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Technical review of ground conditions at Hall School, 23 Crossfield Road, London NW3 4NT Application No.2016/6319/P

Introduction

1. This review has been commissioned by Mr Anthony Kay, of 26 Crossfield Road, for the *Hall School Opposition Group*. Its purpose is to review the ground conditions and Basement Impact Assessment written for Hall School in support of an application for a basement extension at that site. Mr Kay and his neighbours are concerned by the possible affects this excavation will have on their properties, especially all the buildings to the south and east of the site.

2. I am a Chartered Geologist (C.Geol) and registered on the UK Register of Ground Engineering Professionals (RoGEP) at Advisor grade. I am also a Chartered member of the Institution of Water and Environmental Managers (C.WEM) and have over 40 years' experience in geology applied to ground engineering, with basements in London being a feature of the past 10 years. My cv is attached.

Summary

3. The Basement Impact Assessment fails to describe the situation with groundwater in the area around the site and its possible change resulting from ground deformations in response to excavating the basement. Many of the foundations for surrounding buildings are thought to be shallow and are likely to be sensitive to any settlement promoted by ground response associated with this work.

4. The upper levels of this ground are not so strong as to be of no concern; their strength and stiffness varies over the depth of the excavation with stiffness and insitu strength both changing around 7m below ground level. The implications of this should be considered in the numerical modelling and thought should also be given to appropriate instrumentation to monitor ground movement.

Basic geology

5. The site lies close to the centre line of the valley which runs broadly east-west between Hampstead to the north and Primrose Hill to the south, draining surface water derived from them to the former tributaries of the River Tyburn. A few metres below ground level London Clay is encountered but above it lies sediment that has probably been derived from hill wash flowing down from these areas of higher ground and settling out on the valley floor. A borehole not far from the site, at Winchester Road (available on the Borehole Portal Site of the British Geological Survey; BH BGS TQ28SE/1769) depicts this rather well with what are described as one to two metres of dark brown sandy soil and pale brown clay lying above the London Clay itself.

6. The basic geology of the site is thus relatively simple being, from the top down, ground disturbed by man (Made Ground) overlying soft mixtures of clay, silt and gravel which will have probably been transported into the area as mudflows in the geological past, sitting upon relatively undisturbed London Clay. A borehole (BH1) has been drilled at the site as part of the Basement Impact Assessment (BIA) for the application undertaken by Geotechnical & Environmental Associates Ltd. (GEA), to confirm the succession there. Relevant details from that borehole, together with

those of tests completed within it, and tests on samples taken from it, are illustrated in Fig.1. The elevation of ground level at the borehole is not recorded on the borehole logs but has been assessed from the Environment Agency LiDAR height data to be close to 56m OD. The borehole confirms the general geology described above and records a similar succession to that encountered at Winchester Road.

Mechanical properties

7. In Borehole 1 the strength of the ground changes with depth from "*Firm*" (an impression can be made with the thumb) to "*Stiff*" (can just about make an impression with the thumb) to "*Very Stiff*" (can be indented with a thumb nail), but this increase in strength does not occur in a linear way, and that usually reflects the geological history of the profile. In broad terms, the strength of the ground measured in-situ begins to increase at around 7m. The changes from ground level to 7m could be reflecting disturbance of the top section of the ground during the ice age when freezing and thawing repeatedly occurred for considerable periods; such treatment is capable of disturbing ground to depths of 10m and more. Below that, the ground appears to be relatively undisturbed.

8. Samples taken from the ground have strengths that tell a slightly different story; they suggest a fairly simple increase in strength with depth although reflect some change occurring in the gradient for this increase between 6.5m and 9.5m when they do not increase over 3m, so there is something here that is not straightforward. Sand partings were encountered at these depths in the clay recovered from BH1 and these can affect the strength of samples cut for laboratory testing, as the sample increases in volume on unloading causing the clay to suck water from the sandy horizons and soften. That may account for the reduction in the strength of laboratory samples seen over that interval.

9. Fig.1 also shows the approximate depths of the existing basement for Hall School and its proposed extension. A contiguous piled wall has been suggested for retaining the excavation to be created for the basement and its depth has yet to be confirmed. However, it is clear from Fig.1 that it is in areas where ground strength is changing that excavation will occur. Heave has been mentioned in the BIA as an inevitable consequence of excavation and its calculation may be affected by the change in strength of the clay, from *Stiff* to *Very Stiff*, which occurs around this level and by the presence of sand lenses, particularly if these are acting as local micro-aquifers within the clay capable if supplying groundwater that is able to flow at speeds greater than that through the surrounding clay.

