround the proposed redevelopment, as per information provided in Figure 1. One is situated at an approximate distance of 1m south of the southern extent of the proposed basement and the second is located at an approximate distance of 3m south west of the southern boundary of the proposed basement.

Two Northern Underground Line rail running tunnels are located to the south west of the proposed redevelopment and their influence zone is indicated to be within a 4m distance from the site. Two Overground Line rail running tunnels are situated at an approximate distance of 20m south west of the site.

# 3 PROPOSED DEVELOPMENT

## 3.1 Proposed Building

The proposed development comprises a single-level basement construction beneath the northern portion of the existing two storey apartment, which will extend beneath the existing conservatory on the northern side and beyond the eastern outer wall to form a light well.

## 3.2 Proposed Construction Sequence

The proposed construction sequence is provided by the Basement Construction Method Statement prepared by BCS Consulting in September 2017 and is presented in Table 2. This sequence has been used to assess ground movements arising from the construction of the basement retaining walls, basement excavation and construction beneath the existing building. The existing conservatory is proposed to be demolished and replaced by a new one at the footprint of the previous one, hence no significant stress change has been considered for this element.

**Table 2: Preliminary Construction Sequence**

| Stages | Works | Description |
|---|---|---|
| Stage 1 | Installation of basement retaining walls | Installation of concrete retaining wall by underpinning techniques around the basement periphery. (Short term undrained conditions) |
| Stage 2 | Excavation of basement | Excavation to the proposed basement level at 4m bgl. (Short term undrained conditions) |
| Stage 3 | Substructure construction and superstructure load transition at basement level | Construction of the basement slab and transfer of superstructure loads at basement level. (Short term undrained conditions) |
| Stage 4 | Consolidation | The long term movement of the ground under the new structure. (Long term drained conditions) |

# 4 ASSESSMENT OF RISK TO NEIGHBOURING BUILDINGS

## 4.1 General Considerations

An assessment of the ground movements due to the proposed site redevelopment and their impact on the adjacent neighbouring buildings and a TfL tunnel at an approximate distance of 15m was undertaken. Ground movements that could pose a risk to adjacent buildings are those related to the basement retaining wall construction, excavation works and basement construction.

## 4.2 Ground movement analysis

The ground movement analysis comprised:

- Assessment of the vertical ground movements due to the proposed redevelopment and associated changes to the vertical stresses caused by the basement retaining wall construction, excavation and construction of the proposed basement was undertaken using the Oasys PDISP software.
- The analysis is based on Boussinesq's theory and the stratum underlying the site is considered as a semi-infinite isotropic, homogeneous elastic material.
- The basement layout has been developed based on information provided by the Nick Leith-Smith Architecture and Design's Drawing 525/A/1.1001, an extract of which is presented as Figure 2
- The basement formation level is proposed to be at 4.0m bgl
- The loading layout has been modelled as per Figure 5 and comprises the retaining wall construction, the excavation to the formation level, the basement slab and superstructure loads transferred through the newly constructed basement slab to the underlying bearing stratum.
- The ground conditions that have been considered for the analysis are presented in Section 2. London Clay is anticipated to underlie the site and the groundwater level is anticipated to be at approximately 2m bgl. Based on the results of the site investigation, the following geotechnical parameters have been derived for undrained and drained analysis:

**Table 3: Geotechnical parameters**

| Stratum | Depth m bgl (m AOD) | Bulk Density ($kN/m^3$) | Undrained Shear Strength ($kN/m^2$) | Undrained Young's Modulus ($kN/m^2$) | Undrained Poisson's ratio | Drained Young's Modulus ($kN/m^2$) | Drained Poisson's ratio |
|---|---|---|---|---|---|---|---|
| London Clay Formation | Existing ground level to a maximum proven depth of 10.00 m bgl (67.25 to 77.25) | 20 | 50 at ground level increasing to 85 at 10m bgl | 15,000 at ground level to 25,500 at 10m bgl | 0.4 | 12,000 at ground level to 20,400 at 10m bgl | 0.2 |

- Figures 6 to 8 present the vertical displacements produced through the gradual addition of the anticipated loading and unloading due to the proposed redevelopment. The horizontal forces on the basement retaining walls have not been modelled as part of this assessment; hence a simplified stress model has been adopted.
- Table 4 presents the cumulative results of changes in vertical pressure in each side of the building and impact on nearest sides of neighbouring buildings in the sequence of stress changes developed by the retaining wall construction, excavation and basement construction and transfer of superstructure loads.

