Ground and Project CONSULTANTS LTD

35 GREVILLE ROAD, LONDON NW6 5JB

Basement Impact Assessment: Land Stability

July 2015

Client:

Croft Structural Engineers,
Clock Shop Mews,
Rear of 60 Saxon Rd,
SE25 5EH

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1. Introduction

Ground and Project Consultants Ltd have been instructed by Croft Structural Engineers to undertake the land stability element of a Basement Impact Assessment compliant with CPG4, for 35 Greville Road, Kilburn, London NW6 5JB. The property is located in the London Borough of Camden in the Kilburn ward, its location is indicated on Figure 1.

Figure 1: Site Location

2. Scope and Objective

The scope of this report and approach is as follows:

- A review the existing data supplied by Croft has been carried out, including the proposal drawings produced to date, Ground Investigation data, photos of the building and the background data available through LB Camden's website and other freely available data such as BGS geological information.
- In line with the CPG4 guidance:
    - A detailed assessment of the published and encountered geology
    - Development of a ground model including an assessment of geotechnical properties
    - An engineering interpretation including an assessment of slope stability and potential for ground movements.
- Recommendations for additional work/ monitoring and observation have been provided.

This report and the work to support it has been carried out by Jon Smithson who is a Director of Ground and Project Consultants Ltd and is a Chartered Geologist with 30 years' experience.

3. BIA Screening for Slope/Land Stability

A screening exercise has been carried out as per the guidance in CPG4 as follows:

Question	Answer	Action/ Comment
Question 1: Does the existing site include slopes, natural or manmade, greater than 7 degrees? (approximately 1 in 8)	No. The property is located at around 35mAOD and there is no significant change in level across the site.	None
Question 2: Will the proposed re-profiling of landscaping at site change slopes at the property boundary to more than 7deg? (approximately 1 in 8)	No. There are no significant planned changes in surface profile.	None
Question 3: Does the development neighbour land, including railway cuttings and the like, with a slope greater than 7deg? (approximately 1 in 8)	No. The nearest mainline railway lines (underground) are approximately 250m away to the west and north. Underground lines are located approximately 300m and 500m to the west and east respectively.	None
Question 4: Is the site within a wider hillside setting in which the general slope is greater than 7degrees? (approximately 1 in 8)	No, the site is on relatively flat land well away for Hampstead and Primrose Hill. Estimated gradients from OS maps at the property vicinity area of around 1 in 100. Arup Fig 16 confirms no steep slopes in the area.	None
Question 5: Is the London Clay the shallowest strata at the site?	Yes, the geological map (sheet 256) indicates that the site is underlain London Clay with a potential for Head Deposits close to site.	The presence of London Clay close to surface is further discussed in the Impact Assessment.
Question 6: Will any tree/s be felled as part of the proposed development and/or are any works proposed within any tree protection zones where trees are to be retained? (Note that consent is required from LB Camden to undertake work to any tree/s protected by a Tree Protection Order or to tree/s in a Conservation Area if the tree is over certain dimensions).	No but there are mature trees at or close to the property Hand digging is proposed to protect tree roots from damage.	Further discussed in the Impact Assessment.
Question 7: Is there a history of seasonal shrink-swell subsidence in the local area, and/or evidence of such effects at the site?	The structural survey of the property did not reveal any apparent signs of distress. However London Clay is indicated as being present at the property. Head deposits can also have high plasticity.	Further discussed in the Impact Assessment.

