Job Number: 160317

CROFT STRUCTURAL ENGINEERS

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Basement Impact Assessment

Property:

158 Iverson Road
West Hampstead
Camden
NW6 2HH

Client:

Ground& Water Ltd
15 Bow Street
Alton
Hampshire
GU34 1NY

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

Hydrogeology Report	**Land Stability Report**
(Separate Report) Hannah Fraser CGeol	(Separate Report) Jon Smithson CGeol

Revision	Date	Comment
-	09.052016	First Issue
1	27.05.2016	Structural scheme drawings altered

Contents

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Executive (non-technical) Summary

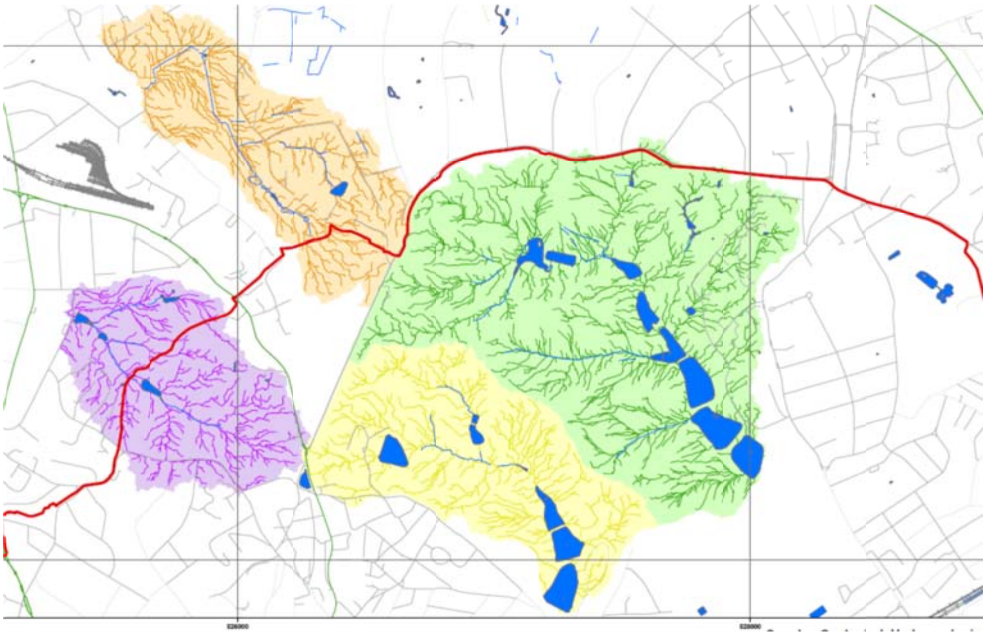
	The London Borough of Camden requires a Basement Impact Assessment (BIA) to be prepared for developments that include basements and lightwells. This document forms the main part of the BIA and gives details on the impact of surface water flow. The scheme design for the proposed subterranean structure is also included. This document should be used in conjunction with the Land Stability BIA (dated March 2016) and the Groundwater BIA (dated April 2016 Ref. 30137). 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 existing property is a three storey mid-terrace building, built from traditional building materials (brickwork and timber). The property comprises a main building and a rear addition. The roof space of the main building provides additional living space. Below the main building there is a shallow basement. There is a small front garden and a larger garden at the back.
Proposed Development	The proposed development involves deepening the existing basement and extending it to the front and rear. This will include a front and rear lightwell. There will also be above ground alterations: the rear addition will be extended and the rear garden will be re-landscaped.

Figure 1: Aerial view with approx. site area indicated

Stage 1 – Screening	Screening identified potential areas of concern and concluded a requirement to proceed to a scoping stage for the potential impacts relating to Land Stability, Hydrogeology, Surface Water and Flooding. The Groundwater BIA drew attention to the need to investigate the depth of the basement relative to the water table, and the proportion of hard surfaces that would affect the proposed development. Land Stability screening identified the site to lie on London Clay. No significant slopes or cuttings were identified. The Screening stage did not identify and surface water for flooding issues other than those that are inherent with all subterranean structures.
Stage 2 – Scoping	The Scoping stage identified the potential impacts and set the parameters required for further study of the areas of concern highlighted in the Screening phase. The property was inspected and a walk over desk survey was completed by an engineer. The information from this was utilised to formulate the requirement for a ground, geology and hydrogeology investigation.
Stage 3 – Site Investigation and Study	A structural engineer inspected the building to determine the current condition of the property. Visual inspections were completed of the adjacent properties to determine if there were signs of structural movement.

	Shallow basements were identified in the neighbouring properties from inspection of planning drawings. A ground investigation with deep boreholes has been completed. London Clay was confirmed to be present at the proposed formation level. Ground water was measured and found to be above formation level.
Stage 4 – Impact Assessment	**Land Stability** The Land Stability BIA concluded that the basement development should not have any significant impacts on the land stability, so long as appropriate measures are adopted during the detailed design and construction phase. These include: suitable control of ground water during construction, appropriately designed retaining walls and monitoring of structures before and during construction. Proposals that demonstrate that this is possible are appended. **Hydrogeology** The Groundwater BIA did not anticipate groundwater levels being significantly affected by the development. The conclusions stipulated adequate water proofing for the basement structure. Suitable groundwater drainage measures were also described. Proposals to meet, to be considered at detailed design stage, are described in this document under 'Initial Design Considerations'. **Drainage & Surface Water Flow** With this site, there are no surface water or flooding issues other than those with are common with all subterranean structures. Measures to mitigate the impacts of these are proposed in the final section of this document.

1. Screening Stage

	This stage identifies any areas for concern, which should be carried forward further investigation.
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?  *Figure 2: Extract from Figure 14 of the GSD (site lies to the south of the shaded areas)* **No.** The site lies outside the areas denoted by Figure 14 of the GSD (extract shown above)
	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?

	Unknown – Due to the construction of the rear extension and the rear lightwell, the flow of water into the ground and the existing surface water drainage system may change. Carry forward to scoping
	Question 3. Will the proposed basement development result in a change to the hard surfaced / paved external areas? **Unknown** – Due to the removal of paving slabs at the rear and subsequent construction of the rear extension and the rear lightwell, the impermeable areas may change. Carry forward to scoping
	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 > 40m AOD.
Flooding from rising / high groundwater	No	Site is located on low permeability London Clay.

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Surface water (pluvial) flooding	No	158 Iverson Road is not on the flooded 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 development may result in a net increase in impermeable areas. This should be investigated further. The main significant flood risks associated with the development is due to the failure of existing sewers in the vicinity of the site. The flow paths of surface water around the property should be investigated further. Carry forward to Site Investigation & Desk Study

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

The existing property is a three storey mid-terrace building, built from traditional building materials (brickwork and timber). The property comprises a main building and a rear addition. The floors for the rear addition are lower than the main building, to suit the overall profile of the ground (the external ground level at the rear is lower). The roof space of the main building provides additional living space. Below the main building there is a shallow basement. There is a small front garden and a larger garden at the back.

Figure 3: Front view of existing property (to the right of the scaffolded façade)

The front yard is hard surfaced, as is the most of the rear garden.

Figure 4: Rear view of existing property

A structural engineer from Croft Structural Engineers visited the site on 20 April 2016.

Proposed Development

The proposed development involves deepening the existing basement and extending it to the front and rear. This will include a front and rear lightwell. There will also be above ground alterations: the rear addition will be extended and the rear garden will be re-landscaped to increase the area of soft-landscaping. An approximate outline of the construction area is shown below. In addition to the basement area, this also areas that are likely to be temporarily occupied for construction purposes.

Figure 5: Aerial view with approx. site area indicated

Croft Structural Engineers Ltd has extensive knowledge of constructing new basements. Over the last 10 years Croft Structural Engineers has been involved in the design of over 500 basements in and around London. The method to be utilised at 158 Iverson Road is:

1. Excavate front to allow for start of underpinning
2. Safely and securely support the existing building above
3. Slowly work from the front to the rear inserting narrow cantilevered retaining walls sequentially using well developed and understood underpinning methods.
4. Prop across the width of the basement, excavate central soil "dumpling"
5. Place reinforcement and cast basement slab
6. Waterproof internal space with a drained cavity system.

For further details of the architectural design, refer to the Archtictects

	drawings.
Site History	As referred to in the Land Stability BIA, historical maps show that the site and the surrounding area have been residential for over 125 years. The report for this includes a map showing the predeveloped area, occupied by fields.
Local Bombing	A highly explosive bomb is recorded in the Aggregate Night Time bomb census as having been dropped nearby, between 7th October and 6th June 1941. This was in closes to Medley Road and was the closest reported bomb.  *Figure 6: Extract from Bomb Survey Map*
Listed Buildings and Conservation Areas	The existing building is not listed. Data from Historic England shows that there are no listed buildings close by.

Figure 7: Extract showing listed buildings

The site is not in a conservation area.

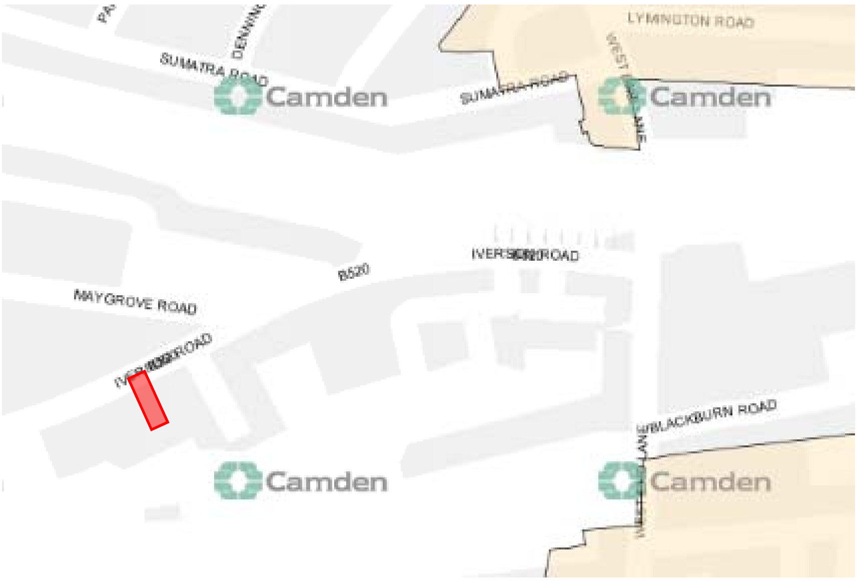

Figure 8: Map showing property located outside of conservation areas (coloured light brown)

Local topography &	The area surrounding the site is on a very slight slope, downwards from north-

external features	west to south-east. Iverson Road is a public highway, which runs past the front of the property. A pavement separates this from the site boundary. The pavement has a kerb which forms and upstand with the road. At the side of the road, there are gullies and there are manholes present close to the centre, which indicate the presence of a trunk sewer below ground level. Rainwater pipes discharge surface water collected from the building into the existing sewer. As previously mentioned, the external areas of the site are mostly covered with hard surfaces. The neighbouring gardens appear to be covered with paving, with pockets of soft landscaping. The walk over survey has confirmed that there are no surface water features (natural or man-made) within the site or on the adjacent sites.
Highways & public footpaths	The site is not within 5m of the public highway. But the front lightwell is within 5m of the pavement.
London Underground and Network Rail	The site is more than 30m away from the nearest national rail line and the nearest subterranean train line. These are unlikely to be affected by the new basement.
UK Power Networks	There are no significant items of electrical infrastructure (such as pylons or substations) in the immediate vicinity.
Proximity of Trees	There are no trees close by, in the rear gardens of the neighbouring properties. There is a tree in the pavement area in front of the property. The trunk of this tree is more than 2m away from the outline of the proposed basement. BS 5837: 2005 *Trees in relation to construction* 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 300mm, the diameter of this circle would be 3.6m. The roots concerned would therefore be within 1.8m from the trunk. These would not be affected by a basement that is 2m away.

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Adjacent Properties

The external facades of the neighbouring properties have been inspected. Planning drawings have also been inspected.

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

In the following descriptions, references to left and right are given when facing the properties from Iverson Road.

No 160 – Property to Left

Property age : late-Victorian (~125 years old)

Property use : residential

Number of storeys : the property is three storeys high above ground level. The loft space has been converted into a habitable room. There is a rear addition which is two storeys high. The floors for the rear addition are lower than the floors in the main building. The main building and the rear addition have recently been altered structurally. A search on Camden Council's website show that retrospective permission is being sought for this [Planning Application No 2015/4502/P].

