Job Number: 171008

CROFT STRUCTURAL ENGINEERS

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Basement Impact Assessment

Property Details:
15 Rosslyn Hill
London
NW3 5UJ

Client Information
Geoff Ho
15 Rosslyn Hill
London
NW3 5UJ

Structural Design Reviewed by	**Above Ground Drainage Reviewed by**
Chris Tomlin MEng CEng MIStructE	Phil Henry BEng MEng MICE

Hydrogeology Report	**Land Stability Report**
Julian Maund MAUND GEO-CONSULTING LTD	Julian Maund MAUND GEO-CONSULTING LTD

Revision	Date	Comment
-	30/01/2018	First Issue
1	14/02/2018	Minor Alterations

Contents

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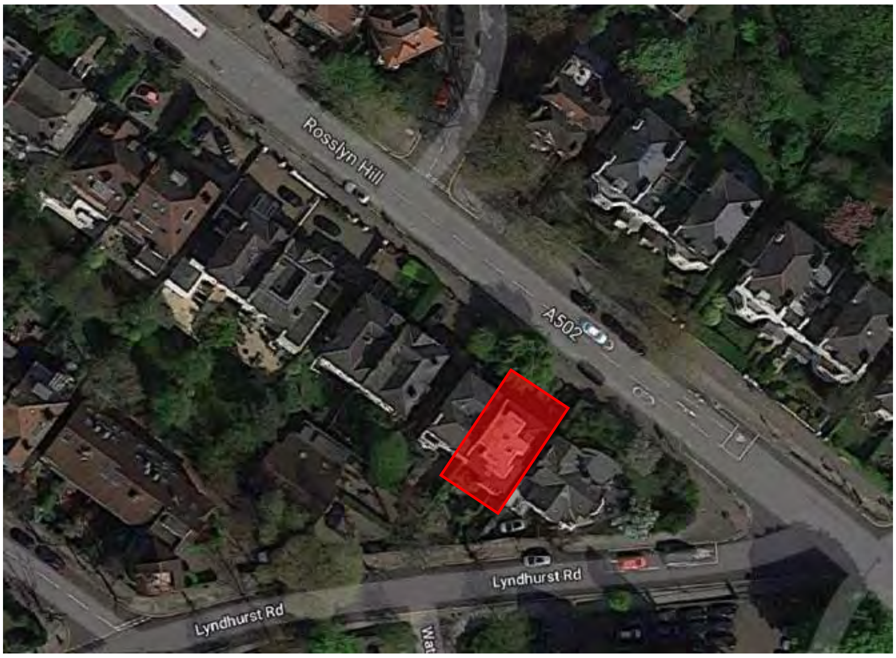
Executive (non-technical) Summary

	The London Borough of Camden requires a Basement Impact Assessment (BIA) to be prepared for developments that include basements and lightwells. This document forms the main part of the BIA and gives details on the impact of surface water flow. The scheme design for the proposed subterranean structure is also included. This document should be used in conjunction with the Land Stability BIA and the Groundwater BIA (Ref. MGC-17-32). These are separate reports and are referred to, where relevant, within this document. This BIA follows the requirements contained within Camden Council's planning guidance CGP4 – Basements and Lightwells (2015). In summary, the council will only allow basement construction to proceed if it does not: • cause harm to the built or natural environment and local amenity • result in flooding • lead to ground instability. In order to comply with the above clauses, a BIA must undertake five stages detailed in CPG 4. This report has been produced in line with Camden planning guidance and associated supporting documents such as CPG1, DP23, DP26, DP25 and DP27. Technical information from 'Camden geological, hydrogeological and hydrological study - Guidance for subterranean development', Issue 01, November 2010 (GSD, hereafter) was also used and is referred to in this assessment.
Existing Property	The site comprises a semi-detached building which is four storeys high above street level. In addition to this there is also a lower ground floor. The building is separated into flats. The property concerned is Flat 2 which occupies the Ground Floor and Lower Ground Floor. The building is constructed from traditional building materials (brickwork and timber). There is a rear garden at street level.
Proposed Development	The proposed development involves the extension of the existing ground floor and basement. This will extend into the rear garden.

	 *Figure 1: Map / Aerial view with approx. site area indicated* Summaries related to Land Stability, Hydrogelology and Surface-water flow are presented in Maund Geo-Consulting. Refer to MGC-17-32.
Stage 1 – Screening	This stage identifies any areas for concern that should be investigated further. The Land Stability and Hydrogeology screening has been carried out by Maund Geo-Consulting. Refer to MGC-17-32. For matters concerning surface water flow, Croft identified possible changes in the areas of hardstanding.
Stage 2 – Scoping	This stage identifies the potential impacts of the areas of concern highlighted in the Screening phase. The Land Stability and Hydrogeology Scoping is described by Maund Geo-Consulting. Refer to MGC-17-32. For matters concerning surface water flow, Croft concluded that the changes in hard surfaced areas are negligible and not a cause for concern.
Stage 3 – Site Investigation and Study	A structural engineer inspected the building to determine the current condition of the property. Features relevant to surface water flow were confirmed on site. A detailed site investigation and desk study is contained within the MGC-17-32 by Maund Geo-Consulting. Visual inspections were completed of the adjacent properties to determine if there were signs of structural movement.

	An engineer assessed the age of the adjacent properties and considered the type of foundations used for that period and assumed these in the design. Facets most relevant to the structural design of the basement are re-presented in this section. Additional features that will have impacts on the construction are also described here.
Stage 4 – Impact Assessment	The BIA by Maund contains a summary of potential impacts related to Land Stability and Hydrogeology. No surface water impacts on the adjacent properties were required for further assessment. Flooding risks were identified which are inherent with all basements. Suitable mitigation measures are proposed.

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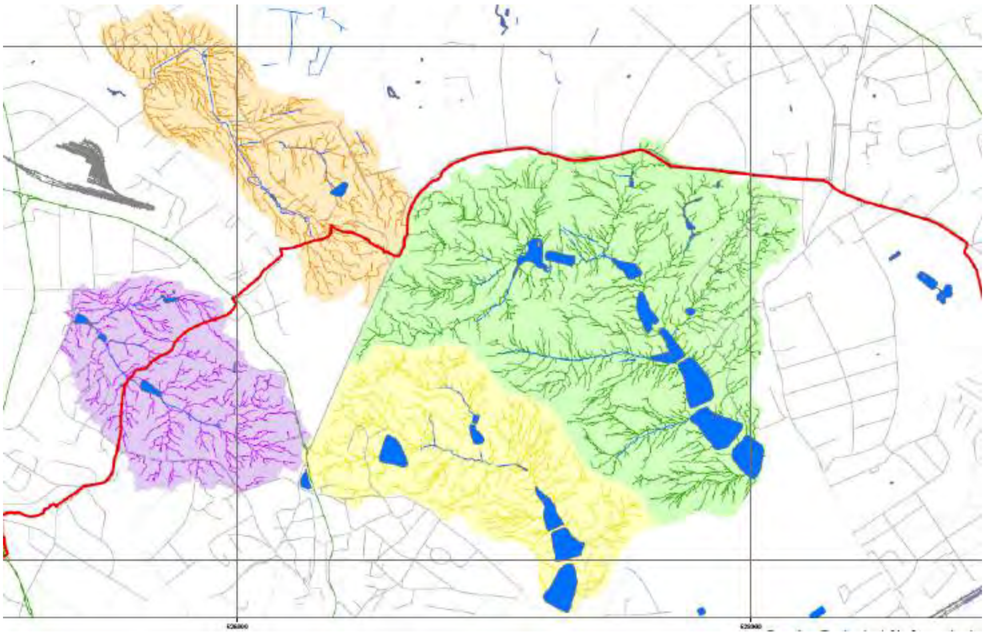
1. Screening Stage

	This stage identifies any areas for concern that should be investigated further.
Land Stability	Refer to the assessment on Land Stability.
Subterranean Flow	Refer to the assessment on Groundwater.
Surface Flow and Flooding	The questions below are taken from the Camden CPG 4 – Basements and Lightwells.
	Question 1: Is the site within the catchment of the pond chains on Hampstead Heath? No. The site lies outside the areas denoted by Figure 14 of the GSD (extract shown below)  *Figure 2: Extract from Figure 14 of the GSD (site lies to the south of the shaded areas)*

	Question 2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route? **No** – The surface water that flows from the proposed development will be routed the same way as before: water is and will be collected from hard surfaced areas and enter the existing drainage system.
	Question 3. Will the proposed basement development result in a change to the hard surfaced /paved external areas? **No.** The external paving and other hard surfaces will be rearranged. However, the total proportion of hard surfaces will remain unchanged
	Question 4. Will the proposed basement result in changes to the inflows (instantaneous and long term) of surface water being received by adjacent properties or downstream watercourses? **No**. Surface water that is received by adjacent properties and downstream watercourses is not from the site. This is will remain the case with the proposed development.
	Question 5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses? **No**. Collected surface water will be from building roofs and paving, as before. The quality of the water received downstream will therefore not change.

Question 6 : Is the site in an area identified to have surface water flood risk according to either the Local Flood Risk Management Strategy or the Strategic Flood Risk Assessment or is it at risk from flooding, for example because the proposed basement is below the static water level of nearby surface water feature?

The potential sources of flooding are summarised below:

Potential Source	Potential Flood Risk at site?	Justification
Fluvial flooding	No	EA Flood Mapping shows Flood Zone 1. Distance from nearest surface watercourse >1km
Tidal flooding	No	Site location is 'inland' and topography > 40mAOD.
Flooding from rising / high groundwater	No	The site is located on Claygate Member (silty clay with low permeability)
Surface water (pluvial) flooding	No	15 Rosslyn Hill is not noted on the flood street list and maps from 1975 or 2002
Flooding from infrastructure failure	Yes	Drainage at or near the site could potentially become blocked or cracked and overflow or leak. Drainage of the basement terrace areas may rely on pumping.
Flooding from reservoirs, canals and other artificial sources	No	There are no reservoirs, canals or other artificial sources in the vicinity of the site that could give rise to a flood risk.

The answers to Questions 1-5 above indicate that the issues related to surface water flow and flooding are not significant. These questions therefore do not have to be carried forward to Scoping Stage.

In answering Question 6, a flood risk assessment is not considered necessary: the property is not on a street that has flooded in 1975 or 2002 and there are no risks to flooding that are greater than those inherent with all subterranean structures. However, the risks associated with infrastructure failure should be investigated further. The assessment, with regards to Surface Water Flow, should be carried forward to Scoping Stage.

2. Scoping Stage

	This stage identifies the potential impacts of the areas of concern highlighted in the Screening phase.
Land Stability	Refer to the assessment on Land Stability.
Subterranean Flow	Refer to the assessment on Groundwater.
Surface Flow & Flooding	**Conceptual Model** The basement will be below an area that is mostly hard-surfaced. There will be no increase in areas covered by hard surfaces. The development will therefore not have any notable impact on surface water flow. It is evident from the screening study that the only significant flood risk associated with the development is due to the failure of incoming water mains and the existing sewers in the vicinity. There are standard design and construction measures that can mitigate this. These are described later in this report.

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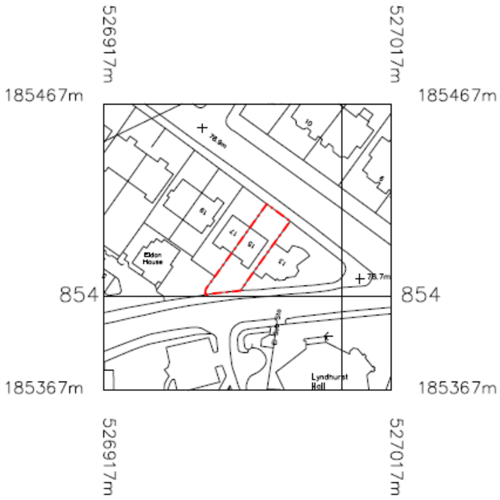
3. Site Investigation and Desk Study

This section identifies the relevant features of the site and its immediate surroundings, providing further scoping where required.

Desk Study and Walkover Survey

Site & Existing Property

The property is located on the south western side of Rosslyn Hill close to its junction with Lyndhurst Road.

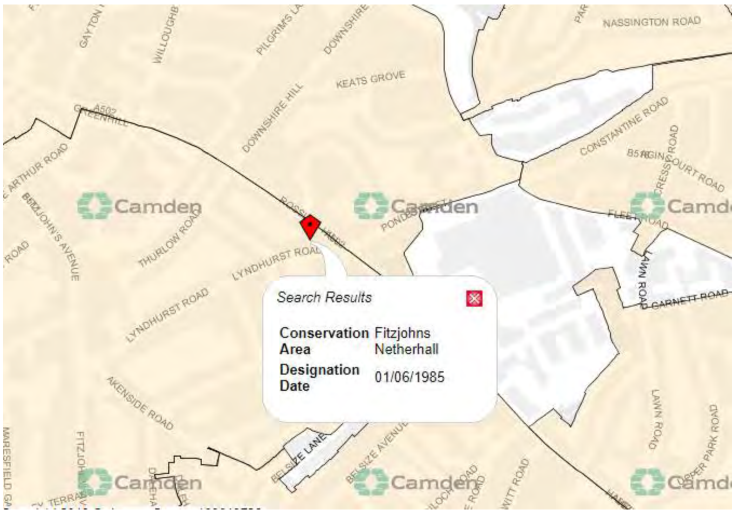


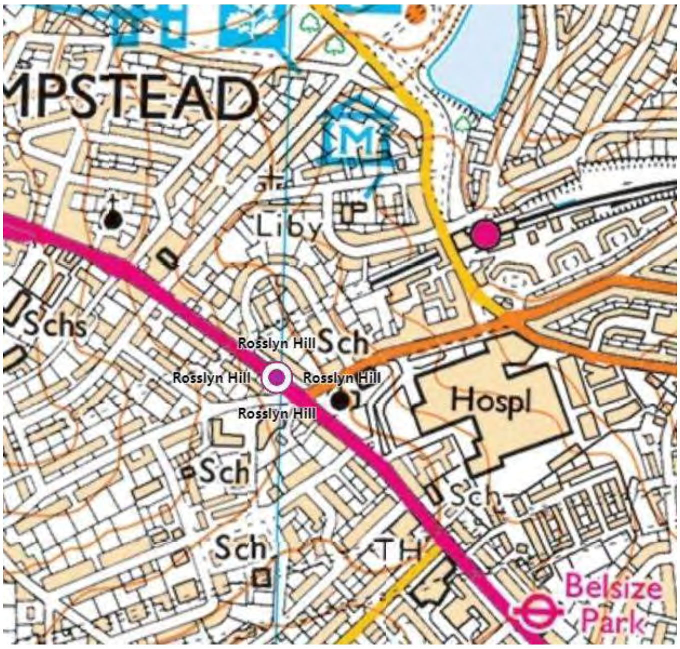
A structural engineer from Croft visited the property on 25th October 2017

The site comprises a semi-detached building which is four storeys high above street level. In addition to this there is also a lower ground floor. The building is separated into flats. The property concerned is Flat 2 which occupies the Ground Floor and Lower Ground Floor.

The building is constructed from traditional building materials (brickwork and timber) and is believed to be approximately 150 years old. There is garden at street level. Paving is present immediately outside of the building perimeter.

Proposed Development	The proposed development involves the extension of an existing basement. This will extend into the rear garden. More details on the proposed structure are given later in this report. Plans showing the extent of the proposed basement are shown on Architectural drawings (EXISTING and PROPOSED, by Beacham Architects, available separately). Drawings showing the structural scheme are appended. The depth of the basement will be approximately 2.0m below garden level and street level. An aerial view of the area is shown below. This site is indicated. In addition to the basement area, this also includes areas that are likely to be temporarily occupied for construction purposes.  *Figure 3: Aerial view with approx. site area indicated* The outline construction sequence is appended to this report.

Listed Buildings and Conservation Areas	Data from Historic England shows that the existing building is not listed.  *Figure 4: Extract showing listed buildings* The site is in a conservation area.  *Figure 5: Extract showing Conservation Area* If the property is in a conservation area, or it is listed then management plan for demolition and construction may be needed. Proposals for what this should include are described later in this report.

Local topography & external features	Inspection of OS maps show that there are no water courses, ponds, water courses or similar open water features within 50m of the site.  *Figure 6: Extract from OS map, with location of site indicated.* The area surrounding the property has a general slope. The slope is gradual; there are no retaining walls for sudden changes in elevation in the immediate vicinity. There are rainwater pipes which discharge below ground level.
Geology	Refer to the Ground Investigation report and the Hydrogeological and Land Stability assessment.
Highways & public footpaths	The area concerned is not within 5m of the public highway.

London Underground and Network Rail

From inspection, the site is more than 30m away from the nearest national rail line and more than 15m away from the nearest subterranean train line. It is unlikely that the development will have any significant effect on tunnels and vice-versa.

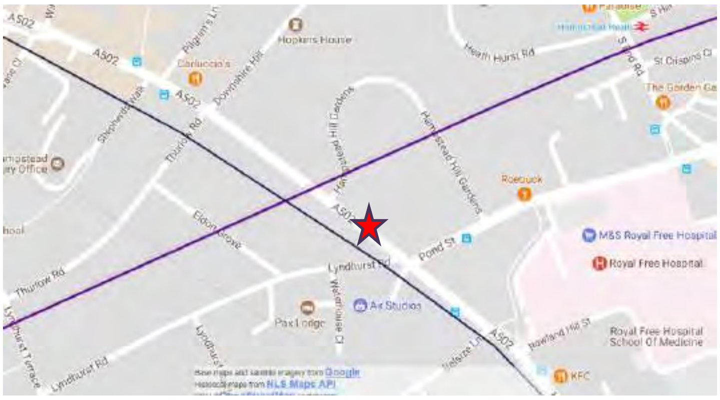


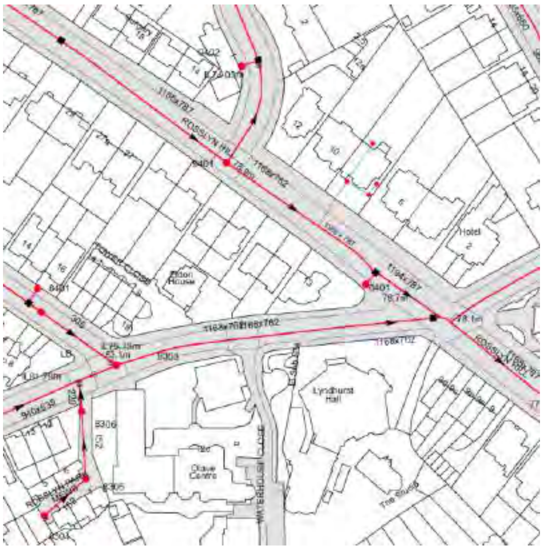
Figure 7: Extract from RAIL MAP online showing proximity of rail lines and subterranean lines

Network Rail have been contacted to confirm that their assets will not be affected. Correspondence is appended. At detailed design stage, after the planning stage is concluded, the design team should continue to liaise with the relevant Asset Management Team for as long as is considered necessary by Network Rail.

LUL have been informed of this proposal (e-mails are appended). At detailed design stage, after the planning stage is concluded, the design team should continue to liaise with the relevant Asset Protection Team for as long as is considered necessary by LUL.

UK Power Networks

There are no significant items of electrical infrastructure (such as pylons or substations) in the immediate vicinity.

Underground Services	As with most streets in London, the most significant assets below ground will be public sewers. Gullies are present in the nearby roads and information from a Thames Water Asset Location search (extract below) confirms the presence of a sewer.  *Figure 8: Map showing sewer route and approx. site area* Record information reveals that the depth of this sewer, along the roads immediately adjacent to the site, varies between 2m and 3m below street level. A detailed utility search should be carried out at detailed design stage, after the planning application is concluded.
Proximity of Trees	There are trees close by, in the neighbouring land. These do not have tree preservation orders. The closest tree is more than 2m away from the outline of the proposed basement. BS 5837: 2012 *Trees in relation to design, demolition and construction – Recommendations* estimates the root protection area (RPA) equivalent to a circle with a radius12 times the stem diameter. Based on the diameter of the tree as being 200mm, the diameter of this circle would be 2.4m. The roots concerned would therefore be within 1.2m from the trunk. These would not be affected by the extended basement which is 2m away.

Adjacent Properties

The external facades of the neighbouring properties have been inspected.

Figure 9: Plan view of site (approx. area outlined in red) and the surrounding properties

Descriptions of the properties are given below.

Nos 13 Rosslyn Hill

Property age : mid-Victorian (~150 years old)

Property use : residential

Number of storeys : the property is three storeys high above ground level.

Is a basement present? : **Yes** – there is a lower ground floor. Drawings of the property available on Camden Council's website confirm the presence of a lower ground floor. The depth of the lower ground floor will need to be confirmed at detailed design stage.

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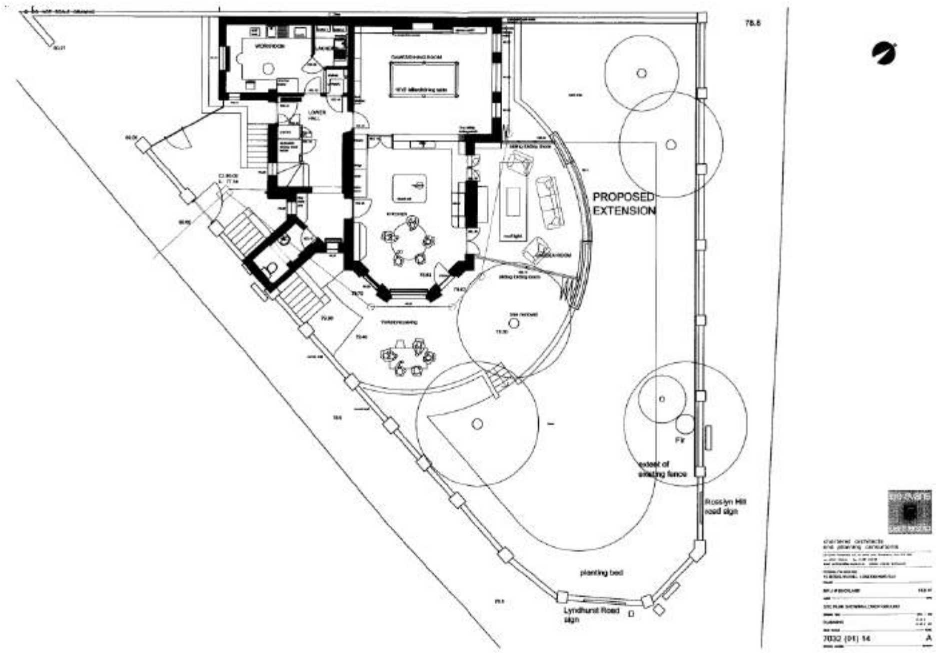
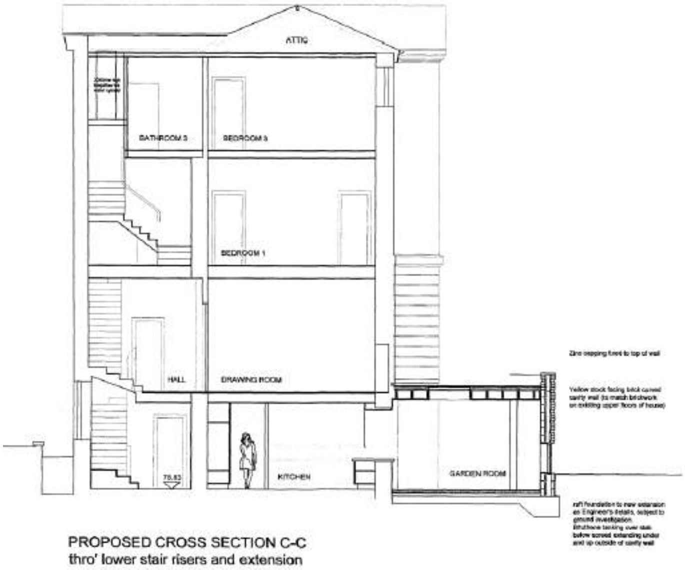
Figure 10: front of No 13 Rosslyn Hill

Structural Defects Noted: None noted





Structural assessment of ongoing movement: from observing the external façade of the building, there were no visible signs of movement.

