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Your Ref:

Our Ref: **12/19442**
August 2012

36 HEATH DRIVE,

LONDON, NW3 7SD

REPORT ON A GROUND INVESTIGATION

Prepared for

Martin Redston Consulting Engineers

Acting on behalf of

Mr T Sanjay Wadhwani

Ref: 12/19442
August 2012

Report on a Ground Investigation

At

36 Heath Drive, London, NW3 7SD

For

Mr T Sanjay Wadhwani

1.0 INTRODUCTION

At the request of Martin Redston Associates, Consulting Structural Engineers to Mr T Sanjay Wadhwani, a ground investigation was carried out in connection with a proposed basement development at the above site. A Phase 1 Preliminary Risk Assessment was presented under separate cover in a Site Analytical Services Limited report (Project No. 12/19442-1) dated July 2012 and a basement impact assessment was also presented in a Site Analytical Services Limited report (Project No. 12/19442-2) dated August 2012.

The information was required for the design and construction of foundations and infrastructure for a new single storey basement together with 5 lightwells, rear and side extensions at ground and first floor, roof re-modelling and internal refurbishments. A study to assess whether any remediation was required for the protection of the end-user from the presence of potential contamination within the soils encountered was outside the scope of the present report.

Anticipated foundation loads for the proposed building are expected to be moderate and of the order of 100-150kN/m^2. Ground slab loadings are expected to be of the order of 10-15kN/m^2.

The recommendations and comments given in this report are based on the ground conditions encountered in the exploratory holes made during the investigation and the results of the tests made in the field and the laboratory. It must be noted that there may be special conditions prevailing at the site remote from the exploratory hole locations which have not been disclosed by the investigation and which have not been taken into account in the report. No liability can be accepted for any such conditions.

This report does not constitute a full environmental audit of either the site or its immediate environs.

2.0 THE SITE AND LOCAL GEOLOGY

(National Grid Reference: TQ 255 855)

2.1 Site Description

The site is situated on the east side of Heath Drive in the Frugal area of Hampstead, London, NW3 7SD and is currently occupied by a large detached two to three-storey residential property with a large rear garden and a double driveway at the front leading from a small curved access road on the east side of Heath Drive, which gives pedestrian access to Bracknell Gardens to the north-east.

The site is surrounded by large detached residential houses along both sides of Heath Drive and the general area is mainly residential in nature, although there are various retail outlets along the Finchley Road approximately 100m south of the site.

The site lies on ground sloping down to the south away from Hampstead Heath towards the Finchley Road, although the site itself is mainly flat and landscaped with the front driveway having a slight slope down from the house to Heath Drive with a drop in elevation of approximately 0.5m.

2.2 Geology

The 1:50000 Geological Survey of Great Britain (England and Wales) covering the area (Sheet 256, 'North London', Solid and Drift Edition) indicates the site to be underlain by Superficial Head deposits resting on the London Clay Formation. Deposits of the overlying Claygate Member are recorded as outcropping about 200m to the north on higher ground.

3.0 SCOPE OF WORK

3.1 General

The scope of the investigation was agreed by the Consulting Engineers and comprised:

- The drilling of two continuous flight auger boreholes to a depth of 12m below ground level (Boreholes 1 and 2).
- The placement of gas and groundwater monitoring standpipes to a depth of 5m below ground level in both of the boreholes.
- Sampling and in-situ testing as appropriate to the ground conditions encountered in the boreholes.

- Interpretative reporting on foundation options for the proposed building works and infrastructure.
- A study into the possibility of the presence of toxic substances in the soil, together with comments on any remediation required was outside the scope of the present investigation.

3.2 Ground Conditions

The locations of the boreholes are shown on the site sketch plan (Figure 1).

The exploratory holes revealed ground conditions that were generally consistent with the geological records and known history of the area and comprised between 0.25m and 1.40m thickness of made ground overlying materials typical of Superficial Head deposits resting on the London Clay Formation.

For detailed information on the ground conditions encountered in the boreholes, reference should be made to the exploratory hole records presented in Appendix A.

The made ground extended down to a depth of 1.40m in Borehole 1 and to a depth of 0.25m in Borehole 2 and generally consisted of a surface layer of topsoil underlain by a mixture of brick and concrete rubble and stiff to very stiff sandy silty clay with fine gravel, ashes and brick fragments.

