GROUND INVESTIGATION REPORT

ST. MARY'S COLLEGE

WALDEGRAVE ROAD

TWICKENHAM

Report Reference C10832

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MICHAEL BARCLAY PARTNERSHIP

CONSULTING ENGINEERS

REPORT ON A GROUND INVESTIGATION

AT

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WALDEGRAVE ROAD

TWICKENHAM

Report Reference C10832 **February 2007**

INTRODUCTION

St. Mary's College, the client, intends to develop part of the college grounds, off Waldegrave Road, Twickenham. The proposals are for a new sports hall and support buildings. The loadings of the new buildings were unknown at the time of writing.

Ground Engineering was instructed by Michael Barclay Partnership, acting on behalf of the client, to carry out a ground investigation. The intrusive investigation was undertaken, at the locations specified by the Engineer, to obtain samples for geotechnical testing to enable foundation design and to obtain samples for chemical analytical testing to assist in assessing the presence of contamination on the site.

LOCATION, TOPOGRAPHY AND GEOLOGY OF THE SITE

The site is situated on the eastern side of Waldegrave Road, Twickenham within the south-western corner of the grounds to St. Mary's College. The site location is shown on Figure 1, the site location plan and is located at approximate National Grid Reference TQ 158 722.

The site is a broadly rectangular shape, approximately 100m long, in an east to west direction, and approximately 60m wide in a north to south direction.

The site was unoccupied at the time of the ground investigation but had been used until immediately before the ground investigation as an overflow car park for the college. The main part of the site was covered with hardcore.

The eastern part of the site was occupied by the western end of an existing sports hall. The southern site boundary was formed by hedges and fences of private rear gardens. The western site boundary was demarcated by Waldegrave Road, with trees alongside. The northern site boundary was marked by temporary wooden fencing with trees and turfed areas of the College grounds beyond.

Access to the site was off Waldegrave Road to the west of the site and around the one-way system of the college to the north. The site was flat-lying and generally level with a very gradual slope up to the east. The spot heights on the drawings provided by the client show reduced levels for the site of 10.50mOD on the western part of the site and 11.00mOD on the eastern part of the site.

The River Thames is approximately 500m to the east of the site.

The 1998 geological map of the area, Sheet 270, shows that the site is underlain by Kempton Park Gravel, with possible Langley Silt, which covers the gravel to the east, over the solid geology of the London Clay Formation. The Upper Chalk is present at depth.

SITE WORK

The site work was undertaken on 2 and 3 January 2007 and consisted of two boreholes and four trial pits at locations specified by the Engineer. One of the trial pits, TP2, was used to undertake a soakaway test and trial pit TP4 was a foundation inspection pit to expose the foundations of the existing sports hall. The locations of the exploratory holes are shown on the enclosed exploratory hole location plan, presented as Figure 2.

Prior to undertaking the exploratory holes, the locations were scanned for services using a CAT scanner and a starter pit was dug to 1.20m depth at the borehole and trial pit locations, to confirm the absence of buried services.

Cable Percussive Boreholes

The boreholes were advanced using weighted claycutter tools, working initially within 150mm diameter casing. Representative small and bulk disturbed samples of soil were taken from the boring tools at regular intervals throughout the boreholes, which were completed at depths of 12.00m and 15.00m. A groundwater sample was obtained from both boreholes.

Undisturbed samples of 100mm in diameter were taken in the clay at regular intervals. The ends of the samples were waxed to maintain them in as representative condition as possible during transit to the laboratory.

A standard penetration test (SPT) was undertaken at regular intervals within the granular strata to give an indication of the in-situ relative density of the material. The test was carried out by driving a 60° apex cone attachment, 50mm diameter, into the soil at the base of the borehole by means of an automatic trip hammer weighing 63.50kg falling freely through 760mm. The penetration resistance was determined as the number of blows required to drive the tool the final 300mm of a total penetration of 450mm into the soil ahead of the borehole.

Upon completion, borehole BH1 was backfilled with arisings.

On completion of borehole BH2 a 50mm diameter gas and groundwater monitoring standpipe was installed to 7.00m. The pipe was perforated from 7.00m depth to within 1.00m of ground level and the annulus backfilled with pea gravel. A bentonite seal was placed between ground surface and 1.00m depth and a gas tap fitted. A protective steel stopcock cover was concreted in place at ground level above the installation.

The borehole records, presented behind the figures, give the descriptions and depths of the various strata encountered, details of all samples taken and the groundwater conditions observed during boring, and on completion.

Trial Pits

A mechanical excavator (JCB) was used to undertake three of the trial pits, TP1, TP2 and TP3, which were advanced to depths of between 2.00m and 3.40m below ground level.

