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22 October 2014

Our ref J13156/MC/01

Mr Andrew Garwood Watkins
Residential Facilities Management Ltd
258 Belsize Road
London
NW6 4BT

Dear Andrew

Re: 18-20 LANCASTER GROVE, LONDON, NW3 4PB

Further to your instruction of 17 September 2014, on behalf of Mena Properties Ltd, we have now completed our analysis of ground movements associated with the proposed construction of a basement at the above site and this letter forms the report of our assessment. A site investigation has previously been carried out by Structural Soils Limited (report ref 722146 Issue 2, dated September 2008), along with an additional borehole completed by GEA in June 2013 and the findings of these investigations have been used in the derivation of parameters for use in this assessment.

The purpose of this assessment has been to determine the effects of the basement construction upon the neighbouring structures in accordance with London Borough of Camden Planning Guidance CPG4.

1.0 PROPOSED DEVELOPMENT

It is understood that the current proposal is to demolish the two existing houses and construct a new two-storey house located largely within the footprint of the existing houses and within the footprint of a previously consented scheme. The proposed house contains a single storey basement below the entire footprint of the new building to a depth of about 4.20 m, with the underside of basement slab at a level of about 4.8 m SD. The ground investigation has indicated that formation level for the proposed basement will be within the London Clay.

Sections and plans by Adam Architecture, dated March 2014, showing the proposed house are included in the appendix, which have been taken from the Camden planning portal (application ref 2014/2811/P).

For the movement analysis the basement has been modelled as a rectangular shaped box, which will be formed by excavation within a contiguous bored pile wall. It is assumed that suitable propping will be provided during the construction of the basement and in the permanent condition, such that the walls may be considered to be stiff for the purpose of the ground movement modelling.

1.1 Limitations

The conclusions and recommendations made in this report are limited to those that can be made on the basis of the investigation. The results of the work should be viewed in the context of the range of data sources consulted, the number of locations where the ground was sampled and the number of soil, gas or groundwater samples tested; no liability can be accepted for information in other data sources or conditions not revealed by the sampling or testing. Any comments made on the basis of information obtained from the client or other third parties are given in good faith on the assumption that the information is accurate; no independent validation of such information has been made by GEA.

2.0 THE SITE

A detailed record of the historical, physical, hydrogeological and environmental setting of the site is presented in the Structural Soils desk study and ground investigation report.

The site is bounded to the north by Lancaster Grove, to the south by the rear gardens of houses fronting onto Eton Avenue and to the east and west by detached two-storey houses. It is understood that the neighbouring properties do not have basements. A planning application was previously submitted for No 22 Lancaster Grove (ref 2014/2037/P) where it was proposed to construct four two-storey houses with a basement following the demolition of the existing house; permission was refused on 3 October 2014.

The site is currently occupied by a vacant two-storey house, which comprises Nos 18 and 20 Lancaster Grove and an adjoining single storey garage along the northern elevation to No 20. A paved driveway is present at the front of the site, which slopes gently down to the south, although the remainder of the site is essentially level.

Along the western elevation is a passageway leading to the rear garden, which comprises a patio along the southern elevation and a central lawn with numerous trees along the perimeters. An approximately 7 m high pine tree is present at the front of the site along the western boundary. Trees are present on the pavement along the northern boundary of the site including a London plane, ash and horse-chestnut tree, reaching heights of approximately 20 m.

3.0 SUMMARY OF GROUND CONDITIONS

The previous ground investigation by Structural Soils comprised a single cable percussion borehole, drilled on the front driveway to a depth of 15.45 m. The borehole indicated the expected ground conditions in that, beneath a moderate thickness of made ground, which was found to extend to a depth of 1.80 m, London Clay was encountered and initially comprised stiff becoming very stiff brown sandy fissured clay. The more weathered London Clay extended to a depth of 9.56 m whereupon very stiff grey sandy fissured clay was encountered and was proved to the full depth investigated of 15.45m. Groundwater was not encountered.

An additional borehole was undertaken by GEA in June 2013 using hand held window sampling equipment and confirmed the ground conditions previously encountered by Structural Soils. As previously, below a layer of made ground which extended to a depth of 1.70 m, the London Clay comprised an initial layer of stiff orange-brown mottled grey silty clay which extended to a depth of 1.90 m. This layer was underlain by stiff brown mottled grey fissured silty clay with occasional partings of orange-brown fine sand and silt and selenite crystals and was proved to the maximum depth investigated of 5.00 m.

Groundwater was not encountered during the drilling of the borehole but a monitoring visit carried out a day later measured groundwater in the standpipe at a depth of 3.80 m. This water level is thought likely to have represented ingress from discrete pockets of groundwater within partings of silt and sand.