Question 8: Is the site within 100m of a watercourse or a potential spring line?	Possibly: Figure 11 of the Arup report indicates a 'Lost River' close by to the North West of the property.	This is further discussed in the Impact Assessment.
Question 9: Is the site within an area of previously worked ground?	None known or suspected.	None
Question 10: Is the site within an aquifer? If so, will the proposed basement extend beneath the water table such that dewatering may be required during construction?	No. The London Clay is classified by the Environment Agency as unproductive strata (rock layers with low permeability and negligible significance for water supply or river base flow). However the basement may extend into the water table.	This is further discussed in the Impact Assessment.
Question 11: Is the site within 50m of the Hampstead Heath ponds?	No. The ponds are around 2.5km to the NNE.	None
Question 12: Is the site within 5m of a highway or pedestrian right of way?	Yes. The basement will be within 5m from the highway and pavement.	Health Safety and environmental measures will be required to be integrated into the building contractors' methods of working. This is further discussed in the Impact Assessment.
Question 13: Will the proposed basement significantly increase the differential depth of foundations relative to neighbouring properties?	The base of the basement slab will be 4.8m below the existing ground (garden) level. There is a neighbouring property (37 Greville Road) within 2-3m of the property on the SE side. Basement details of this property are unknown.	This is further discussed in the Impact Assessment.
Question 14: Is the site over (or within the exclusion zone of) any tunnels, e.g. railway lines?	No. Closest railway tunnels are approximately 300m away	None

4. Site Information

4.1 Existing Property and Basement Proposals

The property at 35 Greville Road is located on the North East side of the road with Mortimer Crescent forming the North West boundary of the property. The property is located relatively flat ground away from Hampstead and Primrose Hills. The elevation of the site is around 35m AOD. The main west coast and east coast and overground train lines into Euston and King's Cross run around 200m to the north in cutting and underground lines (Bakerloo and Jubilee) run around 300m to the West and 600m to the East respectively. The Grand Union Canal runs some 1.5km to the South of the property.

The property is a (estimated) late Victorian three storey detached house in substantial gardens. The lower floor is a lower ground floor partly sunk into the ground. The existing property has a footprint of approximately 330m^2. The plot is approximately 800m^2 with most of the land at the front, i.e. towards Greville Road. The front of the property is approximately 20m from Greville Road itself.

The National Grid reference for the property is TQ2581 8352. The location of the property is provided in Figure 1.

The lower ground floor extends beneath most of the footprint of the property except at the rear. It is also understood that there are a number of mature and semi-mature trees within the gardens of the property.

The basement proposals comprise a single storey construction across virtually the entire footprint of the property and extend beneath part of the front garden approximately 8m from the front of the existing property. The proposals include for a gym, sauna, steam room, study library and rest room. There will be 3 skylights and a new lightwell to the North West side in the garden. The maximum depth of construction will be 4.8m below the garden level.

4.2 Topography

The OS map indicates the property is at around 35m AOD. The ground surface generally flat with estimated gradients of around 1 in 100 local to the property.

4.3 Geology

The available geological mapping (Ref 1.) indicates that the site lies on London Clay which typically comprises a stiff grey fissured clay, weathering to brown near surface. Concretions of argillaceous limestone in nodular form (Claystones) occur throughout the formation. The geological map (North London 256) indicates that the property close to two areas with a 'propensity' for Head Deposits, approximately 1km to the North West and 300m to the East. The Head deposits are probably associated with the higher ground to the North and East. Typically these deposits are thin (<2m) and consist of soft, ocherous brown silty clay with blue-grey mottling in places and angular, frost-shattered fragments of flint occur sporadically throughout. The base of the London Clay is likely to occur some depth below the property. See figure 2 below.