Figure 10: Partial view of new flank wall of No 160

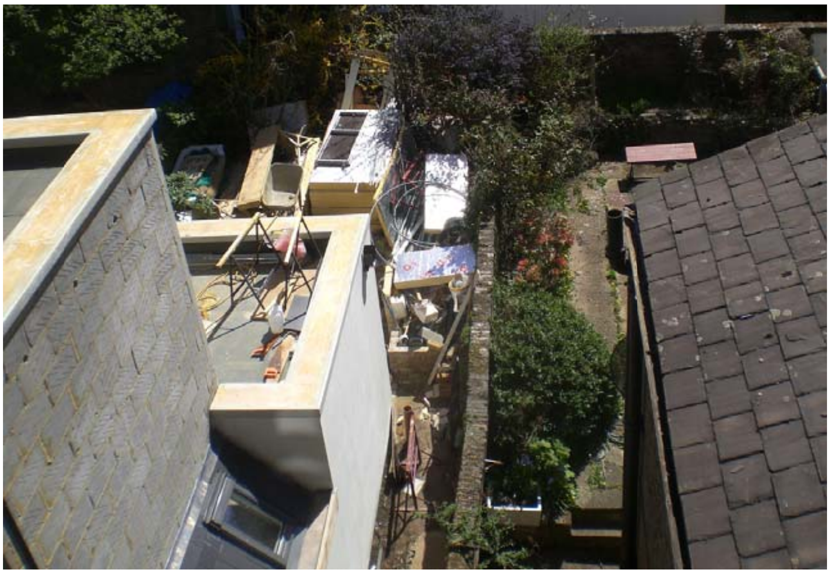


Figure 11: view of altered rear addition of No160 (left hand side)

There is a basement. This is below the main building only. As part of the planning application mentioned above, there are proposals to create a lightwell to the basement, at the front of the property.

Structural defects: No structural defects were noted from the outside.

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

No 156 – Property to	**Property age :** late-Victorian (~125 years old)

Right	**Property use :** residential **Number of storeys :** the property is three storeys high above ground level. The loft space has been converted into a habitable room. There is a rear addition which is two storeys high. As with Nos 158 and 160, the floors in the rear addition are lower than the main building. There is a basement. This is below the main building only. This building comprises separate flats. No 156a is the lowest dwelling. A search on Camden Council's planning website shows that in 2013, permission was granted to extend this property to the rear, at ground level. The site visit has confirmed that this was followed through to construction.  *Figure 12: Rear view of No156a* **Structural defects:** The chimney above the rear addition was noted to be slightly out of plumb.

Figure 13: Rear Addition chimney between 158 and 156b

Structural assessment of ongoing movement: From observing the external façade of the building, there were no visible signs of movement, other than with the chimney stack.

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 document. Data relevant to land stability and subterranean flow is examined separate documents as described below.

Ground Investigation

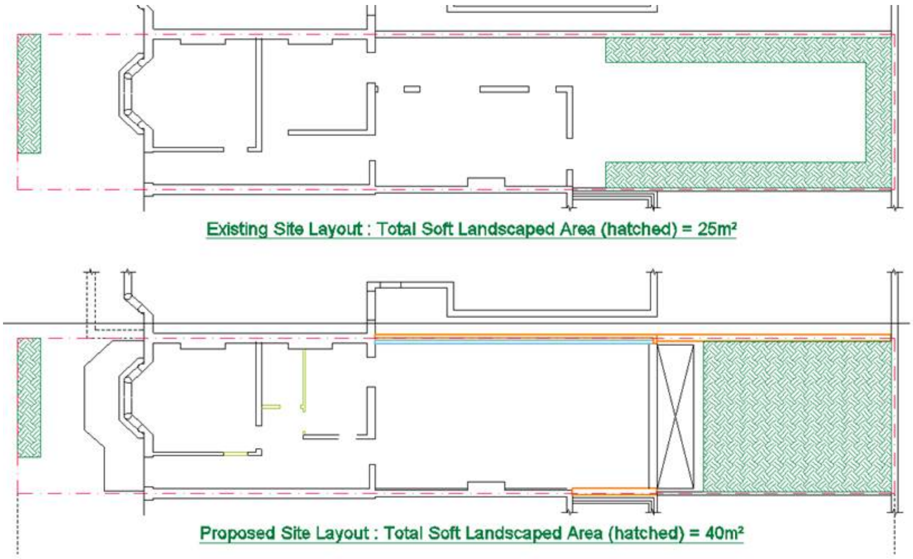
Ground Investigation Brief	The ground investigation was completed by Ground & Water Ltd. From the Scoping Stage, Croft considered that their brief should cover: • Two trial pits to confirm the extent of the existing foundations. The purpose is to consider the effect of the works on the neighbouring properties and the find the ground conditions below the site. • One borehole to a depth of 10m 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. • Laboratory testing to confirm soil make up and properties. • Historic maps did not show any significant contamination sources, therefore no site testing for ground contaminants was requested. • Factual report on soil conditions. • Interpretative reports • 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 Land Stability BIA for land stability issues addressed to Stage 3.
Subterranean Flow	Refer to the Groundwater BIA for hydrogeological issues addressed to Stage 3.
Surface Flow & Flooding	A study of OS maps shows that there are no surface water features, either within or close to the site. A walk over survey has confirmed this. The survey has also confirmed that the site is mostly covered with hard surfaces. Rainwater from these surfaces is likely to flow in the direction of the slope of the surrounding area, ie from north-west to south east. At the front this would be towards the front lightwell. The raised, uninterrupted pavement kerb at the front of the property will assist with preventing any flooding from an inundated road. In the back garden, this would be towards the rear boundary. Due to the terraced construction of the property, surface water cannot flow around the building at ground level. This will remain the case with the new development.

4. Basement Impact Assessment

Subterranean Flow	Refer to Groundwater BIA : conclusions are stated in the Executive Summary
Land Stability	Refer to Land Stability BIA: conclusions are stated in the Executive Summary
Conservation and Listed Buildings	The property is not adjacent to a listed building. The site is not in a conservation area.
Surface water flow and flooding	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'.

Drainage Assessment	
Hard standing	There are proposals to replace part of the paving in the rear garden with soft landscaping. This will result in a net increase in soft landscaping, as indicated below.  *Figure 14: Diagrams indicating an increase in soft landscaping*
SUDS Assessment	Installation of additional SUDS facilities is not required: SUDS is achieved by means of increasing the area soft-landscaping to the site.
Additional Drainage Considerations	The lightwell will create a hard surfaced area at basement level. This will be drained via Aco channels (or similar) and the water will be pumped and discharged into the existing sewer system Due to the overall reduction in hardstanding within the site, there will be no additional discharges into the sewer.

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Ground Movement Assessment & Predicted Damage Category

	The design and construction methodology aims to limit damage to the existing building on the site, and to the neighbouring buildings, to Category 2 or lower as set out in Table 2.5 of CIRIA report C580. For this development, suitable temporary propping during the construction phase will limit the amount of movement due to the basement works. This is described in the Basement Method Statement (appended). A ground movement assessment has been produced by Ground and Water.

Mitigation Measures

A method statement, appended, has been formulated with Croft's experience of over 500 basements completed without error. As mentioned previously, the procedures described in this statement 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.

With the measures listed above, the maximum level of cracking anticipated is 'Hairline' cracking. This can be repaired with normal decorative works. Under the Party Wall Act, minor damage, although unwanted, can be tolerated it is permitted to occur to a neighbouring property as long as repairs are suitability undertaken to rectify this. To mitigate this risk, the Party Wall Act is to be followed and a Party Wall Surveyor will be appointed.

Monitoring

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 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

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

Foundation type

Reinforced concrete cantilevered retaining walls will form the new foundation of the property.

Calculations to demonstrate the feasibility of the retaining walls is carried out using software by TEDDS. The software is specifically designed for retaining walls and ensures that the construction is kept to a limit to prevent damage to the adjacent property.

The overall stability of the walls is designed using K_a & K_p values, while the design of the wall structure uses K_0 values. This approach minimises the level of movement from the concrete affecting the adjacent properties.

The investigations highlight that water is a present. The walls are designed to resist the hydrostatic pressure. 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 is designed for water at the top of the wall.

The design also considers floatation as a risk. The design has accounted 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.

Intended use of structure and user requirements

Family/domestic use
(1 dwelling)

Loading Requirements (EC1-1)

	UDL kN/m²	Concentrated Load kN
Domestic Single Dwellings	1.5	2.0

Part A3 Progressive collapse

Number of Storeys 4 + basement

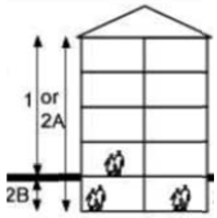
Is the Building Multi Occupancy? No

Class 2A	5 storey single occupancy houses

Change of use

To NHBC guidance compliance is only required to other floors if a material change of use occurs to the property.

Initial Building Class	2A
Proposed Building Class	2A
If class has changed material change has occurred	N/A



4 storey over basement

Lateral Stability	The above ground structure will be transfer the loads to the ground by steel stability frames and masonry piers. The retaining walls will resist the lateral pressures below ground level.
Stability Design	The cantilevered walls are suitable for carry the lateral loading applied from above.
Lateral Actions	Below ground level, reinforced concrete retaining walls are designed to carry the lateral loading applied from above. 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 wall These produce retaining wall thrust. This will be restrained by the opposing retaining wall.
Retained soil Parameters	Design overall stability to K_a & K_p values. Lateral movement necessary to achieve K_a mobilisation is height/500 (from Tomlinson). This is tighter than the deflection limits of the concrete wall.
Water Table	A ground investigation has found that water is present up to 2m below ground level. To account for the worst case conditions, the basement walls should be designed with the water table at the top of the retaining wall.

Additional loading requirements	**Surcharge Loading** The following will be applied as surcharge loads to the front/ front lightwell retaining walls: • 10kN/m² if within 45° of road • Garden Surcharge 2.5kN/m² + 1 m of soil (if present above basement ceiling) 20kN/m² • Surcharge for adjacent property 1.5kN/m² + 4kN/m² for concrete ground bearing slab <u>Highways loading:</u> The basement is within 5m of the pavement but not within 5m of the public highway. <u>Adjacent Properties:</u> All adjacent property footings within 45° to have additional geotechnical engineers input. A line at 45º from the base of the neighbours' wall footing would be intersected by the basement retaining wall. This should be accounted for in the design. The appended calculations show the design of one of the most heavily loaded retaining wall. The most critical parameters have been used for this.
Internal Flooding – Mitigation Measures	As described in previous sections, there are no significant risks of flooding besides those that are inherit in the construction of all subterranean structures, such as flooding due to unexpected failure of the drainage, water mains, etc. Croft would recommend the following measures to reduce these risks: • A pumping mechanism with a non-return valve should 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. • Install a dual pumping system to maintain operation in the event of a failure. This should include a battery backup and a suitable alarm system for warning purposes. • To reduce the impact of surface water flooding, sustainable drainage systems such as on site attenuation should be considered at detailed design stage.
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. 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
Localised Dewatering	Localised dewatering to pins may be necessary. Some engineers may raise theoretical questions about the pumping of water causing localised settlement. Croft SE believes that this argument is a red herring when applied to single storey basements. The reasons for this are as follows: • The water table in the area is variable, • The water level naturally rises and falls over time and does not lead to subsidence • The water table has naturally been rising and falling for over the last 20,000 years; any fines that will have been removed from the soil would have done so already. • If the water table rises and falls naturally why does this not cause subsidence due to fine removals every year? It does not because the soil has been soil is naturally consolidated by the rise and fall of the water table in the area. • The effect of local pumping for small excavations will not affect the local area. • There is only a risk of subsidence from large scale pumping of soil which lowers the water table below is natural lowest level.

Temporary Works	Walls are designed to be temporarily stable. Temporary propping details will be required for the ground and this must be provided by the contractor. Their details should be forwarded to the design stage engineer. Particular attention should be paid to point loads from above. Critical areas where point loads are present from above include: Cross walls Chimney Stacks Door openings To demonstrate the feasibility of the works, a proposed basement construction method statement is appended.

Noise and Nuisance Control	The contractor is to follow the good working practices and guidance laid down in the 'Considerate Constructors Scheme'. The hours of working will be limited to those allowed; 8am to 5pm Monday to Friday and Saturday Morning 8am to 1pm. None of the practices cause undue noise that one would typically expect from a construction site (a conveyor belt typically runs at around 70dB). The site will be hoarded with 8' site hoarding to prevent access. The hours of working will further be defined within the Party Wall Act. The site is to be hoarded to minimise the level of direct noise from the site. 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.
CTMP	The council may require a Construction Traffic Management Plan (CTMP) to be produced at detailed design stage. This is outside the brief of the Basement Impact Assessment and is not covered within Croft's brief. A CTMP would normally be required if the site is, or is adjacent to a listed building or is in a conservation area. This site does not fall under any of these categories.