The standpipe was subsequently monitored about 16 months later and was found to be dry. It is considered that the water initially measured within the standpipe has drained through the sandy or silty layers within the London Clay which is of relatively low permeability. It appears that once each individual pocket of groundwater has drained individual inflows have ceased. On this basis it is surmised that groundwater may be encountered during basement excavation but inflows should not be of significant volumes. A contiguous bored pile wall in association with localised sump pumping should be adequate to deal with any inflows of water into the basement excavation.

In any case, continued monitoring of the standpipe should be continued for as long as possible prior to construction and it would be prudent to carry out trial excavations to the full depth of the proposed excavation in which groundwater ingress could be observed.

4.0 GROUND MOVEMENTS

4.1 Methods of Analysis

An assessment of ground movements surrounding the excavation has been undertaken using the X-Disp computer program licensed from the OASYS suite of geotechnical modelling software from Arup. This program is commonly used within the ground engineering industry and is considered to be an appropriate tool for this analysis.

The X-Disp program has been used to predict ground movements behind the retaining walls that are likely to arise from the installation of the contiguous bored piled walls and then from the subsequent excavation of the basement. For the X-Disp analysis, the soil movement relationships used for the embedded retaining walls are the default values within CIRIA report C580[1], which were derived from a number of historic case studies.

The magnitudes of ground differential movement predicted by the program have been assessed and an indication of likely damage is presented in accordance with the ‘Burland’ damage categories that vary between ‘negligible’ and ‘very severe’.

In addition to the above, an estimate has been made of the likely ground movements that would arise from heave of the underlying London Clay due to unloading that will take place during and after excavation. This analysis has been carried out using the OASYS P-Disp software package (Version 19.2 Build 17) which estimates the likely ground movements based on the assumption that the soils behave elastically; this provides a reasonable approximation to soil behaviour at small strains. Undrained soil parameters have been used to estimate the potential short term movements, which include the “immediate” or elastic movements as a result of the basement excavation. Drained parameters have been used to provide an estimate of the total long-term movement.

The upward ‘heave’ movements that will occur within the excavations as a result of the removal of the existing soils to form the proposed basement and are separate to those predicted by X-Disp, which deals with the downward settlement and inward movements that will take place behind the piled walls. Whilst the majority of the heave movements will be confined within the extent of the basement excavations, some post excavation heave may occur outside the proposed basement. Such heave will go some way to mitigate the downward settlement behind the wall following pile installation and subsequent excavation to form the basement. For the purpose of this analysis, no attempt has been made to combine the potential heave movements predicted by P-Disp to occur outside the proposed basement with those predicted by X-Disp. The X-Disp analysis and subsequent damage assessment are therefore considered to represent a relatively conservative assessment, as they represent the worst case movements and do not include any potential mitigation or recovery as a result of heave.

4.2 Models Used and Assumptions Made

For the X-Disp analysis, the soil movement relationships used for the embedded retaining walls are the default values within CIRIA report C580, which were derived from a number of historic case studies. The piles that form the contiguous bored pile wall have been assumed to be of 9.1 m length which represents an embedded length of 4.8 m and an exposed height of

[1] Gaba, A, Simpson, B, Powrie, W and Beadman, D (2003) *Embedded retaining walls – guidance for economic design* CIRIA Report C580.

4.3 m. This embedment is considered appropriate for a wall where temporary and permanent propping will be provided at ground level and basement levels. On this basis the ground movement curves for 'excavations in front of high stiffness' wall have been adopted as being considered most appropriate for such a wall wholly embedded in London Clay.

The magnitudes of ground movements have been predicted by the program and have been assessed for the area surrounding the basement. In addition, the neighbouring structures comprising the detached houses of Nos 16 and 22 Lancaster Grove located to the west and east respectively have been set as sensitive structures that require a Building Damage Assessment.

The walls of the sensitive structures have been modelled as lines in the analysis and are the lines along which the damage assessment has been undertaken. For clarity, these critical lines are shown on the attached plans. On the basis of the Structural Soils trial pits, it has been assumed that the foundations of the neighbouring properties to the east and west bear at a similar level to Nos 18 and 20, ie a level of about 8.5 m SD, and they are assumed to not have basements.

For the heave analysis, the elastic analysis requires values of soil stiffness at various levels to calculate displacements. Values of stiffness for the soils at this site are readily available from published data and well-established methods have been used to provide our estimates. This relates values of E_u and E', the drained and undrained stiffness respectively, to values of undrained cohesion as described by Padfield and Sharrock[2] and Butler[3] and more recently by O'Brien and Sharp[4]. Relationships of $E_u = 500\ C_u$ and $E' = 300\ C_u$ for the cohesive soils have been used to obtain values of Young's Modulus. More recent published data[5] indicates stiffness values of 750 x Cu for the London Clay and a ratio of E' to Cu of 0.75, but it is considered that the use of the more conservative values provides a sensible approach for a first analysis.

4.3 Wall Movements

The X-Disp analysis has been used to estimate the movements that will occur outside of the proposed basement as a result of pile installation and subsequent excavations. This includes the settlement of the ground (vertical movement) behind the wall and the lateral movement of soil behind the wall (horizontal movement).