The underlying natural material in Borehole 2 initially consisted of stiff mottled sandy clay with occasional fine to medium flint gravel that extended down to a depth of 1.60m below ground level, although this stratum was absent in Borehole 1 and may have been replaced by made ground.

These materials were followed by stiff becoming stiff to very stiff mottled silty clay with occasional partings of silty fine sand and occasional small gypsum crystals. These deposits represent weathered London Clay and extended to respective depths of 7.50m and 6.00m below ground level in Boreholes 1 and 2.

The underlying material comprised of stiff becoming very stiff fissured silty clay with occasional partings of silty fine sand, scattered gypsum crystals and water bearing clay stone nodules. These materials are typical of the more competent unweathered London Clay Formation and extended down to the full depths of investigation of 12.0m below ground level in Boreholes 1 and 2.

3.3 Groundwater

Groundwater was not encountered during boring operations in Borehole 1 and the material remained essentially dry throughout. Groundwater was encountered as a seepage at a depth of 11.00m below ground level in Borehole 2 and is likely to be associated with a claystone nodule which are often found to be water bearing.

It must be noted that the speed of boring is such that there may well be insufficient time for light seepages of groundwater to enter the boreholes and hence be detected, particularly within more cohesive soils of low permeability.

Groundwater was subsequently recorded at respective depths a depth of 2.44m and 2.01m below ground level in the monitoring standpipes installed in Boreholes 1 and 2 after a period of approximately four to five weeks. It is considered that this water level represents the accumulation of surface run-off from the higher ground around Hampstead Heath to the north-east of the site within the relatively permeable made ground and Superficial Head deposits perched on top of the virtually impermeable deposits of the London Clay present at depth.

Isolated pockets of groundwater may be present perched within any less permeable material found at shallower depth on other parts of the site especially within any made ground.

It should be noted that the comments on groundwater conditions are based on observations made at the time of the investigation (June and July 2012) and that changes in the groundwater level could occur due to seasonal effects and also changes in drainage conditions.

4.0 IN-SITU AND LABORATORY TESTS

4.1 In-Situ Tests

In the natural cohesive soils encountered at the site, in-situ shear vane tests were made at regular depth intervals in order to assess the undrained shear strength of the material and indicated that it was of a stiff becoming very stiff consistency with increasing depth below ground level.

In the made ground encountered in Borehole 1, a Mackintosh Probe test was made in order to assess the shear strength of the material based on the methods outlined by Stroud and Butler and the normally accepted correlation as follows:

Mackintosh N75 X 0.38 = SPT 'N' Value

Or

Mackintosh N300 X 0.1 = SPT 'N' Value

The results of the in-situ tests are shown on the appropriate exploratory whole records contained in Appendix A.

4.2 Classification Tests

Atterberg Limit tests were conducted on six selected samples taken from the cohesive natural soils in Boreholes 1 and 2 and showed the samples tested to fall into Classes CH and CV according to the British Soil Classification System.

These are fine grained silty clay soils of high and very high plasticity and as such generally have moderate bearing and settlement characteristics, have a low permeability and a high susceptibility to shrinkage and swelling movements with changes in moisture content, as defined by the NHBC Standards, Chapter 4.2. The results indicated Plasticity Index values between 40% and 48% with all samples being at or above the upper 40% boundary between soils assessed as being of medium swelling and shrinkage potential and those assessed as being of high swelling and shrinkage potential.

The test results are given in Table 1, contained in Appendix B.

4.3 Sulphate and pH Analyses

The results of the sulphate and pH analyses made on two natural soil samples are presented on Table 2, contained in Appendix B. The results show the natural soil samples to have water soluble sulphate contents of up to 1.41g/litre associated with slightly acidic to near neutral pH values.

4.4 In-situ Rising Head Permeability or Soakage Tests

In order to assess the soil infiltration characteristics of the natural superficial soils at the site, an in-situ rising head permeability test was carried out in Borehole 1 using a combination of the methods detailed in Building Research Establishment Digest 365:1991 and British Standard 5930:1981.