**Table 4: Ground Movement Results (Cumulative)**

| Location | Stage 1 | Stage 2 | Stage 3 | Stage 4 |
|---|---|---|---|---|
| Western wall | 0.3 to 0.4mm settlement | 0mm to 5mm heave | 0 to1mm heave | 0 to 1mm heave |
| Eastern wall | 0.3mm to 0.4mm settlement | 2mm to 4mm heave | 0 to 1mm heave | 0 to 1mm heave |
| Northern wall | 0.3mm settlement | 2mm to 6mm heave | 1 to 2mm heave | 1 to 4mm heave |
| Southern Wall | 0.4 to 0.7 settlement | 2 to 5mm heave | 0 to 1mm heave | 0 to 1mm heave |
| Basement slab | 0 to 0.4mm settlement | 5 to 11mm heave | 1 to 4mm heave | 1 to 6mm heave |
| Adjacent building 1.5m south of the proposed basement | 0 to 0.1mm settlement | 0mm | 0mm | 0mm |
| Adjacent building at 3m south west of the proposed basement | 0 to <0.1mm settlement | 0mm | 0mm | 0 to <1mm heave |
| Northern Line tunnel's influence zone 5m away | 0mm | 0mm | 0mm | 0mm |
| Overground line tunnel's at 20m south west | 0mm | 0mm | 0mm | 0mm |

The table above presents the anticipated displacements of the various elements of the proposed redevelopment as well as the examined neighbouring structures. A maximum heave displacement of 11mm is calculated at the excavation stage in the centre of the basement slab but as this displacement would have occurred prior to the slab construction, only post construction displacement are considered relevant to the slab design.

The anticipated strains on adjacent buildings and the existing tunnels were calculated using the anticipated ground movement at the relevant influence distance. The results are presented in Table 5 below:

**Table 5: Tensile Strain (%)**

| Location | Zone of Influence (m) | Stage 1 | Stage 2 | Stage 3 | Stage 4 |
|---|---|---|---|---|---|
| Adjacent building 1.5m south of the proposed basement | 1.5 | <0.05 | <0.05 | <0.05 | <0.05 |
| Adjacent building at 3m south west of the proposed basement | 3 | <0.05 | <0.05 | <0.05 | <0.05 |
| Northern Line tunnel's influence zone 5m away | 5 | <0.05 | <0.05 | <0.05 | <0.05 |
| Overground Line tunnels 20m south west | 20 | <0.05 | <0.05 | <0.05 | <0.05 |

The above values have been used to assess the damage categories for each case. The categorization is presented in Table 6 below:

**Table 6: Building Damage Classification (Burland, 1995)***

| Location | Description of Degree of Damage | Damage Category |
|---|---|---|
| Adjacent building 1.5m south of the proposed basement | Negligible | 0 |
| Adjacent building at 3m south west of the proposed basement | Negligible | 0 |
| Northern Line's influence zone 5m away | Negligible | 0 |
| Overground Line's 20m south west | Negligible | 0 |

* Burland, J.B.(1995), assessment of risk of damage to buildings due to tunnelling and excavation, invited special lecture: 1st international conference on earthquake geotechnical engineering, IS Tokyo '95.

# 5 CONCLUSIONS

## 5.1 Conclusions

An assessment of the ground movements caused by the proposed site redevelopment which mainly comprises a 4m deep single storey basement construction was undertaken. Anticipated displacements were calculated at different stages of the construction including the basement retaining wall construction, excavation, basement construction and transfer of the existing superstructure loads at basement level. An assessment of the impact of the ground movements was undertaken on two adjacent buildings and a TfL rail tunnel, located approximately 15m to the south of the building. Damage assessment on neighbouring structures was based on Burland, 1996, as described within CIRIA document C760.

The assessment has indicated that damage caused to neighbouring structures as a result of the basement construction will be negligible (damage category '0' – Burland, 1995).