The strata exposed were logged and sampled by a geotechnical engineer. Small and large disturbed samples of soil were taken at regular intervals throughout the pit and placed in polycarbonate pots and plastic bulk bags pending geotechnical and chemical analytical testing.

In coarse grained strata in-situ measurements of probing resistance were undertaken using a hand operated dynamic probe (Mackintosh Probe) operated in accordance with manufacturer's instructions, with results recorded as resistance (measured as the number of blows) for a penetration of 0.30m, or as 100 blows for a stated penetration where this was less than 0.30m.

One soakaway test was performed within trial pit TP2 in accordance with BRE Digest 365 at a depth of 2.00m. For the test, water was added to the trial pits and the fall in the water level was measured relative to a datum over a period of up to 90 minutes. This was repeated three times, but during the second filling the trial pit collapsed at a depth of 0.80m. The second and third fillings were completed, but only the results from the first filling have been used in the permeability calculations presented as Appendix A.

Foundation Inspection Pit

One foundation inspection pit, TP4, was excavated using hand tools adjacent to the external north-facing wall of the existing sports building, to expose and inspect the foundations. The foundation inspection pit, TP4, was completed at a depth of 0.60m.

The strata exposed were logged and sampled by a geotechnical engineer. Small disturbed samples of soil were taken at regular intervals throughout the pit and placed in polycarbonate pots pending contamination testing.

In coarse grained strata in-situ measurements of probing resistance were undertaken using a hand operated dynamic probe (Mackintosh Probe) as discussed above.

Gas & Groundwater Monitoring

A return visit was made to monitor the standpipe on 17 January 2007. The levels of oxygen, carbon dioxide and methane gases were recorded using a GA94 gas analyser. Groundwater measurements were also recorded. The gas and groundwater level monitoring results are presented as Appendix B.

LABORATORY TESTING

The samples obtained were inspected in the laboratory and assessments of the soil characteristics have been taken into account during preparation of the exploratory hole records, which are presented behind the figures. The soils have been described in accordance with BS5930:1999. The results of the geotechnical testing are presented as Appendix C and the results of the chemical analytical testing are presented as Appendix D.

The index properties of one soil sample was determined as a guide to soil classification and behaviour. The liquid limit was determined by a cone penetrometer.

Test specimens were prepared at full diameter from selected undisturbed samples. Immediate undrained triaxial compression tests were undertaken on the samples under single confining cell pressures at a pressure equivalent to the overburden pressure at the depth from which the sample was taken. The moisture content and bulk density, of each specimen, were also determined.

The particle size distribution of selected samples of sand and gravel were obtained by sieve analysis. The results of these tests have been presented as particle size distribution curves in Appendix C.

Selected samples of soils were analysed to determine the concentration of soluble sulphates. The pH values were also determined using an electrometric method.

Four soil samples and two groundwater samples were tested for total concentrations of arsenic, cadmium, chromium, lead, mercury, nickel, selenium, phenols and benzo[a]pyrene (the CLEA suite), together with speciated polyaromatic hydrocarbons (PAH), boron, copper and zinc, total and free cyanide, total sulphate, sulphide and pH. The soil organic matter of the soil samples was also determined.

GROUND CONDITIONS

The investigation proved a surface cover of made ground between 0.10m and 1.20m thick over Langley Silt and Kempton Park Gravel. The Langley Silt was only encountered in one of the exploratory holes. Beneath the made ground and Langley Silt, the Kempton Park Gravel was present at depths of between 0.10m and 1.80m beneath which was the solid geology of the London Clay Formation at depths of 6.20m and 6.40m. The base of the London Clay Formation was not encountered by the boreholes which were completed at a maximum depth of 15.00m.

Groundwater was observed at depths of 3.00m and 3.10m in two of the trial pits. Addition of water during boring through the Kempton Park Gravel may have masked the groundwater strikes in the boreholes. During the monitoring visit of 17 January 2007 groundwater was recorded at a depth of 2.76m in borehole BH2.

Made Ground

Made ground was encountered from ground surface to a depth of between 0.10m (TP3) and 1.20m (BH1) below ground level.

In trial pits TP1, TP2, TP3, BH1 and BH2 there was a surface layer, between 0.02m and 0.30m thick, of brown and black or red brown mottled gravelly sand with gravel of ash, flint, quartzite and limestone. This formed the surface of the former car park. Below this surface layer the made ground was described as a black, red brown or dark grey, sandy gravel, gravelly sand or clayey sand and gravel. The gravel comprised clinker, ash, coal, limestone, concrete, brick and flint.

In the foundation inspection pit, TP4, the ground conditions were different from those described above. The upper 0.10m of made ground was described as a brown and orange brown, silty, sandy gravel of ash, flint and quartzite. A layer of yellow brown sand was present between 0.10m and 0.15m depth. Below this between 0.15m below ground level and the base of the inspection pit, at a depth of 0.60m, the made ground was described as a brown and orange, brown slightly gravelly, silty sand. The gravel comprised flint and quartzite.