Nos 17 Rosslyn Hill

Property age : mid-Victorian (~150 years old)

Property use : residential

Number of storeys : the property is three storeys high above ground level.

Is a basement present? : **Yes** – there is a basement. Drawings of the property available on Camden Council's website confirm the presence of a basement. The depth of the basement will need to be confirmed at detailed design stage.

Figure 11: front of No 17 Rosslyn Hill

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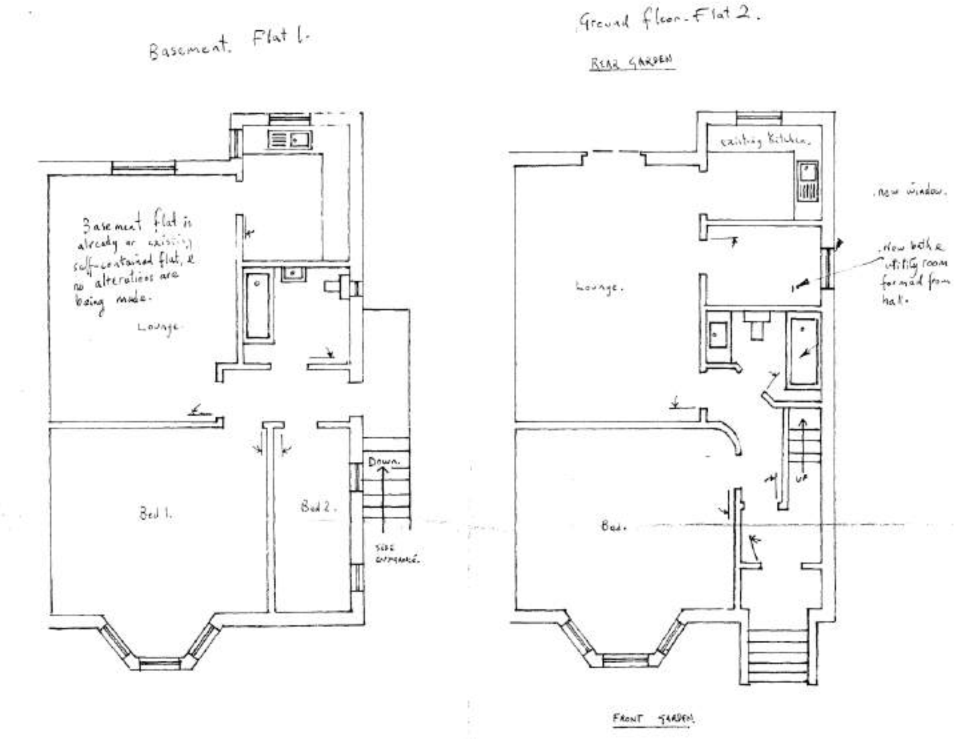
Structural Defects Noted: None noted



Structural assessment of ongoing movement: from observing the external façade of the building, there were no visible signs of movement.

Property to Rear

At the rear of the site there are no properties that are close enough to be affected by the basement.

Monitoring, Reporting and Investigation

The ground investigation report, which has data from initial site investigations and data from subsequent monitoring, is available as a separate report.

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Ground Investigation

Ground Investigation Brief	The ground investigation was completed by Ground & Water Ltd. From the Scoping Stage, Croft considered that their brief should cover: • Three trial pits to confirm the extent of the existing foundations. The purpose is to consider the effect of the works on the neighbouring properties and the find the ground conditions below the site. • Two boreholes. The first one (to rear of the property) to a depth of 5.5m below ground level. The second one (to the front of the property) to a depth of 8.45m below ground level (i.e. more than twice the depth of the proposed basement). • Stand pipe to be inserted to monitor ground water; record initial strike and the water level after 1 month. • Site testing to determine insitu soil parameters. SPT testing to be undertaken. • Laboratory testing to confirm soil make up and properties. • The Historic maps and walk over survey did not highlight any significant contamination sources, therefore no site test of the ground has been requested. • Factual report on soil conditions. • Interpretative reports • Calculation of bearing pressures from SPT. • Indication of Ø (angle of friction) from SPT. • Indication of soil type Refer to the ground investigation report by Ground & Water Ltd, which is submitted as a separate document. Data relevant to land stability and subterranean flow is examined separate documents.

Land Stability	Refer to the combined assessment on Hydrogeology and Land Stability (dated December 2017) for land stability issues addressed to Stage 3.
Subterranean Flow	Refer to the combined assessment on Hydrogeology and Land Stability (dated December 2017) for hydrogeological issues addressed to Stage3.

Surface Flow & Flooding	A walk over survey has confirmed that there are no surface water features, either within or close to the site. The survey has also confirmed that there are no surface flow issues that require further assessment.

4. Basement Impact Assessment

Subterranean Flow	Impacts relating to Land Stability and Groundwater are described within the BIA produced by Maund Geo-Consulting Ltd. Proposed measures to mitigate these, which should be developed further at detailed design stage, are presented in this section.
Conservation and Listed Buildings	If the property is in a conservation area, or it is listed then management plan for demolition and construction may be needed. This is not included in this BIA document and is not within Croft Structural Engineer's brief.
Surface water flow and flooding	As already confirmed there are no surface flow impacts that will affect neighbouring properties. As described in previous sections, the only significant risk of flooding is from failure of infrastructure, such as flooding due to unexpected failure of the drainage, water mains, etc. This risk is inherent in the construction of all subterranean structures. There is a risk of flooding due to the failure of the pumping system but this can be reduced to acceptable levels with appropriate design and installation measures. Measures to mitigate this risk are described later under 'Initial Design Considerations'.

Mitigation Measures Limiting Ground Movement

The BIA by Maund Geo-Consulting Ltd emphasised the requirement for best practice construction methods to limit any ground movements and associated damage to the neighbouring properties.

The proposed construction method, appended to this report, aims to limit damage to acceptable levels. For this development, suitable temporary propping during the construction phase will limit the amount of movement due to the basement works. The procedures will mitigate the impacts that the construction of the basement will have on nearby properties.

The works must be carried out in accordance with the Party Wall Act and condition surveys will be necessary at the beginning and the end of the works. The Party Wall Approval procedure will reinforce the use of the proposed method statement and, if necessary, require it to be developed in more detail with more stringent requirements than those required at planning stage.

It is not expected that any cracking will occur in nearby structures during the works. However, Croft's experience advises that there is a risk of movement to the neighbouring property.

To reduce the risk to the development:

- Employ a reputable firm that has extensive knowledge of basement works.
- Employ suitably qualified consultants Croft Structural Engineers has completed over 500 basements in the last five years.
- Provide method statements for the contractors to follow
- Investigate the ground this has now been done.
- Record and monitor the properties close by. This is completed by a condition survey under the Party Wall Act, before and after the works are completed. Refer to the end of the appended Basement Construction Method Statement.

Monitoring of Structures

In order to safeguard the existing structures during underpinning and new basement construction, movement monitoring is to be undertaken.

Risk Assessment

Monitoring Level proposed	Type of Works.
Monitoring 3 Visual inspection and production of condition survey by Party Wall Surveyors at the beginning of the works and also at the end of the works. Visual inspection of existing party wall during the works. Inspection of the footing to ensure that the footings are stable and adequate. Vertical monitoring movement by standard optical equipment	Basements up to 2.5m deep in clays.

Before the works begin, a detailed monitoring report is required to confirm the implementation of the monitoring. The items that this should cover are:

- Risk Assessment to determine level of monitoring
- Scope of Works
- Applicable standards
- Specification for Instrumentation
- Monitoring of Existing cracks
- Monitoring of movement
- Reporting
- Trigger Levels using a RED / AMBER / GREEN System

Recommend levels are shown within the proposed monitoring statement (appended).

Basement Design & Construction Impacts and Initial Design Considerations

Design Concept	The basement will consist of RC (reinforced concrete) cantilevered retaining walls. These will be designed to resist the lateral loads around the perimeter of the basement. The basement floor structure will comprise reinforced concrete that will be part of the bases of the retaining walls. The RC walls will also transfer vertical loads to the ground. A very small amount of heave is predicted. This will be mitigated by the applied vertical pressure from the base of the retaining walls. The investigations highlight that water is present. The walls are designed to resist the hydrostatic pressure. The water table was recorded as low, below the formation level of the proposed basement. The design of the walls considers long term scenarios. It is possible that a water main may break causing a local high water table. To account for this, the wall should be designed for a water level at 2/3 the height of the basement. The design of basements often considers floatation as a risk. The design for the basement at this site accounts for the weight of the building and the uplift forces from the water. The weight of the building is greater than the uplift, resulting in a stable structure. Drawings showing the structural scheme design are appended.

Additional loading requirements	The lateral earth pressure exerts a horizontal force on the retaining walls. The retaining walls will be checked for resistance to the overturning force this produces. Lateral forces will be applied from: • Soil loads • Hydrostatic pressures • Surcharge loading from behind the retaining walls <u>Surcharge Loading</u> The following will be applied as surcharge loads to the retaining walls: • Garden surcharge 2.5kN/m^2 The appended calculations show the design of one of the most heavily loaded retaining wall. The most critical parameters have been used for this.
Mitigation Measures - Internal Flooding	To mitigate the risks associated with flooding, Croft would recommend the following mitigation measures: • A pumping mechanism will be installed for the proposed basement. There is a likelihood that this may fail and allow excess water to accumulate. If this were to occur, the build-up of water would be gradual and noticeable before it becomes a significant life-threatening hazard. • The pumping system should be a dual mechanism to maintain operation in the event of a failure. This should include a battery backup and a suitable alarm system for warning purposes. • Route all electrical wiring at high level
Mitigation Measures - Drainage and Damp-proofing	The design of drainage and damp-proofing is not within the scope of this assessment and would not normally be expected to be part of the structural engineer's remit at detailed design stage. A common and anticipated detailed design stage approach is to use internal membranes (Delta or similar). These will be integral to the waterproofing of the basement. Any water from this will enter a drainage channel below the slab. This will be pumped and discharged into the exiting sewer system. Additional measures may include external tanking and water resistant concrete for new areas. It is recommended that a waterproofing specialist is employed to ensure all the water proofing requirements are met. The waterproofing specialist must

	name their structural waterproofer. The structural waterproofer must inspect the structural details and confirm that he is happy with the robustness. Due to the segmental construction nature of the basement, it is not possible to water proof the joints. All waterproofing must be made by the waterproofing specialist. He should review the structural engineer's design stage details and advise if water bars and stops are necessary. The waterproofing designer must not assume that the structure is watertight. To help reduce water flow through the joints in the segmental pins, the following measures should be applied: • All faces should be cleaned of all debris and detritus • Faces between pins should be needle hammered to improve key for bonding • All pipe work and other penetrations should have puddle flanges or hydrophilic strips
Mitigation Measures - Localised Dewatering	Monitor water levels 1 month prior to starting on site and throughout the construction process. Localised dewatering to pins may be necessary.

SUDS Considerations	As described previously, the basement will not have any noteworthy impacts on surface flow. The new extension will not significantly alter the net hard surfaced area, as the existing rear garden is predominantly paved. The use of SUDS is not applicable to this development.
Temporary Works	Prior to and works on site, a utility search survey should be done at detailed design stage. In addition to this the contractor should incorporate into his method statement proposals to confirm the presence or absence of services below ground level. The majority of standard services are usually within 900mm of the ground surface. The contractor may consider stipulating trial excavations done by hand to this depth. Temporary propping details will be required. This must be provided by the contractor. Their details should be forwarded to the design stage engineer. Water levels should be monitored for at least one month prior to starting on site and throughout the construction process. Localised dewatering to pin excavations may be necessary. <u>Construction Management</u> The site is in a conservation area. Camden Council will require a management plan for construction, construction traffic and demolition. Proposals for what this should account for are described in the next section. An outline construction programme is appended.

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Construction Impact Mitigation	**The site is in a conservation area**. The contractor should strictly control the impacts on the local amenity. A management plan for demolition and construction will be required at detailed design stage. Considerations that the contractor and the design team should account for in the construction management plan are described below. Noise Control • The hours of working will be limited to those allowed: 8am to 5pm Monday to Friday and Saturday, 8am to 1pm. The hours of working will further be defined within the Party Wall Act and the requirements of Camden Council. • The site will be hoarded with 8' site hoarding to prevent access. • Working in the basement generally requires hand tools to be used. The level of noise generally will be no greater than that of digging of soil. The noise is reduced and muffled by the works being undertaken underground. The level of noise from basement construction works is lower than typical ground level construction due to this. • None of the construction practices cause undue noise greater than what is expected on a typical construction site (a conveyor belt typically runs at around 70dB). Site hoarding acts as a partial acoustic screen and will reduce the level of direct noise from the site. Dust and Vibration Control • Reduce the need to use vibrating and percussive machinery. • Use well-maintained and modern machinery • Plant/vehicles should be cleaned before exiting the site. • Water should be applied to suppress dust • Skips and storage of fine materials should be covered Traffic Control • Consideration of site traffic to, from and along Mornington Crescent should be considered carefully; this should include identifying access and exit routes, planned delivery times and vehicle swept paths. • Banksmen should assist with vehicle movements close to and within the site to ensure the safety of site staff, visitors and other people close to the site. • Construction vehicle movements should be co-ordinated with deliveries to other properties close by and vehicle movements for other construction sites in the vicinity. • A Construction Traffic Management Plan should implement the above. This should be developed at detailed design stage.

The contractor is to follow the good working practices and guidance laid down in the 'Considerate Constructors Scheme'. This scheme commits construction sites to commit to care about appearance, respect the community, protect the environment and secure everyone's safety. The scheme will reinforce the measures above described above.

Figure 12: Examples of sites registered with the Considerate Constructors Scheme

With good construction practices adopted, the impact on the local amenity will be minimised.

Appendix A: Structural Calculations

CPG4 section 5 highlights that other permits and requirements will be necessary after planning. Item 5.1 highlights that Building Regulations will be required. As part of the building control pack full calculations must be undertaken and provided at detailed design stage once planning permission is granted. The calculations must be completed to a recognised Standard (BS or Euro Codes). The calculations must take into account the findings of this report and the recommendations of the auditors.

The design must resist:

- Vertical loads from the proposed works and adjacent properties
- Lateral loads from wind, soil water and adjacent properties
- Loadings in the temporary condition
- All other applied loads on the building
- Uplift forces from hydrostatic effects and soil heave

The final proposed scheme must:

- Provide stability in the temporary condition to all forces
- Provide stability to all forces in the permanent condition

As part of the planning Croft structural engineers has considered some of the pertinent parts of the basement structure to ensure that it can be constructed. <u>The following calculations are not a full set of calculations for the final design</u> which must be provided for building regulations. The structural calculations we consider pertinent and included in this appendix for this development are:

1. Basement wall analysis and partial design

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Project:	15 Rosslyn Hill		Section		Sheet
Date	Jan-18	Rev	Date	Description	
By	CC				
Checked	CT				
Job No	171008	Status			Rev

Ref

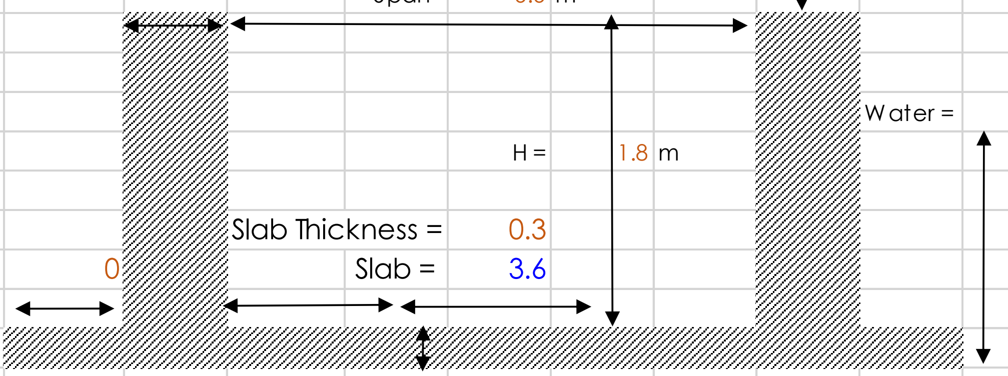
Slab Uplift

Wall DL 40 kN/m   Wall DL 40 kN/m

w= 0.3 m

soil depth above= 0 m

Span= 6.6 m



Water = 1.8 m

H = 1.8 m

Slab Thickness = 0.3

Heel= 0   Slab = 3.6

Toe = 0.3 m

Toewidth= 1.5 m   soil unit weight= 18 kN/m^3

Uplift Calc

Total Dead Load =	Slab=	27	kN/m				
	Toe and heel =	27	kN/m				
	Wall =	27					
	Soil=(	0	+	0	) x 2 +	0 =	0	3.6
	Total Dead load =	161	kN/m				
Total Uplift Force=		129.6	kN/m	f.o.s.=	1.24	No Global Uplift	

Slab Uplift

Slab =	7.5	kN/m	Uplift =	18	
Service Moment =	-57.173	kNm/m			
Factored Design moment=	-71.057	kNm/m			
Factored Design shear =	-43.065	kN/m			

W1 - RC WALL - PERMANENT CONDITION

Location	Area			Type	L	Action	Actions, kN or kN/m			
	L	W	m^2			kN/m^2	Perm., g_k	%	Var., q_k	Total
W1 - RC Wall										
New floor	3	1	3	g_k		5.00	15.0			
				q_k		1.50			4.5	
External wall	5.5	1	5.5	g_k		3.98	21.9			
New Roof	3	1	3	g_k		1.03	3.1			
				q_k		0.75			2.3	
							40.0	kN/m	6.8	kN/m
Garden surcharge = 2.5 kN/m2										

RETAINING WALL ANALYSIS

In accordance with EN1997-1:2004 incorporating Corrigendum dated February 2009 and the UK National Annex incorporating Corrigendum No.1

Tedds calculation version 2.6.11

Retaining wall details

Stem type	Cantilever
Stem height	h_{stem} = **1800** mm
Stem thickness	t_{stem} = **300** mm
Angle to rear face of stem	α = **90** deg
Stem density	γ_{stem} = **25** kN/m^3
Toe length	l_{toe} = **1500** mm
Base thickness	t_{base} = **300** mm
Base density	γ_{base} = **25** kN/m^3
Height of retained soil	h_{ret} = **1800** mm
Angle of soil surface	β = **0** deg
Depth of cover	d_{cover} = **0** mm
Height of water	h_{water} = **1800** mm
Water density	γ_w = **9.8** kN/m^3

Retained soil properties

Soil type	Stiff clay
Moist density	γ_{mr} = **19** kN/m^3
Saturated density	γ_{sr} = **19** kN/m^3
Characteristic effective shear resistance angle	$\phi'_{r.k}$ = **18** deg
Characteristic wall friction angle	$\delta_{r.k}$ = **9** deg

Base soil properties

Soil type	Stiff clay
Soil density	γ_b = **19** kN/m^3
Characteristic effective shear resistance angle	$\phi'_{b.k}$ = **18** deg
Characteristic wall friction angle	$\delta_{b.k}$ = **9** deg
Characteristic base friction angle	$\delta_{bb.k}$ = **12** deg

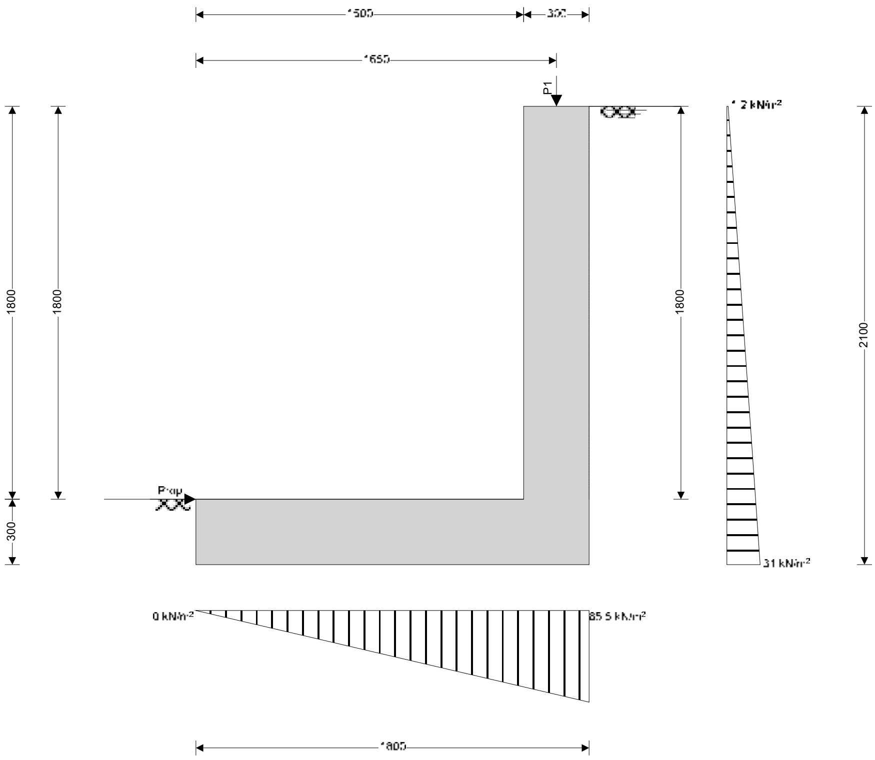
Presumed bearing capacity — $P_{bearing}$ = **100** kN/m^2

Loading details

Variable surcharge load — $Surcharge_Q$ = **2.5** kN/m^2

Vertical line load at 1650 mm — P_{G1} = **40** kN/m

P_{Q1} = **10** kN/m



General arrangement

Calculate retaining wall geometry

Base length — $l_{base} = l_{toe} + t_{stem}$ = **1800** mm

Saturated soil height — $h_{sat} = h_{water} + d_{cover}$ = **1800** mm

Moist soil height — $h_{moist} = h_{ret} - h_{water}$ = **0** mm

Length of surcharge load — $l_{sur} = l_{heel}$ = **0** mm

 - Distance to vertical component — $x_{sur\_v} = l_{base} - l_{heel} / 2$ = **1800** mm

Effective height of wall — $h_{eff} = h_{base} + d_{cover} + h_{ret}$ = **2100** mm

 - Distance to horizontal component — $x_{sur\_h} = h_{eff} / 2$ = **1050** mm

Area of wall stem — $A_{stem} = h_{stem} \times t_{stem}$ = **0.54** m^2

 - Distance to vertical component — $x_{stem} = l_{toe} + t_{stem} / 2$ = **1650** mm