Appendix A: Calculations

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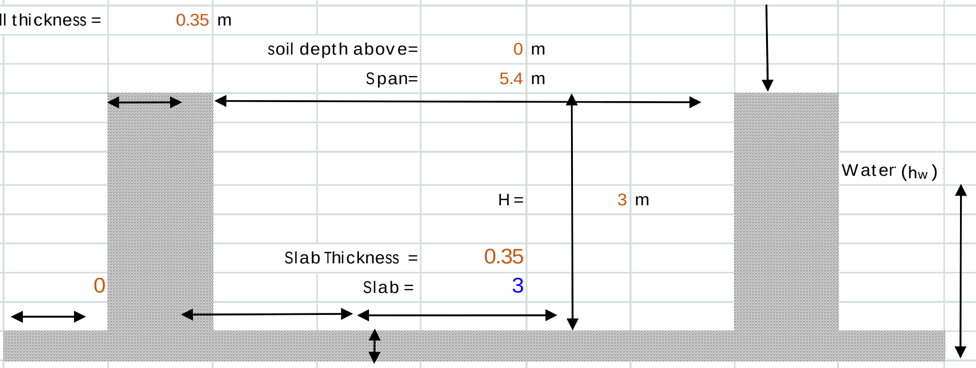
Project:	158 Iversion Rd	Section		Sheet	
Date	May-16	Rev	Date	Description	
By	GW				
Checked					
Job No	160317	Status		Rev	

Ref

Uplift and Heave Calculations

Wall DL1 = 100 kN/m — Wall DL2 100 kN/m
Wall thickness = 0.35 m
soil depth above= 0 m
Span= 5.4 m
Water (h_w) 3 m
H = 3 m
Slab Thickness = 0.35
Slab = 3
Heel= 0
Toe = 0.35 m
Toewidth= 1.2 m
soil unit weight= 18 kN/m^3



Uplift Calc

Total Dead Load

Slab=	26.25	kN/m	= slab thickness x slab weight x 25kN/m^3
Toe and heel =	27.125	kN/m	= (heel length + wall thickness + toe length) x slab thickness x 25kN/m^3 x 2No
RC Wall =	52.5	kN/m	= wall height above (from base) x wall thickness x 25kN/m^3 x 2No
Weight above wall =	200	kN/m	= Wall DL1 + Wall DL2
Total Dead load =	305.875	kN/m	
Total Uplift Force=	183	kN/m	= (wall thickness + span + wall thickness) x h_w x 10kN/m^3
F.o.S.=	1.67	No Global Uplift	

Slab Uplift

Slab =	8.75	kN/m	Uplift =	30	kN/m	= h_w x 10kN/m^3
Service Moment =	-77.5	kNm/m				
Factored Design moment=	-91.6	kNm/m				
Factored Design shear =	-67.8	kN/m				

Global Heave

Weight of building =	305.875	kN/m			
Weight of soil removed =	329.4				
% change =	7%		place	7%	of Slab area as heave protection
width of heave protection =	0.44	m	place	0.44	m of Slab area as heave protection

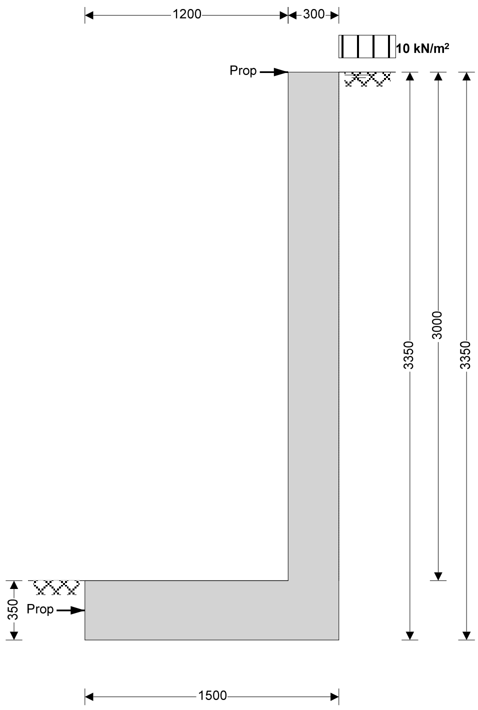
The most critically loaded retaning wall is presented here. This is the retaining wall for the front lightwell.

Refer to Section 1-1 on drawing SL-10.

RETAINING WALL DESIGN

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06



Wall details

Retaining wall type	**Cantilever**		
Height of wall stem	h_{stem} = **3000** mm	Wall stem thickness	t_{wall} = **300** mm
Length of toe	l_{toe} = **1200** mm	Length of heel	l_{heel} = **0** mm
Overall length of base	l_{base} = **1500** mm	Base thickness	t_{base} = **350** mm
Height of retaining wall	h_{wall} = **3350** mm		
Depth of downstand	d_{ds} = **0** mm	Thickness of downstand	t_{ds} = **350** mm
Position of downstand	l_{ds} = **900** mm		
Depth of cover in front of wall	d_{cover} = **0** mm	Unplanned excavation depth	d_{exc} = **0** mm
Height of ground water	h_{water} = **3350** mm	Density of water	γ_{water} = 9.81 kN/m^3
Density of wall construction	γ_{wall} = **23.6** kN/m^3	Density of base construction	γ_{base} = **23.6** kN/m^3
Angle of soil surface	β = **0.0** deg	Effective height at back of wall	h_{eff} = **3350** mm
Mobilisation factor	M = **1.5**		
Moist density	γ_m = **18.0** kN/m^3	Saturated density	γ_s = **21.0** kN/m^3
Design shear strength	ϕ' = **20.0** deg	Angle of wall friction	δ = **0.0** deg
Design shear strength	ϕ'_b = **20.0** deg	Design base friction	δ_b = **18.0** deg
Moist density	γ_{mb} = **18.0** kN/m^3	Allowable bearing	$P_{bearing}$ = **100** kN/m^2

Using Coulomb theory

Active pressure K_a =**0.490** Passive pressure K_p = **3.312**

At-rest pressure K_0 = **0.658**

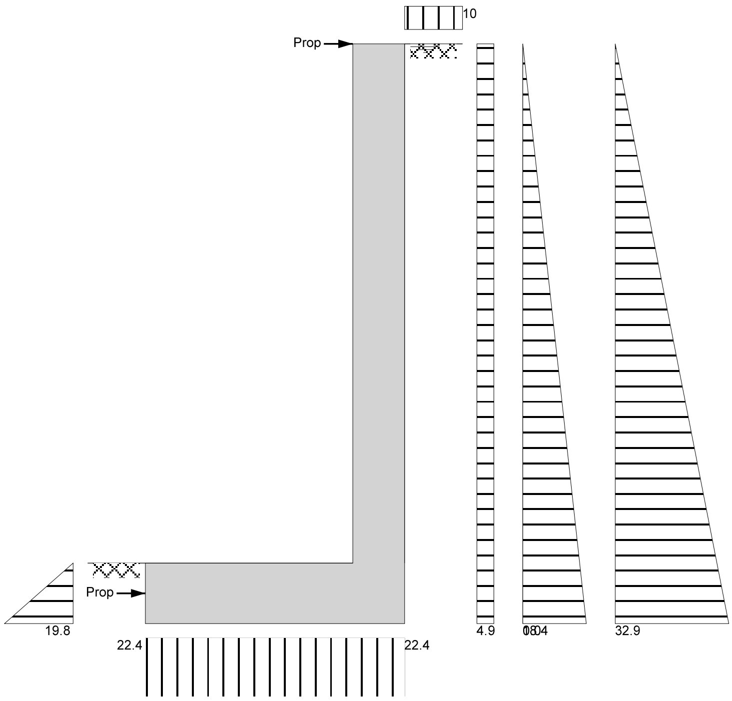
Loading details

Surcharge load Surcharge = **10.0** kN/m^2

Vertical dead load W_{dead} = **0.0** kN/m Vertical live load W_{live} = **0.0** kN/m

Horizontal dead load F_{dead} = **0.0** kN/m Horizontal live load F_{live} = **0.0** kN/m

Position of vertical load l_{load} = **0** mm Height of horizontal load h_{load} = **0** mm



Loads shown in kN/m, pressures shown in kN/m^2

Calculate propping force

Propping force F_{prop} = **87.9** kN/m

Check bearing pressure

Total vertical reaction R = **33.6** kN/m Distance to reaction x_{bar} = **750** mm

Eccentricity of reaction e = **0** mm

Reaction acts within middle third of base

Bearing pressure at toe p_{toe} = **22.4** kN/m^2 Bearing pressure at heel p_{heel} = **22.4** kN/m^2

PASS - Maximum bearing pressure is less than allowable bearing pressure

Calculate propping forces to top and base of wall

Propping force to top of wall F_{prop_top} = **29.996** kN/m Propping force to base of wall F_{prop_base} = **57.860** kN/m

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor γ_{f_d} = **1.4** Live load factor γ_{f_l} = **1.6**

Earth pressure factor γ_{f_e} = **1.4**

Calculate propping force

Propping force F_{prop} = **87.9** kN/m

Calculate propping forces to top and base of wall

Propping force to top of wall $F_{prop\_top\_f}$ = **52.165** kN/m Propping force to base of wall $F_{prop\_base\_f}$ = **97.848** kN/m

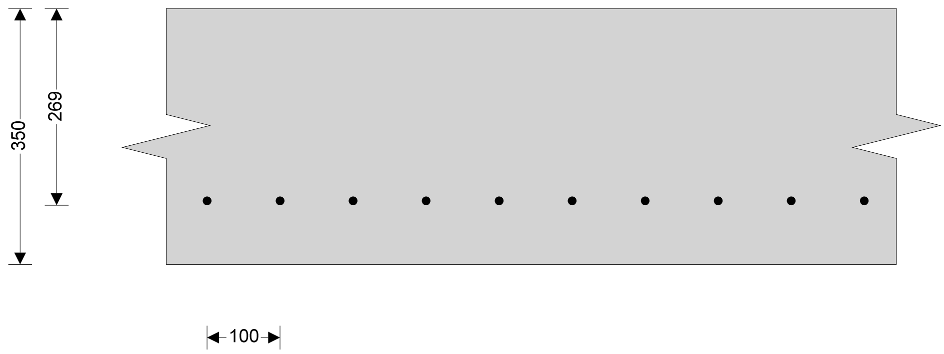
Design of reinforced concrete retaining wall toe (BS 8002:1994)

Material properties

Strength of concrete f_{cu} = **35** N/mm^2 Strength of reinforcement f_y = **500** N/mm^2

Base details

Minimum reinforcement k = **0.13** % Cover in toe c_{toe} = **75** mm



Design of retaining wall toe

Shear at heel V_{toe} = **23.8** kN/m Moment at heel M_{toe} = **18.1** kNm/m

Compression reinforcement is not required

Check toe in bending

Reinforcement provided **B1131 mesh**

Area required $A_{s\_toe\_req}$ = **455.0** mm^2/m Area provided $A_{s\_toe\_prov}$ = **1131** mm^2/m

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress v_{toe} = **0.088** N/mm^2 Allowable shear stress v_{adm} = **4.733** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_toe} = **0.464** N/mm^2

$v_{toe} < v_{c\_toe}$ - No shear reinforcement required

Design of reinforced concrete retaining wall stem (BS 8002:1994)

Material properties

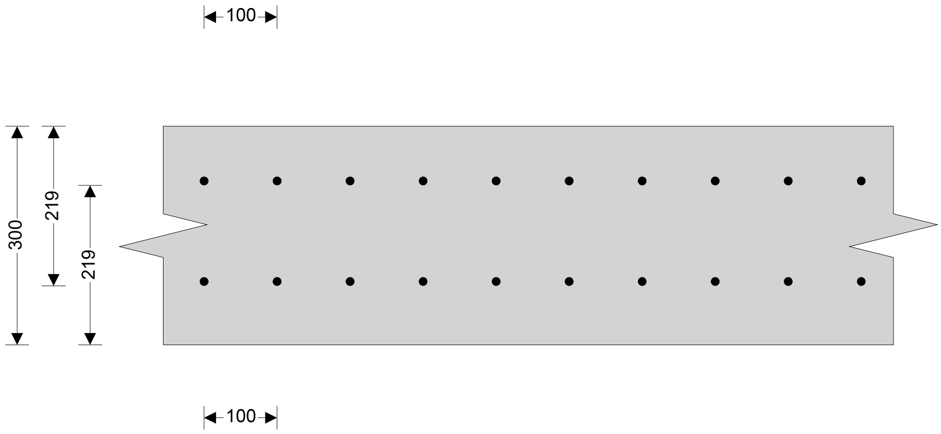
Strength of concrete f_{cu} = **35** N/mm^2 Strength of reinforcement f_y = **500** N/mm^2

Wall details

Minimum reinforcement k = **0.13** %

Cover in stem c_{stem} = **75** mm Cover in wall c_{wall} = **75** mm

Croft Structural Engineers Ltd Rear of 60 Saxon Rd SE25 5EH Selhurst, London	Project 158 Iverson Road, Camden, NW6 2HH				Job Ref. 160317	
	Section Basement Calculations				Sheet no./rev. 4	
	Calc. by GW	Date 09/05/2016	Chk'd by	Date	App'd by	Date



Design of retaining wall stem

Shear at base of stem V_{stem} = **106.3** kN/m   Moment at base of stem M_{stem} = **58.3** kNm/m

Compression reinforcement is not required

Check wall stem in bending

Reinforcement provided **B1131 mesh**

Area required $A_{s\_stem\_req}$ = **650.5** mm^2/m   Area provided $A_{s\_stem\_prov}$ = **1131** mm^2/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress v_{stem} = **0.490** N/mm^2 Allowable shear stress v_{adm} = **4.733** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress v_{c_stem} = **0.637** N/mm^2

$v_{stem} < v_{c\_stem}$ - No shear reinforcement required

Design of retaining wall at mid height

Moment at mid height M_{wall} = **27.5** kNm/m

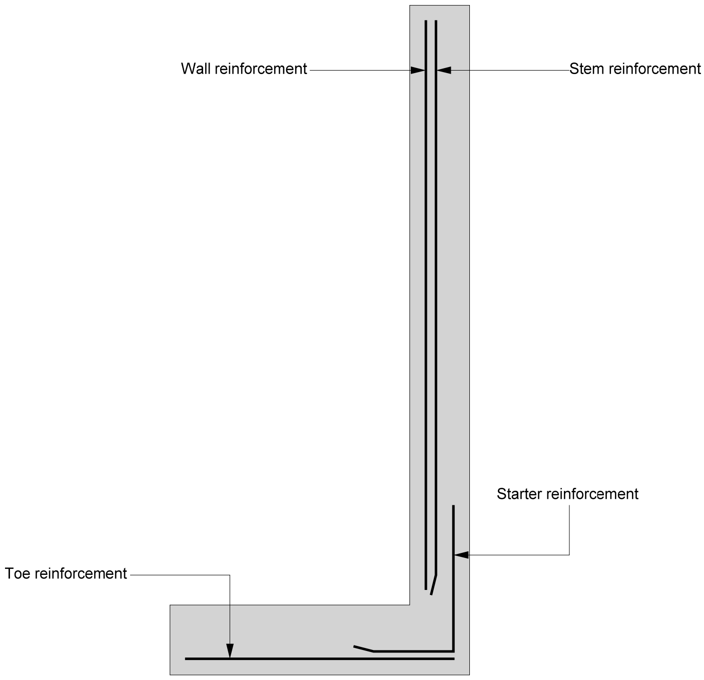
Compression reinforcement is not required

Reinforcement provided **B1131 mesh**

Area required $A_{s\_wall\_req}$ = **390.0** mm^2/m   Area provided $A_{s\_wall\_prov}$ = **1131** mm^2/m

PASS - Reinforcement provided to the retaining wall at mid height is adequate

Indicative retaining wall reinforcement diagram



Toe mesh - B1131 - (1131 mm^2/m)
Wall mesh - B1131 - (1131 mm^2/m)
Stem mesh - B1131 - (1131 mm^2/m)

Above digram is indicavtive only and is not a final design stage representation of the reinforcement to be used.

