

6. GROUND INVESTIGATION

6.1 Introduction

Two phases of ground investigation works have been undertaken at the site by Ashdown Site Investigation Ltd.

The initial phase of ground investigation comprised the drilling of dynamic sampler boreholes during February 2017 for the purposes of performing infiltration tests and to facilitate the installation and monitoring of groundwater standpipes.

The recent ground investigation works comprised the drilling of a second series of dynamic sampler boreholes, together with accompanying in-situ geotechnical testing including in-situ testing adjacent to the previously drilled boreholes. The current fieldwork was carried out between the 9th and 13th July 2018.

The exploratory hole locations from both phases of ground investigation are shown on Figure 2.

Descriptions of the strata encountered and comments on groundwater conditions are shown in the exploratory hole records given in Appendix F, together with notes to assist in their interpretation.

6.2 Exploratory Holes

6.2.1 Dynamic Sampler Boreholes

Eight boreholes, designated WS101 to WS108, were drilled during the current phase of works to depths of either 1.00m or 3.00m below ground level. Previously six boreholes were excavated across the site area; three boreholes (WS01 to WS03) were each drilled to a depth of 3.00m below ground level and a further three boreholes (BH01 to BH03) were drilled to depths of between 11.00m and 12.00m below ground level adjacent to the respectively numbered shallow boreholes (BH01 adjacent to WS01, et cetera).

The boreholes were formed by a series of 1.0m long, open ended, hollow steel tubes of up to 100mm diameter, each containing a removable plastic liner. The tubes, progressively reducing in diameter, were driven into the ground by means of a track-mounted drop weight. Each tube was extracted from the ground using a hydraulically operated jack and the enclosed sample was recovered in its plastic liner.

The system enables the recovery of sub-samples to be taken for detailed examination and laboratory testing.

6.3 Sampling

Disturbed samples of soil were taken at the depths shown in the exploratory hole records and were collected in plastic bags, plastic tubs or amber jars fitted with gas tight lids.

On collection the amber jars were stored in cool boxes with cooling blocks to maintain temperatures below 4°C until transferred to refrigerators upon return to the office and subsequently forwarded to the external accredited chemical testing laboratory.

6.4 In-situ Testing

The depths of in-situ testing, together with the test results, are either given on the exploratory hole records or are summarised separately in Appendix F.

6.4.1 DPSH Dynamic Probe (Super Heavy) Testing

Continuous dynamic probe tests were undertaken adjacent to boreholes WS102 to WS104, together with additional testing (DP101 to DP103) adjacent to the previously drilled boreholes BH01 to BH03. The tests were conducted to depths of between 5.00m and 10.00m below ground level using a super heavy DPSH-B⁵ probing geometry.

The DPSH-B configuration is similar to that of the standard penetration test (SPT); the main differences being that the tip comprises a 90° cone, the driving rods are lighter than those used for SPT testing and the blow counts are recorded over 100mm increments rather than 300mm, as is the case for the SPT.

The blow counts recorded and the calculated dynamic point resistances, which account for inertia of the anvil and driving rods, are presented on the borehole records and separately in Appendix F.

6.4.2 Undrained Shear Strength

During the second phase of ground investigation undrained shear strength determinations were made in-situ within the fine-grained soils using a Geonor hand shear vane.

Additionally, undrained shear strength determinations were made within samples of the fine-grained soils held in the dynamic sampler liners using a hand penetrometer.

6.4.3 California Bearing Ratio Tests

Testing to determine the in-situ California Bearing Ratio (CBR) of soils was conducted at shallow depths adjacent to boreholes WS101 to WS108, and dynamic probes DP101 to DP103 using a Transport Research Laboratory (TRL) cone penetrometer.

6.5 Installations

Groundwater monitoring standpipes were installed to depths of between 10.00m and 12.00m below ground level in boreholes BH01 to BH03 during the initial ground investigation.

Groundwater dataloggers were installed within the boreholes on 13th February 2017 and collected on 2nd March 2017. The dataloggers were programmed to collect readings at 15 minutes intervals. The results of the groundwater monitoring are presented in Appendix F.

⁵ As defined by BS EN ISO 22476-2:2005.

6.6 Laboratory Testing

Laboratory testing was scheduled by Ashdown Site Investigation Ltd. Results from the laboratory tests are provided in Appendix G.

6.6.1 Geotechnical Testing

Geotechnical testing was undertaken by Ashdown Site Investigation Ltd in accordance with the methods given in BS1377⁶. Chemical testing to enable classification of the chemical environment of soils in accordance with BRE SD1⁷ was undertaken by an external UKAS accredited laboratory.