# FIGURES

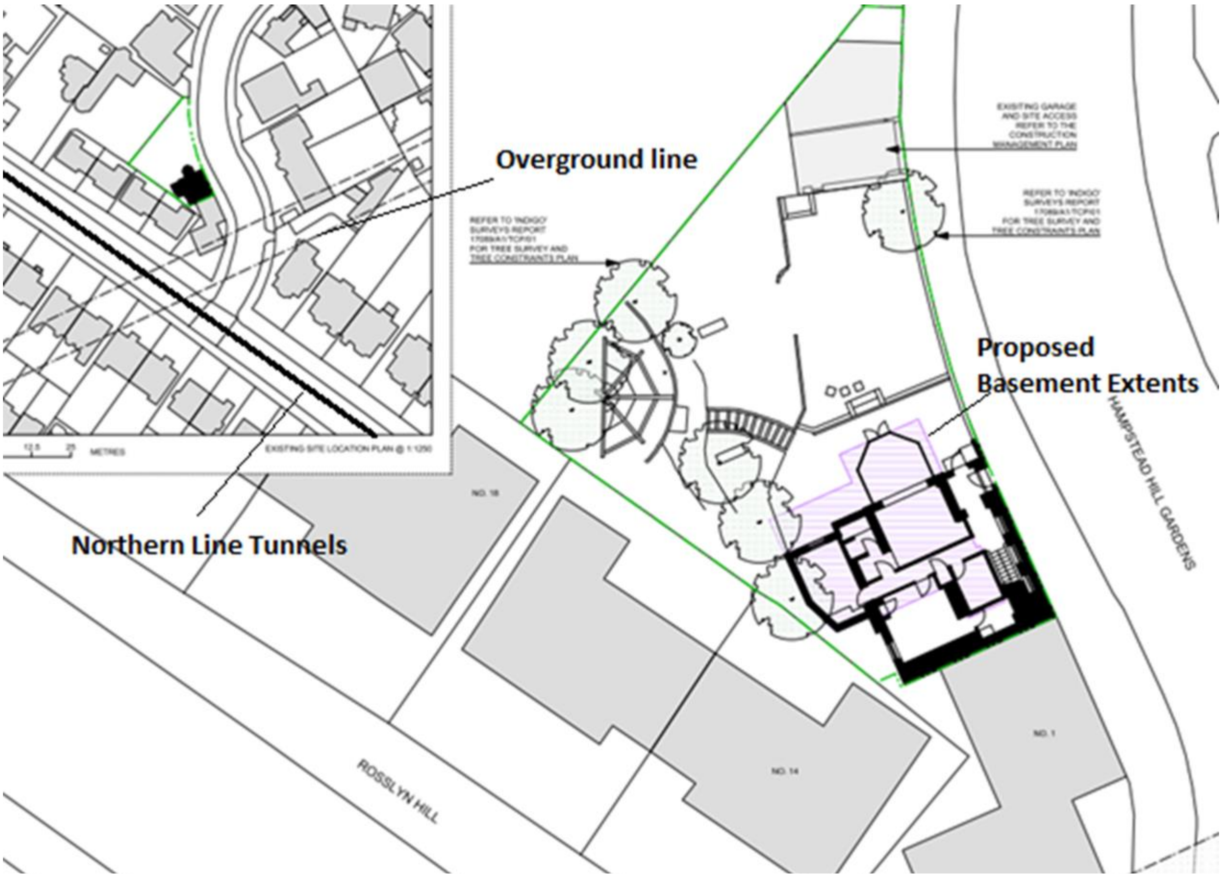


**Figure 1:** Site Location Plan

**Map Date:** 2017

**Scale:** Not to scale

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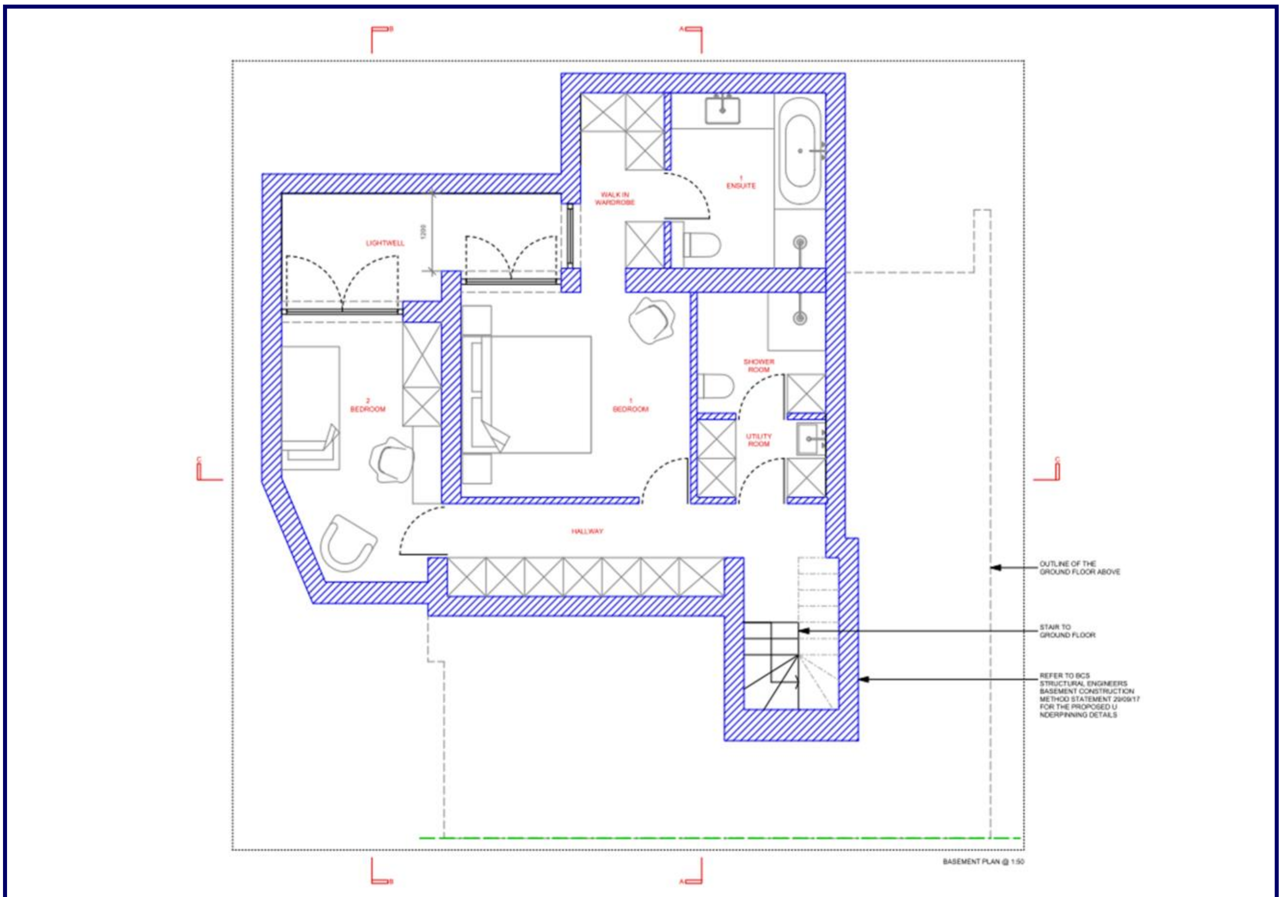