4.5 Gas and Groundwater Monitoring Results

The standpipes installed in Boreholes 1 and 2 were monitored for gas and groundwater levels over a period of approximately four to five weeks and the results are presented on Tables 3, 3a and 3b contained in Appendix B.

The groundwater level measurements indicate that the groundwater level has stabilised after a period of about four to five weeks at respective depths of 2.44m and 2.01m below ground level in the monitoring standpipes installed in Boreholes 1 and 2. It is considered that this water level represents the accumulation of surface run-off emanating from the base of the Claygate Member recorded about 200m north of the site on the higher ground around Hampstead Heath accumulating within the relatively permeable made ground and superficial deposits perched on top of the virtually impermeable deposits of the London Clay present below.

4.5.1 Methane

Methane is a flammable asphyxiating gas, the flammable range being 5 to 15% by volume in air. If such a methane-air mixture is confined in some way and ignited it will explode. The 5% by volume concentration is termed the lower explosive limit (LEL). Methane is a buoyant gas having a density about two-thirds that of air.

Various guidelines have been published to help determine mitigation measures for landfill gas. `Landfill Gas' includes gas which may be generated in natural soils such as organic alluvium peat. Methane presents an explosion and asphyxiant hazard.

Building Research Establishment Report BR212 `Construction of New Buildings on Gas-Contaminated Land', states that if Methane concentrations in the ground are unlikely to exceed 1% by volume and a house or small building is constructed in accordance with its recommendations, then no further protection is required. The recommendations include installing granular under slab venting and sealing floor slabs.

CIRIA Report C665 (2007) "Assessing risks posed by hazardous ground gases to buildings" provides guidance on the monitoring and control of landfill gas. The report suggests a classification system which is summarised in Table 8.5 in the document and employs a method which uses both gas concentrations and borehole flow rates to define a characteristic situation for a site based on the Gas Screening Value (also named the limiting borehole gas volume flow) for methane and carbon dioxide.

4.5.2 Carbon Dioxide

Building Research Establishment Report BR212 `Construction of New Buildings on Gas-Contaminated Land', 1991 states that if carbon dioxide concentrations are above 1.5% by volume then protection should be considered to prevent gas ingress. If concentrations exceed 5% by volume, such protective measures are required. This has been superseded by CIRIA Report C665 (2007), states that if carbon dioxide concentrations are above 5% by volume then protection should be considered to prevent gas ingress.

Carbon Dioxide is a non-flammable toxic gas, which is about 1.5 times as heavy as air and is an asphyxiant hazard.

4.5.3 Carbon Monoxide

The occupational exposure standards for carbon monoxide are 30 pap for long term exposure (8 hours calculated from the HSE Guidance Note EH40, 1991) and 200 pap for short term exposure (15 minutes calculated from the HSE Guidance Note EH40, 1991) (CIRIA Report C665).

4.5.4 Hydrogen Sulphide

Hydrogen sulphide is toxic at low concentrations. The occupational exposure standard for hydrogen sulphide is 10 paps for 8-hour time weighted average reference period and 15 paps for short-term exposure (10 minutes reference period) (HSE Guidance Note EH40, 1991).

4.5.5 Results

The Gas Screening Value is calculated as follows:

The Gas Screening Value (litres of gas per hour) = maximum borehole flow rate (l/h) x maximum gas concentration (%)

On-site monitoring has shown emissions of methane in air of 0.0% and carbon dioxide in air of up to 2.5% recorded during the monitoring visits. The maximum borehole flow rate was 0.0 l/h.

As such the Gas Screening Value for methane at site is 0.0 l/h and the Gas Screening Value for carbon dioxide at site is also 0.0 l/h. As such the worst case value for the site would be less than 0.01 litres of gas per hour.

Carbon monoxide and Hydrogen Sulphide were not detected above the detection limits of the gas monitoring instrument in the boreholes monitored during the monitoring programme.

These results equate to a Characteristic Situation 1, which requires no special precautions at site.

Employing the NHBC `traffic light' characterisation system, the site would be classified as Green in accordance with CIRIA Report C665. Table 8.7 using the Gas Screening Value for methane and carbon dioxide and as such gas prevention measures would not be considered necessary for the site.