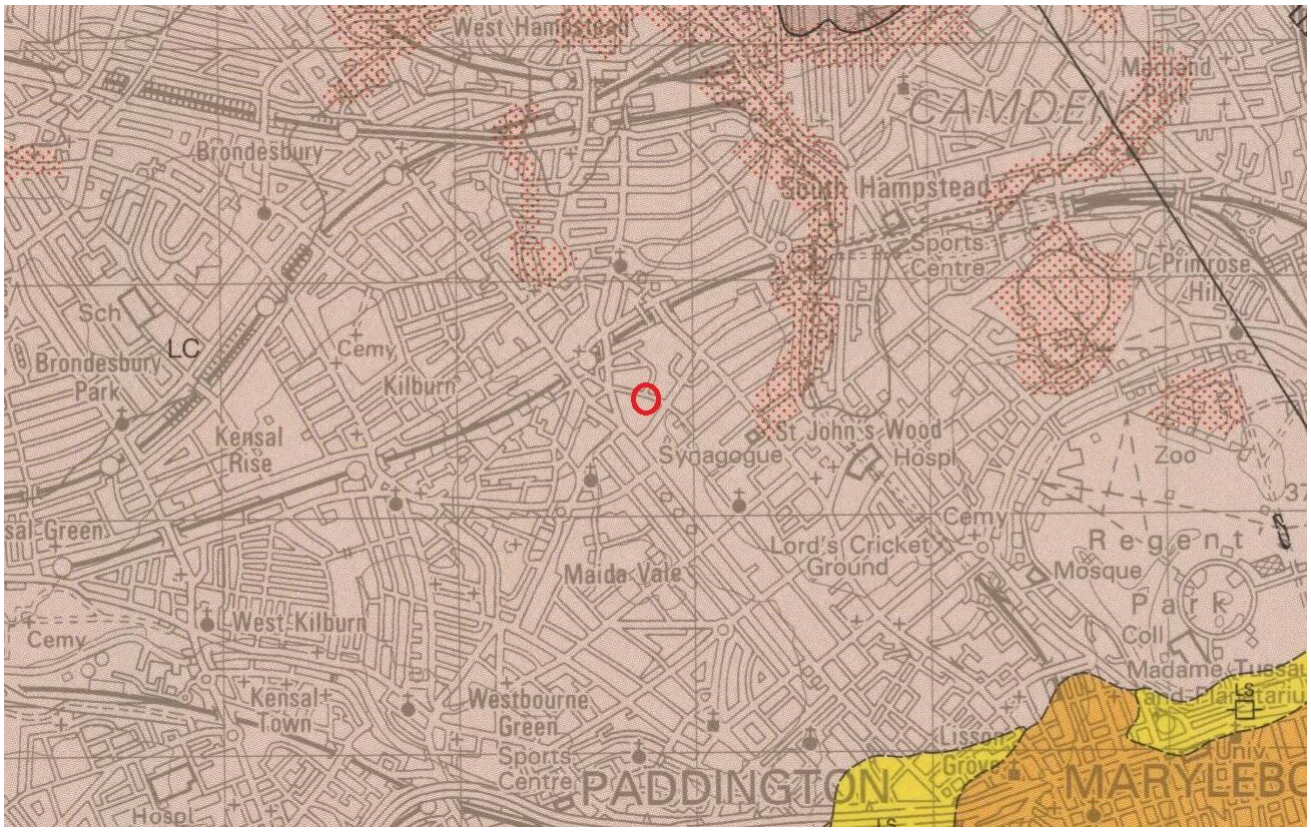

Figure 2: Geology

4.4 Hydrology and Hydrogeology

The OS Map indicates that the Grand Union Canal is around 1.5km to the South of the site. The Hampstead Ponds are approximately 2.5km to the NNE. There are no springs shown on OS mapping. There is a hidden river indicated on Arup Figure 11, approximately 100m to the North West of the site. This appears to be a tributary of the River Westbourne. The London Clay is classified by the Environment Agency as unproductive strata (rock layers with low permeability and negligible significance for water supply or river base flow).

4.5 Groundsure Environmental Data

The Groundsure report gives a wealth of background data on local environmental issues and hazards. The key issues are summarised in the table below:

Drift Deposits	None are indicated on BGS mapping
Made Ground	None indicated on BGS mapping
Surface and Groundwater Abstraction	There are no surface or groundwater abstraction points within 1km of the site.
Past and Current Local Land Uses	There are a number of 'unspecified tanks' shown on historic maps between 100 and 500m of the property. An electricity sub-station has been present at 105m N of the property for some years.
Shrink/ Swell	There is a moderate Hazard of shrink and swell from the London Clay soils
Landslide	Very Low Risk:.
Soluble Rocks	Negligible Risk

Compressible Ground	Negligible Risk
Collapsible Ground	Very Low Risk
Running Sand	Negligible Risk
Mining	None recorded

5. Ground Investigation

A ground investigation (GI) has been carried out at the site by Ground & Water Ltd (G&W) and results of these have been made available by G&W. The GI was carried out in July 2015.