Area of wall base — $A_{base} = l_{base} \times t_{base}$ = **0.54** m^2

 - Distance to vertical component — $x_{base} = l_{base} / 2$ = **900** mm

Using Coulomb theory

Active pressure coefficient — $K_A = \sin(\alpha + \phi'_{r.k})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.k}) \times [1 + \sqrt{[\sin(\phi'_{r.k} + \delta_{r.k}) \times \sin(\phi'_{r.k} - \beta) / (\sin(\alpha - \delta_{r.k}) \times \sin(\alpha + \beta))]}]^2)$ = **0.483**

Passive pressure coefficient — $K_P = \sin(90 - \phi'_{b.k})^2 / (\sin(90 + \delta_{b.k}) \times [1 - \sqrt{[\sin(\phi'_{b.k} + \delta_{b.k}) \times \sin(\phi'_{b.k}) / (\sin(90 + \delta_{b.k}))]}]^2)$ = **2.359**

Bearing pressure check

Vertical forces on wall

Wall stem — $F_{stem} = A_{stem} \times \gamma_{stem}$ = **13.5** kN/m

Wall base — $F_{base} = A_{base} \times \gamma_{base}$ = **13.5** kN/m

Line loads — $F_{P\_v} = P_{G1} + P_{Q1}$ = **50** kN/m

Total — $F_{total\_v} = F_{stem} + F_{base} + F_{water\_v} + F_{P\_v}$ = **77** kN/m

Horizontal forces on wall

Surcharge load — $F_{sur\_h} = K_A \times \cos(\delta_{r.d}) \times Surcharge_Q \times h_{eff}$ = **2.5** kN/m

Saturated retained soil — $F_{sat\_h} = K_A \times \cos(\delta_{r.d}) \times (\gamma_{sr}' - \gamma_w') \times (h_{sat} + h_{base})^2 / 2$ = **9.7** kN/m

Water — $F_{water\_h} = \gamma_w' \times (h_{water} + d_{cover} + h_{base})^2 / 2$ = **21.6** kN/m

Moist retained soil — $F_{moist\_h} = K_A \times \cos(\delta_{r.d}) \times \gamma_{mr}' \times ((h_{eff} - h_{sat} - h_{base})^2 / 2 + (h_{eff} - h_{sat} - h_{base}) \times (h_{sat} + h_{base}))$ = **0** kN/m

Base soil — $F_{pass\_h} = -K_P \times \cos(\delta_{b.d}) \times \gamma_b' \times (d_{cover} + h_{base})^2 / 2$ = **-2** kN/m

Total — $F_{total\_h} = F_{sat\_h} + F_{moist\_h} + F_{pass\_h} + F_{water\_h} + F_{sur\_h}$ = **31.8** kN/m

Moments on wall

Wall stem — $M_{stem} = F_{stem} \times x_{stem}$ = **22.3** kNm/m

Wall base — $M_{base} = F_{base} \times x_{base}$ = **12.2** kNm/m

Surcharge load — $M_{sur} = -F_{sur\_h} \times x_{sur\_h}$ = **-2.6** kNm/m

Line loads — $M_P = (P_{G1} + P_{Q1}) \times p_1$ = **82.5** kNm/m

Saturated retained soil — $M_{sat} = -F_{sat\_h} \times x_{sat\_h}$ = **-6.8** kNm/m

Water — $M_{water} = -F_{water\_h} \times x_{water\_h}$ = **-15.1** kNm/m

Moist retained soil — $M_{moist} = -F_{moist\_h} \times x_{moist\_h}$ = **0** kNm/m

Total — $M_{total} = M_{stem} + M_{base} + M_{sat} + M_{moist} + M_{water} + M_{sur} + M_P$ = **92.4** kNm/m

Check bearing pressure

Propping force — $F_{prop\_base} = F_{total\_h}$ = **31.8** kN/m

Distance to reaction — $\bar{x} = M_{total} / F_{total\_v}$ = **1200** mm

Eccentricity of reaction — $e = \bar{x} - l_{base} / 2$ = **300** mm

Loaded length of base — $l_{load} = l_{base}$ = **1800** mm

Bearing pressure at toe — $q_{toe} = F_{total\_v} / l_{base} \times (1 - 6 \times e / l_{base})$ = **0** kN/m²

Bearing pressure at heel — $q_{heel} = F_{total\_v} / l_{base} \times (1 + 6 \times e / l_{base})$ = **85.5** kN/m²

Factor of safety — $FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel})$ = **1.169**

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

RETAINING WALL DESIGN

In accordance with EN1992-1-1:2004 incorporating Corrigendum dated January 2008 and the UK National Annex incorporating National Amendment No.1

Tedds calculation version 2.6.11

Concrete details - Table 3.1 - Strength and deformation characteristics for concrete

Concrete strength class — C30/37

Characteristic compressive cylinder strength — f_{ck} = **30** N/mm²

Characteristic compressive cube strength — $f_{ck,cube}$ = **37** N/mm²

Mean value of compressive cylinder strength — $f_{cm} = f_{ck} + 8\ N/mm^2$ = **38** N/mm²

Mean value of axial tensile strength — $f_{ctm} = 0.3\ N/mm^2 \times (f_{ck} / 1\ N/mm^2)^{2/3}$ = **2.9** N/mm²

5% fractile of axial tensile strength — $f_{ctk,0.05} = 0.7 \times f_{ctm}$ = **2.0** N/mm²

Secant modulus of elasticity of concrete — $E_{cm} = 22\ kN/mm^2 \times (f_{cm} / 10\ N/mm^2)^{0.3}$ = **32837** N/mm²

Partial factor for concrete - Table 2.1N — γ_C = **1.50**

Compressive strength coefficient - cl.3.1.6(1) α_{cc} = **0.85**

Design compressive concrete strength - exp.3.15 $f_{cd} = \alpha_{cc} \times f_{ck} / \gamma_C$ = **17.0** N/mm^2

Maximum aggregate size h_{agg} = **20** mm

Reinforcement details

Characteristic yield strength of reinforcement f_{yk} = **500** N/mm^2

Modulus of elasticity of reinforcement E_s = **200000** N/mm^2

Partial factor for reinforcing steel - Table 2.1N γ_S = **1.15**

Design yield strength of reinforcement $f_{yd} = f_{yk} / \gamma_S$ = **435** N/mm^2

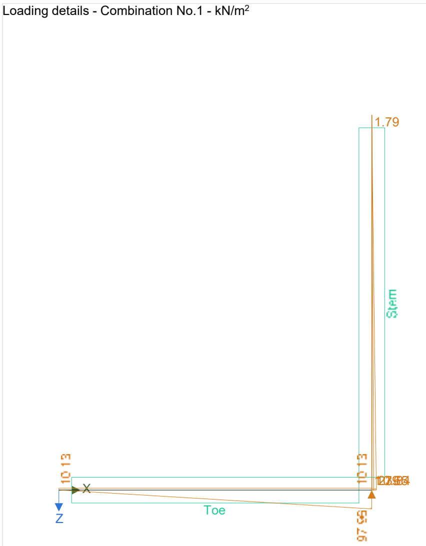
Cover to reinforcement

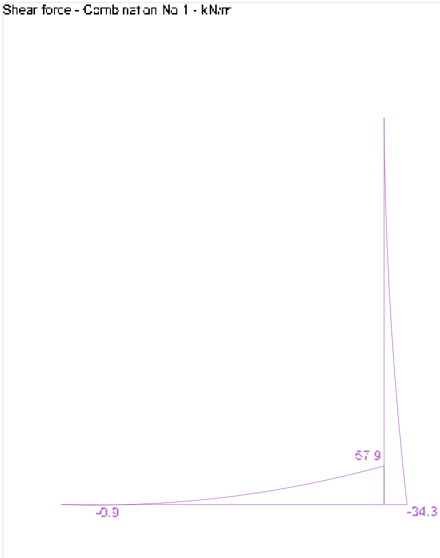
Front face of stem c_{sf} = **40** mm

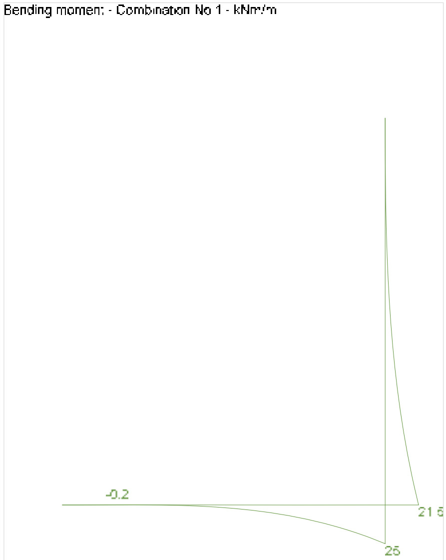
Rear face of stem c_{sr} = **50** mm

Top face of base c_{bt} = **50** mm

Bottom face of base c_{bb} = **75** mm







Check stem design at base of stem

Depth of section h = **300** mm

Rectangular section in flexure - Section 6.1

Design bending moment combination 1 M = **21.5** kNm/m

Depth to tension reinforcement $d = h - c_{sr} - \phi_{sr} / 2$ = **242** mm

$K = M / (d^2 \times f_{ck})$ = **0.012**

K' = **0.207**

K' > K - No compression reinforcement is required

Lever arm $z = \min(0.5 + 0.5 \times (1 - 3.53 \times K)^{0.5}, 0.95) \times d$ = **230** mm

Depth of neutral axis $x = 2.5 \times (d – z)$ = **30** mm

Area of tension reinforcement required $A_{sr.req} = M / (f_{yd} \times z)$ = **215** mm^2/m

Tension reinforcement provided 16 dia.bars @ 200 c/c

Area of tension reinforcement provided $A_{sr.prov} = \pi \times \phi_{sr}^2 / (4 \times s_{sr})$ = **1005** mm^2/m

Minimum area of reinforcement - exp.9.1N $A_{sr.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d$ = **364** mm^2/m

Maximum area of reinforcement - cl.9.2.1.1(3) $A_{sr.max} = 0.04 \times h$ = **12000** mm^2/m

$\max(A_{sr.req}, A_{sr.min}) / A_{sr.prov}$ = **0.363**

PASS - Area of reinforcement provided is greater than area of reinforcement required

Deflection control - Section 7.4

Reference reinforcement ratio	$\rho_0 = \sqrt{(f_{ck} / 1\ N/mm^2)} / 1000$ = **0.005**
Required tension reinforcement ratio	$\rho = A_{sr.req} / d$ = **0.001**
Required compression reinforcement ratio	$\rho' = A_{sr.2.req} / d_2$ = **0.000**
Structural system factor - Table 7.4N	K_b = **0.4**
Reinforcement factor - exp.7.17	$K_s = \min(500\ N/mm^2 / (f_{yk} \times A_{sr.req} / A_{sr.prov}), 1.5)$ = **1.5**
Limiting span to depth ratio - exp.7.16.a	$K_s \times K_b \times [11 + 1.5 \times \sqrt{(f_{ck} / 1\ N/mm^2)} \times \rho_0 / \rho + 3.2 \times \sqrt{(f_{ck} / 1\ N/mm^2)} \times (\rho_0 / \rho - 1)^{3/2}]$ = **160**
Actual span to depth ratio	h_{stem} / d = **7.4**

PASS - Span to depth ratio is less than deflection control limit

Crack control - Section 7.3

Limiting crack width	w_{max} = **0.3** mm
Variable load factor - EN1990 – Table A1.1	ψ_2 = **0.6**
Serviceability bending moment	M_{sls} = **15** kNm/m
Tensile stress in reinforcement	$\sigma_s = M_{sls} / (A_{sr.prov} \times z)$ = **64.7** N/mm^2
Load duration	Long term
Load duration factor	k_t = **0.4**
Effective area of concrete in tension	$A_{c.eff} = \min(2.5 \times (h - d), (h – x) / 3, h / 2)$ = **89917** mm^2/m
Mean value of concrete tensile strength	$f_{ct.eff} = f_{ctm}$ = **2.9** N/mm^2
Reinforcement ratio	$\rho_{p.eff} = A_{sr.prov} / A_{c.eff}$ = **0.011**
Modular ratio	$\alpha_e = E_s / E_{cm}$ = **6.091**
Bond property coefficient	k_1 = **0.8**
Strain distribution coefficient	k_2 = **0.5**
	k_3 = **3.4**
	k_4 = **0.425**
Maximum crack spacing - exp.7.11	$s_{r.max} = k_3 \times c_{sr} + k_1 \times k_2 \times k_4 \times \phi_{sr} / \rho_{p.eff}$ = **413** mm
Maximum crack width - exp.7.8	$w_k = s_{r.max} \times \max(\sigma_s – k_t \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_e \times \rho_{p.eff}), 0.6 \times \sigma_s) / E_s$
	w_k = **0.08** mm
	w_k / w_{max} = **0.267**

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force	V = **34.3** kN/m
	$C_{Rd,c} = 0.18 / \gamma_C$ = **0.120**
	$k = \min(1 + \sqrt{(200\ mm / d)}, 2)$ = **1.909**
Longitudinal reinforcement ratio	$\rho_l = \min(A_{sr.prov} / d, 0.02)$ = **0.004**
	$v_{min} = 0.035\ N^{1/2}/mm \times k^{3/2} \times f_{ck}^{0.5}$ = **0.506** N/mm^2
Design shear resistance - exp.6.2a & 6.2b	$V_{Rd.c} = \max(C_{Rd.c} \times k \times (100\ N^2/mm^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$
	$V_{Rd.c}$ = **128.5** kN/m
	$V / V_{Rd.c}$ = **0.267**

PASS - Design shear resistance exceeds design shear force

Horizontal reinforcement parallel to face of stem - Section 9.6

Minimum area of reinforcement – cl.9.6.3(1)	$A_{sx.req} = \max(0.25 \times A_{sr.prov}, 0.001 \times t_{stem})$ = **300** mm^2/m
Maximum spacing of reinforcement – cl.9.6.3(2)	s_{sx_max} = **400** mm
Transverse reinforcement provided	10 dia.bars @ 200 c/c
Area of transverse reinforcement provided	$A_{sx.prov} = \pi \times \phi_{sx}^2 / (4 \times s_{sx})$ = **393** mm^2/m

PASS - Area of reinforcement provided is greater than area of reinforcement required

Check base design at toe

Depth of section	$h = \mathbf{300}$ mm

Rectangular section in flexure - Section 6.1

Design bending moment combination 1	$M = \mathbf{25}$ kNm/m
Depth to tension reinforcement	$d = h - c_{bb} - \phi_{bb} / 2 = \mathbf{217}$ mm
	$K = M / (d^2 \times f_{ck}) = \mathbf{0.018}$
	$K' = \mathbf{0.207}$

K' > K - No compression reinforcement is required

Lever arm	$z = \min(0.5 + 0.5 \times (1 - 3.53 \times K)^{0.5}, 0.95) \times d = \mathbf{206}$ mm
Depth of neutral axis	$x = 2.5 \times (d – z) = \mathbf{27}$ mm
Area of tension reinforcement required	$A_{bb.req} = M / (f_{yd} \times z) = \mathbf{279}$ mm^2/m
Tension reinforcement provided	16 dia.bars @ 150 c/c
Area of tension reinforcement provided	$A_{bb.prov} = \pi \times \phi_{bb}^2 / (4 \times s_{bb}) = \mathbf{1340}$ mm^2/m
Minimum area of reinforcement - exp.9.1N	$A_{bb.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d = \mathbf{327}$ mm^2/m
Maximum area of reinforcement - cl.9.2.1.1(3)	$A_{bb.max} = 0.04 \times h = \mathbf{12000}$ mm^2/m
	$\max(A_{bb.req}, A_{bb.min}) / A_{bb.prov} = \mathbf{0.244}$

PASS - Area of reinforcement provided is greater than area of reinforcement required

Crack control - Section 7.3

Limiting crack width	$w_{max} = \mathbf{0.3}$ mm
Variable load factor - EN1990 – Table A1.1	$\psi_2 = \mathbf{0.6}$
Serviceability bending moment	$M_{sls} = \mathbf{18.3}$ kNm/m
Tensile stress in reinforcement	$\sigma_s = M_{sls} / (A_{bb.prov} \times z) = \mathbf{66.3}$ N/mm^2
Load duration	Long term
Load duration factor	$k_t = \mathbf{0.4}$
Effective area of concrete in tension	$A_{c.eff} = \min(2.5 \times (h - d), (h – x) / 3, h / 2) = \mathbf{90958}$ mm^2/m
Mean value of concrete tensile strength	$f_{ct.eff} = f_{ctm} = \mathbf{2.9}$ N/mm^2
Reinforcement ratio	$\rho_{p.eff} = A_{bb.prov} / A_{c.eff} = \mathbf{0.015}$
Modular ratio	$\alpha_e = E_s / E_{cm} = \mathbf{6.091}$
Bond property coefficient	$k_1 = \mathbf{0.8}$
Strain distribution coefficient	$k_2 = \mathbf{0.5}$
	$k_3 = \mathbf{3.4}$
	$k_4 = \mathbf{0.425}$
Maximum crack spacing - exp.7.11	$s_{r.max} = k_3 \times c_{bb} + k_1 \times k_2 \times k_4 \times \phi_{bb} / \rho_{p.eff} = \mathbf{440}$ mm
Maximum crack width - exp.7.8	$w_k = s_{r.max} \times \max(\sigma_s – k_t \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_e \times \rho_{p.eff}), 0.6 \times \sigma_s) / E_s$
	$w_k = \mathbf{0.087}$ mm
	$w_k / w_{max} = \mathbf{0.291}$

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force	$V = \mathbf{57.9}$ kN/m
	$C_{Rd,c} = 0.18 / \gamma_C = \mathbf{0.120}$
	$k = \min(1 + \sqrt{(200 \text{ mm} / d)}, 2) = \mathbf{1.960}$
Longitudinal reinforcement ratio	$\rho_l = \min(A_{bb.prov} / d, 0.02) = \mathbf{0.006}$
	$v_{min} = 0.035 \text{ N}^{1/2}/\text{mm} \times k^{3/2} \times f_{ck}^{0.5} = \mathbf{0.526}$ N/mm^2
Design shear resistance - exp.6.2a & 6.2b	$V_{Rd.c} = \max(C_{Rd.c} \times k \times (100 \text{ N}^2/\text{mm}^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$
	$V_{Rd.c} = \mathbf{135.1}$ kN/m

$V / V_{Rd.c}$ = **0.429**

PASS - Design shear resistance exceeds design shear force

Check base design at toe

Depth of section — h = **300** mm

Rectangular section in flexure - Section 6.1

Design bending moment combination 1 — M = **0.2** kNm/m

Depth to tension reinforcement — $d = h - c_{bt} - \phi_{bt} / 2$ = **244** mm

$K = M / (d^2 \times f_{ck})$ = **0.000**

K' = **0.207**

K' > K - No compression reinforcement is required

Lever arm — $z = \min(0.5 + 0.5 \times (1 - 3.53 \times K)^{0.5}, 0.95) \times d$ = **232** mm

Depth of neutral axis — $x = 2.5 \times (d – z)$ = **31** mm

Area of tension reinforcement required — $A_{bt.req} = M / (f_{yd} \times z)$ = **2** mm²/m

Tension reinforcement provided — 12 dia.bars @ 200 c/c

Area of tension reinforcement provided — $A_{bt.prov} = \pi \times \phi_{bt}^2 / (4 \times s_{bt})$ = **565** mm²/m

Minimum area of reinforcement - exp.9.1N — $A_{bt.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d$ = **368** mm²/m

Maximum area of reinforcement - cl.9.2.1.1(3) — $A_{bt.max} = 0.04 \times h$ = **12000** mm²/m

$\max(A_{bt.req}, A_{bt.min}) / A_{bt.prov}$ = **0.65**

PASS - Area of reinforcement provided is greater than area of reinforcement required

Crack control - Section 7.3

Limiting crack width — w_{max} = **0.3** mm

Variable load factor - EN1990 – Table A1.1 — ψ_2 = **0.6**

Serviceability bending moment — M_{sls} = **0** kNm/m

Tensile stress in reinforcement — $\sigma_s = M_{sls} / (A_{bt.prov} \times z)$ = **0** N/mm²

Load duration — Long term

Load duration factor — k_t = **0.4**

Effective area of concrete in tension — $A_{c.eff} = \min(2.5 \times (h - d), (h – x) / 3, h / 2)$ = **89833** mm²/m

Mean value of concrete tensile strength — $f_{ct.eff} = f_{ctm}$ = **2.9** N/mm²

Reinforcement ratio — $\rho_{p.eff} = A_{bt.prov} / A_{c.eff}$ = **0.006**

Modular ratio — $\alpha_e = E_s / E_{cm}$ = **6.091**

Bond property coefficient — k_1 = **0.8**

Strain distribution coefficient — k_2 = **0.5**

k_3 = **3.4**

k_4 = **0.425**

Maximum crack spacing - exp.7.11 — $s_{r.max} = k_3 \times c_{bt} + k_1 \times k_2 \times k_4 \times \phi_{bt} / \rho_{p.eff}$ = **494** mm

Maximum crack width - exp.7.8 — $w_k = s_{r.max} \times \max(\sigma_s – k_t \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_e \times \rho_{p.eff}), 0.6 \times \sigma_s) / E_s$

w_k = **0** mm

w_k / w_{max} = **0**

PASS - Maximum crack width is less than limiting crack width

Secondary transverse reinforcement to base - Section 9.3

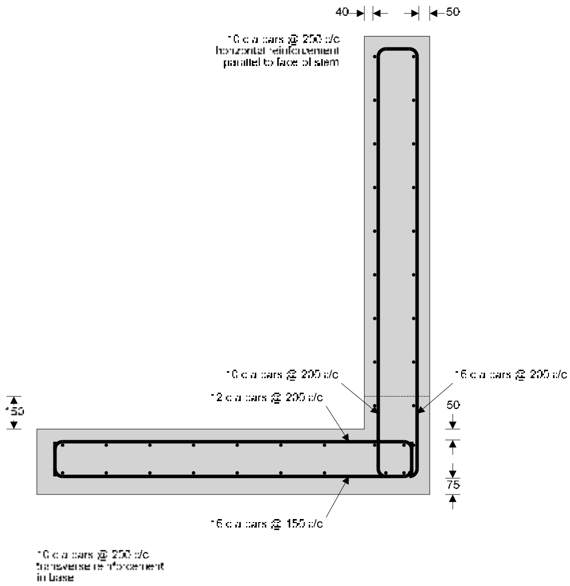
Minimum area of reinforcement – cl.9.3.1.1(2) — $A_{bx.req} = 0.2 \times A_{bb.prov}$ = **268** mm²/m

Maximum spacing of reinforcement – cl.9.3.1.1(3) — s_{bx_max} = **450** mm

Transverse reinforcement provided — 10 dia.bars @ 200 c/c

Area of transverse reinforcement provided — $A_{bx.prov} = \pi \times \phi_{bx}^2 / (4 \times s_{bx})$ = **393** mm²/m

PASS - Area of reinforcement provided is greater than area of reinforcement required



Reinforcement details

W1 - RC WALL - TEMPORARY CONDITION

Location	Area			Type	L	Action	Actions, kN or kN/m			
	L	W	m^2			kN/m^2	Perm., g_k	%	Var., q_k	Total
W1 - RC Wall										
New floor	3	1	3	g_k		5.00	15.0			
				q_k		1.50			4.5	
External wall	5.5	1	5.5	g_k		3.98	21.9			
New Roof	3	1	3	g_k		1.03	3.1			
				q_k		0.75			2.3	
							40.0	kN/m	6.8	kN/m
Garden surcharge = 2.5 kN/m2										