For further information on design and construction details, discussions should be sought with a specialist contractor. Guidance may also be obtained from the BRE Report BR212 'Construction of New Buildings on Gas-Contaminated Land' and CIRIA Report C665 (2007). It may also be prudent to contact the local Environmental Health Officer in order to comply with the Local Authority requirements.

5.0 FOUNDATION DESIGN

5.1 General

It is proposed to construct a new single storey basement to approximately 3.30m below ground level beneath the existing property at 36 Heath Drive, London, NW3 7SD, together with 5 light wells, rear and side extensions at ground and first floor, roof re-modelling and internal refurbishments. Exact details of the finalised structure, layout and loadings were not available at the time of preparation of this report, although foundation loads are expected to moderate and of the order 100-150kN/m^2, whilst ground slab loadings are expected to be of the order of 10-15kN/m^2.

5.2 Conventional Spread Foundations

A result of the inherent variability of uncontrolled fill, (Made Ground) is that it is usually unpredictable in terms of bearing capacity and settlement characteristics. Foundations should therefore, be taken through any made ground and either into, or onto a suitable underlying natural strata of adequate bearing characteristics.

Based on the ground and groundwater conditions encountered in the boreholes, it should be possible to support the proposed new development on conventional basement raft foundations taken down below the made ground and any weak superficial soils and placed in the stiff weathered London Clay deposits encountered at a depth of about 1.10m below existing ground level.

Such foundations placed within natural soils may be designed to allowable net bearing pressures of the order of 200kN/m^2 at 2.00m depth increasing linearly to about 250kN/m^2 at 3.00m depth in order to allow for a factor of safety of about three against general shear failure.

Any soft or loose pockets encountered within otherwise competent formations should be removed and replaced with well compacted granular fill.

In addition, foundations may need to be taken deeper should they be within the zones of influence of either existing or recently felled trees and any proposed tree planting. The depth of foundation required to avoid the zone likely to be affected by the root systems of trees is shown in the recommendations given in NHBC Standards, Chapter 4.2, April 2003, "Building near Trees" and it is considered that this document is relevant in this situation.

5.3 Piled Foundations

In the event that the use of conventional spread foundations proves either impracticable or uneconomical due to the size and depth of foundation required, a piled foundation will be required. In these ground conditions, it is considered that some form of bored and in-situ cast concrete piled foundation with reinforced concrete ground beams should prove satisfactory.

The construction of a piled foundation is a specialist activity and the advice of a reputable contractor, familiar with the type of soil and groundwater conditions encountered at this site should be sought prior to finalising the foundation design. The actual pile working load will depend on the particular type of pile chosen and method of installation adopted.

To achieve the full bearing value a pile should penetrate the bearing stratum by at least five times the pile diameter.

Where piles are to be constructed in groups the bearing value of each individual pile should be reduced by a factor of about 0.8 and a calculation made to check the factor of safety against block failure.

Driven piles could also be used and would develop much higher working loads approximately 2.5 to 3 times higher than bored piles of a similar diameter at the same depth. However, the close proximity of adjacent buildings will in all probability preclude their use due to noise and vibration.

5.4 Retaining Walls

It is proposal to construct a new basement at the site together with five light wells at the rear and side extensions at ground and first floor, roof re-modelling and internal refurbishments. Exact details of the structure, layout and loadings were not available at the time of preparation of this report.

The results of the investigation indicated that made ground occurs to a depth of up to 1.40m below existing ground level. This is followed by stiff becoming very stiff clay deposits down to a depth of at least 12.0m below ground level. The general groundwater level beneath the site lies at a depth of about 2.0m below existing ground level.

Retaining walls should generally be designed as self-supporting cantilevered retaining walls. The excavations for a basement must not affect the integrity of adjacent structures and therefore will need to be supported. Two forms of support could be considered, these being temporary works i.e. sheet piling which could be removed after the earth retaining walls have been constructed or as permanent works incorporated into the final design.

Generally, cantilevered piled walls have an open face to embedded ratio of about one to two, i.e. a supported face three metres in height would require a penetration into the ground of about six metres below the base of the excavation. Should the piled retaining wall be purely an unsupported cantilever, then it is likely that quite deep section sheet piles or large diameter bored piles would be required.