**Figure 2:** Proposed Basement Plan

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**Scale:** Not to scale

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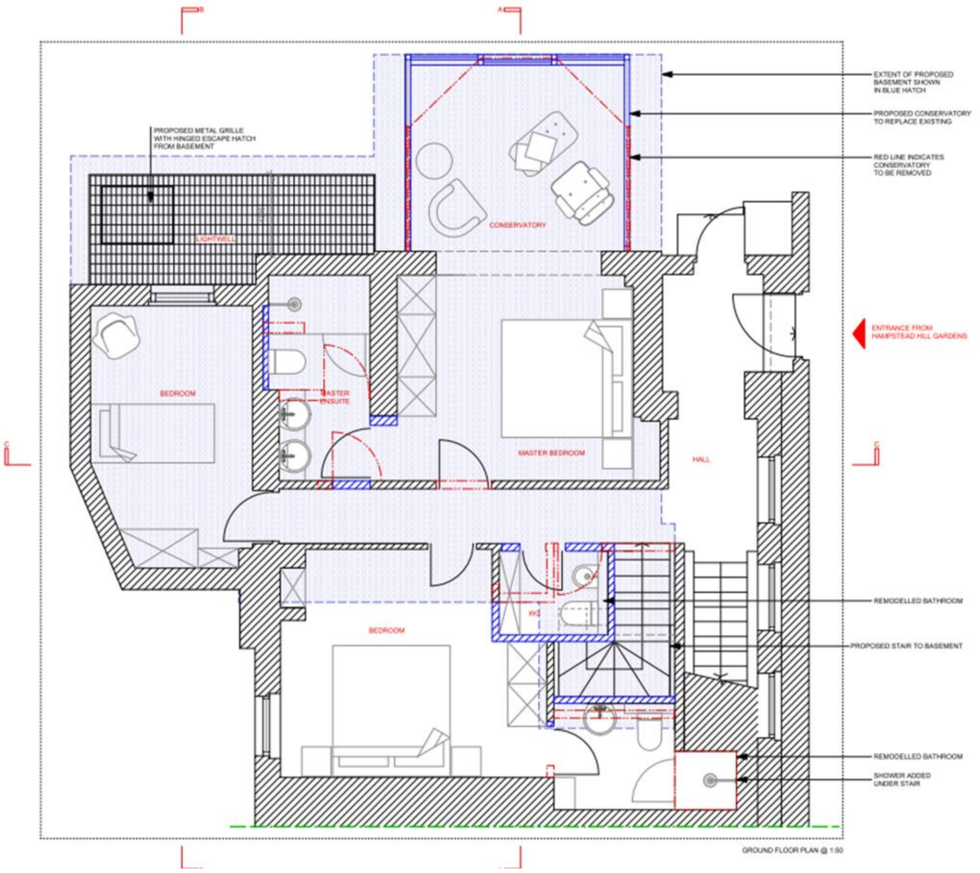