RETAINING WALL ANALYSIS

In accordance with EN1997-1:2004 incorporating Corrigendum dated February 2009 and the UK National Annex incorporating Corrigendum No.1

Tedds calculation version 2.6.11

Retaining wall details

Stem type	Propped cantilever
Stem height	h_{stem} = **1800** mm
Prop height	h_{prop} = **1800** mm
Stem thickness	t_{stem} = **300** mm
Angle to rear face of stem	α = **90** deg
Stem density	γ_{stem} = **25** kN/m^3
Toe length	l_{toe} = **1500** mm
Base thickness	t_{base} = **300** mm
Base density	γ_{base} = **25** kN/m^3
Height of retained soil	h_{ret} = **1800** mm
Angle of soil surface	β = **0** deg
Depth of cover	d_{cover} = **0** mm

Retained soil properties

Soil type	Stiff clay
Moist density	γ_{mr} = **19** kN/m^3
Saturated density	γ_{sr} = **19** kN/m^3
Characteristic effective shear resistance angle	$\phi'_{r.k}$ = **18** deg
Characteristic wall friction angle	$\delta_{r.k}$ = **9** deg

Base soil properties

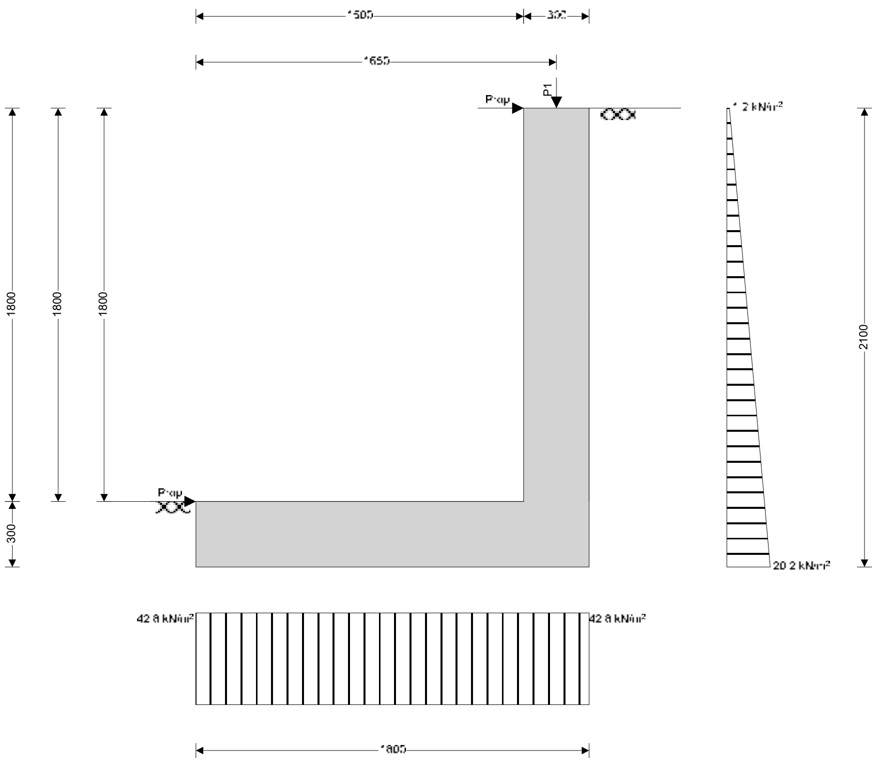
Soil type	Stiff clay
Soil density	γ_b = **19** kN/m^3
Characteristic effective shear resistance angle	$\phi'_{b.k}$ = **18** deg
Characteristic wall friction angle	$\delta_{b.k}$ = **9** deg
Characteristic base friction angle	$\delta_{bb.k}$ = **12** deg
Presumed bearing capacity	$P_{bearing}$ = **100** kN/m^2

Loading details

Variable surcharge load — $Surcharge_Q$ = **2.5** kN/m^2

Vertical line load at 1650 mm — P_{G1} = **40** kN/m

P_{Q1} = **10** kN/m



General arrangement

Calculate retaining wall geometry

Base length — $l_{base} = l_{toe} + t_{stem}$ = **1800** mm

Moist soil height — $h_{moist} = h_{soil}$ = **1800** mm

Length of surcharge load — $l_{sur} = l_{heel}$ = **0** mm

- Distance to vertical component — $x_{sur\_v} = l_{base} - l_{heel} / 2$ = **1800** mm

Effective height of wall — $h_{eff} = h_{base} + d_{cover} + h_{ret}$ = **2100** mm

- Distance to horizontal component — $x_{sur\_h} = h_{eff} / 2$ = **1050** mm

Area of wall stem — $A_{stem} = h_{stem} \times t_{stem}$ = **0.54** m^2

- Distance to vertical component — $x_{stem} = l_{toe} + t_{stem} / 2$ = **1650** mm

Area of wall base — $A_{base} = l_{base} \times t_{base}$ = **0.54** m^2

- Distance to vertical component — $x_{base} = l_{base} / 2$ = **900** mm

Using Coulomb theory

Active pressure coefficient — $K_A = \sin(\alpha + \phi'_{r.k})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.k}) \times [1 + \sqrt{[\sin(\phi'_{r.k} + \delta_{r.k}) \times \sin(\phi'_{r.k} - \beta) / (\sin(\alpha - \delta_{r.k}) \times \sin(\alpha + \beta))]}]^2)$ = **0.483**

Passive pressure coefficient — $K_P = \sin(90 - \phi'_{b.k})^2 / (\sin(90 + \delta_{b.k}) \times [1 - \sqrt{[\sin(\phi'_{b.k} + \delta_{b.k}) \times \sin(\phi'_{b.k}) / (\sin(90 + \delta_{b.k}))]}]^2)$ = **2.359**

Bearing pressure check

Vertical forces on wall

Wall stem $F_{stem} = A_{stem} \times \gamma_{stem} = \mathbf{13.5}$ kN/m

Wall base $F_{base} = A_{base} \times \gamma_{base} = \mathbf{13.5}$ kN/m

Line loads $F_{P\_v} = P_{G1} + P_{Q1} = \mathbf{50}$ kN/m

Total $F_{total\_v} = F_{stem} + F_{base} + F_{P\_v} = \mathbf{77}$ kN/m

Horizontal forces on wall

Surcharge load $F_{sur\_h} = K_A \times \cos(\delta_{r.d}) \times Surcharge_Q \times h_{eff} = \mathbf{2.5}$ kN/m

Moist retained soil $F_{moist\_h} = K_A \times \cos(\delta_{r.d}) \times \gamma_{mr}' \times h_{eff}^2 / 2 = \mathbf{20}$ kN/m

Base soil $F_{pass\_h} = -K_P \times \cos(\delta_{b.d}) \times \gamma_b' \times (d_{cover} + h_{base})^2 / 2 = \mathbf{-2}$ kN/m

Total $F_{total\_h} = F_{moist\_h} + F_{pass\_h} + F_{sur\_h} = \mathbf{20.5}$ kN/m

Moments on wall

Wall stem $M_{stem} = F_{stem} \times x_{stem} = \mathbf{22.3}$ kNm/m

Wall base $M_{base} = F_{base} \times x_{base} = \mathbf{12.2}$ kNm/m

Surcharge load $M_{sur} = -F_{sur\_h} \times x_{sur\_h} = \mathbf{-2.6}$ kNm/m

Line loads $M_P = (P_{G1} + P_{Q1}) \times p_1 = \mathbf{82.5}$ kNm/m

Moist retained soil $M_{moist} = -F_{moist\_h} \times x_{moist\_h} = \mathbf{-14}$ kNm/m

Total $M_{total} = M_{stem} + M_{base} + M_{moist} + M_{sur} + M_P = \mathbf{100.3}$ kNm/m

Check bearing pressure

Propping force to stem $F_{prop\_stem} = (F_{total\_v} \times l_{base} / 2 - M_{total}) / (h_{prop} + t_{base}) = \mathbf{-14.8}$ kN/m

Propping force to base $F_{prop\_base} = F_{total\_h} - F_{prop\_stem} = \mathbf{35.3}$ kN/m

Moment from propping force $M_{prop} = F_{prop\_stem} \times (h_{prop} + t_{base}) = \mathbf{-31}$ kNm/m

Distance to reaction $\bar{x} = (M_{total} + M_{prop}) / F_{total\_v} = \mathbf{900}$ mm

Eccentricity of reaction $e = \bar{x} - l_{base} / 2 = \mathbf{0}$ mm

Loaded length of base $l_{load} = l_{base} = \mathbf{1800}$ mm

Bearing pressure at toe $q_{toe} = F_{total\_v} / l_{base} \times (1 - 6 \times e / l_{base}) = \mathbf{42.8}$ kN/m^2

Bearing pressure at heel $q_{heel} = F_{total\_v} / l_{base} \times (1 + 6 \times e / l_{base}) = \mathbf{42.8}$ kN/m^2

Factor of safety $FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel}) = \mathbf{2.338}$

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

<u>RETAINING WALL DESIGN</u>

In accordance with EN1992-1-1:2004 incorporating Corrigendum dated January 2008 and the UK National Annex incorporating National Amendment No.1

Tedds calculation version 2.6.11

Concrete details - Table 3.1 - Strength and deformation characteristics for concrete

Concrete strength class C30/37

Characteristic compressive cylinder strength $f_{ck} = \mathbf{30}$ N/mm^2

Characteristic compressive cube strength $f_{ck,cube} = \mathbf{37}$ N/mm^2

Mean value of compressive cylinder strength $f_{cm} = f_{ck} + 8$ N/mm^2 = **38** N/mm^2

Mean value of axial tensile strength $f_{ctm} = 0.3$ N/mm$^2 \times (f_{ck} / 1$ N/mm$^2)^{2/3}$ = **2.9** N/mm^2

5% fractile of axial tensile strength $f_{ctk,0.05} = 0.7 \times f_{ctm} = \mathbf{2.0}$ N/mm^2

Secant modulus of elasticity of concrete $E_{cm} = 22$ kN/mm$^2 \times (f_{cm} / 10$ N/mm$^2)^{0.3}$ = **32837** N/mm^2

Partial factor for concrete - Table 2.1N $\gamma_C = \mathbf{1.50}$

Compressive strength coefficient - cl.3.1.6(1) $\alpha_{cc} = \mathbf{0.85}$

Design compressive concrete strength - exp.3.15 $f_{cd} = \alpha_{cc} \times f_{ck} / \gamma_C = \mathbf{17.0}$ N/mm^2

Maximum aggregate size $h_{agg} = \mathbf{20}$ mm

Reinforcement details

Characteristic yield strength of reinforcement f_{yk} = **500** N/mm^2

Modulus of elasticity of reinforcement E_s = **200000** N/mm^2

Partial factor for reinforcing steel - Table 2.1N γ_S = **1.15**

Design yield strength of reinforcement $f_{yd} = f_{yk} / \gamma_S$ = **435** N/mm^2

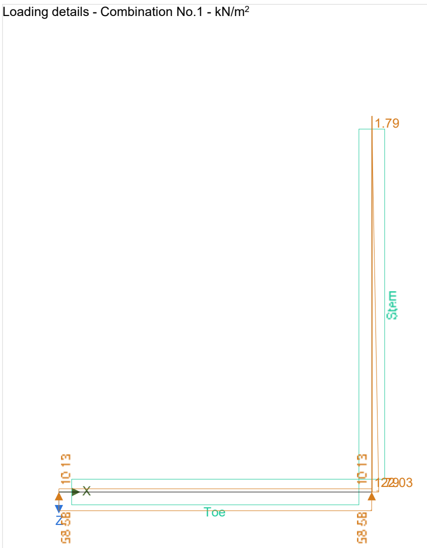
Cover to reinforcement

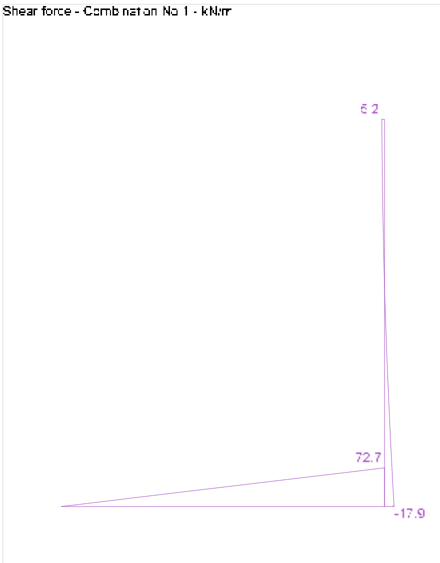
Front face of stem c_{sf} = **40** mm

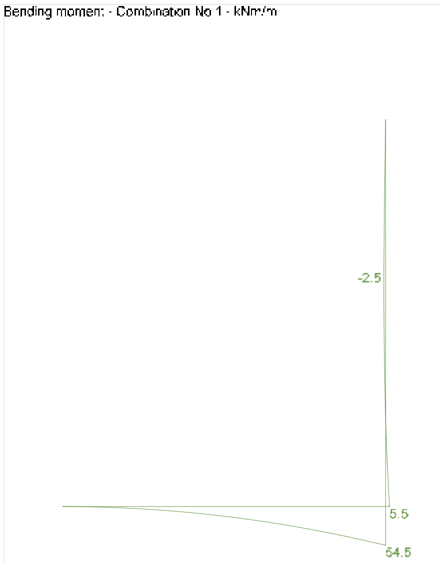
Rear face of stem c_{sr} = **50** mm

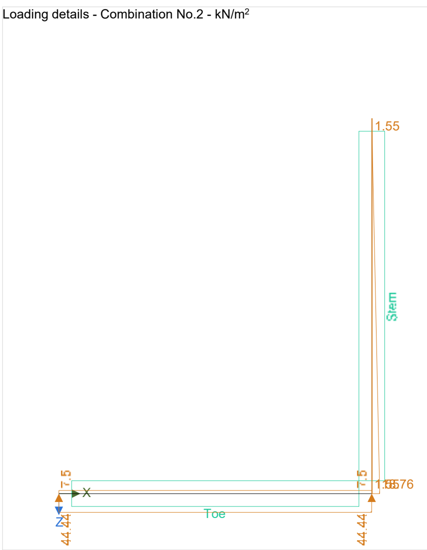
Top face of base c_{bt} = **50** mm

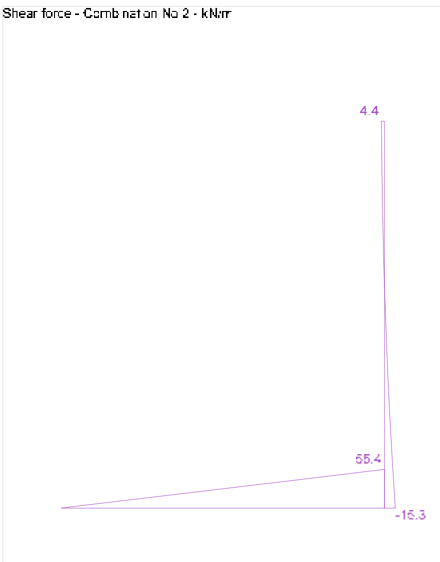
Bottom face of base c_{bb} = **75** mm

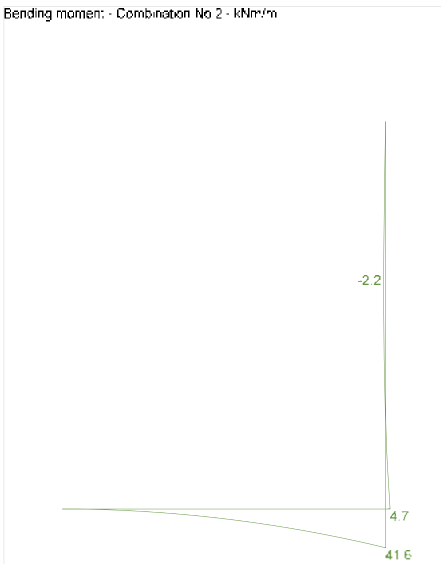












Check stem design at 1015 mm

Depth of section h = **300** mm

Rectangular section in flexure - Section 6.1

Design bending moment combination 1	M = **2.5** kNm/m
Depth to tension reinforcement	$d = h - c_{sf} - \phi_{sx} - \phi_{sfM} / 2$ = **245** mm
	$K = M / (d^2 \times f_{ck})$ = **0.001**
	K' = **0.207**

K' > K - No compression reinforcement is required

Lever arm	$z = \min(0.5 + 0.5 \times (1 - 3.53 \times K)^{0.5}, 0.95) \times d$ = **233** mm
Depth of neutral axis	$x = 2.5 \times (d – z)$ = **31** mm
Area of tension reinforcement required	$A_{sfM.req} = M / (f_{yd} \times z)$ = **25** mm²/m
Tension reinforcement provided	10 dia.bars @ 200 c/c
Area of tension reinforcement provided	$A_{sfM.prov} = \pi \times \phi_{sfM}^2 / (4 \times s_{sfM})$ = **393** mm²/m
Minimum area of reinforcement - exp.9.1N	$A_{sfM.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d$ = **369** mm²/m
Maximum area of reinforcement - cl.9.2.1.1(3)	$A_{sfM.max} = 0.04 \times h$ = **12000** mm²/m
	$\max(A_{sfM.req}, A_{sfM.min}) / A_{sfM.prov}$ = **0.94**

PASS - Area of reinforcement provided is greater than area of reinforcement required

Deflection control - Section 7.4

Reference reinforcement ratio	$\rho_0 = \sqrt{}(f_{ck} / 1\ N/mm^2) / 1000$ = **0.005**
Required tension reinforcement ratio	$\rho = A_{sfM.req} / d$ = **0.000**
Required compression reinforcement ratio	$\rho' = A_{sfM.2.req} / d_2$ = **0.000**
Structural system factor - Table 7.4N	K_b = **1**
Reinforcement factor - exp.7.17	$K_s = \min(500\ N/mm^2 / (f_{yk} \times A_{sfM.req} / A_{sfM.prov}), 1.5)$ = **1.5**
Limiting span to depth ratio - exp.7.16.a	$K_s \times K_b \times [11 + 1.5 \times \sqrt{}(f_{ck} / 1\ N/mm^2) \times \rho_0 / \rho + 3.2 \times \sqrt{}(f_{ck} / 1\ N/mm^2) \times (\rho_0 / \rho - 1)^{3/2}]$ = **10775.2**
Actual span to depth ratio	h_{prop} / d = **7.3**

PASS - Span to depth ratio is less than deflection control limit

Crack control - Section 7.3

Limiting crack width	w_{max} = **0.3** mm
Variable load factor - EN1990 – Table A1.1	ψ_2 = **0.6**
Serviceability bending moment	M_{sls} = **1.7** kNm/m
Tensile stress in reinforcement	$\sigma_s = M_{sls} / (A_{sfM.prov} \times z)$ = **19** N/mm²
Load duration	Long term
Load duration factor	k_t = **0.4**
Effective area of concrete in tension	$A_{c.eff} = \min(2.5 \times (h - d), (h – x) / 3, h / 2)$ = **89792** mm²/m
Mean value of concrete tensile strength	$f_{ct.eff} = f_{ctm}$ = **2.9** N/mm²
Reinforcement ratio	$\rho_{p.eff} = A_{sfM.prov} / A_{c.eff}$ = **0.004**
Modular ratio	$\alpha_e = E_s / E_{cm}$ = **6.091**
Bond property coefficient	k_1 = **0.8**
Strain distribution coefficient	k_2 = **0.5**
	k_3 = **3.4**
	k_4 = **0.425**
Maximum crack spacing - exp.7.11	$s_{r.max} = k_3 \times c_{sf} + k_1 \times k_2 \times k_4 \times \phi_{sfM} / \rho_{p.eff}$ = **525** mm
Maximum crack width - exp.7.8	$w_k = s_{r.max} \times \max(\sigma_s – k_t \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_e \times \rho_{p.eff}), 0.6 \times \sigma_s) / E_s$
	w_k = **0.03** mm
	w_k / w_{max} = **0.1**

PASS - Maximum crack width is less than limiting crack width

Check stem design at base of stem

Depth of section — $h = \mathbf{300}$ mm

Rectangular section in flexure - Section 6.1

Design bending moment combination 1 — $M = \mathbf{5.5}$ kNm/m

Depth to tension reinforcement — $d = h - c_{sr} - \phi_{sr} / 2 = \mathbf{244}$ mm

$K = M / (d^2 \times f_{ck}) = \mathbf{0.003}$

$K' = \mathbf{0.207}$

K' > K - No compression reinforcement is required

Lever arm — $z = \min(0.5 + 0.5 \times (1 - 3.53 \times K)^{0.5}, 0.95) \times d = \mathbf{232}$ mm

Depth of neutral axis — $x = 2.5 \times (d - z) = \mathbf{31}$ mm

Area of tension reinforcement required — $A_{sr.req} = M / (f_{yd} \times z) = \mathbf{54}$ mm²/m

Tension reinforcement provided — 12 dia.bars @ 200 c/c

Area of tension reinforcement provided — $A_{sr.prov} = \pi \times \phi_{sr}^2 / (4 \times s_{sr}) = \mathbf{565}$ mm²/m

Minimum area of reinforcement - exp.9.1N — $A_{sr.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d = \mathbf{368}$ mm²/m

Maximum area of reinforcement - cl.9.2.1.1(3) — $A_{sr.max} = 0.04 \times h = \mathbf{12000}$ mm²/m

$\max(A_{sr.req}, A_{sr.min}) / A_{sr.prov} = \mathbf{0.65}$

PASS - Area of reinforcement provided is greater than area of reinforcement required

Deflection control - Section 7.4

Reference reinforcement ratio — $\rho_0 = \sqrt{(f_{ck} / 1\ N/mm^2)} / 1000 = \mathbf{0.005}$

Required tension reinforcement ratio — $\rho = A_{sr.req} / d = \mathbf{0.000}$

Required compression reinforcement ratio — $\rho' = A_{sr.2.req} / d_2 = \mathbf{0.000}$

Structural system factor - Table 7.4N — $K_b = \mathbf{1}$

Reinforcement factor - exp.7.17 — $K_s = \min(500\ N/mm^2 / (f_{yk} \times A_{sr.req} / A_{sr.prov}), 1.5) = \mathbf{1.5}$

Limiting span to depth ratio - exp.7.16.a — $K_s \times K_b \times [11 + 1.5 \times \sqrt{(f_{ck} / 1\ N/mm^2)} \times \rho_0 / \rho + 3.2 \times \sqrt{(f_{ck} / 1\ N/mm^2)} \times (\rho_0 / \rho - 1)^{3/2}] = \mathbf{3327}$

Actual span to depth ratio — $h_{prop} / d = \mathbf{7.4}$

PASS - Span to depth ratio is less than deflection control limit

Crack control - Section 7.3

Limiting crack width — $w_{max} = \mathbf{0.3}$ mm

Variable load factor - EN1990 – Table A1.1 — $\psi_2 = \mathbf{0.6}$

Serviceability bending moment — $M_{sls} = \mathbf{3.8}$ kNm/m

Tensile stress in reinforcement — $\sigma_s = M_{sls} / (A_{sr.prov} \times z) = \mathbf{29.1}$ N/mm²