Groundwater

10. The mechanical properties of ground are intimately related to presence and pressure of groundwater and here the BIA provides very little useable data. No water was encountered by BH1 when drilled (28th Oct 2015). An 8m standpipe was installed within it but was dry when inspected on two later visits (6th Nov and 4th Dec 2015); this is odd and requires explanation. Three further holes were made during the ground investigation for the BIA, two of which had 5m standpipes inserted to measure groundwater; they recorded water levels at around 2.5m (in Made Ground) and 1.2m (in Clay) below ground level. No details of the standpipe construction are given so it is not possible to know whether the Made Ground, in which readily available water is to be expected, has been sealed off. The investigators (Ground Engineering Associates) believe the standpipes were linking water in the Made

Ground above to that in the clay beneath and this is quite possible. However it leaves a number of questions relating to groundwater unresolved, as follows;

10.1 What is the nature of groundwater flow in the Made Ground and how might it be affected by the works proposed if the ground at depth moves and causes these superficial deposits to deform, changing the pore pressures within them and possibly creating an hydraulic connection linking the superficial deposits to the London Clay below, and with the excavation being dug within it?

10.2 What is the distribution of pressure head within the London Clay and its sand lenses, and how might this affect the stiffness and strength of the clay, and how might these change if an hydraulic pathway is created as described above?

10.3 How do both of these scenarios respond to rainfall?

11. It is common for a lack of water encountered during an investigation to be interpreted as an absence of water. There are a number of reasons why water is not encountered and they include the nature of the equipment used to detect it, the manner with which it was installed, the period over which measurements are made, and the fluctuation of water levels, as well as the absence of water. Water would be expected on this site as it sits in a valley and questions 10.1 to 10.3 above should be answered.

Made Ground

12. Made Ground is extremely difficult to describe; in many cases it is essentially a mixture of 95% or more of what was there before (grey/brown silty clay with gravel and rootlets) with 5% or less of anthropological debris, such as bricks, clinker and the like. The problem with describing this material is in identifying what it was like before being disturbed by man. That makes the task of attributing it to a likely geological process of transport and accumulation extremely difficult. It is probable that much of the Made Ground on this site originated as watery sediment deposited in the floor of the valley by flows down the hills to the north and south, to be locally reworked by streams when they flowed. Sand and/or gravel was encountered in all the holes, including that at Winchester Road, emphasising that this alluvial winnowing has probably left behind stringers of permeable sediment following anastomosing stream paths across the valley floor. This means the geology of the Made Ground is likely to be very variable, both horizontally and vertically and it is into this geology that many of the shallow foundations of properties neighbouring the school are likely to be located.

13. Borehole 1 also records that the clay immediately beneath Made Ground is blocky and this is a hall mark of desiccation. It is thus not surprising that newer properties in Crossfield Road are thought by some residents to be founded on piles. At the time of writing nothing is known about these but if present they are probably no longer than 3m. If they exist, their response to ground movement associated with the excavation of the basement would have to be considered.

14. Of the remaining boreholes (2, 3 and 4) only samples from hole 3 reflected a softening of the clay beneath the Made Ground with the clay being described as "*Soft*" (can be moulded between the fingers), although it is noted that it rapidly became Firm with depth. This suggests that the Made Ground, and in particular the sand and gravel layers and lenses within it, carry water in sufficient quantities to wet and soften the underlying clay.

15. These upper layers therefore need to be considered with care; they can desiccate and hydrate. Volumetric change with seasons would be expected and anecdotal evidence from residents suggests this is so. Under these circumstances the condition of drains and sewers is likely to be fragile with any break either encouraging drainage from the ground to them or permitting discharge from them to the ground. Either way, the mechanical properties of the ground will change and a ground response can be expected.

The BIA

16. The BIA completed by GEA provides a generally fair reflection of the ground with the exception of ground water, for which almost nothing is known, and ground strength; both these are needed to ensure that predictions from numerical modelling, of the magnitude and extent of ground movement associated with basement excavation, are based on realistic idealisations and assumptions.

17. It was not correct for the Screening of Groundwater (Section3.1.1 of the GEA report) to answer “No” to Question 1b; the basement will extend beneath the water table which will probably be in the Made Ground for most of the time. Likewise, it was not correct to answer “No” to Question 6, because the lowest point of the excavation is below local spring lines, which will be on the sides of the high ground to the north and south of the site. Ponds are not affected.

18. So, there are issues that the screening for Groundwater should have identified and further investigation for ground water needs to confirm the items 10.1 to 10.3 above. This requires monitoring over a period of at least one wet season and that should be initiated as soon as possible for background readings to be acquired.