**Figure 3:** Proposed Ground Level Plan

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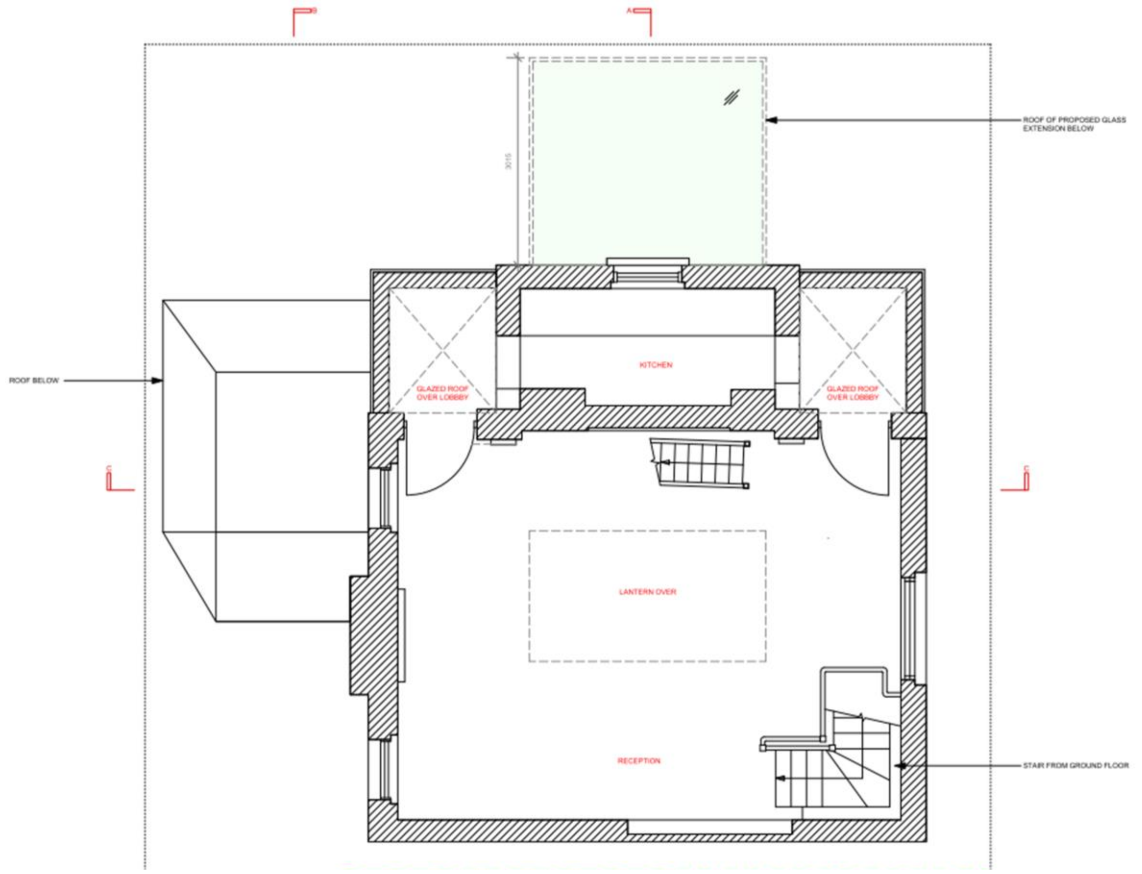


**Figure 4:** Proposed First Floor Plan

**Date:** 2017

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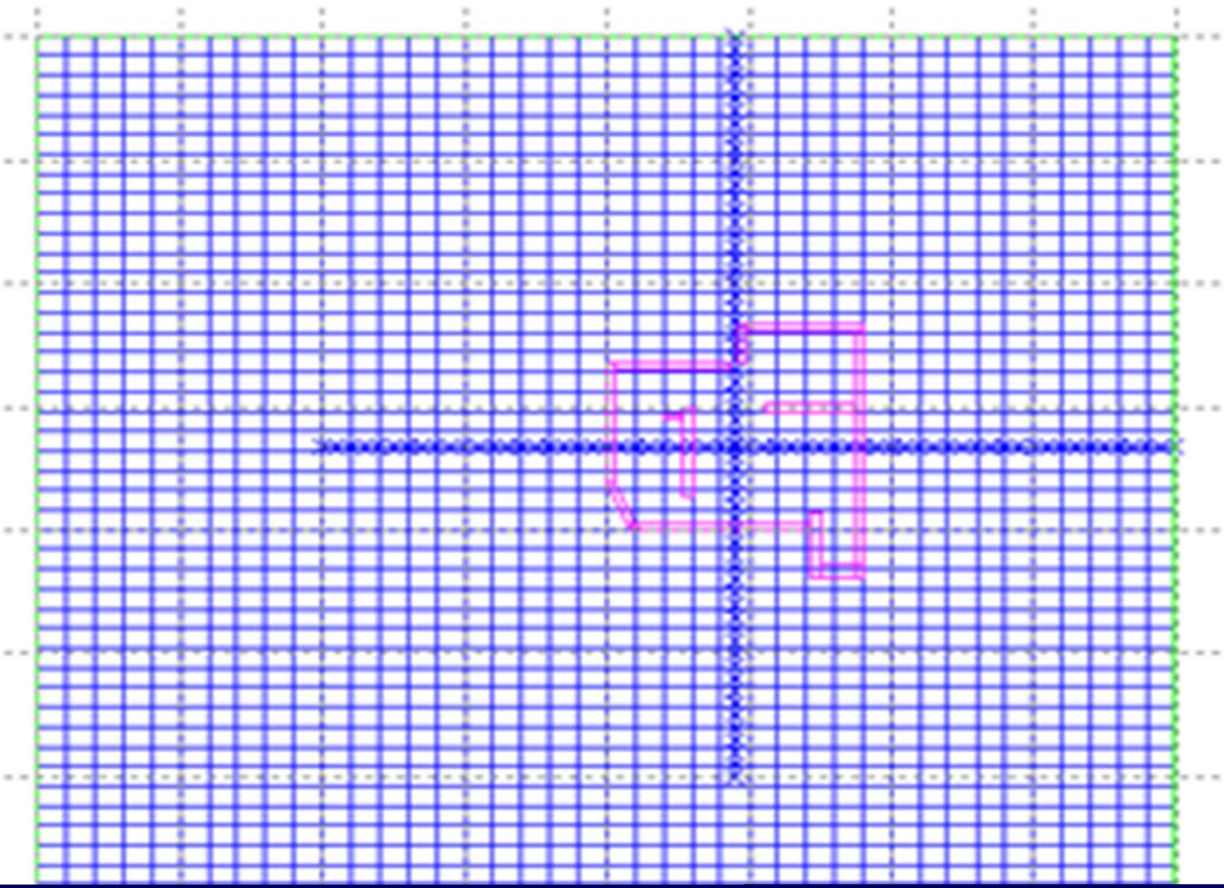