6.6.2 Chemical Testing

Chemical testing of selected samples was undertaken by a laboratory with recognised (UKAS and MCERTS) accreditation for quality control.

⁶ BS1377:1990 Parts 1 to 8, Methods of test for soils for civil engineering purposes.

⁷ BRE Special Digest 1:2005 Concrete in Aggressive Ground.

7. GROUND CONDITIONS

7.1 Stratigraphy

7.1.1 Surface Covering

The borehole records indicate the presence of a shallow but laterally discontinuous thickness of topsoil at the site.

7.1.2 Made Ground

Made ground, generally comprising slightly gravelly slightly sandy clay, was recorded to depths of between 0.30m and 1.10m below ground level. The gravel fraction comprised variable quantities of brick, chalk, flint, charcoal-like material, bituminous-like material and wood.

The thickness of these anthropogenic soils appeared to generally increase slightly towards the southern end of the site.

7.1.3 London Clay Formation

Underlying the made ground/surfacing, the investigation progressed into undisturbed stiff, becoming very stiff with depth, locally gravelly, clay deposits which persisted to the full depth of the majority of boreholes and to depths of between 3.00m and 5.00m below ground level within the deep boreholes (BH01 to BH03).

These soils are considered to mainly represent the London Clay Formation deposits indicated to be present on the published geological map, though in places the uppermost part of this stratum in the southern part of the site may be representative of Head deposits.

7.1.4 Lambeth Group

Underlying the London Clay Formation, the deep boreholes progressed into undisturbed very stiff clay deposits and dense sand deposits to the full depth of the ground investigation at 12.00m below ground level.

These soils are considered to represent deposits of the Lambeth Group deposits expected to underlie the London Clay Formation deposits at this site.

7.2 Stability

Each of the exploratory holes was recorded to remain stable during the course of drilling.

7.3 Groundwater Conditions

Previously (R17-11936, March 2017) the dataloggers installed in boreholes BH01 and BH02 recorded the equilibrium groundwater table at depths of between approximately 2.00m and 2.50m, in the northern (BH01) and central (BH02) parts of the site, rising above this level to close to surface during rainfall events around the 27th of February. A further two rainfall events are shown as peaks on the 3rd and 5th March. During the current phase of works, with the

R18-13087

exception of borehole WS101, all of the new exploratory holes were recorded as dry on completion. It is considered that the groundwater recorded to lie at 0.60m depth in WS101 on completion of drilling is likely to originate from the made ground soils.

8. GEOTECHNICAL ASSESSMENT

The geotechnical assessment has been prepared in connection with the development proposals shown on the drawing included in Appendix A.

In summary the proposed development is understood to comprise the erection of nine new dwellings with associated garages, private gardens and access road.

At the time of writing, no details were available concerning the specific loads likely to be applied to the foundations.

8.1 Foundations

8.1.1 Soil Shrinkage/Heave Potential

The fine-grained soils of the London Clay Formation deposits have been classified as clays of low/intermediate to very high plasticity and with plasticity indices in the range of 19% to 55%, the soils may be expected to exhibit up to a high volume change potential.

It is recommended that the design of precautions against shrinkage and heave for any new foundation system (spread footings, piles, pile caps and ground beams etc.) should assume a high volume change potential for the fine-grained Head/London Clay Formation soils and take into account current guidance such as that given by the Building Research Establishment (BRE)⁸ or the National House Builders Council (NHBC)⁹.

Whilst this report has been prepared to provide advice to assist designers in undertaking detailed design, the report itself does not represent a detailed design statement. It is recommended that an arboricultural survey of the site should be conducted to establish the species and maturity of the existing trees in the areas of the proposed new buildings. The survey should be extended to include a review of historical photographs and detailed site plans (if available) to establish the species and location of any felled trees that may affect foundation design. The information obtained from the arboricultural survey, information on proposed planting schemes and the findings of this report should be provided to the structural engineer responsible for the detailed design of foundation systems, including assessment of minimum founding depths for spread foundations, requirements for sleeving or reinforcing of piled foundations and requirements for placement of void formers et cetera.

8.1.2 Spread Foundations

8.1.2.1 Foundation Depths for Spread Foundations

Foundations should be constructed so as to bear below soils that are likely to be affected by significant soil volume changes caused by seasonal changes in moisture content in order to avoid damage to foundations that could otherwise arise. In addition, all made ground should be regarded as being variable in nature and state of compaction and, as such, unsuitable as a founding medium for shallow footings. New footings should be constructed so as to bear below made ground / disturbed natural soils and soil subject to seasonal soil volume changes, whichever is the deeper, and onto undisturbed, competent, natural deposits.