The ground movements predicted for pile installation and subsequent basement excavation have also been combined to allow a damage assessment to be carried out.

The predicted movements are summarised in the table below and, as discussed above, represent the maximum likely vertical and inward movements behind the walls of the proposed basement at the level where they are likely to be most critical, in this case the foundation level.

Phase of Works	Wall Movement (mm)	
	Vertical Settlement	Horizontal Movement
Pile Installation (contiguous wall)	Less than 5	Less than 5
Basement Excavation (excavation in front of high stiffness wall)	Less than 5	5 to 10
Combined Movements	5 to 10	10 to 15

2 Padfield CJ and Sharrock MJ (1983) *Settlement of structures on clay soils.* CIRIA Special Publication 27
3 Butler FG (1974) *Heavily overconsolidated clays: a state of the art review.* Proc Conf Settlement of Structures, Cambridge, 531-578, Pentech Press, Lond
4 O'Brien AS and Sharp P (2001) *Settlement and heave of overconsolidated clays - a simplified non-linear method.* Part Two, Ground Engineering, Nov 2001, 48-53
5 Burland JB, Standing, JR, and Jardine, FM (2001) Building response to tunnelling, case studies from construction of the Jubilee Line Extension. CIRIA Special Publication 200

The analysis has indicated that the maximum vertical and horizontal settlements that will result from pile installation are unlikely to exceed 5 mm. The maximum vertical settlement that will take place behind the walls as a result of the basement excavation is unlikely to exceed 5 mm with up to 10 mm of horizontal movement.

The total, or combined, vertical ground movements are not likely to exceed 10 mm of settlement, whilst the maximum horizontal movements are anticipated to between 10 mm and 15 mm.

The movements presented are considered to represent a worst case scenario and will be further minimised due to control of the propping in the temporary works and a regime of monitoring.

4.4 Damage to Neighbouring Structures

The combined movements resulting from both pile installation and basement excavation have been used to carry out an assessment of the likely damage to adjacent properties and the results are summarised in the table below

Building Damage Assessment		
Sensitive Structure	**Elevation**	**Burland Scale**
No 16 Lancaster Grove	South	Category 1 – Very Slight
	East	Category 0 – Negligible
	North	Category 0 – Negligible
	West	Movement below sensitivity limit
No 22 Lancaster Grove	South	Category 0 – Negligible
	East	Movement below sensitivity limit
	North	Category 1 – Very Slight
	West	Category 0 – Negligible
	Garage South	Category 1 – Very Slight
	Garage East	Category 0 – Negligible
	Garage North	Category 1 – Very Slight
	Garage West	Category 1 – Very Slight

The building damage assessment for the sensitive structures identified in the above table predicts that the effect on the adjacent properties would be ‘negligible’ to ‘very slight’ as defined in the Burland damage categories. On this basis, the damage that would inevitably occur as a result of such an excavation would fall within the acceptable limits.

4.5 Heave Movements

The proposed development comprises the demolition of Nos 18 and 20 Lancaster Grove and subsequent construction of a new two-storey house with single level basement extending to a depth of about 4.30 m, a level of about 4.8 m SD.

Formation level of the basement will be within the London Clay and the construction of the new basement will result in a net unloading of roughly 85 kN/m². The foundation loads of the new structure are not known at present but it is assumed they will be largely supported upon the bored pile wall. The movements quoted are those that might be expected for unrestrained soil within the basement that is allowed to heave.

The soil strengths and stiffnesses are based on the results of the SPT results from the Structural Soils Limited cable percussion borehole and the relationships set out in Section 4.2 above. A rigid lower boundary for the analysis has been set within the London Clay at a depth of about 50 m below the proposed formation level of the basement at a level of about -45.0 m SD.
The analysis output movement contour plots are included within the appendix. Full tabular results can be provided upon request.

The P-Disp analysis indicates that, by the time the basement excavation is complete, up to 15 mm of heave is likely to have taken place at the centre of the proposed basement excavation, reducing to less than 10 mm along the edges.

In the long term, following completion of the development construction, a further 10 mm to 15 mm of heave is estimated as a result of long term swelling of the underlying London Clay in the centre of the basement excavation with a further 10 mm of heave predicted at the edges.

In order to mitigate the effects of heave on the new building, the basement box could be designed to transmit heave forces into the wall piles or onto tension piles within the basement. Alternatively, a void should be incorporated into the design of the basement floor slab to accommodate these potential long term movements. If a compressible material is used beneath the slab, it will need to be designed to be able to resist the potential uplift forces generated by the ground movements. In this respect potential heave pressures are typically taken to equate to around 50 % to 60 % of the total unloading pressure.

5.0 CONCLUSIONS

The analysis has concluded that the predicted damage to the neighbouring properties would be either ‘Negligible’ or ‘Very Slight’. On this basis, the damage that would inevitably occur as a result of such an excavation would fall within the acceptable limits.