**Figure 5:** Loading Layout

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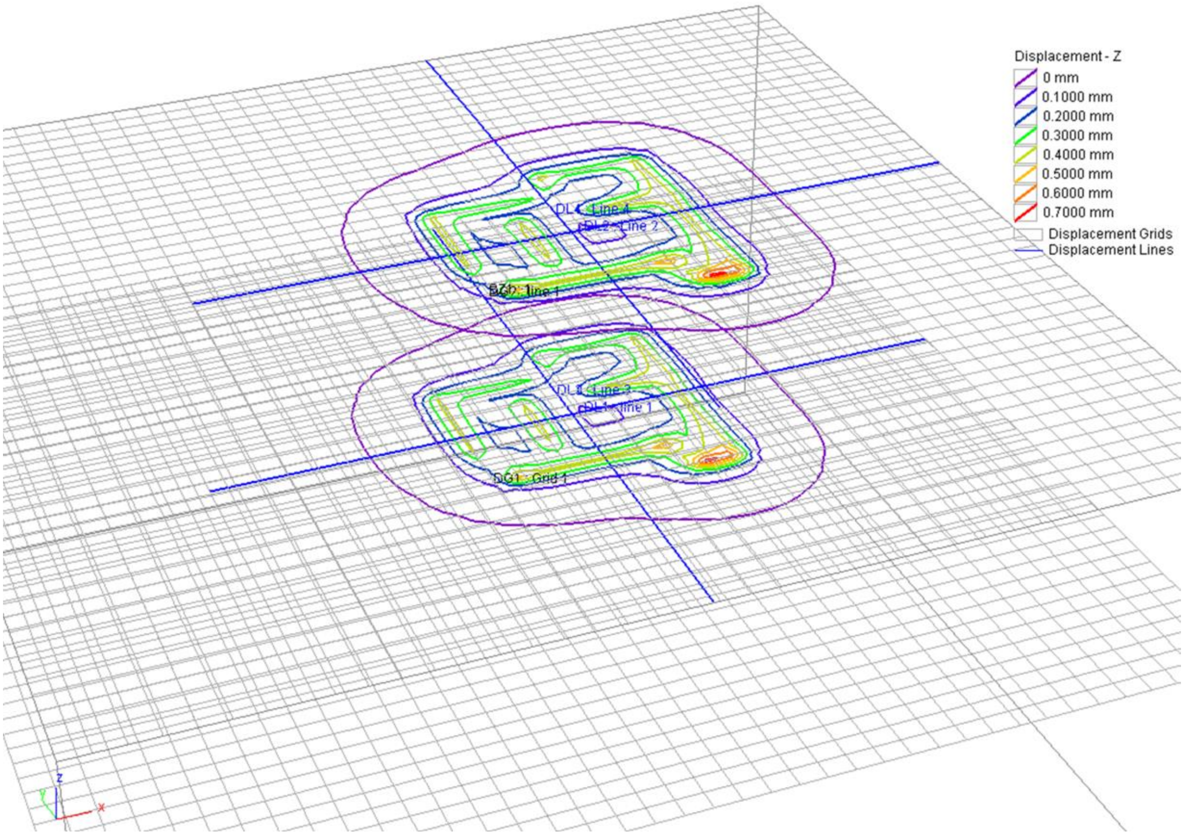