The work comprised one window sample borehole (WS1) to 6.00m at the rear of the property along with a dynamic probe to 10m bgl.

The borehole encountered a thin cover of Made Ground 0.60m thick, described as Brown/dark brown gravelly very sandy to sandy clay. Gravel consists of flint, brick and tile fragments. It likely represents reworked natural ground with some man made material associated with the property construction. The London Clay was encountered beneath this to the base of the borehole and was described as a mid-brown and grey mottled silty CLAY, with Selenite crystals noted. Silt lenses were noted throughout.

The dynamic probe indicated relatively low shear strengths to 6m bgl, correlating to soft to firm and firm through to stiff from 6m. These represent relatively low results for London Clay and may indicate disturbance.

No trial pits were excavated at site to inspect foundations due to lack of available access.

A standpipe piezometer was installed in WS1 to 5.00m depth. Groundwater was not encountered during drilling. However return visits in August 2015 by Ground&Water to site dipped groundwater levels at 0.83m bgl and 0.94m bgl.

Laboratory tests were carried out on the samples collected from the borehole. Testing consisted of the following:

4 No. Atterberg Limit test
8 No. moisture content determination
2 No. Soluble Sulphate, pH and related tests for Concrete Classification on soil samples

All of the moisture content tests were conducted in London Clay. These show little variation and no discernible pattern with depth, ranging from 28 to 31%. Atterberg tests were all carried in London Clay and showed consistent values as follows:

- Plastic Limit : 25 to 28%
- Liquid Limit: 75 to 80%
- Plasticity Index: 49 to 53%

The low moisture content relative to liquid and plastic limit (just above plastic limit) suggests a relatively high shear strength and stiff consistency.

6. Conceptual Ground Model

From the above a conceptual Ground model has been developed and is presented in tabular form below:

Strata	Typical Description	Depth at Property encountered in GI	Geotechnical Properties – Tentative Characteristic Values*	Other
Made Ground	Brown silty sandy clay with gravel, gravel is brick, concrete, flint	Ground level to 0.60m	N/A	Made Ground is unlikely to be encountered to a significant depth. It should not be relied upon as a bearing strata. Likely to be deeper in areas of existing foundations and lower ground floor.
London Clay	Soft/Firm becoming stiff silty CLAY with silt lenses	From 0.60m (likely to be deeper in areas close to existing foundations and lower ground floor)to depth unproven	C' =0 ϕ' = 20° Cu = 40 increasing to 100kN/m^2 at depth. Use 50kN/m^2 at formation**	Clay is of high plasticity.
Groundwater		0.83m bgl	Highest dipped level in August	May significantly vary seasonally or after prolonged wet or dry periods.

Table 3: Summary of Strata Characteristics

*The determination of parameters is tentative due to the lack of test data.

**The undrained shear strength may have been considerably underestimated by the dynamic probing exercise. Strength should be verified by hand held shear vane/ inspection during ground excavation.

7. Impact Assessment

There are no major issues which should seriously affect the viability of the construction of the new basement. However the assessment of the geological environment of 35 Greville Road and the screening exercise indicate some areas for further discussion in this report with suggested mitigation where appropriate.

7.1 **London Clay:** The basement will be founded in the London Clay. The soils are of high plasticity and high volume change potential. The basement will be founded at around 4.8m bgl, therefore below any seasonal shrink and swell. The London Clay soils are known for their high levels of soluble sulphate. The concrete mix design should take appropriate account of sulphate levels in accordance with BRE Special Digest 1.

7.2 **Trees**: Mature and semi-mature trees are located in the garden and in the vicinity of the property. Care should be taken to minimise root damage during construction works. It is understood that hand digging will take place to attempt to minimise root damage. Should trees be removed there is potential for the soils to swell as a result and this should be accounted for in design.

7.3 **Watercourses**: There is evidence that a 'lost river', a tributary to the River Westbourne is possibly located to the north west of the property. It is highly unlikely that any culvert or trace of this will be encountered at the site. However vigilance should be exercised during excavations for the basement.