SLAB CALCULATIONS

RC SLAB DESIGN (BS8110:PART1:1997)

TEDDS calculation version 1.0.04

CONCRETE SLAB DESIGN (CL 3.5.3 & 4)

SIMPLE ONE WAY SPANNING SLAB DEFINITION

Overall depth of slab h = **250** mm

Cover to tension reinforcement resisting sagging c_b = **50** mm

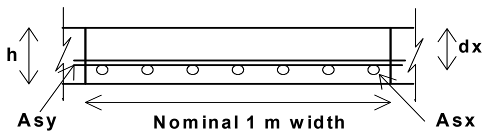
Trial bar diameter D_{tryx} = **12** mm

Depth to tension steel (resisting sagging)

$d_x = h - c_b - D_{tryx}/2$ = **194** mm

Characteristic strength of reinforcement f_y = **500** N/mm^2

Characteristic strength of concrete f_{cu} = **35** N/mm^2



One-way spanning slab
(simple)

ONE WAY SPANNING SLAB (CL 3.5.4)

MAXIMUM DESIGN MOMENTS IN SPAN

Design sagging moment (per m width of slab) m_{sx} = **95.0** kNm/m

CONCRETE SLAB DESIGN – SAGGING – OUTER LAYER OF STEEL (CL 3.5.4)

Design sagging moment (per m width of slab) m_{sx} = **95.0** kNm/m

Moment Redistribution Factor β_{bx} = **1.0**

Area of reinforcement required

$K_x = abs(m_{sx}) / (d_x^2 \times f_{cu})$ = **0.072**

$K'_x = \min (0.156 , (0.402 \times (\beta_{bx} - 0.4)) - (0.18 \times (\beta_{bx} - 0.4)^2))$ = **0.156**

Outer compression steel not required to resist sagging

Slab requiring outer tension steel only - bars (sagging)

$z_x = \min ((0.95 \times d_x),(d_x \times (0.5+\sqrt{(0.25-K_x/0.9)})))$ = **177** mm

Neutral axis depth $x_x = (d_x - z_x) / 0.45$ = **38** mm

Area of tension steel required

$A_{sx\_req} = abs(m_{sx}) / (1/\gamma_{ms} \times f_y \times z_x)$ = **1235** mm^2/m

Tension steel

Provide 16 dia bars @ 150 centres outer tension steel resisting sagging

$A_{sx\_prov} = A_{sx}$ = **1340** mm^2/m

Area of outer tension steel provided sufficient to resist sagging

TRANSVERSE BOTTOM STEEL - INNER

Inner layer of transverse steel

Provide 16 dia bars @ 150 centres

A_{sy_prov} = A_{sy} = **1340** mm^2/m

Check min and max areas of steel resisting sagging

Total area of concrete A_c = h = **250000** mm^2/m

Minimum % reinforcement k = **0.13** %

A_{st_min} = k × A_c = **325** mm^2/m

A_{st_max} = 4 % × A_c = **10000** mm^2/m

Steel defined:

Outer steel resisting sagging A_{sx_prov} = **1340** mm^2/m

Area of outer steel provided (sagging) OK

Inner steel resisting sagging A_{sy_prov} = **1340** mm^2/m

Area of inner steel provided (sagging) OK

SHEAR RESISTANCE OF CONCRETE SLABS (CL 3.5.5)

Outer tension steel resisting sagging moments

Depth to tension steel from compression face d_x = **194** mm

Area of tension reinforcement provided (per m width of slab) A_{sx_prov} = **1340** mm^2/m

Design ultimate shear force (per m width of slab) V_x = **70** kN/m

Characteristic strength of concrete f_{cu} = **35** N/mm^2

Applied shear stress

$v_x = V_x / d_x$ = **0.36** N/mm^2

Check shear stress to clause 3.5.5.2

$v_{allowable} = \min((0.8\ N^{1/2}/mm) \times \sqrt{(f_{cu})}, 5\ N/mm^2)$ = **4.73** N/mm^2

Shear stress - OK

Shear stresses to clause 3.5.5.3

Design shear stress

f_{cu_ratio} = if (f_{cu} > 40 N/mm^2 , 40/25 , f_{cu}/(25 N/mm^2)) = **1.400**

$v_{cx} = 0.79\ N/mm^2 \times \min(3,100 \times A_{sx\_prov} / d_x)^{1/3} \times \max(0.67,(400\ mm / d_x)^{1/4}) / 1.25 \times f_{cu\_ratio}^{1/3}$

v_{cx} = **0.75** N/mm^2

Applied shear stress

v_x = **0.36** N/mm^2

No shear reinforcement required

CONCRETE SLAB DEFLECTION CHECK (CL 3.5.7)

Slab span length l_x = **3.000** m

Design ultimate moment in shorter span per m width m_{sx} = **95** kNm/m

Depth to outer tension steel d_x = **194** mm

Tension steel

Area of outer tension reinforcement provided A_{sx_prov} = **1340** mm^2/m

Area of tension reinforcement required A_{sx_req} = **1235** mm^2/m

Moment Redistribution Factor β_{bx} = **1.00**

Modification Factors

Basic span / effective depth ratio (Table 3.9) $ratio_{span\_depth}$ = **20**

The modification factor for spans in excess of 10m (ref. cl 3.4.6.4) has not been included.

$f_s = 2 \times f_y \times A_{sx\_req} / (3 \times A_{sx\_prov} \times \beta_{bx})$ = **307.2** N/mm^2

$factor_{tens} = \min(2, 0.55 + (477 N/mm^2 - f_s) / (120 \times (0.9 N/mm^2 + m_{sx} / d_x^2)))$ = **0.963**

Calculate Maximum Span

This is a simplified approach and further attention should be given where special circumstances exist. Refer to clauses 3.4.6.4 and 3.4.6.7.

Maximum span $l_{max} = ratio_{span\_depth} \times factor_{tens} \times d_x$ = **3.74** m

Check the actual beam span

Actual span/depth ratio l_x / d_x = **15.46**

Span depth limit $ratio_{span\_depth} \times factor_{tens}$ = **19.27**

Span/Depth ratio check satisfied

CHECK OF NOMINAL COVER (SAGGING) – (BS8110:PT 1, TABLE 3.4)

Slab thickness h = **250** mm

Effective depth to bottom outer tension reinforcement d_x = **194.0** mm

Diameter of tension reinforcement D_x = **16** mm

Diameter of links L_{diax} = **0** mm

Cover to outer tension reinforcement

$c_{tenx} = h - d_x - D_x / 2$ = **48.0** mm

Nominal cover to links steel

$c_{nomx} = c_{tenx} - L_{diax}$ = **48.0** mm

Permissable minimum nominal cover to all reinforcement (Table 3.4)

c_{min} = **35** mm

Cover over steel resisting sagging OK

Appendix B: Construction Method Statement

Job Number: 160317

CROFT STRUCTURAL ENGINEERS

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

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Basement Method Statement

Property:

158 Iverson Road
West Hampstead
Camden
NW6 2HH

Client:

Ground& Water Ltd
15 Bow Street
Alton
Hampshire
GU34 1NY

Revision	Date	Comment
-	09.05.2016	First Issue

Contents

CROFT STRUCTURAL ENGINEERS

158 Iverson Road

1. Basement Formation Suggested Method Statement

1.1. This method statement provides an approach that will allow the basement design to be correctly considered during construction. The statement also contains proposals for the temporary support to be provided during the works. The Contractor is responsible for the works on site and the final temporary works methodology and design on this site and any adjacent sites.

1.2. This method statement has been written by a Chartered Engineer. The sequencing has been developed using guidance from ASUC (Association of Specialist Underpinning Contractors).

1.3. This method has been produced to allow for improved costings and for inclusion in the Party Wall Award. Final site conditions need there to be flexibility in the method statement: Should the site staff require alterations to the Method statement this is allowed once an alternative methodology, of the changes is provided, and an Addendum to the Party Wall Award will be required.

1.4. Contact Party Wall Surveyors to inform them of any changes to this method statement.

1.5. On this development, the approach is: construct the underpin segments that will support the permanent steel work insert the new steelwork remove load from above and place it onto new supporting steelwork cast the remainder of the retaining walls that will form the perimeter of the basement.

1.6. On this project the retaining walls are required to be propped at both the top and bottom of the wall in the final case. During construction, in the temporary condition, the edge of the slab is buttressed against the soil in the middle of the property: Temporary props will be provided near the head and will provide support until the concrete has gained sufficient strength. Skin friction between the concrete base and the soil provides further resistance. In the temporary case, the main lateral support is provided by back propping to the central soil mass. The central soil mass is to be removed in 1/3 portions and cross propping subsequently added.

1.7. A ground investigation has been undertaken. The soil present at formation level is London Clay

1.8. The bearing pressures have been limited to 100kN/m^2.

1.9. The water table is expected to encountered at 2m below ground level

1.10. The structural waterproofer (not Croft) must comment on the proposed design and ensure that he is satisfied that the proposals will provide adequate waterproofing.

1.1. Provide engineers with concrete mix, supplier, delivery and placement methods two weeks prior to the first pour. Site mixing of concrete should not be employed apart from in small sections (less than 1m^3). The contractor must provide a method on how to achieve site mixing to the correct specification. The contractor must undertake toolbox talks with staff to ensure site quality is maintained.

2. Enabling Works

2.1. The site is to be hoarded with ply board sheets, at least 2.2m high, to prevent unauthorised public access.

2.2. Licences for skips and conveyors should be posted on the hoarding.

2.3. Provide protection to public where conveyor extends over footpath. Depending on the requirements of the local authority, construct a plywood bulkhead over the pavement. Hoarding to have a plywood roof covering over the footpath, night-lights and safety notices.

2.4. Dewater: Water is expected at 2m below ground level. This is to be dealt with by localised pumping. Typically achieved by a small sump pump in a bucket.

2.5. On commencement of construction, the contractor will determine the foundation type, width and depth. Any discrepancies will be reported to the structural engineer in order that the detailed design may be modified as necessary.

3. Basement Sequencing

3.1. Begin by placing cantilevered walls 1 and 2 as noted on plans. (Cantilevered walls to be placed in accordance with Section 4.)

3.1.1. Install ground drainage pipes prior to casting wall base and stem.

3.2. Needle and prop the front wall over.

Figure 1 Example of needling to existing wall

3.3. Continue excavating section pins (3-10) to form front lightwell. (Follow methodology in Section 4)

3.4. Place cantilevered retaining wall to the left side of front opening. After 48 hours place cantilevered retaining wall to the right side of front opening.

3.5. Install conveyor.

3.6. Continue cantilevered wall formation around perimeter of basement following the numbering sequence on the drawings.

3.6.1. Excavation for the next numbered sequential sections of underpinning shall not commence until at least 8 hours after drypacking of previous works. Excavation of adjacent pin to not commence until 48 hours after drypacking. (24hours possible due to inclusion of Conbextra 100 cement accelerator to dry pack mix). No more than

3.6.2. Floor over to be propped as excavation progresses. Steelwork to support floor to be inserted as works progress.

3.7. Cast base to internal wall. Construct wall to provide support to floor and steels as works progress.

3.8. Excavate and cast floor slab

3.8.1. Excavate 1/3 of the middle section of basement floor. As excavation proceeds, place Slim Shore props at a maximum of 2.5m c/c across the basement. Locate props at a third of the height of the wall.

Fix top waler beams along head of wall. Excavate a 1/3 of the middle section of basement floor. As excavation proceeds place Slimhor props at a maximum of 2.5m c/c across the basement. Locate props at a 1m from the base of the wall and also to the waler beam at high level.

3.8.2. Continue excavating the next 1/3 and prop then repeat for the final 1/3.

3.8.3. Place below-slab drainage. Croft recommends that all drainage is encased in concrete below the slab and cast monolithically with the slab. Placing drainage on pea shingle below the slab allows greater penetration for water ingress.