19. With regard to strength, or more pertinently, to stiffness, a better understanding of the variations within depth in the upper 10m of the profile is justified as the largest changes that have been detected in strength and stiffness occur over that section. Simply taking conservative values for these parameters on the basis that if the predictions based on these are acceptable, then those for the actual values will be acceptable too, need not be correct logic; the difference in values and the distance over which they occur (i.e. the anisotropy of the ground) is also of relevance. A better basis for justifying the values used in the modelling should be provided to offer a reasonable basis for comparing measured movements from monitoring with those predicted.

20. The answer “No” to Q7 of the Stability Screening Assessment (Section 3.1.2 of the GEA report) does not sit comfortably with the description of “blocky fissuring” from 1.35m to 3.0m below ground level, seen in the core recovered BH 1. This suggests desiccation in the past and the natural moisture content at present is close to the Plastic Limit. Further, as mentioned earlier, some occupiers believe that the terrace to the south of the site of 9 houses (seven in Crossfield Road and two in Eaton Avenue), constructed in the 1960’s, may be built on piles, suggesting, if correct, that the designers knew of a propensity for settlement in the area. GEA acknowledge the ability of the ground to respond in this way but make no link to the experience of surrounding properties and restrict their comments to the site itself.

21. If the 1960’s terrace at the corner of Crossfield Road and Eaton Avenue is founded on piles and ground at depth below them moves, then the effects of that movement on the piles should also be considered.

22. GEA then identify three "issues" from these screening assessments which they believed needed scoping with the aid of further investigations, of which Borehole 1 and the other invasive investigations were part. None of GEA's issues cover the points identified in this report.

Conclusions

23. The BIA needs to provide further information on ground water and ground stability, both of which have the potential at his site of causing short term and long term problems to the surround properties and their utilities.

24. The work required is not onerous but does need the installation of appropriate instrumentation and a sensible programme of observation to provide the answers to the questions posed and ensure the design and construction is suitable for the surrounding ground.

25. Questions of ground stability may also demand a better definition of strength and stiffness in the upper 10m of ground and the installation of monitoring to detect ground movements with depth as excavation progresses.

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26th January 2017

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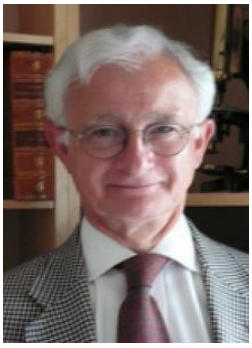
References

Geotechnical & Environmental Associates Desk Study and Basement *Impact Assessment Report for The Hall School, 23 Crossfield Street, London NW3 4NU*. Ref J15302, Issue No.1. 15th August 2015



SHORT BIOGRAPHY (2016)
Dr Michael Henry de FREITAS C.Geol., C.WEM
UK Registered Ground Engineering Adviser (RoGEP)

Present position:	Emeritus Reader in Engineering Geology, Imperial College London and Director of First Steps Ltd., Director & Co-owner of First Steps Ltd
Higher Education:	BSc (Hons) 1st Class. Geology. London 1964 PhD. Engineering Geology. London 1982 Diploma of Imperial College. 1982
Chartership:	Chartered Geologist. 9710. 1990 Chartered Water & Environmental Manager 2009
Registration:	UK Registered Ground Engineering Adviser (RoGEP); 68302453. 2014
Awards:	Sir Henry Miers Prize of the Mineralogical Society; 1964. Safety in Construction medal of the Institution of Civil Engineers; 1997. Chevalier L'Ordre des Palmes Academiques; 2001 Rudolph Glossop Medal of the Geological Society; 2008 William Smith Medal of the Geological Society, 2016
Publications:	The authorship of two text books, contributor to four books, editor of seven books, author of over 50 refereed papers in geotechnical journals, and of 24 un-refereed publications in conferences.

Membership of Professional Bodies, Learned Societies, etc.:

Geological Society of London (F) 1960 – onwards
International Soc. Rock Mechanics 1967 – onwards
Institution of Water & Environmental Management (M) 1969 – onwards
Royal Geographical Society (F) 1974 – onwards
International Assoc. Engineering Geologists (M) 1979 – onwards
International Assoc. Hydrogeologists 1983 – onwards
British Geotechnical Society (M) 1985 – onwards
Geologists' Association (M) 1989 - onwards