7.4 **Groundwater**: Groundwater was encountered above the proposed basement formation level and close to ground level. Whilst the borehole remained dry, the monitoring standpipe did encounter groundwater as high as 0.83m bgl, in a relatively dry summer. It is recommended that a design level of ground surface is used. Groundwater may be encountered during the works, particularly as seepages through sand or silt layers noted I the borehole record within London Clay or at the base of the Made Ground. These should be and should managed carefully to prevent ground loss particularly through loss of fines and softening of formation. Consideration should be given to limiting the size and time of face exposures during construction should significant flows be encountered during construction. Baseline and ongoing regular monitoring of the building and its immediate neighbours for settlement and movement/distress is highly recommended during building works and for a short period after completion. It is recommended that ongoing monitoring of groundwater levels is carried out during and up to the end of construction of the basement structure.

7.5 **Basement Depth**: The basement is proposed to be constructed involving an excavation to approximately 4.8m below the garden level. There is an adjacent building (No.37) approximately 3m to the SW. The proposals to construct the basement involves construct a contiguous bored pile wall for the basement at 35 Greville Road. Potential for ground loss is present with contiguous bored pile walls particularly where sandy lenses are present. Monitoring of movement should be carried out before and during construction up to the end of the construction period.

7.6 **Proximity to Pavement/Highway:** Basement construction will occur within 5m of the pavement and highway, on the NW side of the property along Mortimer Crescent. Appropriate Health and Safety measures including hoardings, control of plant movements and materials and waste storage.

8. Assessment of Ground Movement

An assessment of ground movements has been carried out as follows:

- The magnitude of ground movements has been assessed for both wall installation and excavation in front of the retaining structure.
- A damage assessment in relation to the neighbouring property.
- An assessment of heave due to the excavation and resultant unloading of the soils.

Various drawings developed by Croft and the Project manager have been reviewed and used to inform this exercise along with correspondence with Croft.

The following key assumptions have been made:

- The maximum excavation depth is approximately 4.8m bgl.
- A contiguous bored pile wall will be installed around the perimeter of the basement.
- A high wall stiffness has been assumed.
- In the permanent case the wall will always be propped at high level.
- The adjoining property (No.37) is 3m from the subject property.
- The width of no. 37 has been assumed to be 10m with a height of 12m.

Using table 2.2 and figure 2.8 from C580 the following assessments of movements *due to installation of the contiguous pile wall* have been developed:

Distance from wall (m)	**0**	**3 (Near side of 37)**	**13 (Far side of 37)**
Horizontal Movement (mm)	5	4	<1
Vertical Movement (mm)	5	4	2

These figures assume a wall installation depth of 12m and the calculated values will vary in direct proportion to wall depth.

From figure 2.11 in C580 the following assessments of ground movements have been developed due the excavation of soils in front of the wall. An excavation depth of 4.8m has been assumed.

Distance from wall (m)	**0**	**3 (Near side of 37)**	**13 (Far side of 37)**
Horizontal Movement (mm)	7	6	2
Vertical Movement (mm)	2	4 (~max)	1

This assumes that the wall is propped high and therefore a high stiffness can be assumed when reading from the graphs. It is understood that there will be adequate propping in the temporary case to justify this assumption and in the permanent case the structure will provide adequate support to the retaining walls and act as a high level prop.

There are a number of key points to note in using this assessment:

- Most ground movement will occur during wall installation, excavation and construction so the adequacy of temporary support will be critical in limiting ground movements.
- The speed of propping and support is key to limiting ground movements
- The movements calculated correspond to good workmanship.
- The assessment assumes the wall is in stiff/competent clay.
- Larger movements will be expected where soft soils are encountered at, above and below formation or ground loss is allowed to occur.

Ground movement can be minimised by adopting a number of measures, including:

- Ensuring that adequate propping is in place during construction
- Installation of the first (stiff) support quickly and early in the excavation and construction sequence
- Avoid leaving ground or the wall unsupported
- Minimise deterioration of the central soil mass by the use of blinding/ covering with a waterproof membrane.
- Avoid overbreak
- Control dewatering to minimise fines removal and drawdown.

In terms of building damage assessment and with reference to Table 2.5 of C580 (after Burland et al, 1977), the 'Description of typical damage' given the *calculated* ground movements is likely to be 'Slight'.