3.8.4. Place reinforcement for basement slab.

3.8.5. Building Control Officer and Engineer are to be informed five working days before reinforcement is ready and invited for inspection.

3.8.6. Once inspected, pour concrete.

3.9. Provide structure to ground floor and water proofing to retaining walls as required. It is recommended to leave 3-4 weeks between completion of the basement and installing drained cavity. This period should be used to locate and fill any localised leakage of the basement

4. Underpinning and Cantilevered Walls

4.1. Prior to installation of new structural beams in the superstructure, the contractor may undertake the local exploration of specific areas in the superstructure. This will confirm the exact form and location of the temporary works that are required. The permanent structural work can then be undertaken whilst ensuring that the full integrity of the structure above is maintained.

4.2. Provide propping to floor where necessary.

4.3. Excavate first section of retaining wall (no more than 1000mm wide). Where excavation is greater than 1.2m deep, provide temporary propping to sides of excavation to prevent earth collapse (Health and Safety). A 1000mm width wall has a lower risk of collapse to the heel face.

4.4. Excavation of pins involves working in confined spaces and the following measures should be applied:

- Operatives must wear a harness and there must be a winch above the excavation.
- An attendant must be present at all times, at ground level, while excavation is occupied.
- A rescue plan must be produced prior to the works as well as a task-specific risk and method statement.
- Working in the confined space should require a permit to work.

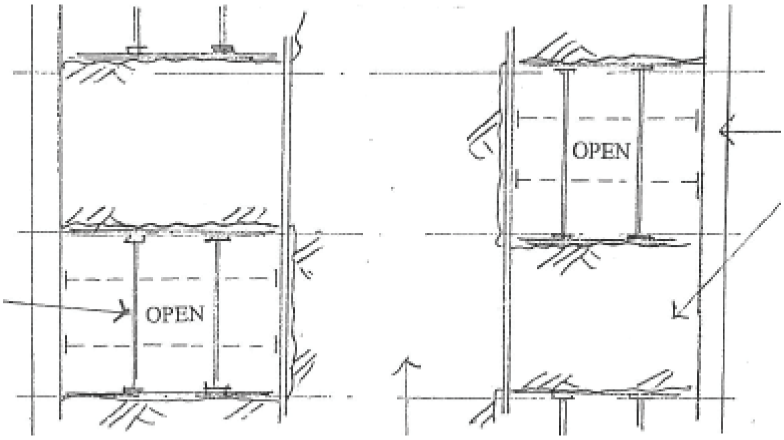

Figure 2 – Schematic Plan view of soil propping

Figure 3 Propping examples

Figure 4 Examples of excavations of pins

Figure 5 Examples of completed walls and back propping to central soil mass

4.5. Backpropping of rear face: Rear face to be propped in the temporary conditions with a minimum of 2 trench sheets. Trench sheets are to extend over entire height of excavation. Trench sheets can be placed in short sections as the excavation progresses.

Figure 6 Example of trench sheet back propping

4.5.1. If the ground is stable, trench sheets can be removed as the wall reinforcement is placed and the shuttering is constructed.

4.5.2. Where soft spots are encountered, leave in trench sheets or alternatiively back prop with precast lintels or sacrificial boards. If the soil support to the ends of the lintels is insufficient, then brace the ends of the PC lintels with 150x150 C24 timbers and prop with Acrows diagonally back to the ground.

4.5.3. Where voids are present behind the lintels or trench sheeting, grout voids behind sacrificial propping. Grout to be 3:1 sand/cement packed into voids.

4.5.4. Prior to casting, place layer of DPM between trench sheeting (or PC lintels) and new concrete. The lintels are to be cut into the soil by 150mm either side of the pin. A site stock of a minimum of 10 lintels should be present to prevent delays due to ordering.

4.6. If cut face is not straight, or sacrificial boards noted previously have been used, place a 15mm cement particle board between sacrificial sheets or against the soil prior to casting. Cement particle board is to line up with the adjacent owner's face of wall. The method adopted, to prevent localised collapse of the soil, is to install these progressively, one at a time. Cement particle board must be used in any condition where overspill onto the adjacent owner's land is possible.

4.7. Excavate base. If soil over is unstable, prop top with PC lintel and sacrificial prop.

4.8. Visually inspect the footings and provide propping to local brickwork. If necessary install sacrificial Acrow, or pit props, and cast into the retaining wall.

4.9. Clear underside of existing footing.

4.10. Local Authority inspection to be carried out for approval of excavation base.

4.11. Place blinding.

4.12. Place reinforcement for retaining wall base and stem. Drive H16 Bars U-bars into soil along centre line of stem to act as shear ties to adjacent wall underpin.

4.13. Site supervisor to inspect and sign off works before proceeding to next stage.

4.13.1. For pins 1, 3 and 5, inform the engineer five days before the reinforcement is ready, to allow for inspection of the reinforcement prior to casting.

4.14. Cast base. On short stems it is possible to cast base and wall at the same time. It is essential that pokers/vibrators are used to compact concrete.

4.15. Concrete Testing:

4.15.1. For first 3 pins take 4 cubes and test at 7 days then at 14 days and inform engineer of results. Test last cube at 28 days. If cube test results are low then action into concrete specification and placement method must be considered.

4.15.2. If results are good from first three pins, then from the 4th pin onwards take 2 cubes of concrete from every third pin and store for testing. Test one at 28 days. If result is low, test second cube. Provide results to client and design team on request or if values are below those required.

Ensure that concrete is of sufficient strength check engineer's specifications

4.15.3. A record of dates for the concrete pouring of each pin must be kept on site.

4.15.4. The location of where cubes were taken and their reference number must be recorded.

4.16. Horizontal temporary prop to base of wall to be inserted. Alternatively cast base against soil.

4.17. Place shuttering and pour concrete for retaining wall. Stop a minimum of 75mm from the underside of existing footing. It is essential that pokers/vibrators are used, hitting shutters is **not** considered adequate.

4.18. 24 hours after pouring the concrete pin, the gap shall be filled using a dry-pack mortar. Ram in dry-pack between the top of the retaining wall and existing masonry.

4.18.1. If gap is greater than 120mm, place a line of engineering bricks to the top of the wall. Dry pack from the engineering bricks to existing masonry.

4.19. After 24 hours, the temporary wall shutters can be removed.

4.20. Trim back existing masonry corbel and concrete on internal face.

4.21. Site supervisor to inspect and sign off for proceeding to the next stage. A record will be kept of the sequence of construction, which will be in strict accordance with recognised industry procedures.

5. Floor Support

Timber Floor

5.1. The timber floor will remain in situ and be supported by a series of steel beams, to provide open areas in the basement.

5.2. Position 100 x 100mm temporary timber beams, lightly packed, to underside of joists either side of existing sleeper wall and support with vertical Acrow props @ 750 centres. Remove sleeper walls and insert steel beams as a replacement. Steel beams to bear onto concrete padstones built into the masonry walls (refer to Structural Engineer's details for padstone and beam sizes)

5.3. Dismantle props and remove timber plates on completion of installation of permanent steel beams.

6. Supporting existing walls above basement excavation

6.1. Where steel beams need to be installed directly under load-bearing walls, temporary works will be required to enable this installation. Support comprises the temporary installation of steel needle beams at high level, supported on vertical props. This will enable safe removal of brickwork below and installation of the new beams and columns.

6.1.1. The condition of the brickwork must be inspected by the foreman to determine its condition and to assess the centres of needles. The foreman must inspect upstairs to consider where loads are greatest. Point loads between windows should be given greater consideration.

6.1.2. Needles are to be spaced to prevent the brickwork above 'saw toothing'. Where brickwork is good, needles must be placed at a maximum of 1100mm centers. Lighter needles or Strongboys should be placed at tighter centres under door thresholds

6.2. Props are to be placed on sleepers on firm ground or, if necessary, temporary footings will be cast.

6.3. Once the props are fully tightened, the brickwork will be broken out carefully by hand. All necessary platforms and crash decks will be provided during this operation.

6.4. Decking and support platforms to enable handling of steel beams and columns will be provided as required.

6.5. Once full structural bearing is provided via beams and columns down to the new basement floor level, the temporary works will be redundant and can be safely removed.

6.6. Any voids between the top of the permanent steel beams and the underside of the existing walls will be packed out as necessary. Voids will be drypacked with a 1:3 (cement: sharp sand) drypack layer, between the top of the steel and underside of brickwork above.

6.7. Any voids in the brickwork left after removal of needle beams can at this point be repaired by bricking up and/or drypacking, to ensure continuity of the structural fabric.

7. Approval

7.1. Building Control Officer/Approved Inspector to inspect pin bases and reinforcement prior to casting concrete.

7.2. Contractor to keep list of dates of pins inspected and cast.

7.3. One month after the work is completed, the contractor is to contact Adjoining Party Wall Surveyor to attend site and complete final condition survey and to sign off works.

8. Basement Temporary Works Design Lateral Propping

This calculation has been provided for the trench sheet and prop design of standard underpins in the temporary condition. There are gaps left between the sheeting and as such no water pressure will occur. Any water present will flow through the gaps between the sheeting and will be required to be pumped out.

Trench sheets should be placed at regular centres to deal with the ground. It is expected that the soil between the trench sheeting will arch. Looser soil will require tighter centres. It is typical for underpins to be placed at 1200c/c in this condition the highest load on a trench sheet is when 2 No.s trench sheets are used. It is for this design that these calculations have been provided.

Soil and ground conditions are variable. Typically one finds that, in the temporary condition, clays are more stable and the C_u (cohesive) values in clay reduce the risk of collapse. It is this cohesive nature that allows clays to be cut into a vertical slope. For these calculations, weak sand and gravels have been assumed. The soil properties are:

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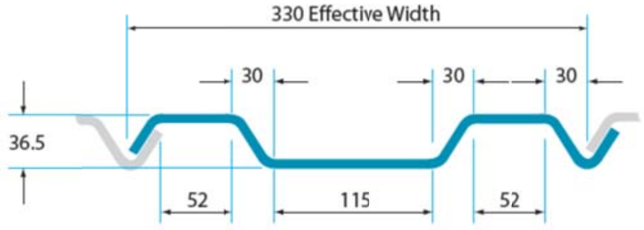
Trench Sheet Design

Soil Depth	Dsoil = 3000mm	
Surcharge	sur = 10kN/m^2	
Soil Density	γ = 20kN/m^3	
Angle of Friction	ϕ = 25°	
	$k_a = (1 - \sin(\phi)) / (1 + \sin(\phi))$	= **0.406**
	$k_p = 1 / k_a$	= **2.464**
Soil pressure bottom	soil = $k_a * \gamma *$ Dsoil	= **21.916**kN/m^2
Surcharge pressure	surcharge = sur * k_a	= **4.059** kN/m^2

STANDARD LAP

The overlapping trench sheeting profile is designed primarily for construction work and also temporary deployment.



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Technical Information

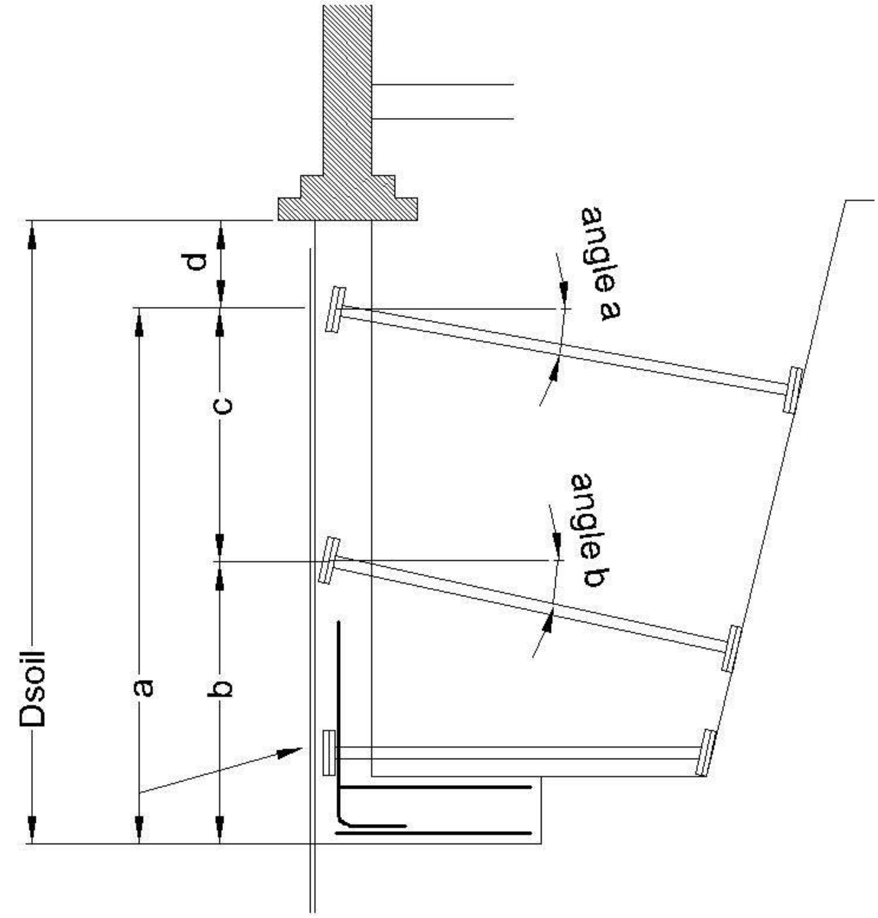
Effective width per sheet (mm)	330
Thickness (mm)	3.4
Depth (mm)	35
Weight per linear metre (kg/m)	10.8
Weight per m^2 (kg)	32.9
Section modulus per metre width (cm^3)	48.3
Section modulus per sheet (cm^3)	15.9
I value per metre width (cm^4)	81.7
I value per sheet (cm^4)	26.9
Total rolled metres per tonne	92.1