Load duration — Long term

Load duration factor — $k_t = \mathbf{0.4}$

Effective area of concrete in tension — $A_{c.eff} = \min(2.5 \times (h - d), (h - x) / 3, h / 2) = \mathbf{89833}$ mm²/m

Mean value of concrete tensile strength — $f_{ct.eff} = f_{ctm} = \mathbf{2.9}$ N/mm²

Reinforcement ratio — $\rho_{p.eff} = A_{sr.prov} / A_{c.eff} = \mathbf{0.006}$

Modular ratio — $\alpha_e = E_s / E_{cm} = \mathbf{6.091}$

Bond property coefficient — $k_1 = \mathbf{0.8}$

Strain distribution coefficient — $k_2 = \mathbf{0.5}$

$k_3 = \mathbf{3.4}$

$k_4 = \mathbf{0.425}$

Maximum crack spacing - exp.7.11 — $s_{r.max} = k_3 \times c_{sr} + k_1 \times k_2 \times k_4 \times \phi_{sr} / \rho_{p.eff} = \mathbf{494}$ mm

Maximum crack width - exp.7.8 — $w_k = s_{r.max} \times \max(\sigma_s - k_t \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_e \times \rho_{p.eff}), 0.6 \times \sigma_s) / E_s$

$w_k = \mathbf{0.043}$ mm

$w_k / w_{max} = \mathbf{0.144}$

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force — V = **17.9** kN/m

$C_{Rd,c} = 0.18 / \gamma_C$ = **0.120**

k = min(1 + √(200 mm / d), 2) = **1.905**

Longitudinal reinforcement ratio — $\rho_l = \min(A_{sr.prov} / d, 0.02)$ = **0.002**

$v_{min} = 0.035\ N^{1/2}/mm \times k^{3/2} \times f_{ck}^{0.5}$ = **0.504** N/mm²

Design shear resistance - exp.6.2a & 6.2b — $V_{Rd.c} = \max(C_{Rd.c} \times k \times (100\ N^2/mm^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$

$V_{Rd.c}$ = **123** kN/m

$V / V_{Rd.c}$ = **0.145**

PASS - Design shear resistance exceeds design shear force

Check stem design at prop

Depth of section — h = **300** mm

Rectangular section in shear - Section 6.2

Design shear force — V = **5.2** kN/m

$C_{Rd,c} = 0.18 / \gamma_C$ = **0.120**

k = min(1 + √(200 mm / d), 2) = **1.905**

Longitudinal reinforcement ratio — $\rho_l = \min(A_{sr1.prov} / d, 0.02)$ = **0.002**

$v_{min} = 0.035\ N^{1/2}/mm \times k^{3/2} \times f_{ck}^{0.5}$ = **0.504** N/mm²

Design shear resistance - exp.6.2a & 6.2b — $V_{Rd.c} = \max(C_{Rd.c} \times k \times (100\ N^2/mm^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$

$V_{Rd.c}$ = **123** kN/m

$V / V_{Rd.c}$ = **0.042**

PASS - Design shear resistance exceeds design shear force

Horizontal reinforcement parallel to face of stem - Section 9.6

Minimum area of reinforcement – cl.9.6.3(1) — $A_{sx.req} = \max(0.25 \times A_{sr.prov}, 0.001 \times t_{stem})$ = **300** mm²/m

Maximum spacing of reinforcement – cl.9.6.3(2) — s_{sx_max} = **400** mm

Transverse reinforcement provided — 10 dia.bars @ 200 c/c

Area of transverse reinforcement provided — $A_{sx.prov} = \pi \times \phi_{sx}^2 / (4 \times s_{sx})$ = **393** mm²/m

PASS - Area of reinforcement provided is greater than area of reinforcement required

Check base design at toe

Depth of section — h = **300** mm

Rectangular section in flexure - Section 6.1

Design bending moment combination 1 — M = **54.5** kNm/m

Depth to tension reinforcement — $d = h - c_{bb} - \phi_{bb} / 2$ = **217** mm

$K = M / (d^2 \times f_{ck})$ = **0.039**

K' = **0.207**

K' > K - No compression reinforcement is required

Lever arm — $z = \min(0.5 + 0.5 \times (1 - 3.53 \times K)^{0.5}, 0.95) \times d$ = **206** mm

Depth of neutral axis — $x = 2.5 \times (d – z)$ = **27** mm

Area of tension reinforcement required — $A_{bb.req} = M / (f_{yd} \times z)$ = **608** mm²/m

Tension reinforcement provided — 16 dia.bars @ 150 c/c

Area of tension reinforcement provided — $A_{bb.prov} = \pi \times \phi_{bb}^2 / (4 \times s_{bb})$ = **1340** mm²/m

Minimum area of reinforcement - exp.9.1N — $A_{bb.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d$ = **327** mm²/m

Maximum area of reinforcement - cl.9.2.1.1(3) — $A_{bb.max} = 0.04 \times h$ = **12000** mm²/m

$\max(A_{bb.req}, A_{bb.min}) / A_{bb.prov}$ = **0.454**

PASS - Area of reinforcement provided is greater than area of reinforcement required

Crack control - Section 7.3

Limiting crack width	w_{max} = **0.3** mm
Variable load factor - EN1990 – Table A1.1	ψ_2 = **0.6**
Serviceability bending moment	M_{sls} = **39.7** kNm/m
Tensile stress in reinforcement	$\sigma_s = M_{sls} / (A_{bb.prov} \times z)$ = **143.6** N/mm^2
Load duration	Long term
Load duration factor	k_t = **0.4**
Effective area of concrete in tension	$A_{c.eff} = \min(2.5 \times (h - d), (h – x) / 3, h / 2)$ = **90958** mm^2/m
Mean value of concrete tensile strength	$f_{ct.eff} = f_{ctm}$ = **2.9** N/mm^2
Reinforcement ratio	$\rho_{p.eff} = A_{bb.prov} / A_{c.eff}$ = **0.015**
Modular ratio	$\alpha_e = E_s / E_{cm}$ = **6.091**
Bond property coefficient	k_1 = **0.8**
Strain distribution coefficient	k_2 = **0.5**
	k_3 = **3.4**
	k_4 = **0.425**
Maximum crack spacing - exp.7.11	$s_{r.max} = k_3 \times c_{bb} + k_1 \times k_2 \times k_4 \times \phi_{bb} / \rho_{p.eff}$ = **440** mm
Maximum crack width - exp.7.8	$w_k = s_{r.max} \times \max(\sigma_s – k_t \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_e \times \rho_{p.eff}), 0.6 \times \sigma_s) / E_s$
	w_k = **0.189** mm
	w_k / w_{max} = **0.631**

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

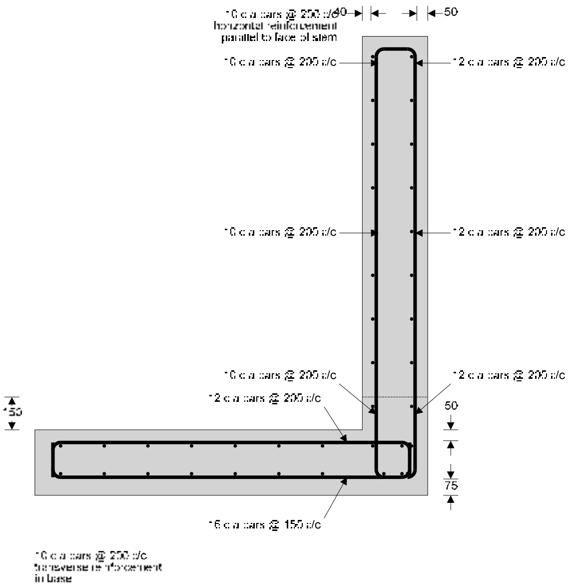
Design shear force	V = **72.7** kN/m
	$C_{Rd,c} = 0.18 / \gamma_C$ = **0.120**
	$k = \min(1 + \sqrt{(200 mm / d)}, 2)$ = **1.960**
Longitudinal reinforcement ratio	$\rho_l = \min(A_{bb.prov} / d, 0.02)$ = **0.006**
	$v_{min} = 0.035 N^{1/2}/mm \times k^{3/2} \times f_{ck}^{0.5}$ = **0.526** N/mm^2
Design shear resistance - exp.6.2a & 6.2b	$V_{Rd.c} = \max(C_{Rd.c} \times k \times (100 N^2/mm^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$
	$V_{Rd.c}$ = **135.1** kN/m
	$V / V_{Rd.c}$ = **0.538**

PASS - Design shear resistance exceeds design shear force

Secondary transverse reinforcement to base - Section 9.3

Minimum area of reinforcement – cl.9.3.1.1(2)	$A_{bx.req} = 0.2 \times A_{bb.prov}$ = **268** mm^2/m
Maximum spacing of reinforcement – cl.9.3.1.1(3)	s_{bx_max} = **450** mm
Transverse reinforcement provided	10 dia.bars @ 200 c/c
Area of transverse reinforcement provided	$A_{bx.prov} = \pi \times \phi_{bx}^2 / (4 \times s_{bx})$ = **393** mm^2/m

PASS - Area of reinforcement provided is greater than area of reinforcement required



Reinforcement details

Appendix B: Construction Programme

<u>The Contractor is responsible for the final construction programme</u>

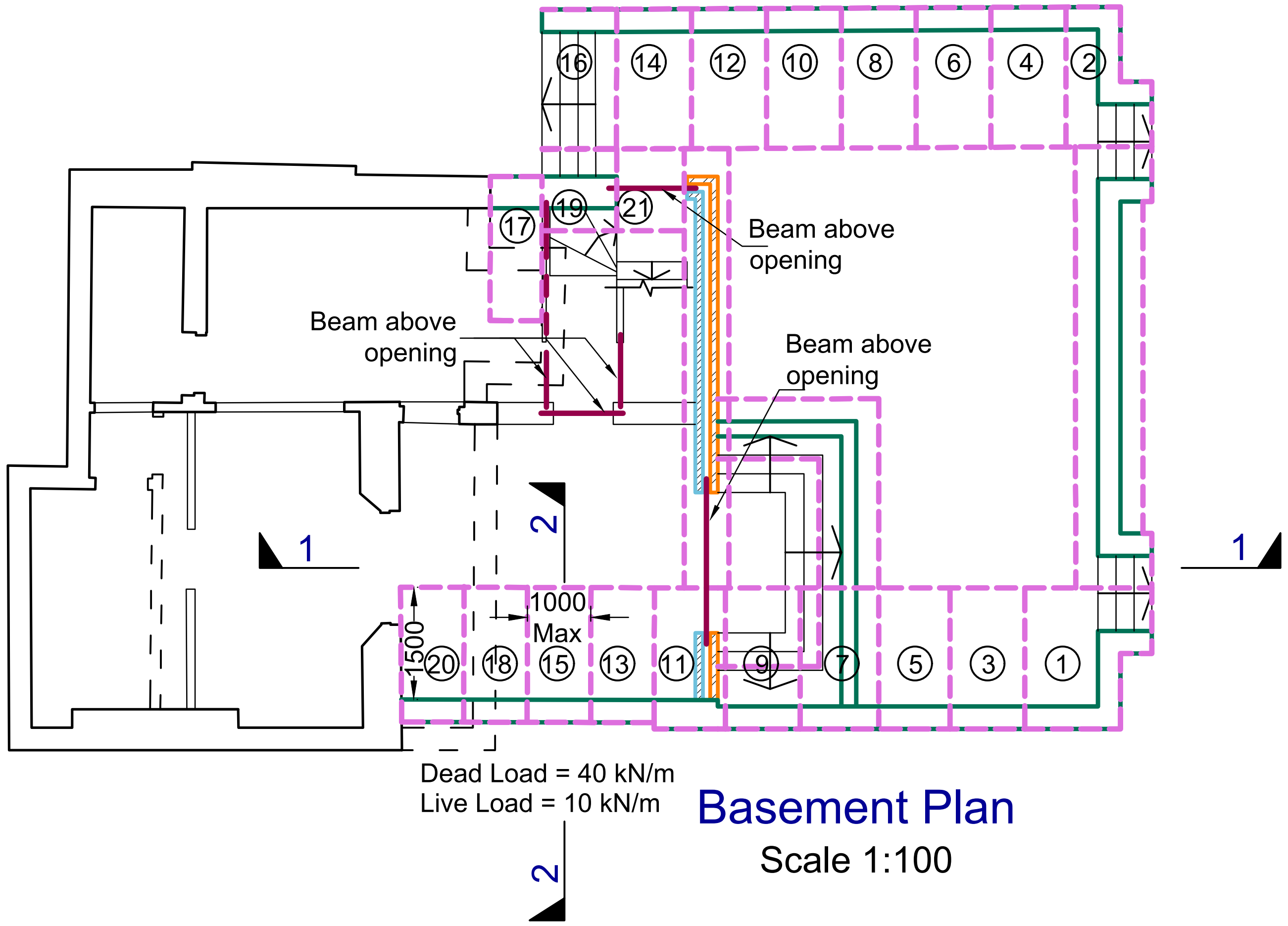
Outline construction Programme

(For planning purposes only)

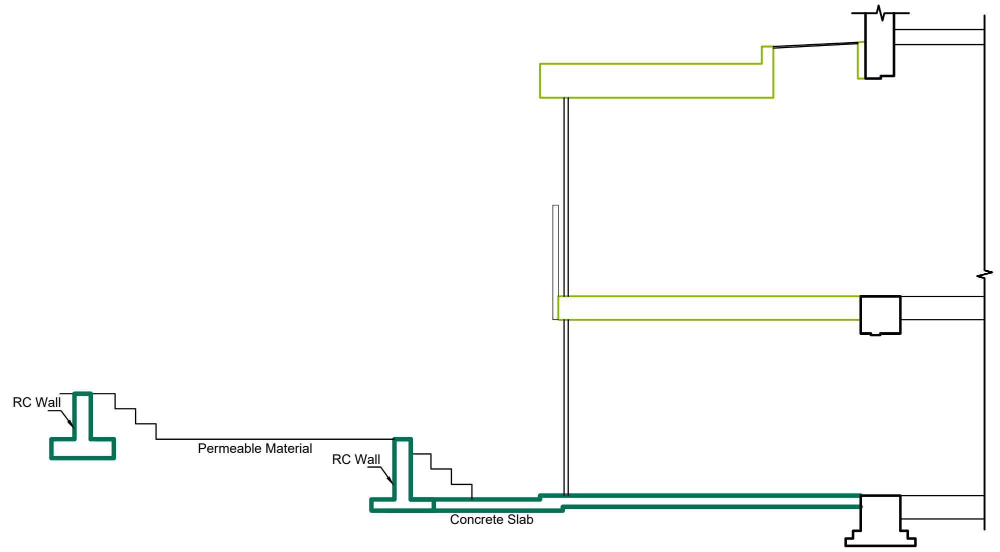
	Months															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Planning approval																
Detailed Design																
Tender																
Party Walls																
Monitoring of Adjacent structures																
Enabling works																
Basement Construction																
Superstructure construction																

Appendix C: Structural Drawings

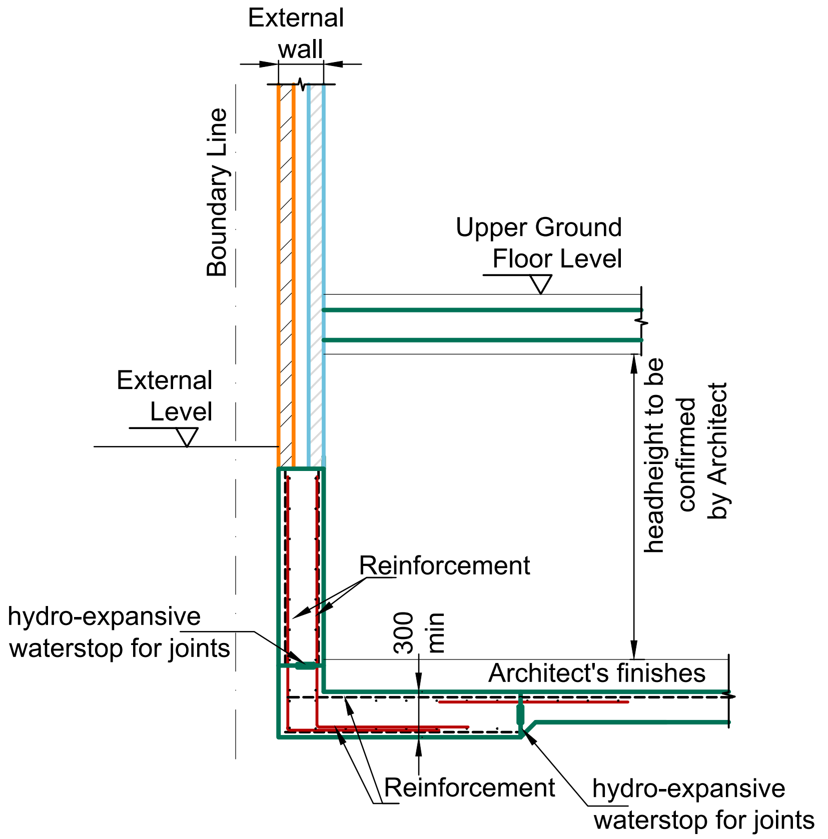
1:100 Basement Plan
1:100 Ground Floor plan
1:50 Section
1:100 Section



Basement Plan
Scale 1:100



Section 1-1
Scale 1:100



Section 2-2
Scale 1:50

Rev	Date	Amendments
1	30/01/2018	Minor Alterations
-	30/11/2017	First issue for comment

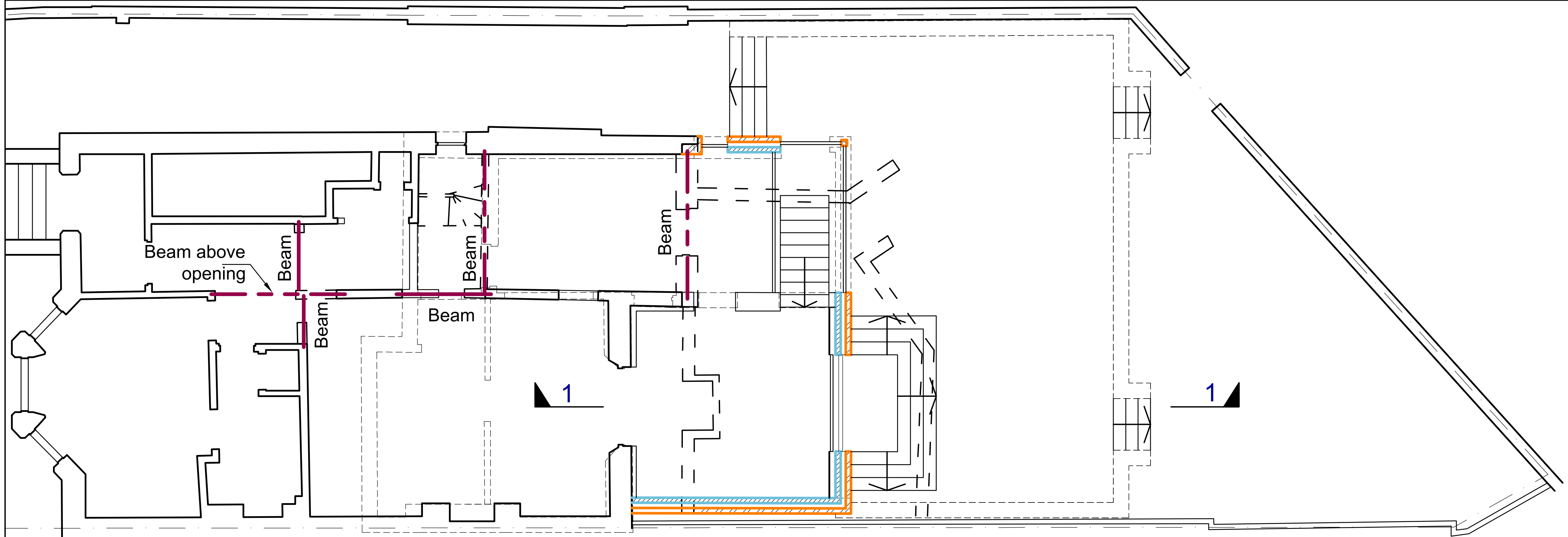
Job Number: 171008	Date: Nov '17
Dwg Number: SL-10	Rev: 1
Drawn: CC	Ch'kd: PH
Scale: As shown @ A3	

Client: Geoff Ho

Project: 15 Rosslyn Hill

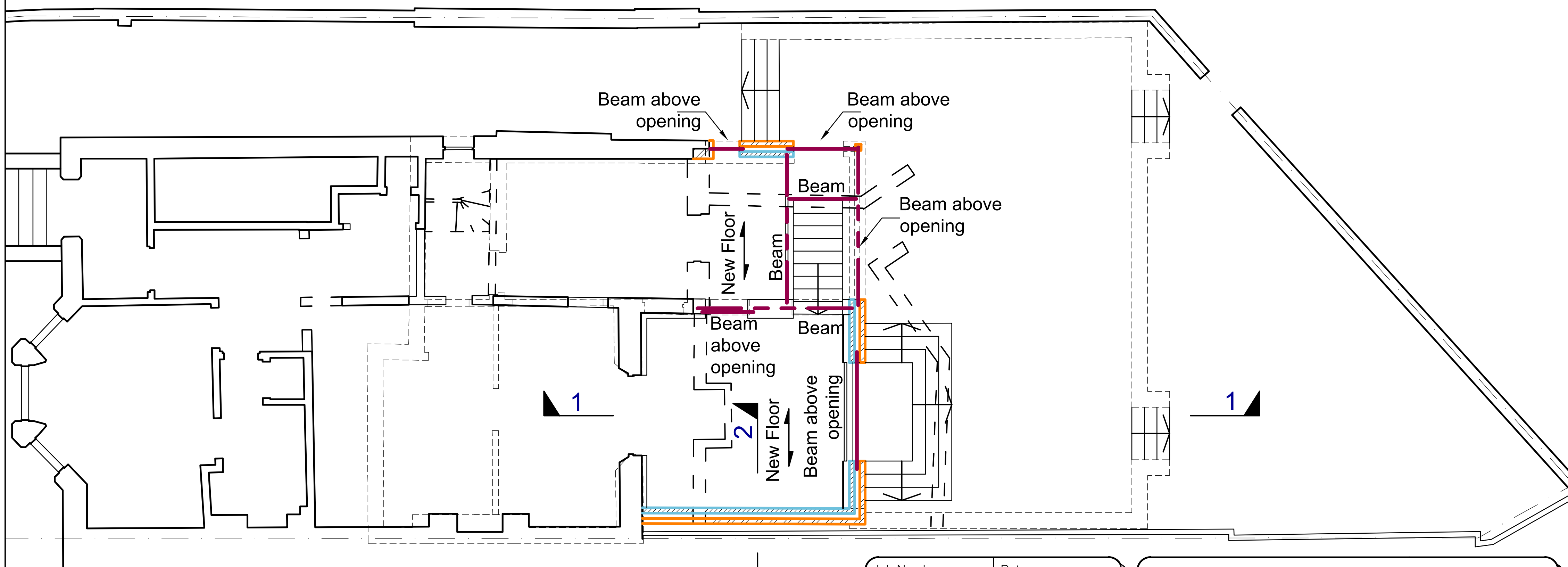
Title : Basement and Section

Croft Structural Engineers
Clockshop Mews, r/o 60 Saxon Rd, London, SE25 5EH.
020 8684 4744
www.croftse.co.uk