Langley Silt

Langley Silt was encountered in one of the exploratory holes only, borehole BH2, on the north-eastern part of the site, between 1.10m and 1.80m depth.

The Langley Silt was described as a firm orange-brown and dark brown mottled, slightly gravelly, sandy clay. The gravel comprised flint and quartzite.

Kempton Park Gravel

The Kempton Park Gravel was encountered at depths of between 0.10m (TP3) and 1.80m (BH2). The Kempton Park Gravel was described as a dense, medium dense or very dense, becoming medium dense below 4.00m and 4.20m depth, orange-brown, slightly clayey or slightly silty, very sandy gravel or slightly gravelly, slightly silty sand, occasionally sand and gravel with rare flint cobbles. The gravel comprised flint, quartz and quartzite.

The base of the Kempton Park Gravel was encountered in the boreholes at depths of 6.20m and 6.40m, but was not encountered in the trial pits, which were completed at a maximum depth of 3.40m.

London Clay

The London Clay was encountered at depths of 6.20m (BH2) and 6.40m (BH1) and extended to the base of the boreholes, which were completed at depths of 12.00m (BH1) and 15.00m (BH2).

In borehole BH1 the upper 0.60m, between depths of 6.40m and 7.00m, the London Clay was reworked and described as a firm, dark brown, slightly gravelly clay with rare cobbles. The gravel and cobbles comprised flint.

At depth of 7.00m (BH1) and 6.20m (BH2) the London Clay was described as a firm or stiff, becoming stiff, locally very stiff, fissured below 6.20m and 8.45m depth, dark grey clay with fine sand or silt partings. Rare shell fragments were observed.

Groundwater

Groundwater was observed at a depth of 3.00m in trial pit TP1 and 3.10m in trial pit TP3. Trial pits TP2 and TP4 were dry.

Water was added to both the boreholes between depths of approximately 2m and 4m to assist drilling within the Kempton Park Gravel and probably masked the groundwater strike. After cessation of addition of water the standing water in the borehole was measured at depths of 3.20m (BH2) and 3.50m (BH1). After completion of boring, the boreholes were damp and after withdrawal of the casing the boreholes were dry. During the monitoring visit of 17 January 2007 groundwater was encountered at a depth of 2.76m within the installation in borehole BH2.

Roots

Live roots were generally observed to depths of between 0.60m and 1.70m. Live roots were not observed in TP1 and TP2.

Foundation Inspection Pit

One foundation inspection pit, TP4, was excavated to expose the foundations of the northern side of the existing sports hall present at the eastern end of the site. The foundation inspection pit showed a concrete footing at a depth of 0.40m below ground level. The concrete footing was 0.10m thick with a projection of 0.24m. The base of the concrete footing was met at a depth of 0.50m below ground level founding within made ground.

Evidence of Contamination

Based on inspection, the made ground contained ash, asphalt and rare clinker and coal fragments.

No olfactory or visual evidence of hydrocarbon contamination was detected within the soils beneath this site.

COMMENTS ON THE GROUND CONDITIONS IN RELATION TO FOUNDATION DESIGN AND CONSTRUCTION

The results of the intrusive investigation showed the presence of a surface layer of made ground up to 1.20m thick. Beneath the made ground, in one location Langley Silt was encountered. The made ground and Langley Silt were underlain by Kempton Park Gravel to depths of between 6.20m and 6.40m, below which was the solid geology of the London Clay.

It is recommended that foundations be taken through the made ground and Langley Silt and brought to bear on the underlying Kempton Park Gravel. The medium dense, Kempton Park Gravel at a depth of 1.20m would have an allowable bearing pressure of 250kN/m^2 for strip foundations up to 1.20m wide.

Traditional Foundations

The results of the intrusive investigation showed the presence of a surface layer of made ground up to 1.20m thick.

The results of the Atterberg Limits test on the sample of Langley Silt, recovered from borehole BH2 at a depth of 1.10m, showed a plasticity index of 10% which rates it as a soil of low shrinkage and heave potential. However it recommended that foundations be taken through the made ground and Langley Silt and brought to bear on the underlying Kempton Park Gravel.

The medium dense, locally dense and locally very dense, non-shrinkable, Kempton Park Gravel at a depth of 1.20m, locally 1.80m where the laterally non-persistent Langley Silt is present, has an allowable bearing pressure of 250kN/m^2 for strip foundations up to 1.20m wide for immediate settlement in the order of 25mm.

New foundations should be kept structurally independent from those of the adjacent building to prevent any damaging differential movements between them. If the new structure is to be tied in to the existing structure, then some form of movement joint should be incorporated.