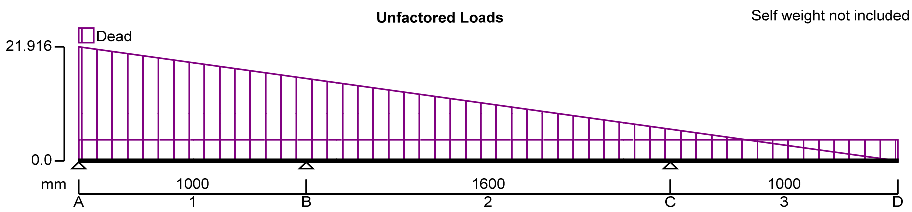
$S_{xx} = 15.9\ cm^3$

$p_y = 275 N/mm^2$

$I_{xx} = 26.9 cm^4$

$A = (1m * 32.9kg/m^2) / (7750kg/m^3) =$ **4245.161** mm^2





CONTINUOUS BEAM ANALYSIS - INPUT

BEAM DETAILS

Number of spans = **3**

Material Properties:

Modulus of elasticity = **205** kN/mm^2 Material density = **7860** kg/m^3

Support Conditions:

Support A	Vertically **"Restrained"**	Rotationally **"Free"**
Support B	Vertically **"Restrained"**	Rotationally **"Free"**
Support C	Vertically **"Restrained"**	Rotationally **"Free"**
Support D	Vertically **"Free"**	Rotationally **"Free"**

Span Definitions:

Span 1	Length = **1000** mm	Cross-sectional area = **4245** mm^2	Moment of inertia = **269.×10^3** mm^4
Span 2	Length = **1600** mm	Cross-sectional area = **4245** mm^2	Moment of inertia = **269.×10^3** mm^4
Span 3	Length = **1000** mm	Cross-sectional area = **4245** mm^2	Moment of inertia = **269.×10^3** mm^4

LOADING DETAILS

Beam Loads:

Load 1 UDL Dead load **4.1** kN/m

Load 2 VDL Dead load **21.9** kN/m to **0.0** kN/m

LOAD COMBINATIONS

Load combination 1

Span 1 1.4×Dead

Span 2 1.4×Dead

Span 3 1.4×Dead

CONTINUOUS BEAM ANALYSIS - RESULTS

Support Reactions - Combination Summary

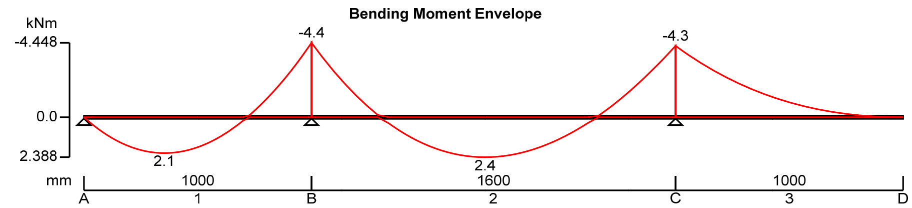
Support A	Max react = **-12.3** kN	Min react = **-12.3** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support B	Max react = **-38.5** kN	Min react = **-38.5** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support C	Max react = **-24.8** kN	Min react = **-24.8** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support D	Max react = **0.0** kN	Min react = **0.0** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm

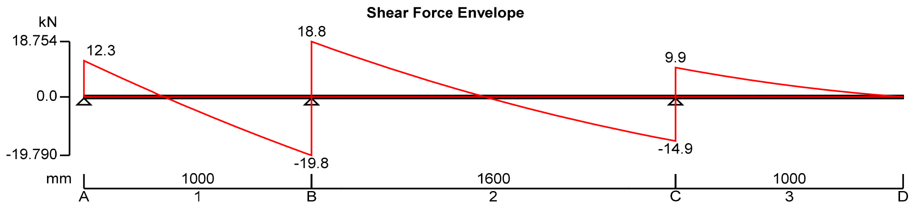
Beam Max/Min results - Combination Summary

Maximum shear = **18.8** kN   Minimum shearF_{min} = **-19.8** kN

Maximum moment = **2.4** kNm   Minimum moment = **-4.4** kNm

Maximum deflection = **17.1** mm   Minimum deflection = **-0.1** mm





Number of sheets Nos = 3

Moment   M_allowable = Sxx * py * Nos = **13.118**kNm

Deflection   D = / Nos = **5.699**mm

Acro Load   Acro = R_{max_B} / 2 = -19.272kN

Safe working loads for Acrow Props — loads given in kN

For normal purposes 1 kilo Newton (kN) = 100 kg	Height	m / ft	2.0 / 6.6	2.25 / 7.4	2.5 / 8.2	2.75 / 9.0	3.0 / 9.8	3. / 10
TABLE A Props loaded concentrically and erected vertically	Prop size 1 or 2		35	35	35	34	27	23
	Prop size 3					34	27	23
	Prop size 4							32
TABLE B Props loaded concentrically and erected 1½° max. out of vertical	Prop size 1 or 2 or 3		35	32	26	23	19	17
	Prop size 4							24
TABLE C Props loaded 25 mm eccentricity and erected 1½° max. out of vertical	Prop size 1 or 2 or 3		17	17	17	17	15	13
	Prop size 4							17
TABLE D Props loaded concentrically and erected 1½° out of vertical and laced with scaffold tubes and fittings	Prop size 3					35	33	32
	Prop size 4							35

Acrow Props A or B are acceptable placed 0.5m from top, middle and 1m from bottom

Cross Props

Props should be placed a third up the wall measured from the bottom slab.

Surcharge	sur = 10kN/m^2
Soil Density	γ = 20kN/m^3

Angle of Friction	ϕ = 25°	
Soil Depth	Dsoil = 3000mm	
	k_a = (1 - sin(ϕ)) / (1 + sin(ϕ))	= **0.406**
	k_p = 1 / k_a	= **2.464**
1 - sin(ϕ)	= **0.577**	

Soil force bottomsoilforce = k_a * γ * Dsoil * Dsoil / 2 = **36.527**kN/m

Surcharge Force Surchargeforce = k_a * sur * Dsoil = **12.176**kN/m

Place Props every other pin spacing = 2m

Propforce Propforce = spacing * (soilforce + Surchargeforce) = **97.406**kN

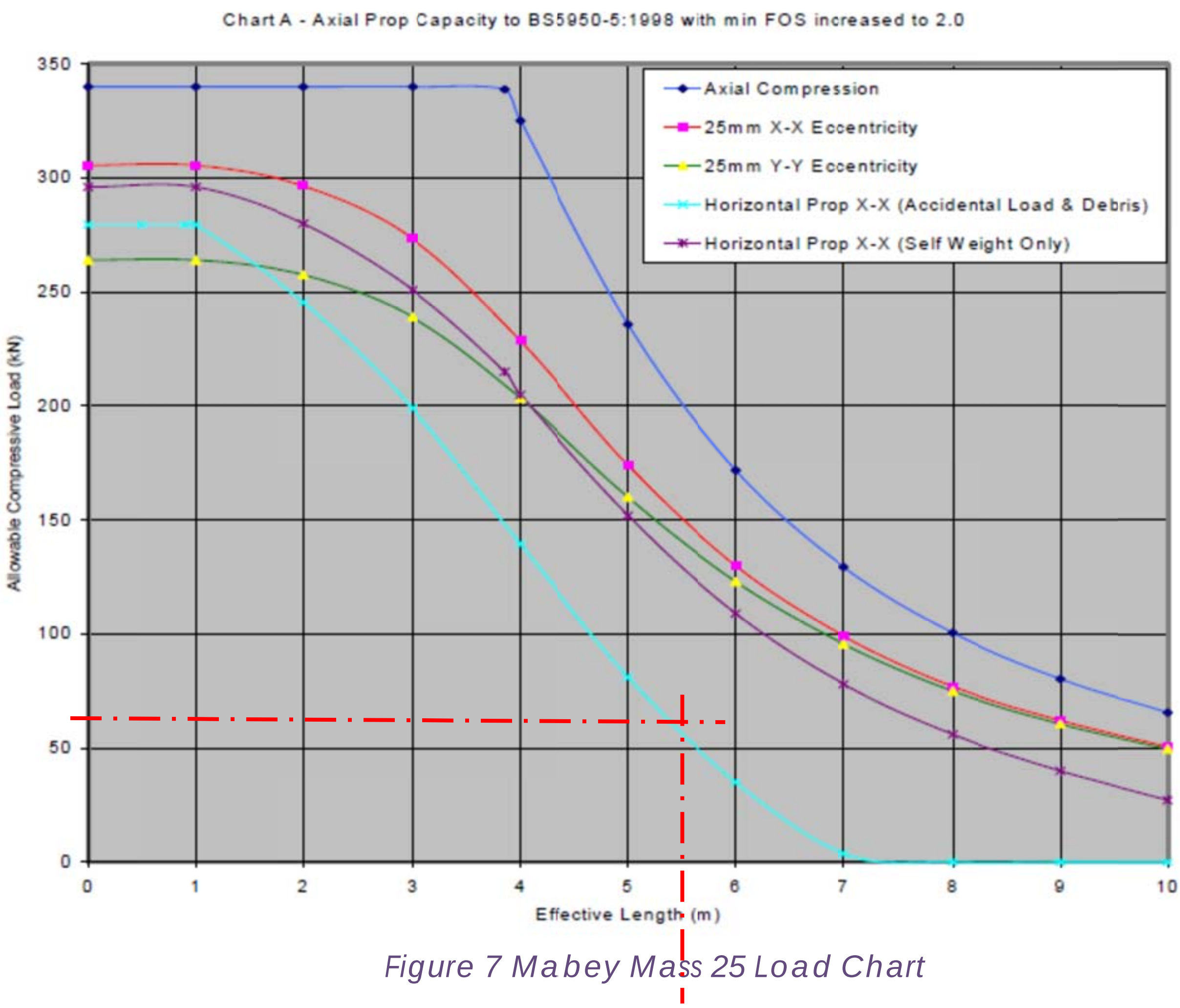


Figure 7 Mabey Mass 25 Load Chart

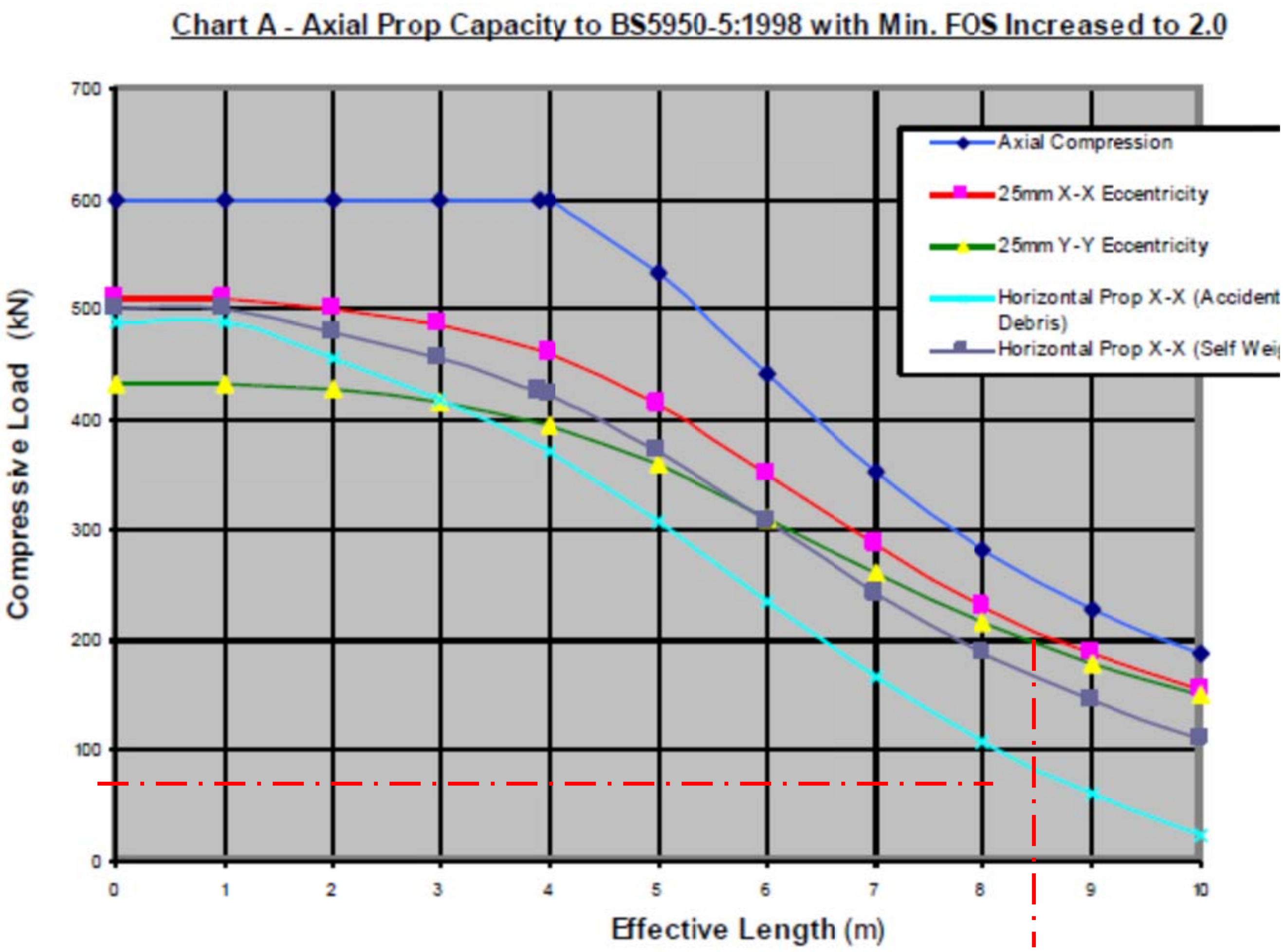


Figure 8 Mabey Mass 50 Load Chart

Provide Mabey Mass 50 at 2m Centres at 1/3 the height of the wall.