Reflected Ceilings Ground Floor Plan

Scale 1:100



Ground Floor Plan

Scale 1:100

Rev	Date	Amendments
-	30/11/2017	First issue for comment

Job Number 171008	Date Nov '17
Dwg Number SL-20	Rev -
Drawn CC	Ch'kd PH
Scale As shown @ A3	

Client: Geoff Ho

Project: 15 Rosslyn Hill

Title : Ground Floor Plan

Croft Structural Engineers

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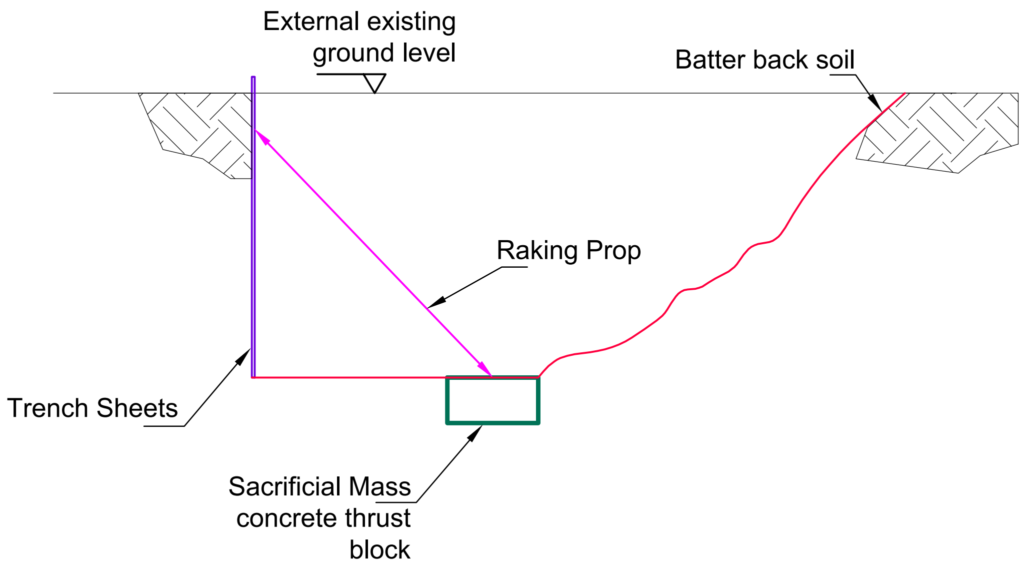
www.croftse.co.uk

Appendix D: Construction Sequence and Temporary Works Proposals

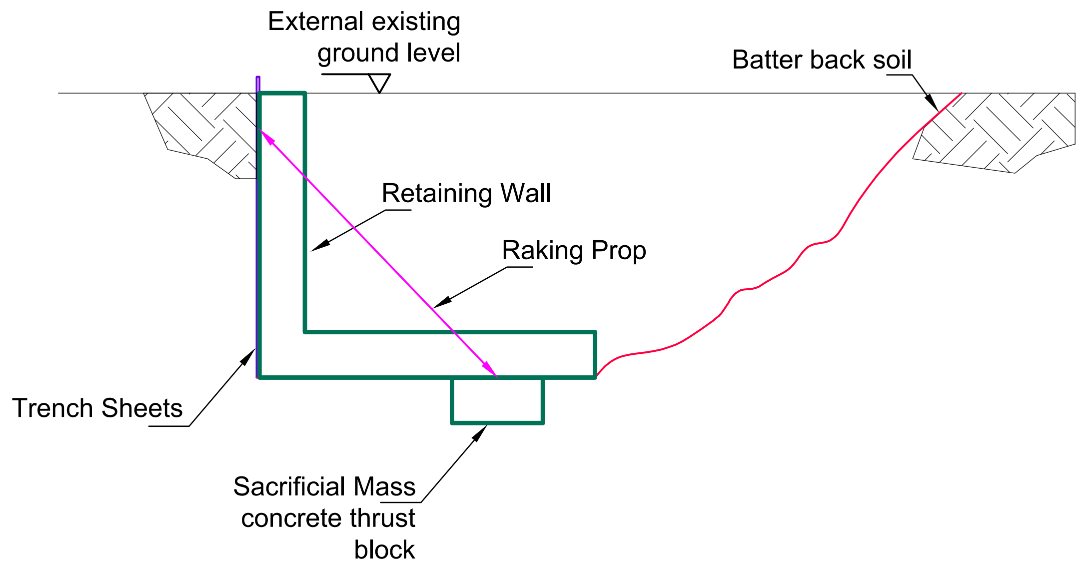
Phase 1

1. Excavate against neighboring property and install raking props and trench sheets and excavation progresses



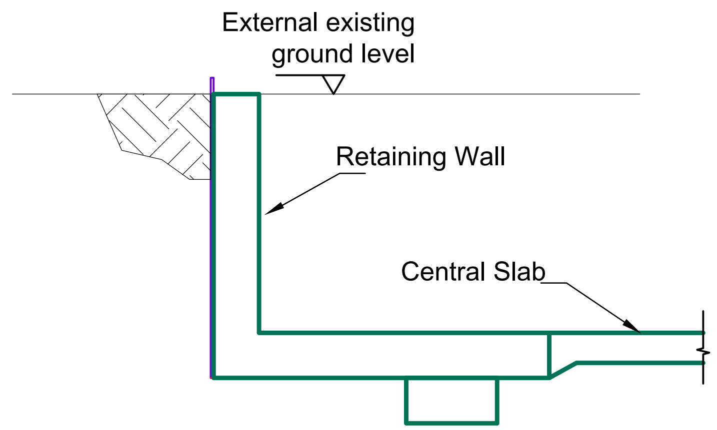
Phase 2

1. Cast Retaining wall and Base. Cast around raking props.
2. Remove Props after concrete pads gain sufficient strength



Phase 3

1. Excavate and cast remainder of base slab
2. Proceed with above ground construction



- PLANNING ISSUE -
NOT FOR CONSTRUCTION

Rev	Date	Amendments
-	30/01/2018	First issue for comment

Job Number: 171008	Date: Jan '18
Dwg Number: TW-10	Rev: -
Drawn: CC	Ch'kd: PH
Scale: As shown @ A3	

Client: Geoff Ho

Project: 15 Rosslyn Hill

Title : Construction Sequence and Temporary Works Proposals

Croft Structural Engineers
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Appendix E: Proposed Monitoring Statement

Job Number: 171008

CROFT STRUCTURAL ENGINEERS

Croft Structural Engineers
Clock Shop Mews
Rear of 60 Saxon Road
London SE25 5EH

T: 020 8684 4744
E: enquiries@croftse.co.uk
W: www.croftse.co.uk

Structural Monitoring Statement

Property:

Flat 2,
15 Rosslyn Hill,
Camden
NW3 5UJ

Client:

Mr Geoff Ho

Revision	Date	Comment
-	30.01.2018	First Issue

Contents

1. Introduction

Basement works are intended at 15 Rosslyn Hill. The structural works for this may require monitoring, depending on the requirements made during the planning application and the stipulations of the subsequent Party Wall Awards. . This statement describes the procedures for the Principal Contractor to follow to observe any movement that may occur to the existing properties, and also describes mitigation measures to apply if necessary.

2. Risk Assessment

The purpose of this risk assessment is to consider the impact of the proposed works and how they impact the party wall. There are varying levels of inspection that can be undertaken and not all works, soil conditions and properties require the same level of protection. In the table below, Monitoring Level 5 is considered the most appropriate.

Monitoring Level Proposed	Type of Works.
Monitoring 1 Visual inspection and production of condition survey by Party wall surveyors at the beginning of the works and also at the end of the works.	• Loft conversions, cross wall removals, insertion of padstones. • Survey of LUL and Network Rail tunnels. • Mass concrete, reinforced and piled foundations to new build properties.

Monitoring 2 Visual inspection and production of condition survey by Party Wall Surveyors at the beginning of the works and also at the end of the works. Visual inspection of existing party wall during the works. Inspection of the footing to ensure that the footings are stable and adequate.	• Removal of lateral stability and insertion of new stability fames • Removal of main masonry load bearing walls. • Underpinning works less than 1.2m deep
Monitoring 3 Visual inspection and production of condition survey by Party Wall Surveyors at the beginning of the works and also at the end of the works. Visual inspection of existing party wall during the works. Inspection of the footing to ensure that the footings are stable and adequate. Vertical monitoring movement by standard optical equipment	• Lowering of existing basement and cellars more than 2.5m • Underpinning works less than 3.0m deep in clays • Basements up to 2.5m deep in clays
Monitoring 4 Visual inspection and production of condition survey by Party Wall Surveyors at the beginning of the works and also at the end of the works. Visual inspection of existing party wall during the works. Inspection of the footing to ensure that the footings are stable and adequate. Vertical monitoring movement by standard optical equipment Lateral movement between walls by laser measurements	• New basements greater than 2.5m and shallower than 4m Deep in gravels • Basements up to 4.5m deep in clays • Underpinning works to Grade I listed building

Monitoring 5 Visual inspection and production of condition survey by Party wall surveyors at the beginning of the works and also at the end of the works. Visual inspection of existing party wall during the works. Inspection of the footing to ensure that the footings are stable and adequate. Vertical & lateral monitoring movement by theodolite at specific times during the projects.	• Underpinning works to Grade I listed buildings • Basements to Listed building • Basements deeper than 4m in gravels • Basements deeper than 4.5m in clays • Underpinning, basements to buildings that are expressing defects.
Monitoring 6 Visual inspection and production of condition survey by Party wall surveyors at the beginning of the works and also at the end of the works. Visual inspection of existing party wall during the works. Inspection of the footing to ensure that the footings are stable and adequate. Vertical & lateral monitoring movement by electronic means with live data gathering. Weekly interpretation	• Double storey basements supported by piled retaining walls in gravels and soft sands. (N<12)
Monitoring 7 Visual inspection and production of condition survey by Party wall surveyors at the beginning of the works and also at the end of the works. Visual inspection of existing party wall during the works. Inspection of the footing to ensure that the footings are stable and adequate. Vertical & lateral monitoring movement by electronic means with live data gathering with data transfer.	• Larger multi-storey basements on particular projects.

3. Scheme Details

This document has been prepared by Croft Structural Engineers Ltd. It covers the development of an extension of an existing basement. This will extend below part of the garden at 15 Rosslyn Hill.

Scope of Works

The works comprise:

- Visual Monitoring of the party wall
- Attachment of Tell tales or Demec Studs to accurately record movement of significant cracks.
- Attachment of levelling targets to monitor settlement.

- The monitoring of the above instrumentation is in accordance with Appendix A. The number and precise locations of instrumentation may change during the works; this shall be subject to agreement with the Principal Contractor (PC).
- All instruments are to be adequately protected against any damage from construction plant or private vehicles using clearly visible markings and suitable head protection e.g. manhole rings or similar. Any damaged instruments are to be immediately replaced or repaired at the contractors own cost.
- Reporting of all data in a manner easily understood by all interested parties.
- Co-ordination of these monitoring works with other site operations to ensure that all instruments can be read and can be reviewed against specified trigger values both during and post construction.
- Regular site meetings by the Principal Contractor (PC) and the Monitoring Surveyor (MS) to review the data and their implications.
- Review of data by Croft Structural Engineers

In addition, the PC will have responsibility for the following:

- Review of methods of working/operations to limit movements, and
- Implementation of any emergency remedial measures if deemed necessary by the results of the monitoring.

The Monitoring Surveyor shall allow for settlement and crack monitoring measures to be installed and monitored on various parts of the structure described in Table 1 as directed by the PC and Party Wall Surveyor (PWS) for the Client.

Item	Instrumentation Type
Party Wall Brickwork	
Settlement monitoring	Levelling equipment & targets
Crack monitoring	Visual inspection of cracking, Demec studs where necessary

Table 1: Instrumentation

General

The site excavations and substructure works up to finished ground slab stage have the potential to cause vibration and ground movements in the vicinity of the site due to the following:

a) Removal of any existing redundant foundations / obstructions;
b) Installation of reinforced concrete retaining walls under the existing footings;
c) Excavations within the site

The purpose of the monitoring is a check to confirm building movements are not excessive.

This specification is aimed at providing a strategy for monitoring of potential ground and building movements at the site.

This specification is intended to define a background level of monitoring. The PC may choose to carry out additional monitoring during critical operations. Monitoring that should be carried out is as follows:

a) Visual inspection of the party wall and any pre-existing cracking

b) Settlement of the party wall

All instruments are to be protected from interference and damage as part of these works.

Access to all instrumentation or monitoring points for reading shall be the responsibility of the Monitoring Surveyor (MS). The MS shall be in sole charge for ensuring that all instruments or monitoring points can be read at each visit and for reporting of the data in a form to be agreed with the PWS. He shall inform the PC if access is not available to certain instruments and the PC will, wherever possible, arrange for access. He shall immediately report to the PC any damage. The Monitoring Surveyor and the Principal Contractor will be responsible for ensuring that all the instruments that fall under their respective remits as specified are fully operational at all times and any defective or damaged instruments are immediately identified and replaced.

The PC shall be fully responsible for reviewing the monitoring data with the MS - before passing it on to Croft Structural Engineers - determining its accuracy and assessing whether immediate action is to be taken by him and/or other contractors on site to prevent damage to instrumentation or to ensure safety of the site and personnel. All work shall comply with the relevant legislation, regulations and manufacturer's instructions for installation and monitoring of instrumentation.

Applicable Standards and References

The following British Standards and civil engineering industry references are applicable to the monitoring of ground movements related to activities on construction works sites:

1. BS 5228: Part 1: 1997 - Noise and Vibration Control on Construction and Open Sites -Part 1.Code of practice for basic information and procedures for noise and vibration control, Second Edition, BSI 1999.
2. BS 5228: Part 2: 1997 - Noise and Vibration Control on Construction and Open Sites -Part 2.Guide to noise and vibration control legislation for construction and demolition including road construction and maintenance, Second Edition, BSI 1997.
3. BS 7385-1: 1990 (ISO 4866:1990) - Evaluation and measurement for vibration in buildings - Part 1: Guide for measurement of vibrations and evaluation of their effects on buildings, First Edition, BSI 1990.
4. BS 7385-2: 1993 - Evaluation and measurement for vibration in buildings - Part 2: Guide to damage levels from ground-borne vibration, First Edition, BSI 1999.
5. CIRIA SP 201 - Response of buildings to excavation-induced ground movements, CIRIA 2001.

SPECIFICATION FOR INSTRUMENTATION

General

The Monitoring Contractor is required to monitor, protect and reinstall instruments as described. The readings are to be recorded and reported. The following instruments are defined:

a) Automatic level and targets: A device which allows the measurement of settlement in the vertical axis. To be installed by the MS.

b) Tell-tales and 3 stud sets: A device which allows measurement of movement to be made in two axes perpendicular to each other. To be installed by the MS.

Monitoring of existing cracks

The locations of tell-tales or Demec studs to monitor existing cracks shall be agreed with Croft Structural Engineers.

Instrument Installation Records and Reports

Where instrumentation is to be installed or reinstalled, the Monitoring Surveyor, or the Principal Contractor, as applicable, shall make a complete record of the work. This should include the position and level of each instrument. The records shall include base readings and measurements taken during each monitoring visit. Both tables and graphical outputs of these measurements shall be presented in a format to be agreed with the CM. The report shall include photographs of each type of instrumentation installed and clear scaled sections and plans of each instrument installed. This report shall also include the supplier's technical fact sheet on the type of instrument used and instructions on monitoring.

Two signed copies of the report shall be supplied to the PWS within one week of completion of site measurements for approval.

Installation

All instruments shall be installed to the satisfaction of the PC. No loosening or disturbance of the instrument with use or time shall be acceptable. All instruments are to be clearly marked to avoid damage.

All setting out shall be undertaken by the Monitoring Surveyor or the Principal Contractor as may be applicable. The precise locations will be agreed by the PC prior to installation of the instrument.

The installations are to be managed and supervised by the Instrumentation Engineer or the Measurement Surveyor as may be applicable.

Monitoring

The frequencies of monitoring for each Section of the Works are given in Appendix A.

The following accuracies/ tolerances shall be achieved:

Party Wall settlement	±1.5mm
Crack monitoring	±0.75mm

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REPORT OF RESULTS AND TRIGGER LEVELS

General

Within 24 hours of taking the readings, the Monitoring Surveyor will submit a single page summary of the recorded movements. All readings shall be immediately reviewed by Croft Structural Engineers prior to reporting to the PWS (Party Wall Surveyor).

Within one working day of taking the readings the Monitoring Contractor shall produce a full report (see below).

The following system of control shall be employed by the PC and appropriate contractors for each section of the works. The Trigger value, at which the appropriate action shall be taken, for each section, is given in Table 2, below.

The method of construction by use of sequential underpins limits the deflections in the party wall.

Between the trigger points, which are no greater than 2 m apart, there should be no more than 4mm.

Above Monitoring Level 3, lateral movement is required to be measured and the proposed trigger limit is 3mm

During works measurements are taken, these are compared with the limits set out below:

MOVEMENT		CATEGORY	ACTION
Vertical	Horizontal		
0mm-4mm	0-3mm	Green	No action required
4mm-7mm	3-6mm	AMBER	Detailed review of Monitoring: Check studs are OK and have not moved. Ensure site staff have not moved studs. If studs have moved reposition. Relevel to ensure results are correct and tolerance is not a concern. Inform Party Wall surveyors of amber readings. Double the monitoring for 2 further readings. If stable revert back. Carry out a local structural review and inspection. Preparation for the implementation of remedial measures should be required. Double number of lateral props
7mm-10mm	6-8mm		Implement remedial measures review method of working and ground conditions
>10mm	>8mm	RED	Implement structural support as required; Cease works with the exception of necessary works for the safety and stability of the structure and personnel; Review monitoring data and implement revised method of works

Table 2 – Movement limits between adjacent sets of Tell-tales or stud sets

Any movements which exceed the individual amber trigger levels for a monitoring measure given in Table 2 shall be immediately reported to the PWS, and a review of all of the current monitoring data for all monitoring measures must be implemented to determine the possible causes of the trigger level being exceeded. Monitoring of the affected location must be increased and the actions described above implemented. Assessment of exceeded trigger levels must not be carried out in isolation from an assessment of the entire monitoring regime as the monitoring measures are inter-related. Where required, measures may be implemented or prepared as determined by the specific situation and combination of observed monitoring measurement data.

Standard Reporting

1 No. electronic copy of the report in PDF format shall be submitted to the PWS.

The Monitoring Surveyor shall report whether the movements are within (or otherwise) the Trigger Levels indicated in Table 2. A summary of the extent of completion of any of the elements of works and any other significant events shall be given. These works shall be shown in the form of annotated plans (and sections) for each survey visit both local to the instrumentation and over a wider area. The associated changes to readings at each survey or monitoring point shall be then regulated to the construction activity so that the cause of any change, if it occurs, can be determined.

The Monitoring Surveyor shall also give details of any events on site which in his opinion could affect the validity of the results of any of the surveys.

The report shall contain as a minimum, for each survey visit the following information:

a) The date and time of each reading:
b) The weather on the day:
c) The name of the person recording the data on site and the person analysing the readings together with their company affiliations;
d) Any damage to the instrumentation or difficulties in reading;
e) Tables comparing the latest reading with the last reading and the base reading and the changes between these recorded data;
f) Graphs showing variations in crack width with time for the crack measuring gauges; and
g) Construction activity as described. It is very important that each set of readings is associated with the extent of excavation and construction at that time. Readings shall be accompanied by information describing the extent of works at the time of readings. This shall be agreed with the PC.

Spread-sheet columns of numbers should be clearly labelled together with units. Numbers should not be reported to a greater accuracy than is appropriate. Graph axis should be linear and clearly labelled together with units. The axis scales are to be agreed with the PC before the start of monitoring and are to remain constant for the duration of the job unless agreed otherwise. The specified trigger values are also to be plotted on all graphs.

The reports are to include progress photographs of the works both general to the area of each instrument and globally to the main Works. In particular, these are to supplement annotated plans/sections described above. Wherever possible the global photographs are to be taken from approximately the same spot on each occasion. The locations of these points on site are to be determined by the engineer at detailed design stage.

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Erroneous Data

All data shall be checked for errors by the Monitoring Surveyor prior to submission. If a reading that appears to be erroneous (i.e. it shows a trend which is not supported by the surrounding instrumentation), he shall notify the PC immediately, resurvey the point in question and the neighbouring points and if the error is repeated, he shall attempt to identify the cause of the error. Both sets of readings shall be processed and submitted, together with the reasons for the errors and details of remedial works. If the error persists at subsequent survey visits, the Monitoring Surveyor shall agree with the PC how the data should be corrected. Correction could be achieved by correcting the readings subsequent to the error first being identified to a new base reading.

The Monitoring Surveyor shall rectify any faults found in or damage caused to the instrumentation system for the duration of the specified monitoring period, irrespective of cause, at his own cost.

Trigger Values

Trigger values for maximum movements as listed in Table 2. If the movement exceeds these values then action may be required to limit further movement. The PC should be immediately advised of the movements in order to implement the necessary works.

It is important that all neighbouring points (not necessarily a single survey point) should be used in assessing the impact of any movements which exceed the trigger values, and that rechecks are carried out to ensure the data is not erroneous. A detailed record of all activities in the area of the survey point will also be required as specified elsewhere.

Responsibility for Instrumentation

The Monitoring Surveyor shall be responsible for: managing the installation of the instruments or measuring points, reporting of the results in a format which is user friendly to all parties; and immediately reporting to all parties any damage. The Monitoring Surveyor shall be responsible for informing the PC of any movements which exceed the specified trigger values listed in Table 2 so that the PC can implement appropriate procedures. He shall immediately inform the PWS of any decisions taken.

APPENDIX A
MONITORING FREQUENCY

INSTRUMENT	FREQUENCY OF READING
Settlement monitoring and Monitoring existing cracks	**<u>Pre-construction</u>** Monitored once. **<u>During construction</u>** Monitored after every pin is cast for first 4 no. pins to gauge effect of underpinning. If all is well, monitor after every other pin. **<u>Post construction works</u>** Monitored once.

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APPENDIX B

An Analysis on allowable settlements of structures (Skempton and MacDonald (1956))

The most comprehensive studies linking self-weight settlements of buildings to structural damage were carried out in the 1950's by Skempton and MacDonald (1956) and Polshin and Tokar. These studies show that damage is most often caused by differential settlements rather than absolute settlements. More recently, similar empirical studies by Boscardin and Cording (1989) and Boone (1996) have linked structural damage to ground movements induced by excavations and tunnelling activities.

In 1955 Skempton and MacDonald identified the parameter $\delta\rho/L$ as the fundamental element on which to judge maximum admissible settlements for structures. This criterion was later confirmed in the works of GRANT *et al.* [1975] and WALSH [1981]. Another important approach to the problem was that of BURLAND and WROTH [1974], based on the criterion of maximum tensile strains.