⁸ www.bre.co.uk : BRE Digests 240, 241 and 242, Low rise buildings on shrinkable clay soils, parts 1, 2 and 3; and BRE Digest 298, The influence of trees on house foundations in clay soils and BRE Digest 412, Desiccation in clay soils.

⁹ <http://www.nhbc.co.uk/> : NHBC Standards, Chapter 4.2.

Summary guidance on suitable minimum foundation depths to protect against the effects of seasonal soil volume changes is presented in the table below but designers undertaking detailed design of foundations should follow the detailed guidance such as that provided within Chapter 4.2 of the NHBC Standards.

Table 8. Indicative Minimum Foundation Depths

Tree Type	Water Demand of Tree	Tree Distance to Tree Height Ratio (D/H)									
		0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.80	1.00	1.25
		Minimum Foundation Depth Required in High Volume Change Potential Soils (m)									
Broad Leaf	High	†					2.50	2.30	1.90	1.50	1.00*
	Moderate	2.40	2.25	2.05	1.85	1.65	1.50	1.30	1.00*	1.00*	1.00*
	Low	1.80	1.65	1.50	1.35	1.20	1.00*	1.00*	1.00*	1.00*	1.00*
Coniferous	High	†			2.20	1.80	1.40	1.00*	1.00*	1.00*	1.00*
	Moderate	2.40	2.00	1.60	1.20	1.00*	1.00*	1.00*	1.00*	1.00*	1.00*

* Minimum foundation depth required to protect against soil volume changes.

† Foundations deeper than 2.50m require specialist design to protect against soil volume changes.

Details on the water demand and mature height of common trees is given within Table 3 of Chapter 4.2 of the NHBC standards which should be referred to when assessing minimum foundation depths required for the proposed development. A summary is provided in the table below.

Table 9. Indicative Summary of Water Demand and Mature Height of Common Trees

Tree Type	High Water Demand		Moderate Water Demand		Low Water Demand	
	Tree	Height (m)	Tree	Height (m)	Tree	Height (m)
Broad Leaf	Elm	18 – 24*	Acacia	18	Birch	14
	Oak	16 – 24*	Alder	18	Elder	10
	Poplar	15 – 28*	Apple	10	Fig	8
	Willow	16 – 24*	Ash	11 – 23*	Hazel	8
	Eucalyptus	18	Laurel	10	Holly	12
	Hawthorn	10	Beech	20	Honey Locust	14
			Blackthorn	8	Hornbeam	17
			Cherry	8 – 17*	Laburnum	12
			Chestnut	20 – 24*	Magnolia	9
			Lime	22	Mulberry	9
			Maple	8 – 18*	Tulip Tree	20
			Pear	12		
			Plane	26		
			Plum	10		
			Sycamore	22		
			Tree of Heaven	20		

Tree Type	High Water Demand		Moderate Water Demand		Low Water Demand	
	Tree	Height (m)	Tree	Height (m)	Tree	Height (m)
Coniferous			Walnut	18		
			Whitebeam	12		
	Cypress	18 – 20*	Cedar	20		
			Douglas Fir	20		
			Larch	20		
			Monkey Puzzle	18		
			Pine	20		
			Spruce	18		
			Wellingtonia	30		
			Yew	12		

* Dependent on particular species.

8.1.2.2 Bearing Capacity for Spread Foundations

For design purposes, a net allowable bearing capacity of 150kN/m² may be assumed for spread (pad or strip) foundations up to 1.5m across bearing within the London Clay Formation soils of at least stiff consistency. The quoted bearing capacity is expected to limit settlement to less than 25mm.

8.1.3 Piled Foundations

Consideration could be given to supporting the proposed development on piled foundations, which could be sleeved to minimise the risk of damage through soil shrinkage/heave.

It is considered that the London Clay Formation deposits and underlying Lambeth Group soils would provide support to piled foundations by a combination of side adhesion (skin friction) and end bearing.

The proven ground conditions would indicate that bored piles could be employed to provide a suitable foundation solution. However, the method of installation would have to accommodate the presence of groundwater at relatively shallow depth. In addition, the selection of piling techniques should consider access constraints applicable to particular plant and potential vibration effects on existing services, structures and roadways.

Depending on the method employed it is considered likely that driving displacement (driven) piles through the stiff to very stiff soils of the London Clay Formation the very stiff and dense soils of the Lambeth Group may prove difficult.

For the purpose of this initial discussion and for reasons given above, consideration has been given to the adoption of bored piles, the use of which would prove beneficial as, this method enables temporary steel casing to be installed to stabilise the pile bore and a range of boring tools, including chisels, can be employed to progress pile bores through difficult ground. The use of bentonite slurry may be required where high groundwater pressures are encountered within sand horizons in order to avoid sand rising within the pile bore.