Heave of the ground will occur within the basement due to soil removal and consequent unloading of the soil. Using elastic and consolidation theories, both immediate and longer term heave movements have been calculated for within the basement. These are maximum calculated figures and apply to the centre of the basement. The figures will be significantly lower at the edges and lower still at the corners.

Immediate upward (elastic) movements have been calculated at 7mm. These will be completed upon completion of soil excavation. Longer term soil swelling will also occur and this has been calculated at 9mm.

9. Mitigation against Ground Movement

As discussed above building damage assessment with reference to Table 2.5 of C580 (after Burland et al, 1977), has been assessed as 'Slight'.

It is noted that the suggested values and graphs developed in C580 are conservative and represent an upper bound of actual measured values of ground movements.

Case studies such as Pont Street, presented in Ground Engineering (Ball, Langdon and Creighton, 2014), confirm the conservative nature of the C580 predictions. They noted that for typical London ground conditions, the maximum value of 0.04% suggested by C580 was approximately double measured values.

The authors reviewed the case study data published in CIRIA C580 and noted that "for the installation of contiguous piled walls in ground conditions similar to those at Pont Street (Kempton Park Gravel over London Clay), a reasonable argument could be made for halving these movements to 0.02% of the pile length". The key to achieving this is workmanship during pile wall installation and support to the pile wall once complete and before any substantial excavation. At Pont Street piles were installed on a "hit one miss three" basis, such that horizontal stress relief/ground movement never occurred concurrently on two adjacent piles. This approach is recommended at Greville Road.

In conclusion the design and control of the works are essential in limiting and controlling ground movements.

- Employ a reputable firm that has extensive knowledge of basement works.
- Employ suitably qualified consultants with significant track record in basement design and construction supervision.
- Install piles on a hit one miss three basis.
- Provide high level propping to the piled wall both during temporary works and in the permanent case.
- Provide detailed method statements and clear construction sequencing for the contractors to follow
- Record and monitor the external properties. This is completed by a condition survey on under the Party Wall Act before and after the works are completed. Refer to the basement construction method statement for relevant proposals.
- Allow for unforeseen ground conditions. Loose soil for example is often a concern; the method statement and drawings show the use of precast lintels to areas of soft ground. This follows guidance from the underpinning association.

10. Conclusions

The methodology and approach of CPG4 has been followed in developing this BIA with respect to Land stability. It is concluded that with the construction of the new basement at 35 Greville Road should not have significant impacts on land stability provided that:

- Groundwater inflow, if encountered, is reduced to a minimum and properly controlled such that there is no significant wash out of fine material. Groundwater levels should be monitored before and during construction.
- The property is close to 37 Greville Road. The construction of the basement should be carried out by a competent contractor experienced in residential basement construction. Precautions must be taken to maintain the stability of the excavations, prevent significant ground movements and manage groundwater inflows.
- The installation of the piled wall should follow the guidance advised above and should be installed by an experienced and competent contractor, with ability and experience to work with restricted access and headroom.
- Excavation should only proceed to a significant depth once temporary propping of the wall has been installed.
- The transition between the temporary prop and permanent prop support should be sequenced to avoid the case of an unsupported wall.
- Care should be taken to minimise the disturbance and damage to trees and their roots. Should trees be removed then an assessment of the potential for swelling of the London Clay soils should be carried out.
- Concrete should be designed in accordance with BRE Special Digest 1 accounting for the sulphate conditions anticipated.
- Monitoring of the structures is carried out before and during construction. The exact nature of this monitoring should be determined by the structural engineer.

11. References

1. BGS Geological Map Sheet 256.
2. Arup: Camden Geological, Hydrogeological and Hydrological Study.
3. Croft Structural Engineers: Design drawings available at the time of reporting.
4. Ground&Water GWPR1303: Ground Investigation Report: 35 Greville Road, London NW6 5JB.
5. Groundsure Enviroinsight report for 35 Greville Road, GS-2340478

APPENDIX

Groundsure Enviroinsight Report GS-1466122