Appendix C: Monitoring Proposals

Job Number: 160317

CROFT STRUCTURAL ENGINEERS

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Structural Monitoring Statement

Property:

158 Iverson Road
West Hampstead
Camden
NW6 2HH

Client:

Ground& Water Ltd
15 Bow Street
Alton
Hampshire
GU34 1NY

Revision	Date	Comment
-	09.05.2016	First Issue
1	26.05.2016	Trigger levels altered

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Contents

CROFT STRUCTURAL ENGINEERS

1. Introduction

Basement works are intended to 158 Iverson Road. The structural works for this require 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.

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 proposed construction of a new basement underneath the existing structure at 158 Iverson Road.

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

CROFT STRUCTURAL ENGINEERS

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.

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 (giving a combined horizontal distance of 4m between two points either side of each node), there should be no more than:

Allowable movement to BS5950 for brittle finishes

<u>Vertical</u> = Span / 360 = 4000mm / 360 = 11.1mm

Croft proposes a tighter recommendation of <u>2mm</u>

Above Monitoring Level 3, lateral movement is required to be measured. Based on studs placed 1m above ground level (which will be 4500mm above the formation level), the figures should be

<u>Horizontal</u> = Height / 500 = 4500mm / 500 = 9mm

Croft proposes a tighter recommendation of <u>2mm</u>

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

MOVEMENT		CATEGORY	ACTION
Vertical	Horizontal		
0-2mm	0-2mm	Green	No action required
2-5mm	2-5mm	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
5-8mm	5-8mm		Implement remedial measures review method of working and ground conditions
>8mm	>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.

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	**Pre-construction** Monitored once. **During construction** 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. **Post construction works** 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 δρ/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.

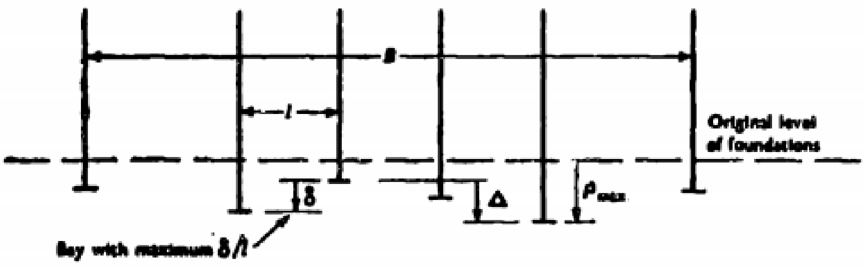

Figure 2.1 – Diagram illustrating the definitions of maximum angular distortion, δ/l, maximum settlement, ρ_{max}, and greatest differential settlement, Δ, for a building with no tilt (Skempton and MacDonald, 1956).

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.

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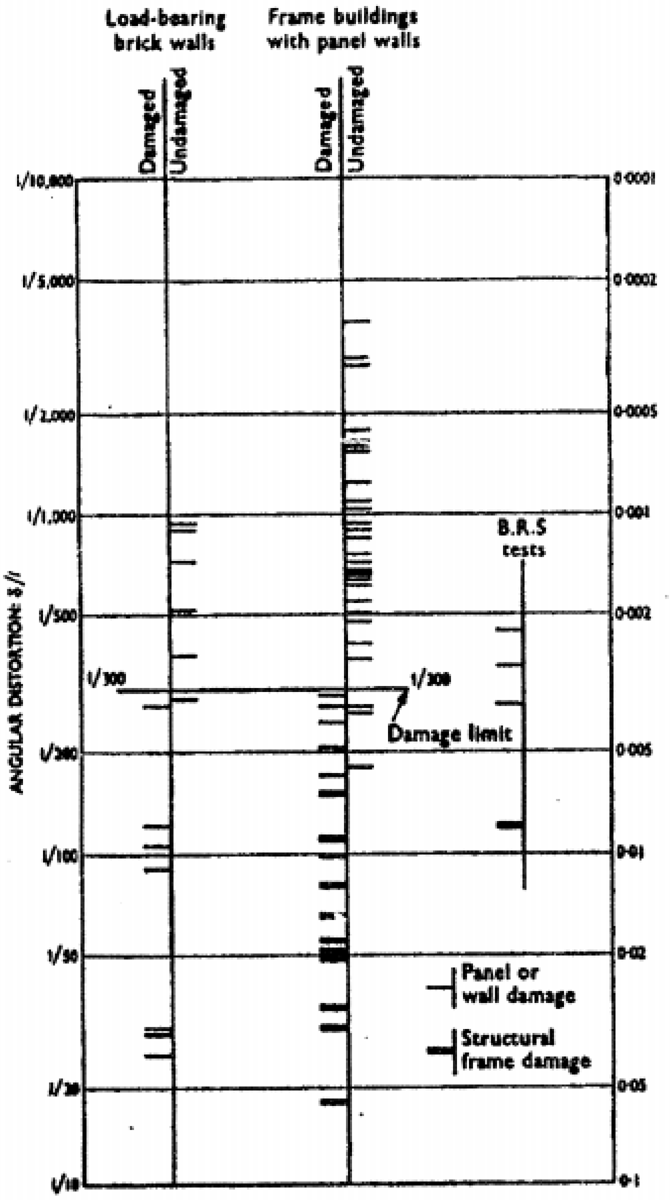
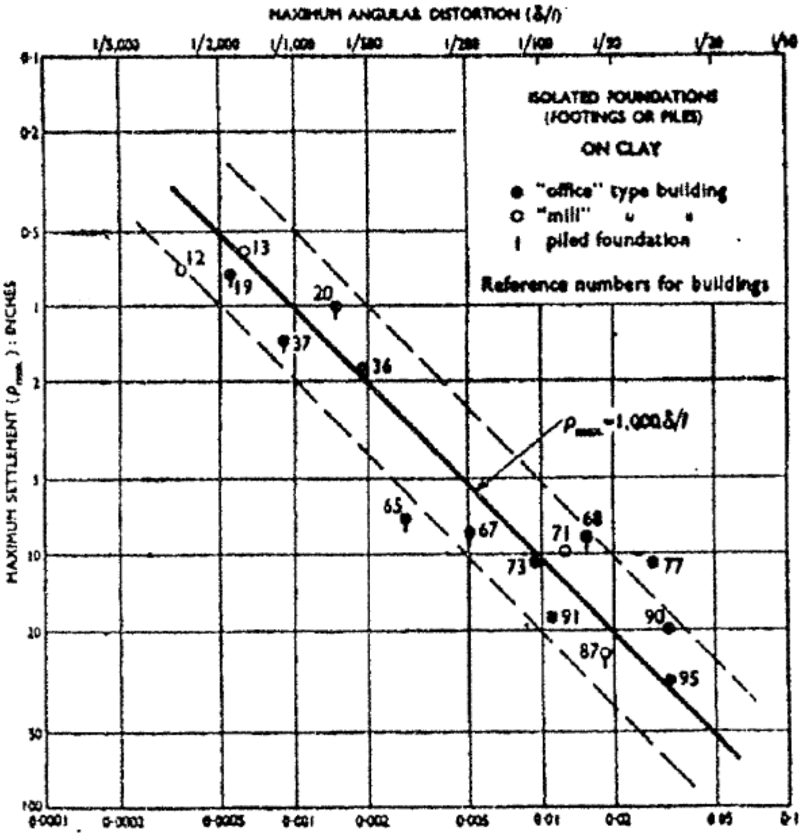
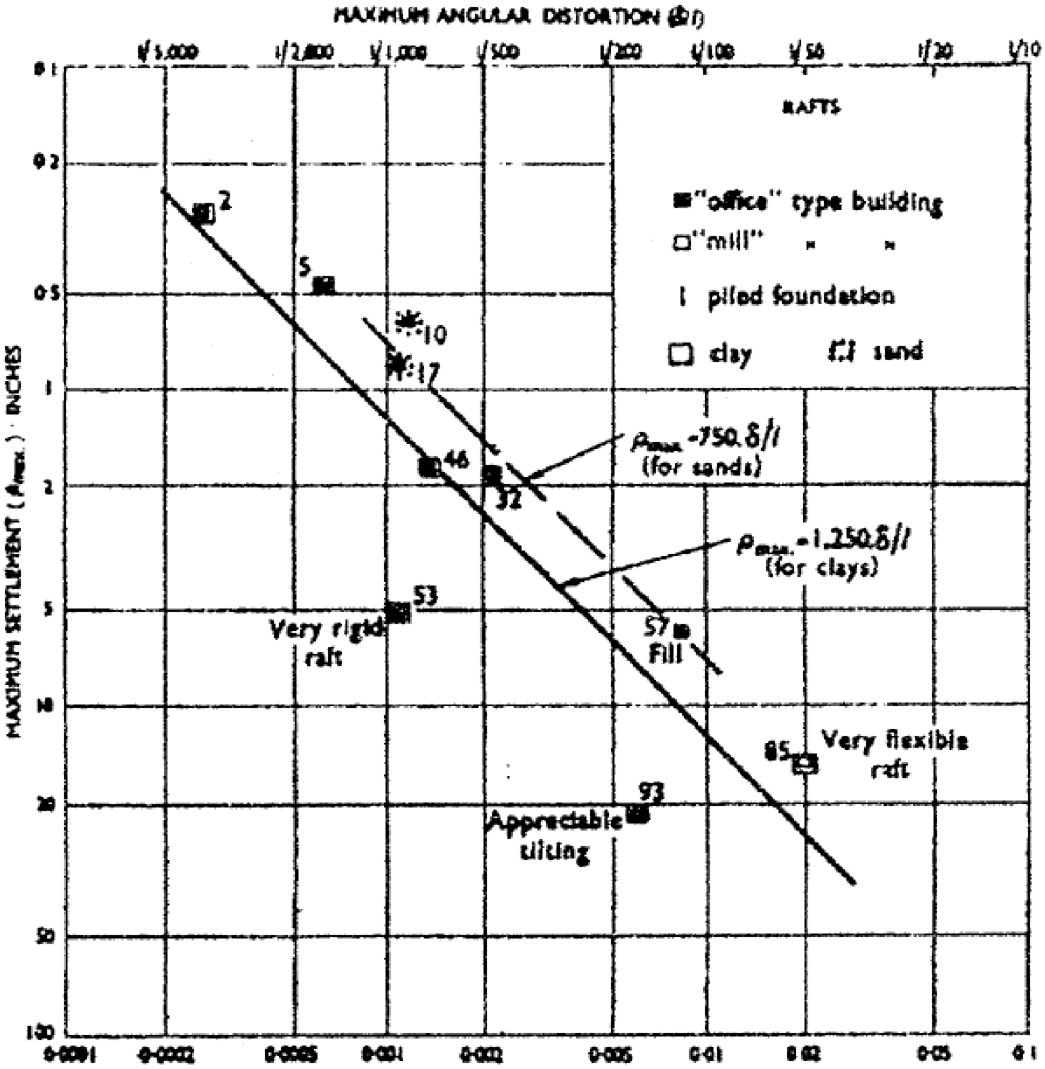


Figure 2: Skempton and MacDonald's analysis of field evidence of damage on traditional frame buildings and loadbearing brick walls