The two phases of work, piling and subsequent excavation will in practice be separated by a number of weeks during which time construction of capping beams and pile curing will take place. This will provide an opportunity for the ground movements during and immediately after piling to be measured and the data acquired can be fed back into the design and compared with the predicted values. Such a comparison will allow the ground model to be reviewed and the predicted wall movements to be reassessed prior to the main excavation taking place so that propping arrangements can be adjusted if required.

We trust that the foregoing comments are sufficient for your needs and we would be pleased to discuss the findings in more detail if required and to provide any additional assistance that may be necessary.

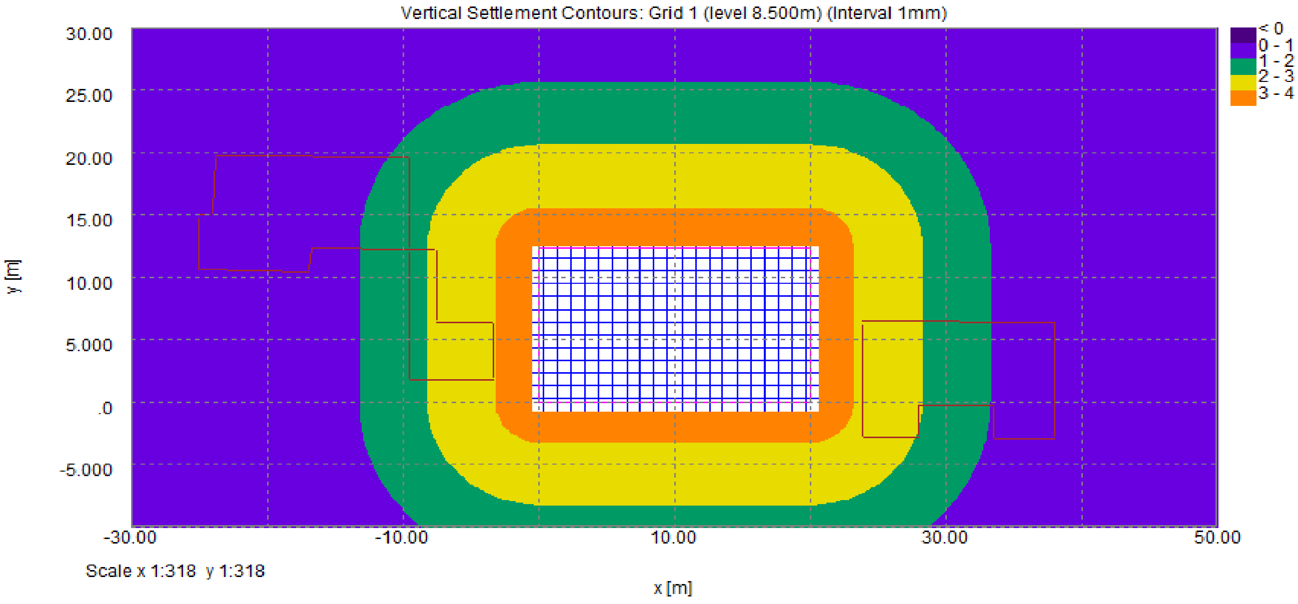
Yours sincerely
GEOTECHNICAL & ENVIRONMENTAL ASSOCIATES