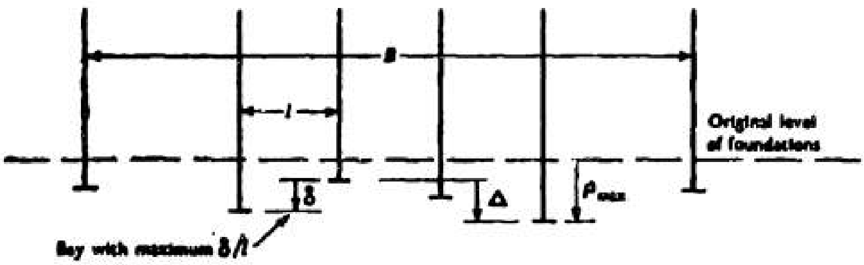


Figure 2.1 – Diagram illustrating the definitions of maximum angular distortion, δ/l, maximum settlement, ρ_{max}, and greatest differential settlement, Δ, for a building with no tilt (Skempton and MacDonald, 1956).

Figure 1: Diagram illustrating the definitions of maximum angular distortion, δ/l, maximum settlement, ρ_{max}, and greatest differential settlement ,Δ , for a building with no tilt (Skempton and MacDonald, 1956)

The differential settlement is defined as the greatest vertical distance between two points on the foundation of a structure that has settled, while the angular distortion, is the difference in elevation between two points, divided by the distance between those points.

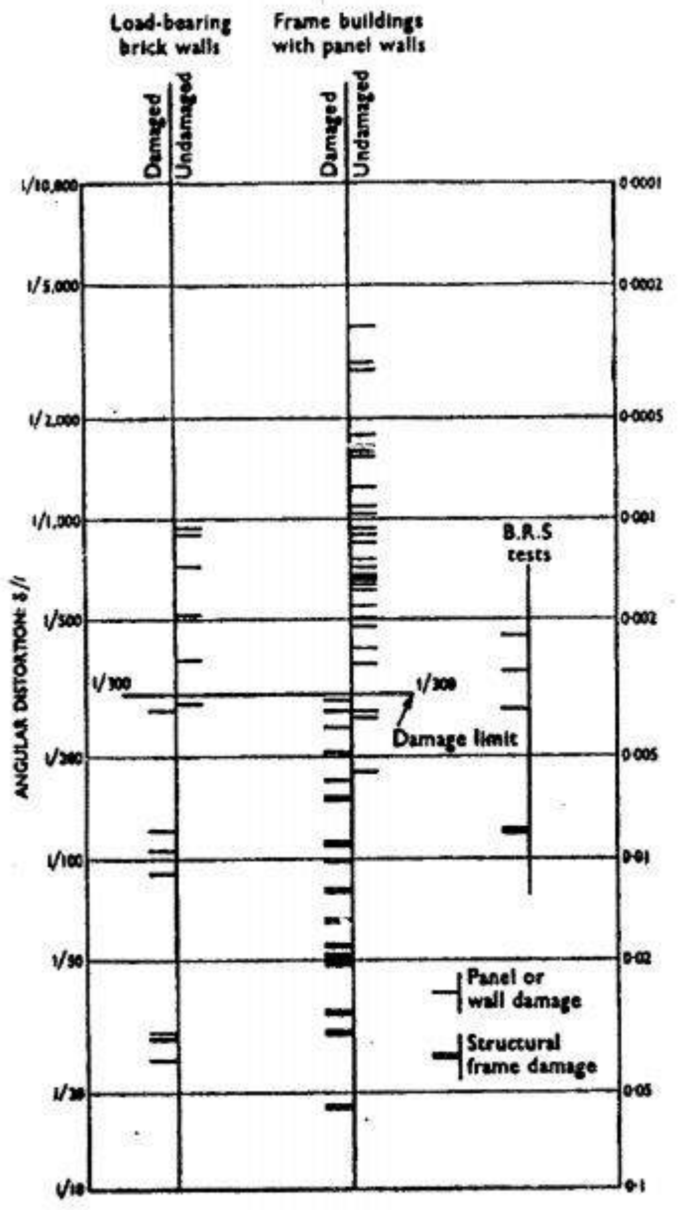
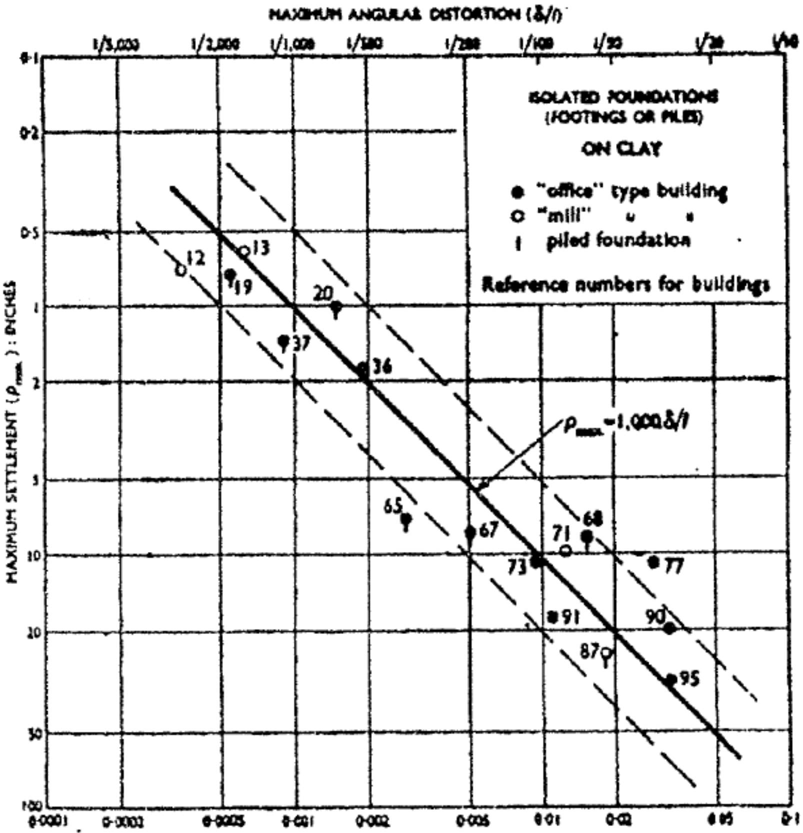
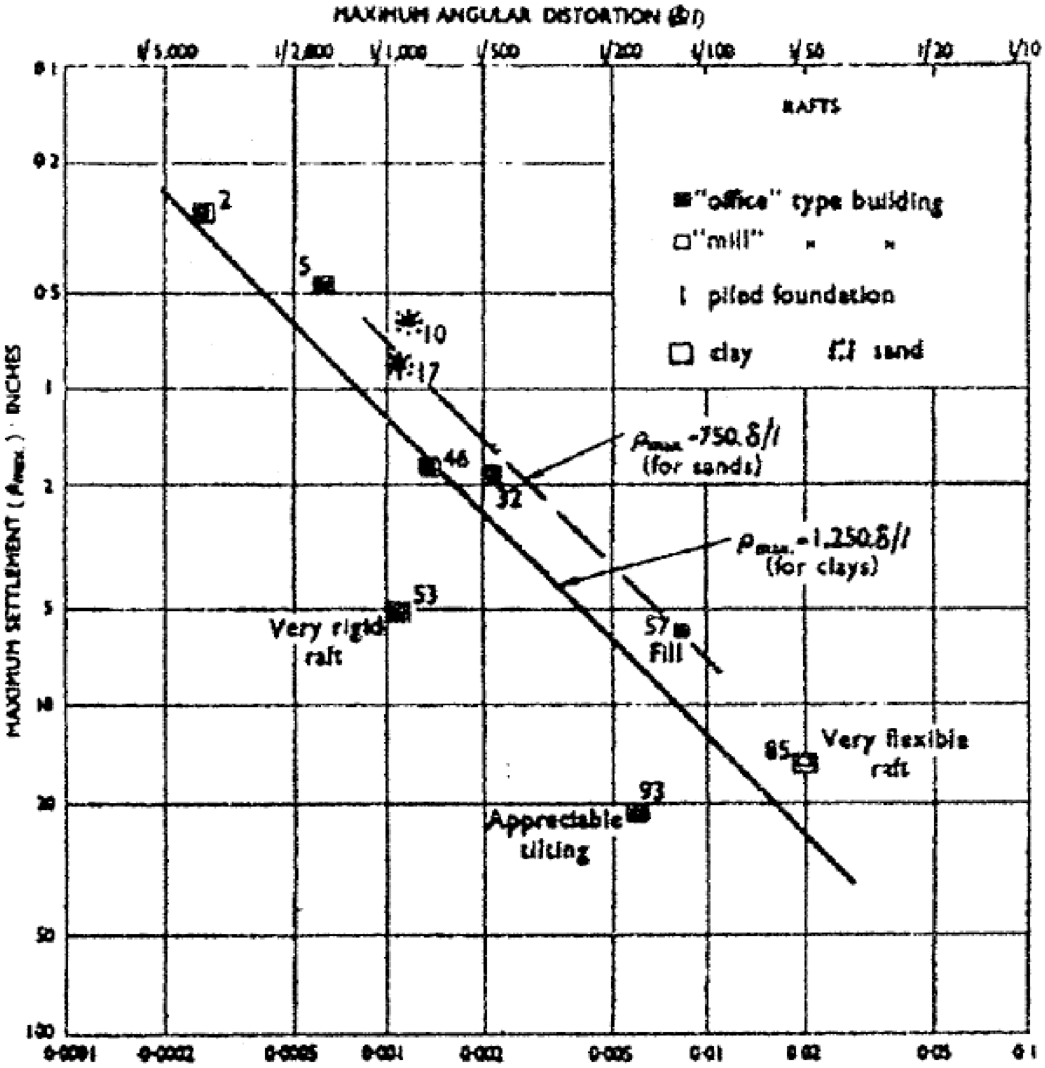


Figure 2: Skempton and MacDonald's analysis of field evidence of damage on traditional frame buildings and loadbearing brick walls

Data from Skempton and MacDonald's work suggest that the limiting value of angular distortion is 1/300. Angular distortion, greater than 1/300 produced visible cracking in the majority of buildings studied, regardless of whether it was a load bearing or a frame structure. As shown in the figure 2.

Other key findings by Skempton and MacDonald include limiting values of δ/l for structure, and a relationship between maximum settlement, ρ_{max} and δ/l for structures founded on sands and clays. The charts below show these relations for raft foundations and isolated footings.





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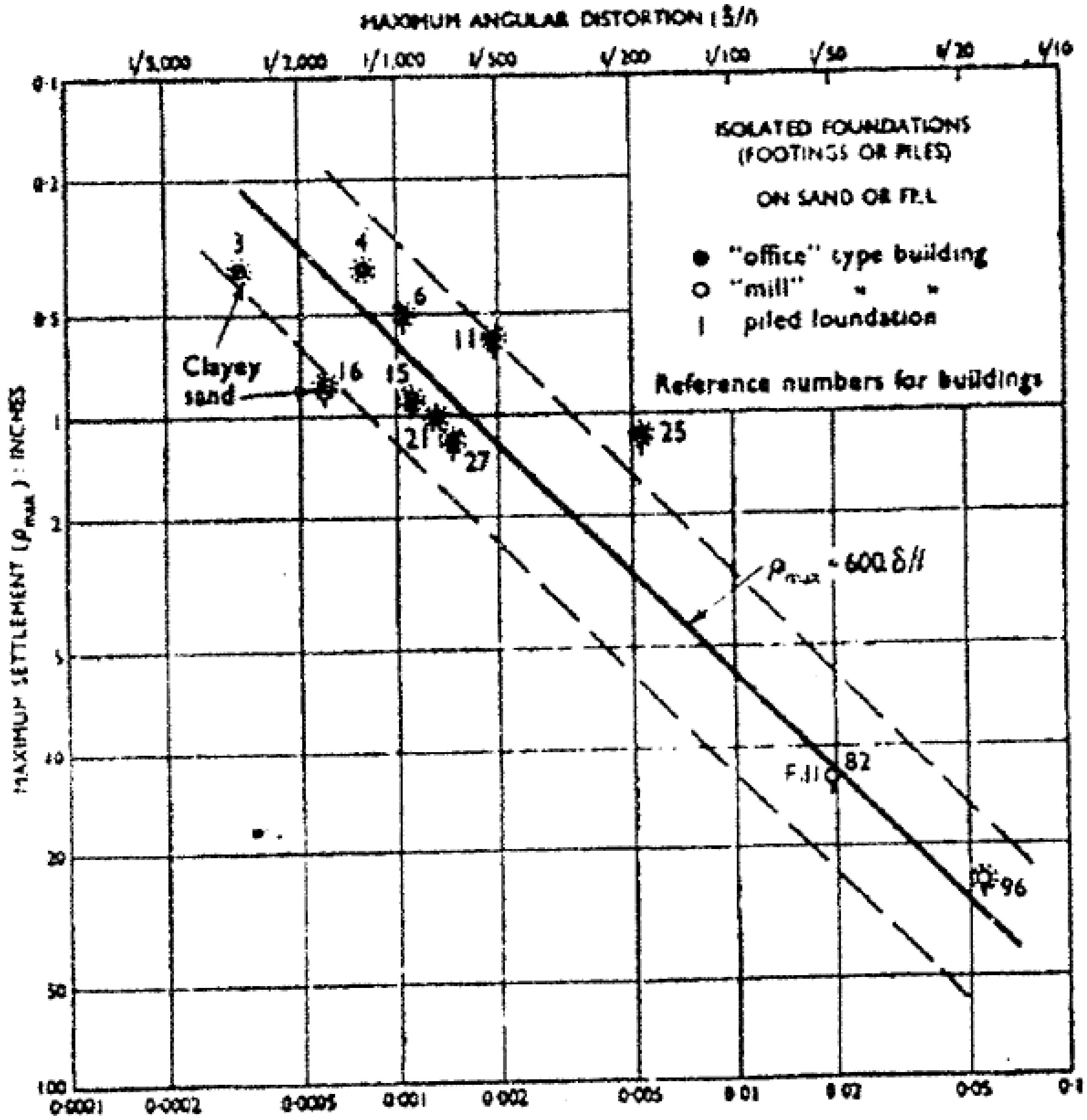

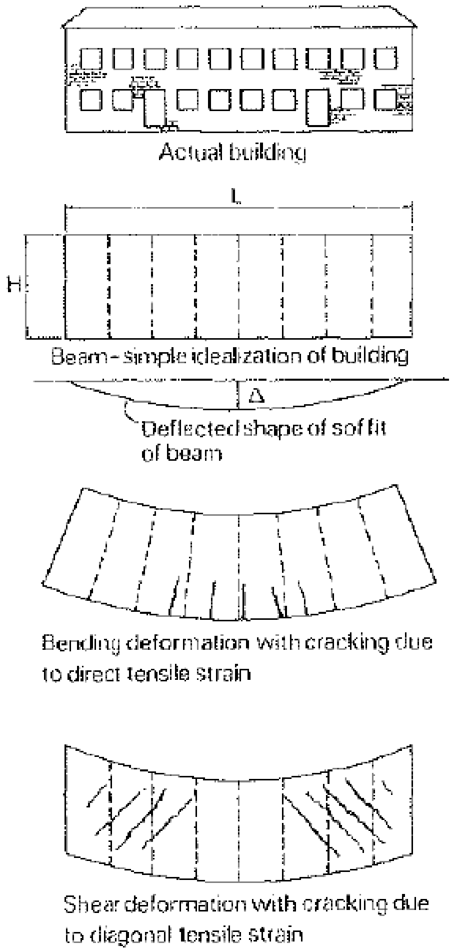

TABLE I

Angular distorsion	Characteristic situation
1/300	Cracking of the panels in frame buildings of the traditional type, or of the walls in load-bearing wall buildings;
1/150	Structural damage to the stanchions and beams;
1/500	Design limit to avoid cracking;
1/1000	Design limit to avoid any settlement damage.

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Appendix F: Communication with Network Rail and LUL

Concetta Cosenza

From: Leighton Matthew <Matt.Leighton@networkrail.co.uk>
Sent: Tuesday, January 30, 2018 11:09 AM
To: Medlock Ben
Cc: Concetta Cosenza
Subject: FW: Planning Stage Enquiry for 15 Rosslyn Hill, Camden NW3 5UJ

Morning Ben

Hope you're having a good week. Could you have a look at the below enquiry from Concetta for me please? It looks to fall under London South East on this occasion (line ref BOK2 @ 1m 1700yds). I think it'll need a quick referral to your Asset Protection Team to see if it would raise any concerns for them. It is approx. 50m from the tunnel as far as I can tell.

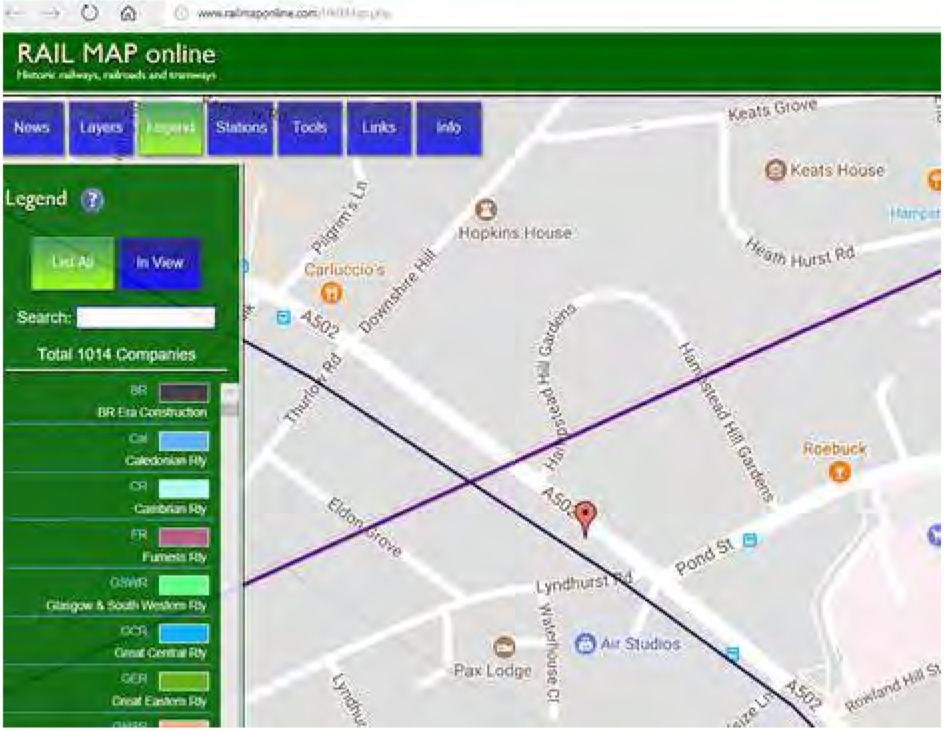
Kind regards,

Matt

Matt Leighton
Town Planning Technician | Property
Network Rail
George Stephenson House | Toft Green |York |YO1 6JT
M 07710 959 632
E matt.leighton@networkrail.co.uk
www.networkrail.co.uk/property

From: Concetta Cosenza [mailto:ccosenza@croftse.co.uk]
Sent: 30 January 2018 10:16
To: Leighton Matthew
Cc: Town Planning LNE
Subject: Planning Stage Enquiry for 15 Rosslyn Hill, Camden NW3 5UJ

Dear Mr Leighton,
We are involved in the planning application of a basement (not more than 4m deep below street level) for a property which is appears to be relatively close to one of your assets. The property is in Camden, at the above address. We believe that it may be within 100m, not less than 30m, of one of your lines (possibly the London & North Western Rly), please refer to the attached/inserted image).



Please could your confirm that, given the large distance, we do not need to go through any approval in principle procedures with your asset protection team. Otherwise, please could advise what steps we should take at Planning stage and beyond.

Kind regards

Concetta Cosenza
Structural Engineer
MSc, BEng

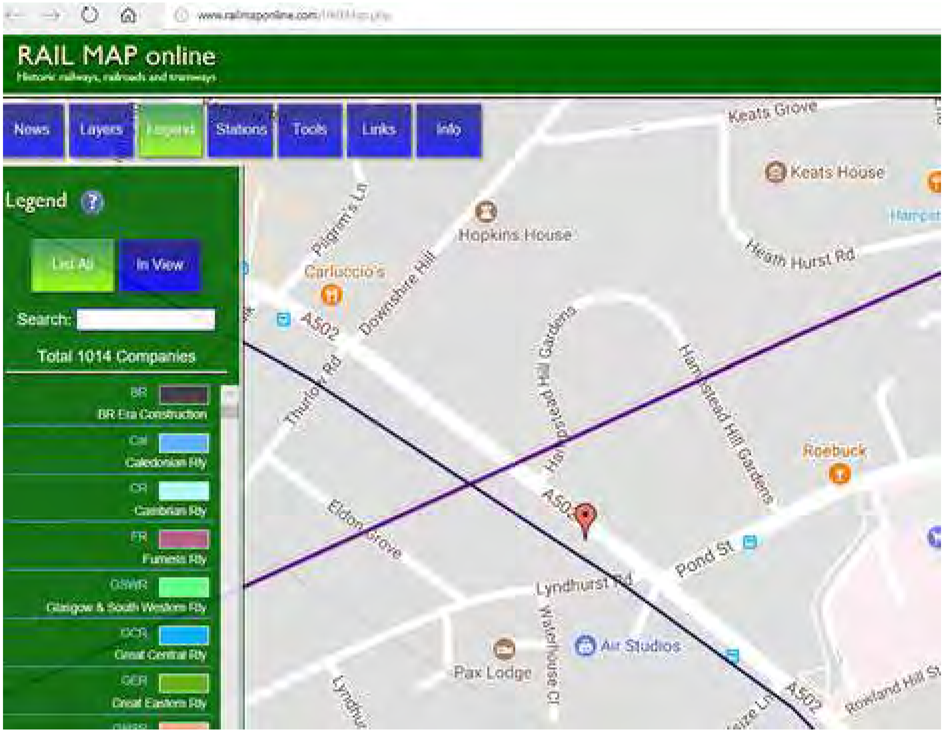
CROFT STRUCTURAL ENGINEERS
Clock Shop Mews, Rear of 60 Saxon Rd, SE25 5EH
t: 020 8684 4744
dir: 0208 684 4977
w: ccosenza@croftse.co.uk
Follow us at @CroftStructures

Concetta Cosenza

From: Concetta Cosenza <ccosenza@croftse.co.uk>
Sent: Tuesday, January 30, 2018 10:19 AM
To: 'john.cadman@tube.tfl.gov.uk'
Subject: Planning Stage Enquiry for 15 Rosslyn Hill, Camden NW3 5UJ [Filed 30 Jan 2018 10:19]

Dear John,

We are involved in the planning application of a basement (not more than 4 m deep below ground level) for a property which is appears close to a tube line (see attached image). The property is in Camden and is possibly within 15m of the Northern line.



Please could you advise:

- At design stage, would we need a correlation survey for this?
- At design stage, would our client need to sign an RoCD?
- At design stage, will the client be expected to comply with G0023 and S050?
- At planning stage, will LUL require anything more from us besides notification (by way of this e-mail) and stating whether the above will be necessary at a later stage?

Please let us know if any of the above applies.

Kind regards

Concetta Cosenza
Structural Engineer
MSc, BEng

CROFT STRUCTURAL ENGINEERS
Clock Shop Mews, Rear of 60 Saxon Rd, SE25 5EH

t: 020 8684 4744
dir: 0208 684 4977
w: ccosenza@croftse.co.uk
Follow us at @CroftStructures

Please consider the environment before printing this email

Appendix G: Asset Location Search by Thames Water

Asset location search

Property Searches

Croft Structural Engineers
Clockshop Mews
60Rear of 60 Saxon Rd
LONDON
SE25 5EH

Search address supplied	15 Rosslyn Hill London NW3 5UJ
Your reference	15 Rosslyn Hill
Our reference	ALS/ALS Standard/2017_3678904
Search date	30 October 2017

Keeping you up-to-date

Knowledge of features below the surface is essential in every development. The benefits of this not only include ensuring due diligence and avoiding risk, but also being able to ascertain the feasibility for any commercial or residential project.