**Figure 6:** Stage 1 Retaining Walls Installation

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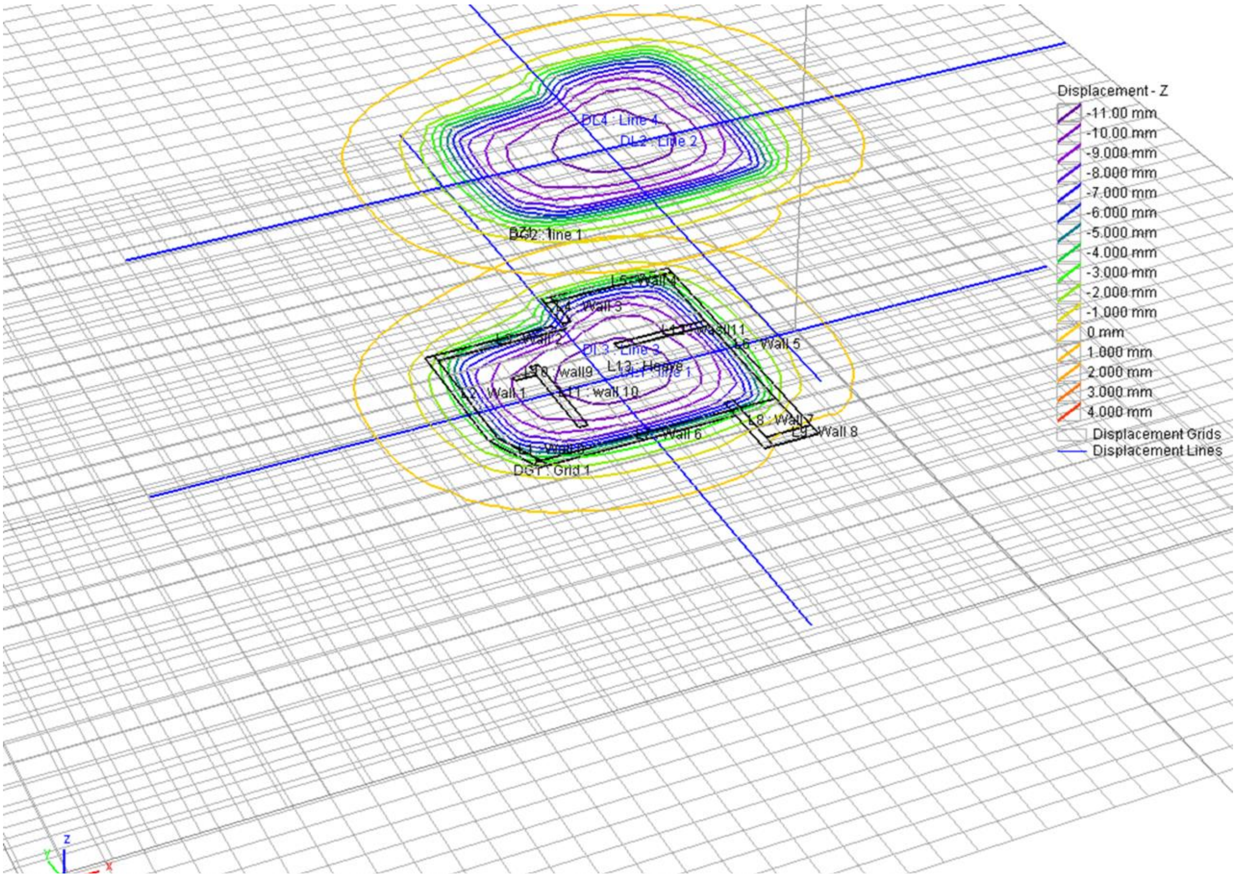


**Figure 7** Stage 2 Excavation

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**Scale:** Not to scale


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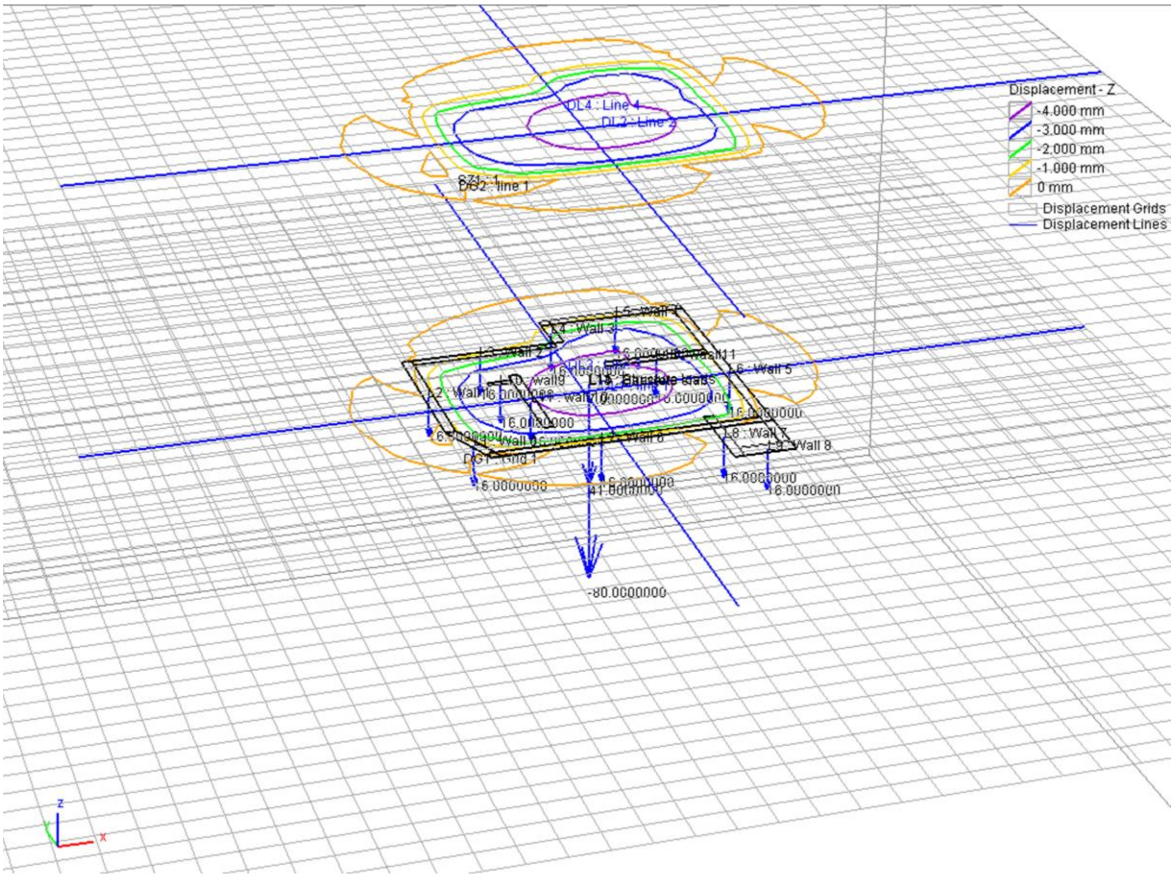