The section of the sheet or the diameter of the piles could be reduced by installing a braced waling to the wall. Piles placed as part of the permanent works would be propped by the roof to the basement and would not be acting purely as a cantilevered support in the long term.

To reduce the likelihood of loss of ground if a sheet piled wall was adopted when removing the sheets, it is considered that the sheet piles should be incorporated into the final wall design. Assuming that the earth retaining wall will be propped, i.e. have its base slab and first floor slab cast in place soon after excavation, it is unlikely that full, if any, earth pressures will act on the wall while it is not propped. The greatest force acting on the wall, in the short term, is likely to be from the hydrostatic head should water percolate and be retained to the rear of the earth retaining structure.

Given the unknown depth of the proposed basement (and therefore unknown founding material), the design parameters for each element of soil recorded in the relevant exploratory holes are provided in Table A below. The depth of pile penetration can be calculated once structural details of the proposed basement are known.

Founding Material	Depth to top (m)	Description	Critical Angle of Shearing Resistance (°) (Φ'_{crit})[1]	Coefficient active pressure (Ka)	Coefficient passive resistance (Kp)
London Clay	1.40 to 1.60	Stiff becoming very stiff silty CLAY	21	0.45	2.2

Table A. Summary of design parameters for proposed basement foundation

Notes:

1. Calculated using guidance from BS8002

2. As the depth and structural details of the proposed basement are unknown these values should be used as guidance only.

The main phase of uplift or heave will come immediately following the excavation of the basement when the greatest elastic rebound of the soil (caused by the loss of the overburden pressure) will occur. Heave can be reduced by proceeding with the excavation in stages and observing and recording any movement that occurs over a set period of time. It may therefore be advantageous to delay the construction until an adequate proportion of the uplift has occurred. Once this monitoring period has elapsed and a suitably qualified engineer is confident that the majority of uplift has occurred, basement construction can commence.

Should a basement raft foundation be adopted, then there is also a potential for some total and differential settlement and consequently the foundation should be constructed on a 300mm thick proof rolled layer of gap graded granular fill and be of a sufficient stiffness to be capable of allowing for a minimum of two linear metres loss of support. Any service entry and exit points should be designed to accommodate settlement by the use of sealed flexible joints.

These processes and other ways of dealing with ground movements are described at length in BS8004 (British Standard Code of Practice for Foundations).

5.5 Basement Floor Slab

Due to the potential for swelling within the natural cohesive soils it is recommended that the ground slabs should be designed as being fully suspended.

5.6 Excavations

Shallow excavations for foundations and services are likely to require nominal side support in the short term and groundwater is unlikely to be encountered in significant quantities once any accumulated surface water within the made ground has been removed. Deeper and longer excavations below approximately 1.5m below existing ground level will require close side support and some inflows of groundwater are likely to be encountered.

The results of the in-situ permeability test indicated the apparent permeability of the materials at the site to be of the order of 2.4×10^{-7} m/sec, assuming that the cohesive soils are effectively impermeable This value lies approximately midway in the range of published data for fissured and weathered clays and / or silty sands and is classed as very low to low permeability material of poor drainage characteristics.

Consequently, this value should be adopted for the design of any proposed dewatering system.

Normal safety precautions should be taken if excavations are to be entered.

5.7 Chemical Attack on Buried Concrete

The results show the natural soil samples to have water soluble sulphate contents of up to 1.41g/litre associated with slightly acidic to near neutral pH values.

In these conditions, it is considered that deterioration of buried concrete due to sulphate or acid attack is likely to occur unless precautions are taken. The final design of buried concrete according to Tables C1 and C2 of BRE Special Digest 1:2005 should be in accordance with Class DS-2 conditions.

In addition, segregations of gypsum were noted within the London Clay and scattered small gypsum crystals were also noted at depth. Consequently, it is considered that any buried concrete at depth may be attacked by such sulphates in solution and that it would be prudent to design any such deep buried concrete in accordance with full Class DS-2 conditions.

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Site Analytical Services Ltd.		REF: 12/19442
LOCATION: 36 Heath Drive, Hampstead, London NW3 7SD		FIG: 1
TITLE: Site Sketch Plan	DATE: June 2012	SCALE: NTS