Learned Society (Geological Society) & Professional service

2012 – onwards	Lead Author; Geol Soc Working Party Report (Glacial & Periglacial EG)
2012	Panel Member for the 2012 audit for C.Geol
2011 – onwards	Panel Member for the Register of Ground Engineering Professionals
2010	Panel Member for the 2010 audit for C.Geol
2009 – onwards	Chairman London Basin Forum Working Gp. of the Geol. Soc. London
2008	Glossop Lecturer
2005 – 2007	Chairman of the Fellowship and Validation Committee

2004 – 2005	Member of the Fellowship and Validation Committee.
1998 – onwards	Provider of Continuing Professional Development courses
1993 – onwards	Scrutineer for status of Chartered Geologist
1990 – 1994	Member of the Geological Society Awards Committee.
1990 – 1992	Chairman Engineering Group, Geological Society
1988 – 1990	Vice Chairman. Engineering Group of the Geological Society,
1981 – 1984	Editor Quart. Jour. Engineering Geology for the Geological Society.
1978 – 1979	Vice-President of the Geological Society.
1971 – 1984	Editor Geological Society Handbooks.
1976 – 1979	Member of Council of Geological Society and Chairman for the Promotion Co-ordinating Committee

International Society (Int. Assoc. Engineering Geologists) service

1996 – 2003	Chairman for International Assoc. Engineering Geologists Commission on Teaching and Training.
1994 – 1996	Secretary for International Assoc. Engineering Geologists

Research Council and national bodies

1996 – 1997	Chairman of the CIRIA working party report for British Stratigraphical Nomenclature
1991 – 1994	Member of ICE (Ground Board Committee) on Inadequate Site Investigation
1991 – 1993	Member BSI Committee: Ground Investigation, for the revision of BS 5930
1986 – 1988	Panel Member Natural Environment Research Council Research Grants Committee for Geology.

International invitations

1984 – onwards	External Examiner for the Technical University of Delft & Hong Kong, and many universities in the UK.
1974 - onwards	Visiting lecturer to Technical University of Athens; University of Complutense. Madrid; University of Stockholm (KTB); Guest touring lecturer, Beijing and Wuhan. University of Wuhan & University of Seoul.
1997	Commission 4 Rapporteur for Int. Assoc. Eng. Geol. (Athens)
1994	Rapporteur. 7th Int. Congr. Int. Assoc. Eng. Geol. (Lisbon)

Personal consulting

1974 – onwards	Widely on practical matters of engineering geology to contractors, designers and regulators both in the private and the public sector, in the UK and overseas. Work involving the practical solutions of problems arising from groundwater, stability and materials at surface and below ground. Previous contracts include: Brighton Outfall tunnel; Dublin City Corporation (Dublin Port Tunnel); Railway Procurement Agency (Ireland) (Metro North Tunnel & surface works); ARUP Geotechnics (Havant Thicket reservoir); South African Council of Geoscience (Nuclear power sites), United Utilities Penrith UID scheme (for consortium Kier Murphy Interserve), London Borough of Camden, Donaldson Associates (various tunnels and pipelines), Parish of St Helier, Jersey (dispute resolution).

Of particular relevance to Basements;

Advice to and involvement with ARUP, the Heath and Hampstead Soc and London Borough of Camden with the drafting and implementation of CPG4
Advisor on hydrology to Heath and Hampstead Soc
Consultant for 25 basements to date within the London Borough of Camden, and others within the Royal Boroughs of Kensington & Chelsea, and Richmond upon Thames, with particular reference to the practical assessment of ground water management and ground response both on site and below surrounding properties.
Expert witness for the basement at 9 Downshire Hill, 2 Green Close & 9 Pilgrim's Lane
Liaising with MP's Karen Buck and Tulip Siddiq & Senior Manager for Planning GLA on matters relating to planning and best practice for basements in London.

Research experience

Over 40 years' experience in the geological controls on geotechnical properties gained from studying the stability and behaviour of rock and soil slopes, the shear strength of clean and infilled rock surfaces, comminution in shear zones, rock and mineral reaction to water, weak rocks and the nature of boundary layers. Also the influence of basement tectonics and their reactivation on the sedimentation and geotechnical characters of cover rock sequences and their implication for ground investigation and ground models.

Present employment

My time has been divided between teaching on the MSc in Engineering Geology in the Dept. Civil Engineering at Imperial College London, working at First Steps, the company I founded with a colleague in 2000, consulting as outlined above and continuing research with colleagues at Imperial and elsewhere. All major consultants and many contractors have sent staff to our courses at First Steps; in-house courses are also provided, the largest being to the Royal Engineers at Chatham. Web-based learning systems have also been developed to train those involved with creating Ground Models, the latest being Lapworth's Logs. All courses are endorsed by the Geological Society of London.