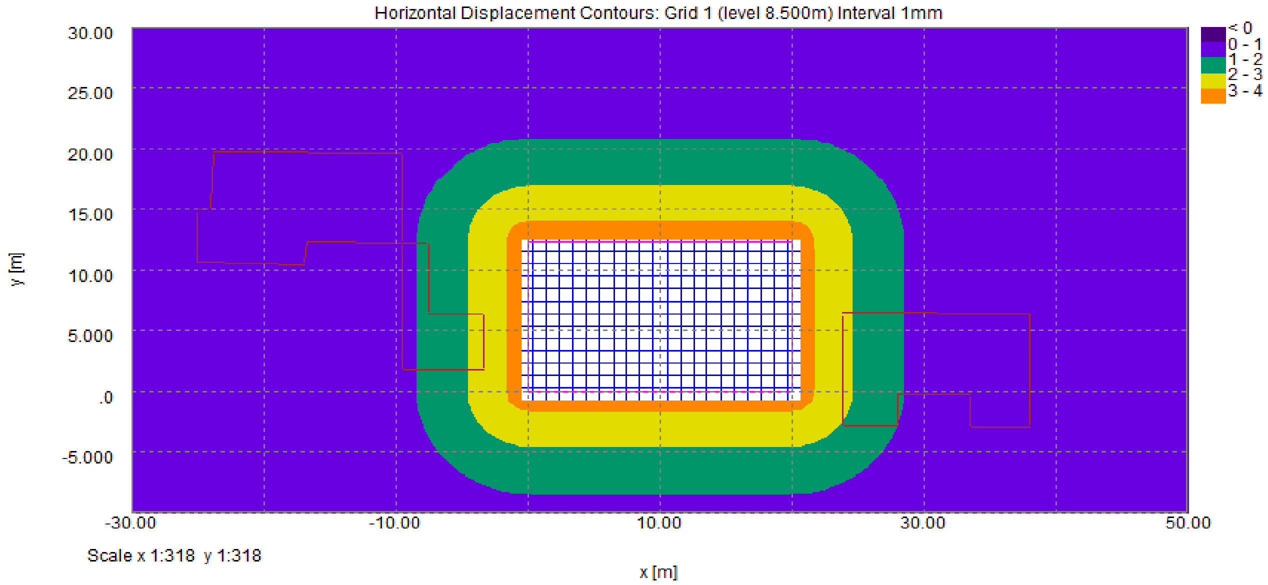
Martin Cooper

BEng CEng MICE FGS
Encs

GEA Geotechnical & Environmental Associates	Tyttenhanger House Coursers Road St Albans Herts AL4 0PG	**Ground Movements Piling Phase**

Site	: 18 - 20 Lancaster Grove, London NW3 4PB	**Job Number** J13156
Client	: Mena Properties Limited	
Engineer	: Residential Facilities Management Limited	**Sheet** 1 / 3





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Ground Movements Excavation Phase

Job Number J13156

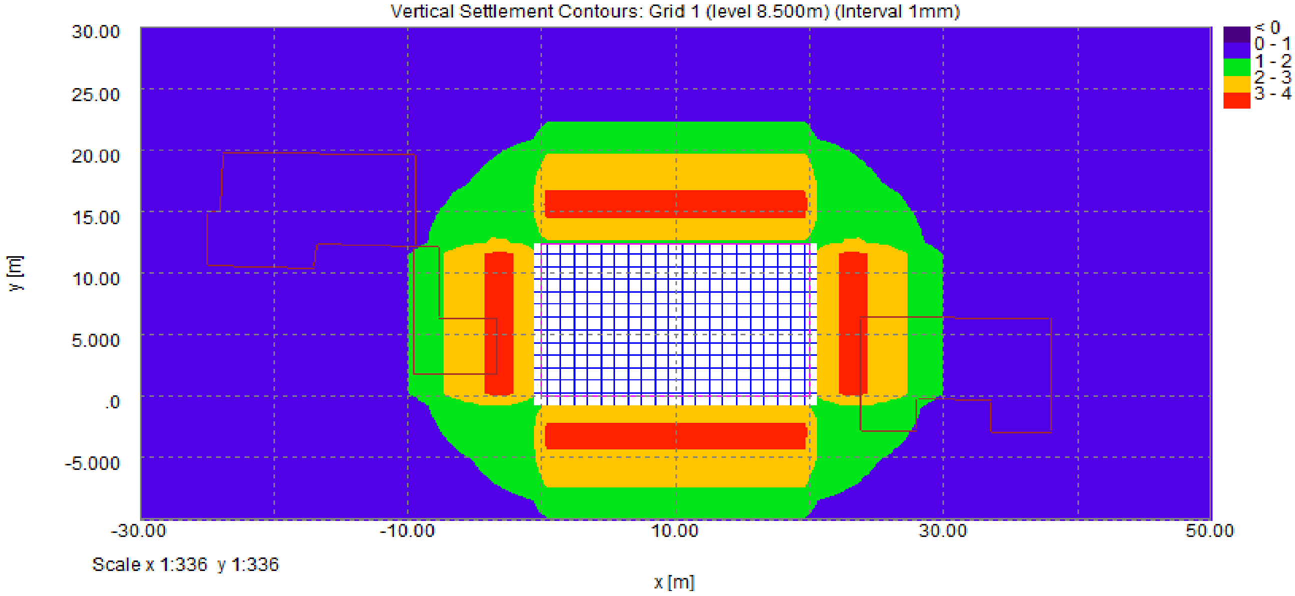
Sheet 2 / 3

Site : 18 - 20 Lancaster Grove, London NW3 4PB

Client : Mena Properties Limited

Engineer : Residential Facilities Management Limited

Vertical Settlement Contours: Grid 1 (level 8.500m) (Interval 1mm)