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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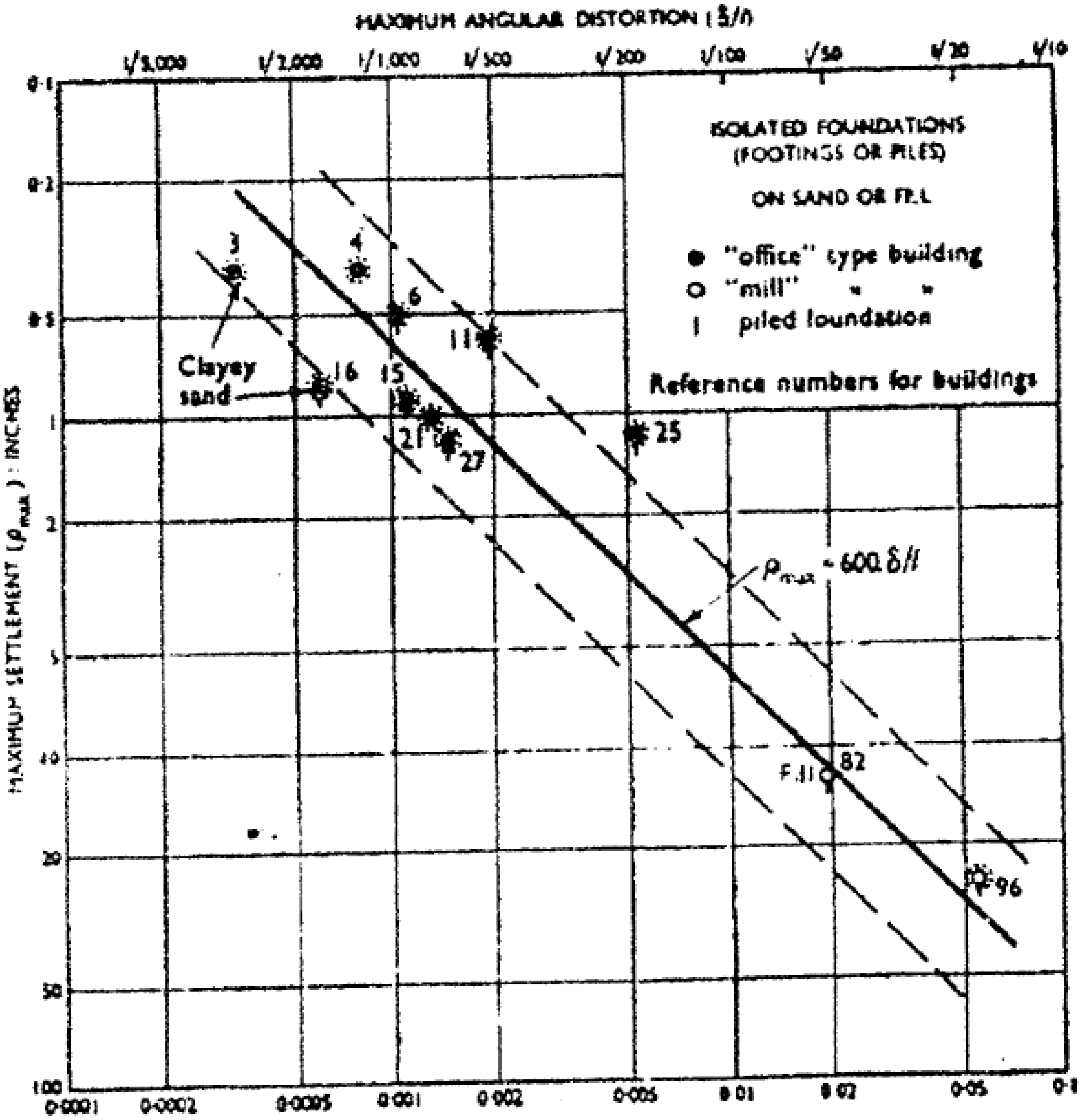


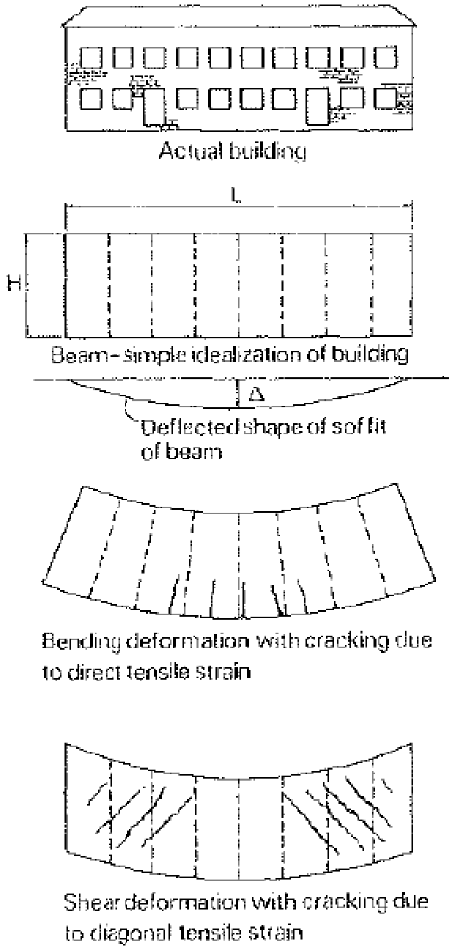
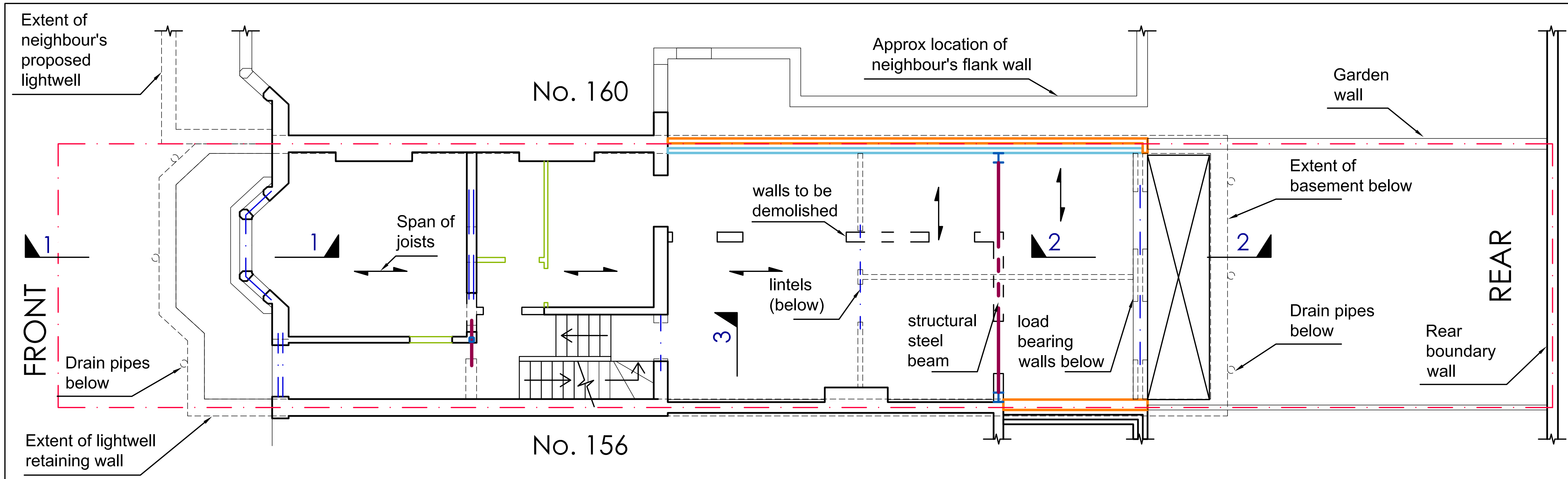


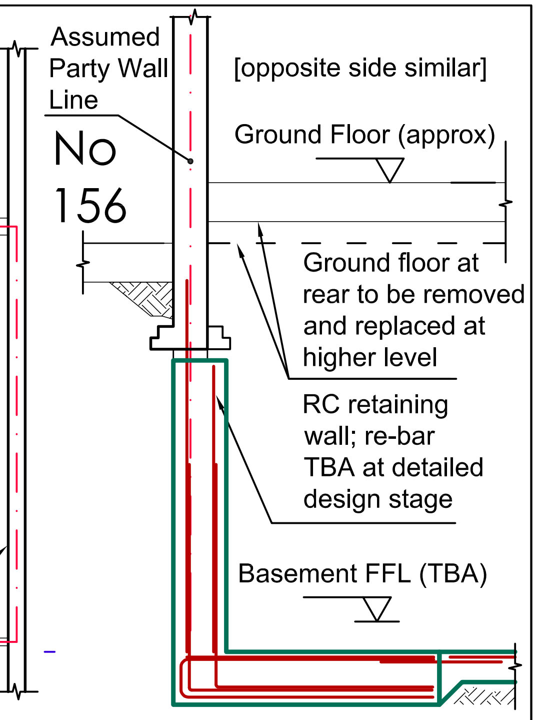
TABLE I

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.

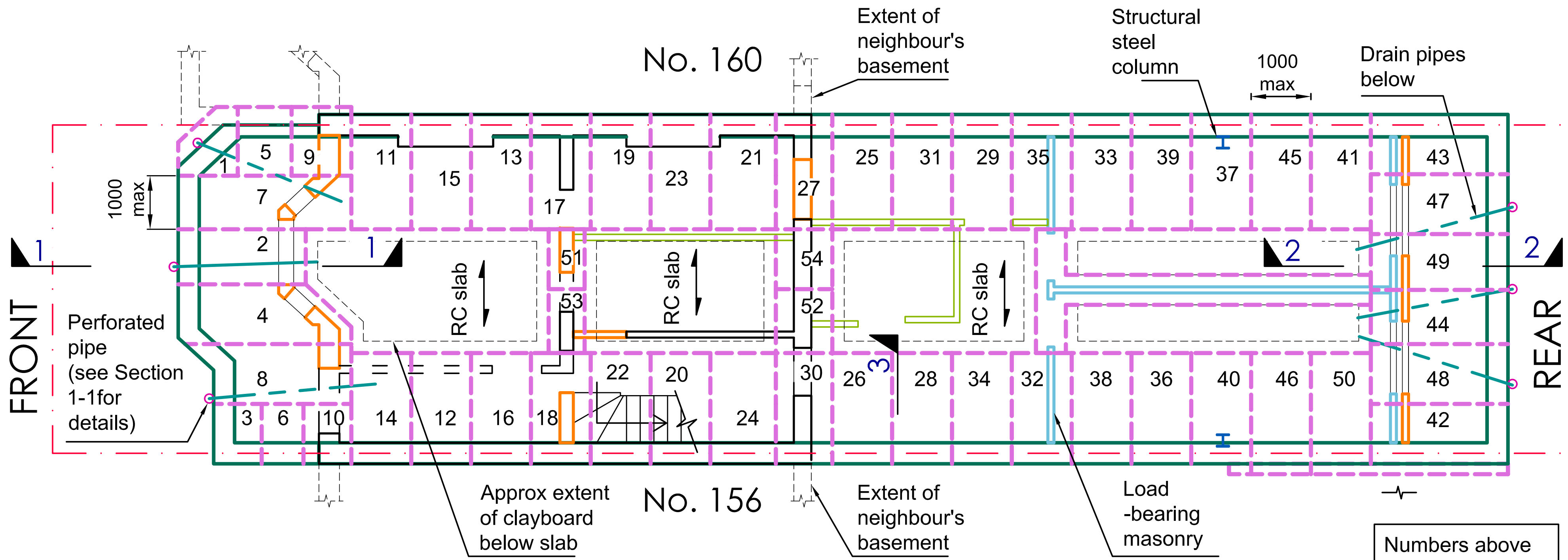
Appendix D: Structural Drawings



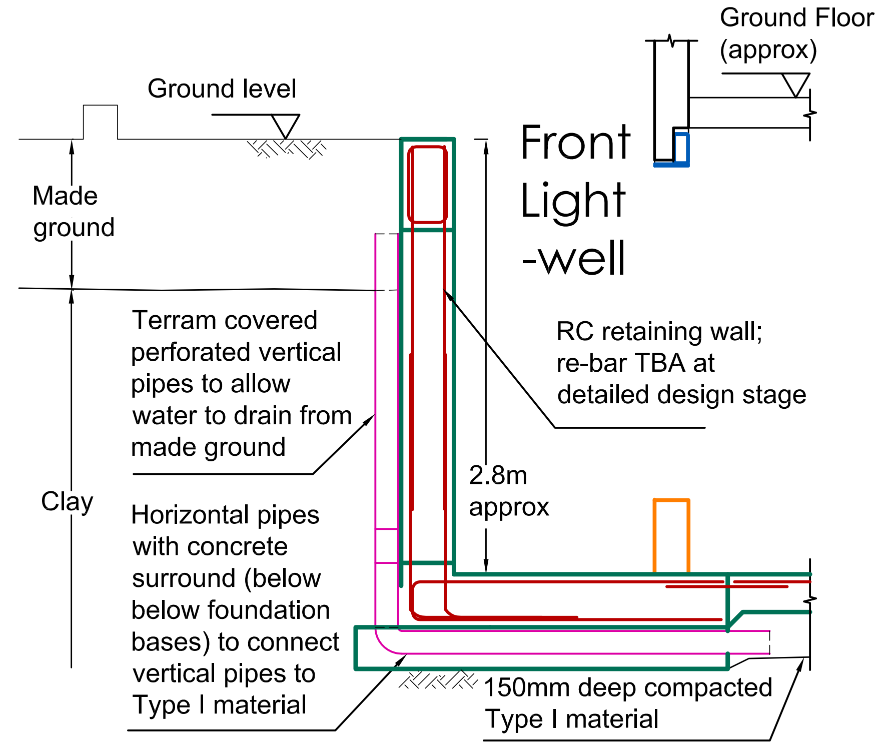
Ground Floor Plan (1:100)



Section 3-3 (1:50)



Basement Plan (1:100)



Section 1-1 (Sect'n 2-2 similar) (1:50)

Numbers above denote proposed pin construction sequence

- PLANING ISSUE -
NOT FOR CONSTRUCTION

Rev	Date	Amendments
1	27.05.2016	Section 3-3 added
-	06.05.2016	First issue for comment

Job No. 160317	Client: Ground & Water Ltd
Dwg No. SL-10	Project: 158 Iverson Rd, Camden
Date May 2016 / Rev 1	Title: Basement Structural Scheme Design
Drawn GW / Chk'd NM	
Scale As shown @ A3	

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