An asset location search provides information on the location of known Thames Water clean and/or wastewater assets, including details of pipe sizes, direction of flow and depth. Please note that information on cover and invert levels will only be provided where the data is available.

Thames Water Utilities Ltd
Property Searches, PO Box 3189, Slough SL1 4WW
DX 151280 Slough 13

searches@thameswater.co.uk
www.thameswater-propertysearches.co.uk

0845 070 9148

Search address supplied: 15, Rosslyn Hill, London, NW3 5UJ

Dear Sir / Madam

An Asset Location Search is recommended when undertaking a site development. It is essential to obtain information on the size and location of clean water and sewerage assets to safeguard against expensive damage and allow cost-effective service design.

The following records were searched in compiling this report: - the map of public sewers & the map of waterworks. Thames Water Utilities Ltd (TWUL) holds all of these.

This searchprovides maps showing the position, size of Thames Water assets close to the proposed development and also manhole cover and invert levels, where available.

Please note that none of the charges made for this report relate to the provision of Ordnance Survey mapping information. The replies contained in this letter are given following inspection of the public service records available to this company. No responsibility can be accepted for any error or omission in the replies.

You should be aware that the information contained on these plans is current only on the day that the plans are issued. The plans should only be used for the duration of the work that is being carried out at the present time. Under no circumstances should this data be copied or transmitted to parties other than those for whom the current work is being carried out.

Thames Water do update these service plans on a regular basis and failure to observe the above conditions could lead to damage arising to new or diverted services at a later date.

Contact Us

If you have any further queries regarding this enquiry please feel free to contact a member of the team on 0845 070 9148, or use the address below:

Thames Water Utilities Ltd
Property Searches
PO Box 3189
Slough
SL1 4WW

Email: searches@thameswater.co.uk
Web: www.thameswater-propertysearches.co.uk

Waste Water Services

Please provide a copy extract from the public sewer map.

Enclosed is a map showing the approximate lines of our sewers. Our plans do not show sewer connections from individual properties or any sewers not owned by Thames Water unless specifically annotated otherwise. Records such as "private" pipework are in some cases available from the Building Control Department of the relevant Local Authority.

Where the Local Authority does not hold such plans it might be advisable to consult the property deeds for the site or contact neighbouring landowners.

This report relates only to sewerage apparatus of Thames Water Utilities Ltd, it does not disclose details of cables and or communications equipment that may be running through or around such apparatus.

The sewer level information contained in this response represents all of the level data available in our existing records. Should you require any further Information, please refer to the relevant section within the 'Further Contacts' page found later in this document.

For your guidance:

- The Company is not generally responsible for rivers, watercourses, ponds, culverts or highway drains. If any of these are shown on the copy extract they are shown for information only.
- Any private sewers or lateral drains which are indicated on the extract of the public sewer map as being subject to an agreement under Section 104 of the Water Industry Act 1991 are not an 'as constructed' record. It is recommended these details be checked with the developer.

Clean Water Services

Please provide a copy extract from the public water main map.

Enclosed is a map showing the approximate positions of our water mains and associated apparatus. Please note that records are not kept of the positions of individual domestic supplies.

For your information, there will be a pressure of at least 10m head at the outside stop valve. If you would like to know the static pressure, please contact our Customer Centre on 0800 316 9800. The Customer Centre can also arrange for a full flow and pressure test to be carried out for a fee.

For your guidance:

- Assets other than vested water mains may be shown on the plan, for information only.
- If an extract of the public water main record is enclosed, this will show known public water mains in the vicinity of the property. It should be possible to estimate the likely length and route of any private water supply pipe connecting the property to the public water network.

Payment for this Search

A charge will be added to your suppliers account.

Further contacts:

Waste Water queries

Should you require verification of the invert levels of public sewers, by site measurement, you will need to approach the relevant Thames Water Area Network Office for permission to lift the appropriate covers. This permission will usually involve you completing a TWOSA form. For further information please contact our Customer Centre on Tel: 0845 920 0800. Alternatively, a survey can be arranged, for a fee, through our Customer Centre on the above number.

If you have any questions regarding sewer connections, budget estimates, diversions, building over issues or any other questions regarding operational issues please direct them to our service desk. Which can be contacted by writing to:

Developer Services (Waste Water)
Thames Water
Clearwater Court
Vastern Road
Reading
RG1 8DB

Tel: 0800 009 3921
Email: developer.services@thameswater.co.uk

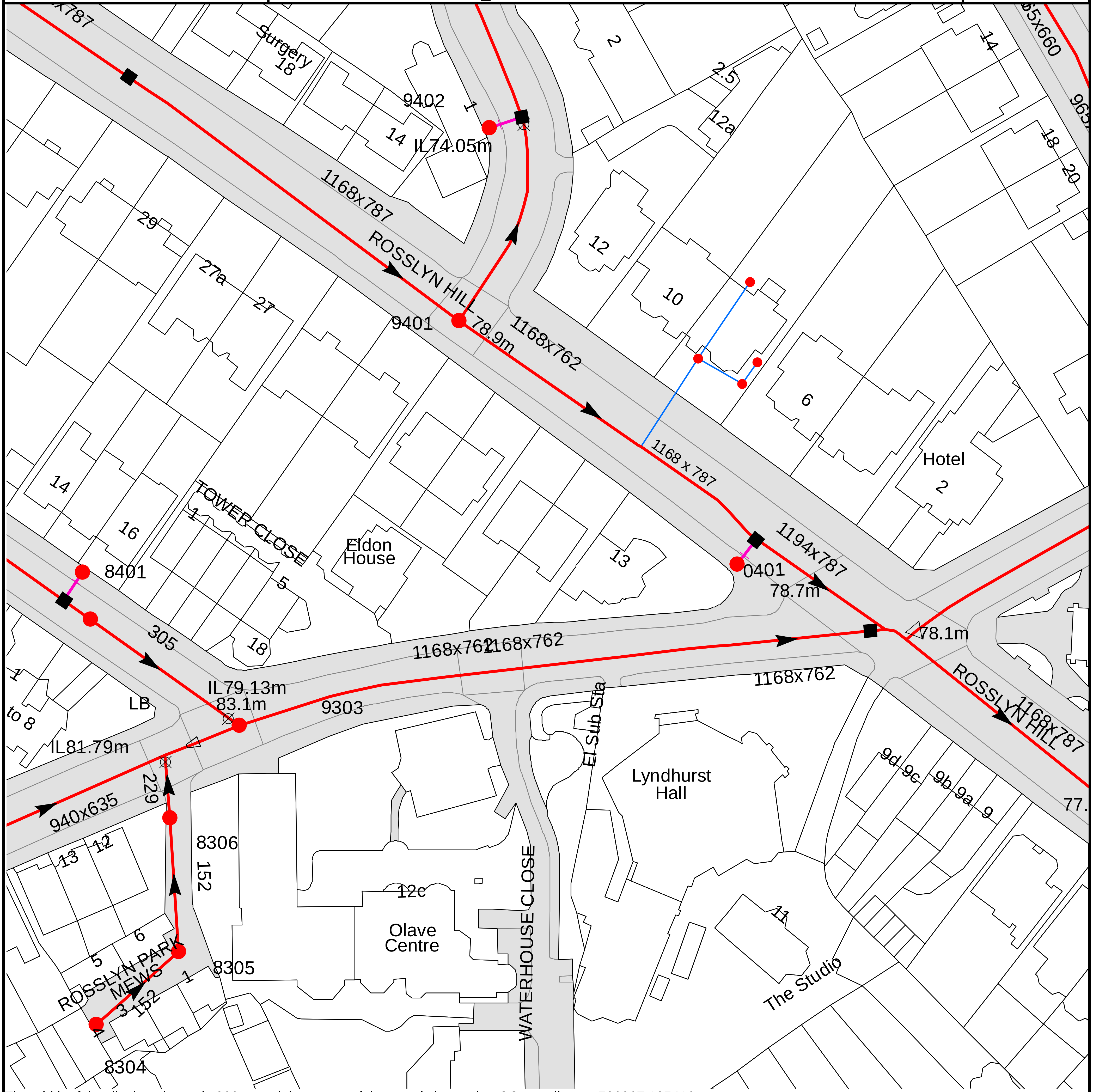
Clean Water queries

Should you require any advice concerning clean water operational issues or clean water connections, please contact:

Developer Services (Clean Water)
Thames Water
Clearwater Court
Vastern Road
Reading
RG1 8DB

Tel: 0800 009 3921
Email: developer.services@thameswater.co.uk

Asset Location Search Sewer Map - ALS/ALS Standard/2017_3678904



The width of the displayed area is 200 m and the centre of the map is located at OS coordinates 526967,185416

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

NB. Levels quoted in metres Ordnance Newlyn Datum. The value -9999.00 indicates that no survey information is available

Manhole Reference	Manhole Cover Level	Manhole Invert Level
9401	78.9	74.93
9402	n/a	n/a
041A	n/a	n/a
8401	n/a	n/a
841A	n/a	n/a
8304	85.71	84.87
8306	84.01	82.32
8305	84.91	83.93
9303	82.92	79.05
941A	n/a	n/a
0401	n/a	n/a
041C	n/a	n/a
041B	n/a	n/a

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

Thames Water

ALS Sewer Map Key

Public Sewer Types (Operated & Maintained by Thames Water)

Foul: A sewer designed to convey waste water from domestic and industrial sources to a treatment works.

Surface Water: A sewer designed to convey surface water (e.g. rain water from roofs, yards and car parks) to rivers or watercourses.

Combined: A sewer designed to convey both waste water and surface water from domestic and industrial sources to a treatment works.

- Trunk Surface Water
- Trunk Foul
- Storm Relief
- Trunk Combined
- Vent Pipe
- Bio-solids (Sludge)
- Proposed Thames Surface Water Sewer
- Proposed Thames Water Foul Sewer
- Gallery
- Foul Rising Main
- Surface Water Rising Main
- Combined Rising Main
- Sludge Rising Main
- Proposed Thames Water Rising Main
- Vacuum

Sewer Fittings

A feature in a sewer that does not affect the flow in the pipe. Example: a vent is a fitting as the function of a vent is to release excess gas.

- Air Valve
- Dam Chase
- Fitting
- Meter
- Vent Column

Operational Controls

A feature in a sewer that changes or diverts the flow in the sewer. Example: A hydrobrake limits the flow passing downstream.

- Control Valve
- Drop Pipe
- Ancillary
- Weir

End Items

End symbols appear at the start or end of a sewer pipe. Examples: an Undefined End at the start of a sewer indicates that Thames Water has no knowledge of the position of the sewer upstream of that symbol, Outfall on a surface water sewer indicates that the pipe discharges into a stream or river.

- Outfall
- Undefined End
- Inlet

Other Symbols

Symbols used on maps which do not fall under other general categories

- Public/Private Pumping Station
- Change of characteristic indicator (C.O.C.I.)
- Invert Level
- Summit

Areas

Lines denoting areas of underground surveys, etc.

- Agreement
- Operational Site
- Chamber
- Tunnel
- Conduit Bridge

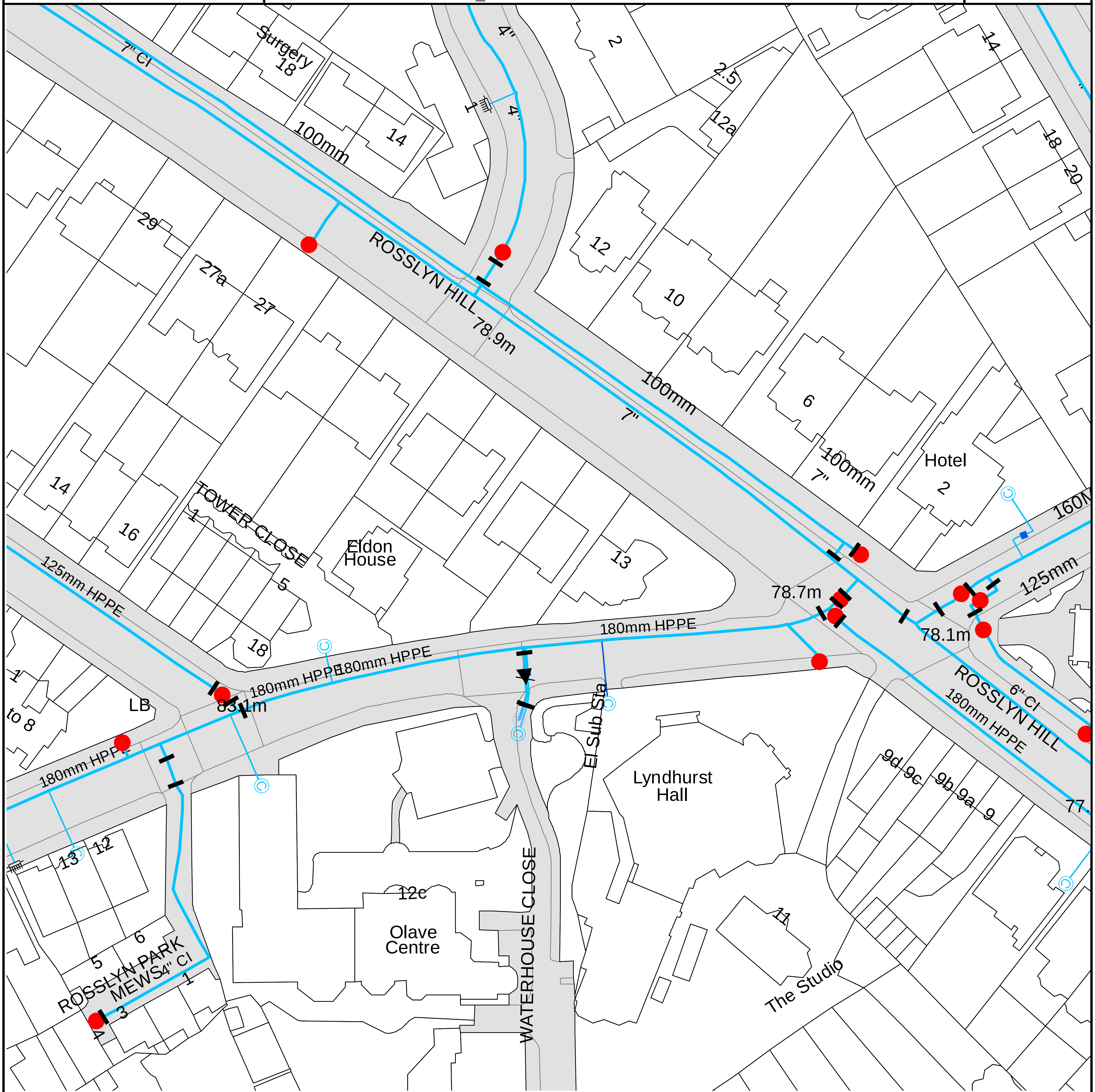
Other Sewer Types (Not Operated or Maintained by Thames Water)

- Foul Sewer
- Surface Water Sewer
- Combined Sewer
- Gulley
- Culverted Watercourse
- Proposed
- Abandoned Sewer

Notes:

1) All levels associated with the plans are to Ordnance Datum Newlyn.
2) All measurements on the plans are metric.
3) Arrows (on gravity fed sewers) or flecks (on rising mains) indicate direction of flow.
4) Most private pipes are not shown on our plans, as in the past, this information has not been recorded.
5) 'na' or '0' on a manhole level indicates that data is unavailable.
6) The text appearing alongside a sewer line indicates the internal diameter of the pipe in milimetres. Text next to a manhole indicates the manhole reference number and should not be taken as a measurement. If you are unsure about any text or symbology present on the plan, please contact a member of Property Insight on 0845 070 9148.

Asset Location Search Water Map - ALS/ALS Standard/2017_3678904



The width of the displayed area is 200 m and the centre of the map is located at OS coordinates 526967, 185416.

The position of the apparatus shown on this plan is given without obligation and warranty, and the accuracy cannot be guaranteed. Service pipes are not shown but their presence should be anticipated. No liability of any kind whatsoever is accepted by Thames Water for any error or omission. The actual position of mains and services must be verified and established on site before any works are undertaken.

ALS Water Map Key

Water Pipes (Operated & Maintained by Thames Water)

4"

Distribution Main: The most common pipe shown on water maps. With few exceptions, domestic connections are only made to distribution mains.

16"

Trunk Main: A main carrying water from a source of supply to a treatment plant or reservoir, or from one treatment plant or reservoir to another. Also a main transferring water in bulk to smaller water mains used for supplying individual customers.

3" SUPPLY

Supply Main: A supply main indicates that the water main is used as a supply for a single property or group of properties.

3" FIRE

Fire Main: Where a pipe is used as a fire supply, the word FIRE will be displayed along the pipe.

3" METERED

Metered Pipe: A metered main indicates that the pipe in question supplies water for a single property or group of properties and that quantity of water passing through the pipe is metered even though there may be no meter symbol shown.

Transmission Tunnel: A very large diameter water pipe. Most tunnels are buried very deep underground. These pipes are not expected to affect the structural integrity of buildings shown on the map provided.

Proposed Main: A main that is still in the planning stages or in the process of being laid. More details of the proposed main and its reference number are generally included near the main.

PIPE DIAMETER	DEPTH BELOW GROUND
Up to 300mm (12")	900mm (3')
300mm - 600mm (12" - 24")	1100mm (3' 8")
600mm and bigger (24" plus)	1200mm (4')

Valves

- General Purpose Valve
- Air Valve
- Pressure Control Valve
- Customer Valve

Hydrants

- Single Hydrant

Meters

- Meter

End Items

Symbol indicating what happens at the end of a water main.

- Blank Flange
- Capped End
- Emptying Pit
- Undefined End
- Manifold
- Customer Supply
- Fire Supply

Operational Sites

- Booster Station
- Other
- Other (Proposed)
- Pumping Station
- Service Reservoir
- Shaft Inspection
- Treatment Works
- Unknown
- Water Tower

Other Symbols

- Data Logger

Other Water Pipes (Not Operated or Maintained by Thames Water)

Other Water Company Main: Occasionally other water company water pipes may overlap the border of our clean water coverage area. These mains are denoted in purple and in most cases have the owner of the pipe displayed along them.

Private Main: Indiates that the water main in question is not owned by Thames Water. These mains normally have text associated with them indicating the diameter and owner of the pipe.

Terms and Conditions

All sales are made in accordance with Thames Water Utilities Limited (TWUL) standard terms and conditions unless previously agreed in writing.

1. All goods remain in the property of Thames Water Utilities Ltd until full payment is received.
2. Provision of service will be in accordance with all legal requirements and published TWUL policies.
3. All invoices are strictly due for payment 14 days from due date of the invoice. Any other terms must be accepted/agreed in writing prior to provision of goods or service, or will be held to be invalid.
4. Thames Water does not accept post-dated cheques-any cheques received will be processed for payment on date of receipt.
5. In case of dispute TWUL`s terms and conditions shall apply.
6. Penalty interest may be invoked by TWUL in the event of unjustifiable payment delay. Interest charges will be in line with UK Statute Law 'The Late Payment of Commercial Debts (Interest) Act 1998'.
7. Interest will be charged in line with current Court Interest Charges, if legal action is taken.
8. A charge may be made at the discretion of the company for increased administration costs.

A copy of Thames Water's standard terms and conditions are available from the Commercial Billing Team (cashoperations@thameswater.co.uk).

We publish several Codes of Practice including a guaranteed standards scheme. You can obtain copies of these leaflets by calling us on 0800 316 9800

If you are unhappy with our service you can speak to your original goods or customer service provider. If you are not satisfied with the response, your complaint will be reviewed by the Customer Services Director. You can write to her at: Thames Water Utilities Ltd. PO Box 492, Swindon, SN38 8TU.

If the Goods or Services covered by this invoice falls under the regulation of the 1991 Water Industry Act, and you remain dissatisfied you can refer your complaint to Consumer Council for Water on 0121 345 1000 or write to them at Consumer Council for Water, 1st Floor, Victoria Square House, Victoria Square, Birmingham, B2 4AJ.

Ways to pay your bill

Credit Card	**BACS Payment**	**Telephone Banking**	**Cheque**
Call **0845 070 9148** quoting your invoice number starting CBA or ADS / OSS	Account number **90478703** Sort code **60-00-01** A remittance advice must be sent to: **Thames Water Utilities Ltd., PO Box 3189, Slough SL1 4WW.** or email **ps.billing@thameswater.co.uk**	By calling your bank and quoting: Account number **90478703** Sort code **60-00-01** and your invoice number	Made payable to '**Thames Water Utilities Ltd**' Write your Thames Water account number on the back. Send to: **Thames Water Utilities Ltd., PO Box 3189, Slough SL1 4WW** or by DX to **151280 Slough 13**

Thames Water Utilities Ltd Registered in England & Wales No. 2366661 Registered Office Clearwater Court, Vastern Rd, Reading, Berks, RG1 8DB.

Search Code

IMPORTANT CONSUMER PROTECTION INFORMATION

This search has been produced by Thames Water Property Searches, Clearwater Court, Vastern Road, Reading RG1 8DB, which is registered with the Property Codes Compliance Board (PCCB) as a subscriber to the Search Code. The PCCB independently monitors how registered search firms maintain compliance with the Code.

The Search Code:

- provides protection for homebuyers, sellers, estate agents, conveyancers and mortgage lenders who rely on the information included in property search reports undertaken by subscribers on residential and commercial property within the United Kingdom
- sets out minimum standards which firms compiling and selling search reports have to meet
- promotes the best practise and quality standards within the industry for the benefit of consumers and property professionals
- enables consumers and property professionals to have confidence in firms which subscribe to the code, their products and services.

By giving you this information, the search firm is confirming that they keep to the principles of the Code. This provides important protection for you.

The Code's core principles

Firms which subscribe to the Search Code will:

- display the Search Code logo prominently on their search reports
- act with integrity and carry out work with due skill, care and diligence
- at all times maintain adequate and appropriate insurance to protect consumers
- conduct business in an honest, fair and professional manner
- handle complaints speedily and fairly
- ensure that products and services comply with industry registration rules and standards and relevant laws
- monitor their compliance with the Code

Complaints

If you have a query or complaint about your search, you should raise it directly with the search firm, and if appropriate ask for any complaint to be considered under their formal internal complaints procedure. If you remain dissatisfied with the firm's final response, after your complaint has been formally considered, or if the firm has exceeded the response timescales, you may refer your complaint for consideration under The Property Ombudsman scheme (TPOs). The Ombudsman can award compensation of up to £5,000 to you if he finds that you have suffered actual loss as a result of your search provider failing to keep to the Code.

Please note that all queries or complaints regarding your search should be directed to your search provider in the first instance, not to TPOs or to the PCCB.

TPOs Contact Details

The Property Ombudsman scheme
Milford House
43-55 Milford Street
Salisbury
Wiltshire SP1 2BP
Tel: 01722 333306
Fax: 01722 332296
Email: admin@tpos.co.uk

You can get more information about the PCCB from www.propertycodes.org.uk

PLEASE ASK YOUR SEARCH PROVIDER IF YOU WOULD LIKE A COPY OF THE SEARCH CODE