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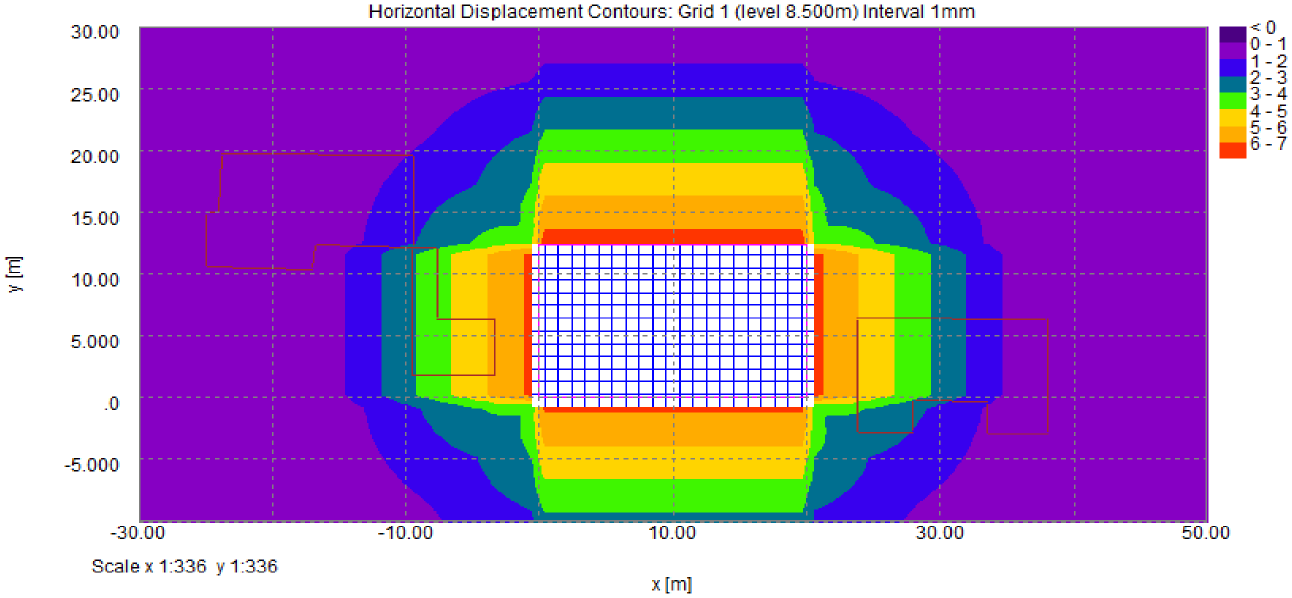