The base of foundation excavations should be inspected on completion to ensure that the condition of the soil complies with that assumed in the design. Should pockets of inferior material be present, they should be removed and replaced with well graded hardcore or lean mix concrete. The excavated surface should be protected from deterioration and a blinding layer of concrete used where foundations are not completed promptly.

Floor Slab

The naturally deposited soils would be capable of providing support for a reinforced ground bearing slab to be used, providing that the sub-grade is inspected and well-compacted. Any soft, root infested or desiccated clay fill should be removed and replaced with well-graded, compacted, coarse grained fill material. However, some differential movement may occur across a slab, where it spans different soil types such as between the Langley Silt and Kempton Park Gravel.

Removal and replacement of foundations or slabs from any former buildings or structures that may have been present on the site will be required in order to eliminate the presence of 'hard spots'. Any such foundations should be grubbed out and replaced with suitably compacted coarse-grained material.

Foundation Excavations

The groundwater table is likely to fluctuate seasonally, but based on the groundwater levels found at the time of the investigation, excavations to depths of up to 2.50m below current ground level, should remain dry. However, care should be taken where foundation excavations approach the water table, since the founding stratum could be loosened or the excavation base fail. Inflows of groundwater from the Kempton Park Gravel are likely to be fast and may be accompanied by 'running sand' conditions. It is unlikely that pumping from screened sumps would cope with inflows. Based on the particle size distribution the Kempton Park Gravel has a permeability in the order of 2.9×10^{-4}m/s to 1.4×10^{-3}m/s. It would therefore be necessary to keep foundation excavations above the groundwater level.

Shallow foundation excavations required to reach the Kempton Park Gravel would not be expected to remain stable even in the short term. Excavation sides should be battered back where space permits and statutory safety precautions should not be neglected, with side support required for all excavations where personnel are to enter them. Similarly adequate side support will be necessary where excavations are adjacent to existing neighbouring structures and care should be taken to ensure that the foundations to such buildings are not undermined.

Drainage

The soakaway test was performed in trial pit TP2, within Kempton Park Gravel, at a depth of 2.00m below ground level. The results of the soakaway test gave an estimate of the soil infiltration rate (f) of 1.23 x 10^{-5}m/sec. Both sets of results rate the ground conditions as having a good drainage potential, based on BS8004:1986, which is typical of clean sands and sand and gravel mixtures. Should soakaway drainage be used then chambers should incorporate silt and leaf traps in their design to ensure the good infiltration rates do not deteriorate with time.

The Kempton Park Gravel may be susceptible to volume reduction or loss of fines, hence settlement, if inundated by storm or surface water. It is therefore important that large volumes of water, such as discharged in soakaways, are not allowed to infiltrate such strata close to the proposed buildings. Soakaways should therefore be placed a minimum distance of 5m from the proposed sports hall and any existing buildings.

Sulphate Conditions

Sulphate analyses on samples of soil yielded concentrations within Design Sulphate Class DS-1 of the appended BRE Special Digest 1 (2005), Table C2 presented in Appendix C. The pH values of the samples were 7.3 and 8.2 indicating alkaline conditions. Based on these results, an Aggressive Chemical Environment for Concrete (ACEC) Class of AC-1 should be adopted, when specifying a Design Chemical Class (DC Class) for buried concrete on this site, as detailed in the above document.

Sulphate analyses on samples of groundwater yielded concentrations within Design Sulphate Class DS-1 of the appended BRE Special Digest 1. The pH values of the samples were 7.3 and 7.4 also indicating alkaline conditions. Based on these results, an Aggressive Chemical Environment for Concrete (ACEC) Class of AC-1 is confirmed.

Geothermal Energy Source

A truly geothermal system relies on the radiogenic heat produced by deep granitic rock masses. However the terminology geothermal is also used to describe the heating and cooling systems which rely on the temperature difference within the earth produced by solar heating of the land mass.

The ground conditions beneath this site would not be suitable for the truly geothermal system, but most ground conditions are suitable for utilising the solar generated heat differences between superficial soils and those at depth.

The underlying geology of the site is not important as the system relies solely on the difference in ground temperature between surface soils which lose and gain heat quickly and the sub-surface souls which remain at broadly the same temperature throughout the year.

There are two types of system as follows:

- A network of pipes below the surface which cover a large area or
- Several deep pipes installed in bored holes which penetrate to greater depths.

A specific ground investigation would be required to assess the possible depth of installation of the bored holes and also to assess the temperature differences within the ground with respect to depth. A possible means of acquiring this information would be using Cone Penetration Test (CPT) rig to a depth of say 50m say with continuous temperature monitoring.

A geothermal heating and cooling specialist should be consulted for more detailed information on the appropriate system to use on this site and the method of investigation required.

The ground investigation could be undertaken at any time, but the installation of a proposed heating and cooling system would be more appropriate during or before the foundation construction for practical reasons.