**Figure 8:** Stage 3 – Slab construction & Superstructure loads transfer (Short term conditions)

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**Scale:** Not to scale

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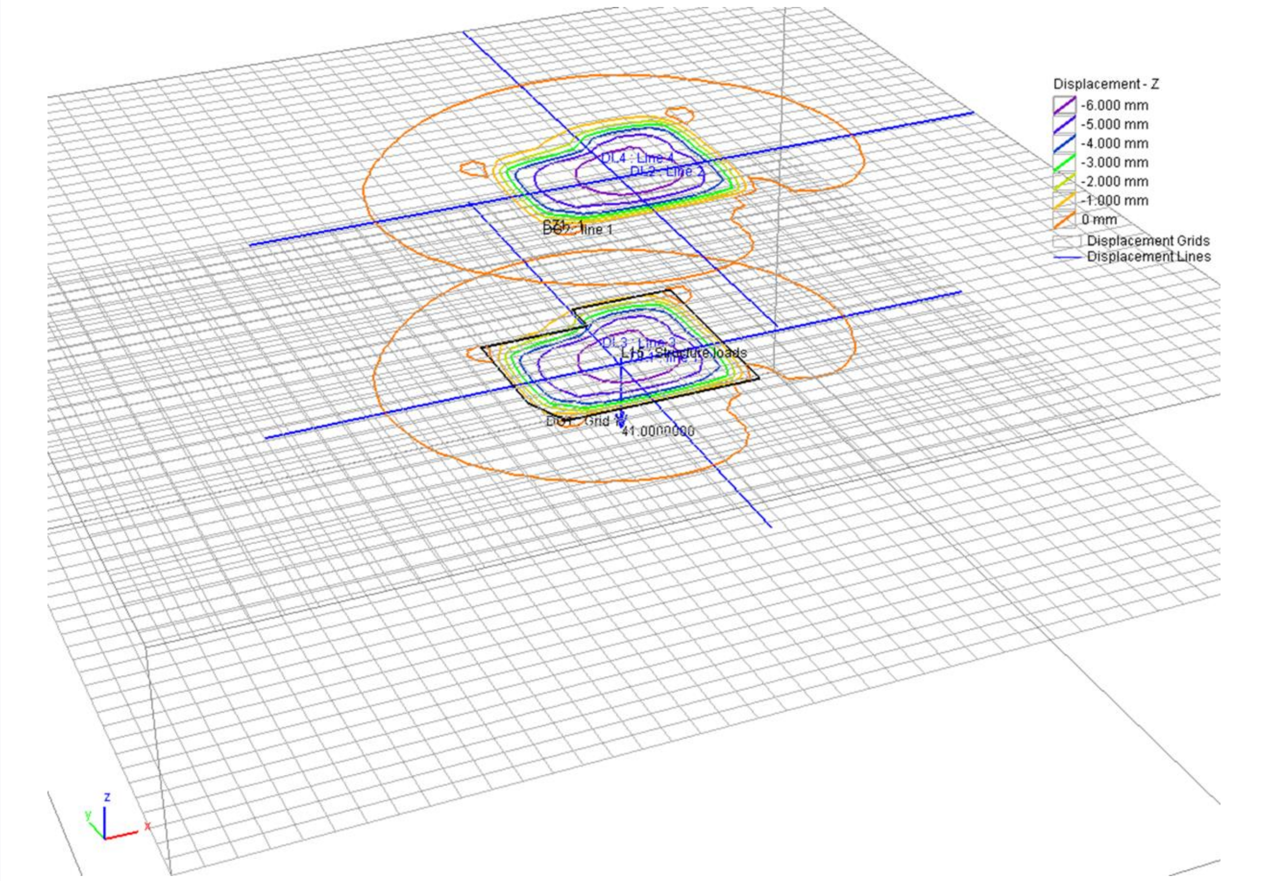


**Figure 8:** Stage 4 – Slab construction & Superstructure loads transfer (Long term drained conditions)

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