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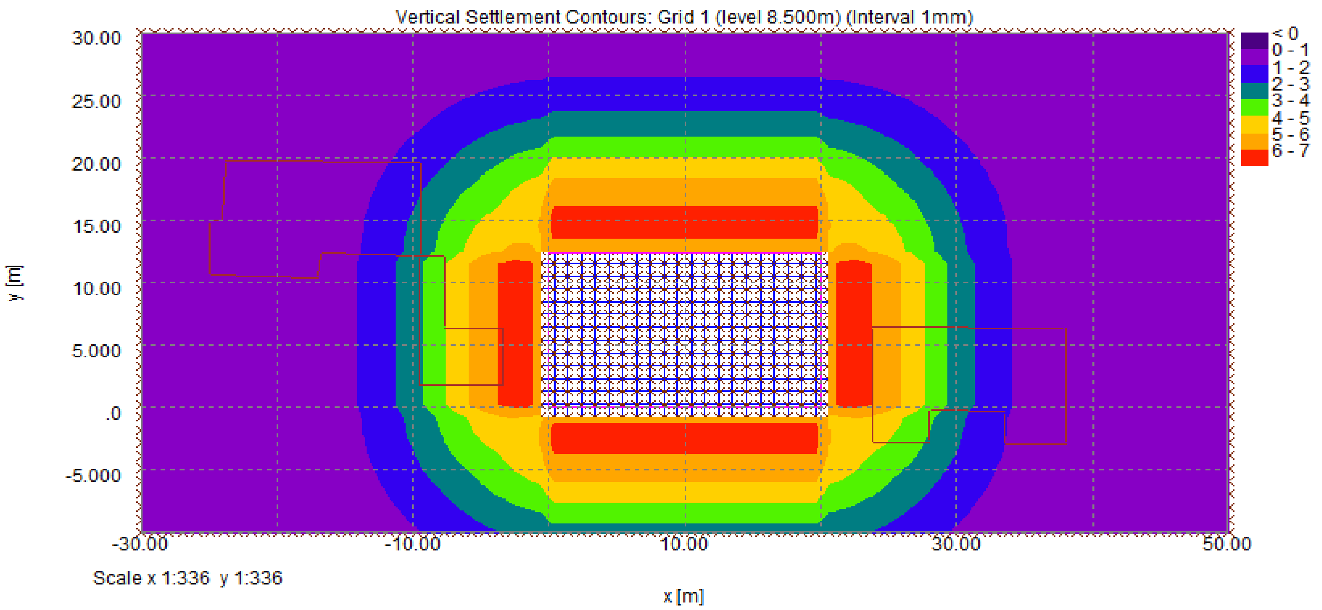
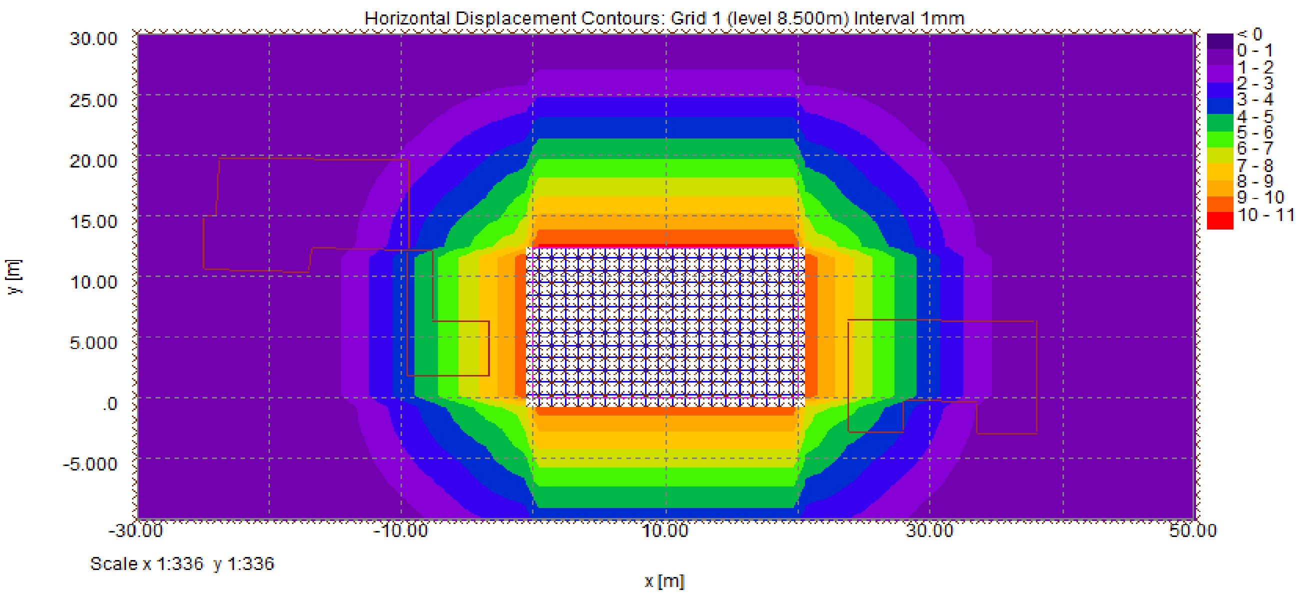
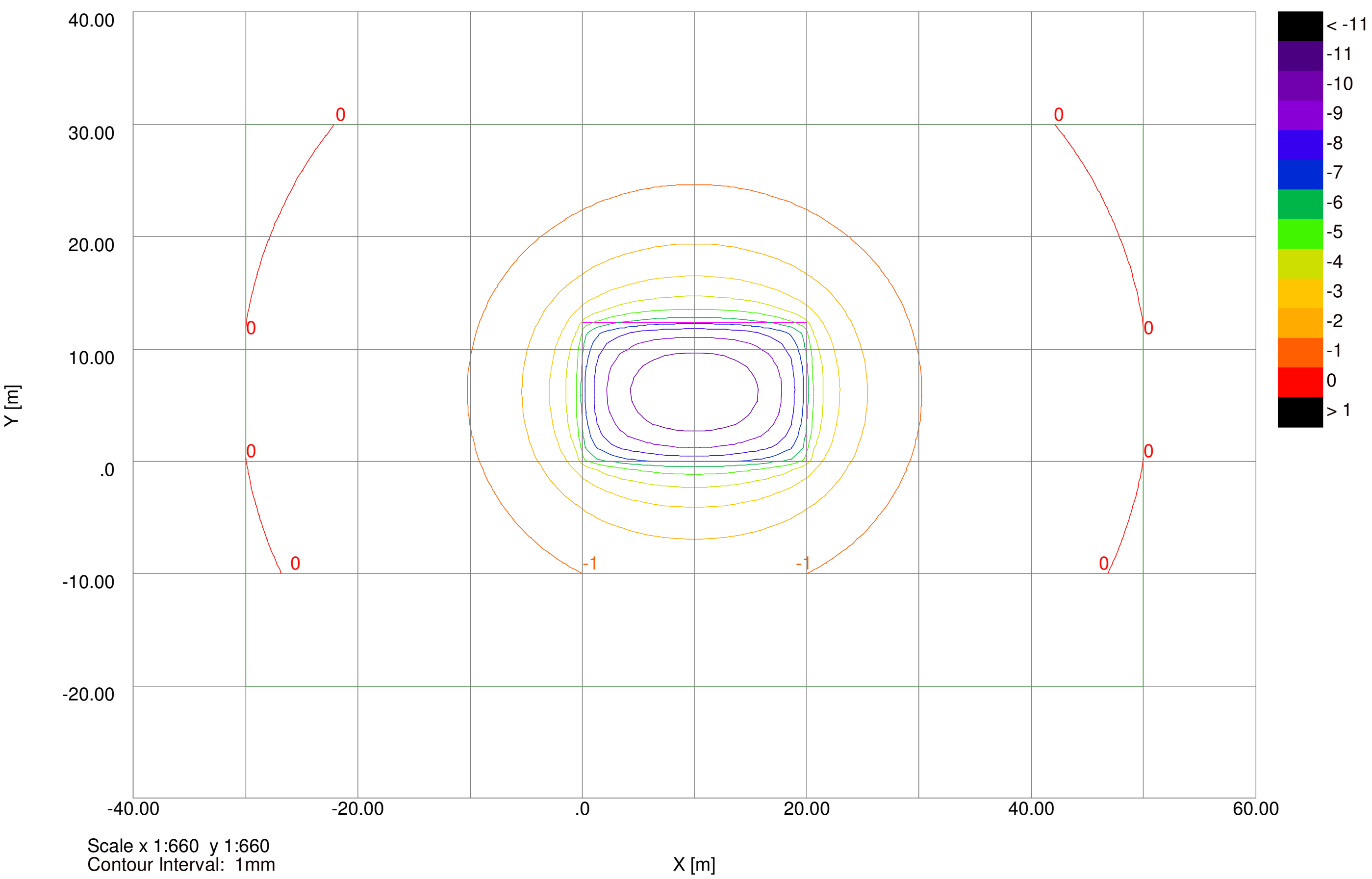
Ground Movements Combined Phases

Site	: 18 - 20 Lancaster Grove, London NW3 4PB	**Job Number** J13156
Client	: Mena Properties Limited	
Engineer	: Residential Facilities Management Limited	**Sheet** 3 / 3





Settlement Contours : Grid 1 at 4.800m



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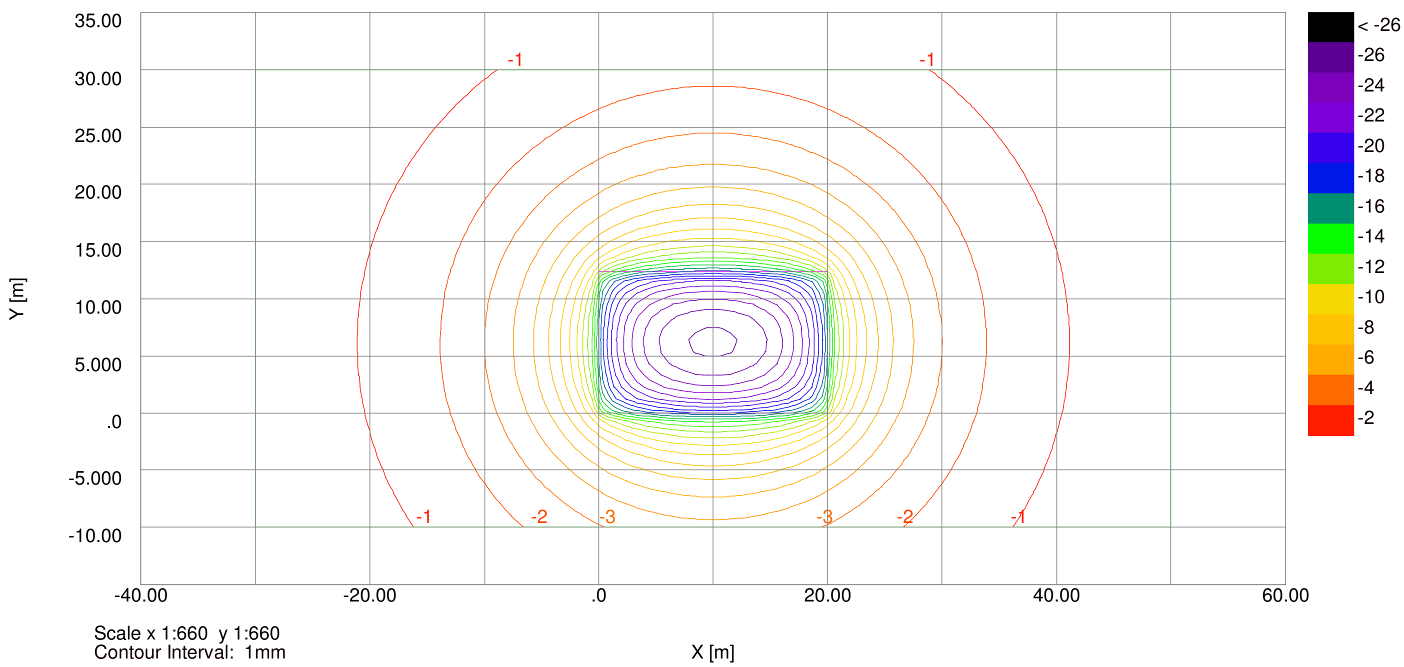
Contour Interval: 1mm

Settlement Contours : Grid 1 at 4.800m



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