Job Number: 161206

CROFT STRUCTURAL ENGINEERS

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Basement Impact Assessment

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Summary, Surface Water BIA and Design and Construction Proposals

Property

26 West Hill Park
Camden
N6 6ND

Client

Mrs Konopleva
c/o
Nadia Gobova

Structural design reviewed by	Surface-water BIA reviewed by
Chris Tomlin MEng CEng MIStructE	Phil Henry BEng MEng MICE

Land Stability and Groundwater BIA [separate report] reviewed by
Dr Martin Preene CEng FICE CGeol

Revision	Date	Comment
-	06.06.2017	First Issue

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Executive (non-technical) Summary

	The London Borough of Camden requires a BIA (Basement Impact Assessment) to be prepared for developments that include basements and lightwells. This document forms the main part of the BIA and gives details on the impact of surface water flow. The scheme design for the proposed subterranean structure is also included. This document should be used in conjunction with the Land Stability BIA and the Groundwater BIA (dated May 2017, Ref. BIA/8417). This is a separate report and is 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, CPG3, DP23, DP26, DP25 and DP27. Technical information from 'Camden geological, hydrogeological and hydrological study - Guidance for subterranean development', Issue 01, November 2010 (GSD, hereafter) was also used and is referred to in this assessment.
Existing Property	The site comprises a three storey detached residential property. There is a garden at the rear. There is also a partially landscaped area and a garage to the front of the main building. The land within the site boundary is sloped. Due to the sloped nature of the site, the lowest floor is at street level at the front and extends below garden level at the rear.
Proposed Development	The proposed development involves extending the lower ground floor to the front and rear. The rear extension will include a swimming pool. Most of this extension will be below the level of the rear garden. The front extension will be below a paved area beyond the front entrance of the building. There will also be alterations to the structure above ground level.
Stage 1 – Screening	The BIA identified the following issues that should be carried forward to the Scoping stage:

	Subterranean flow (ground water) • Claygate Member is expected to be the highest natural strata below the surface. This is classified as a secondary aquifer; however, this has a low level of permeability. • The basement is anticipated to extend below the water table • The site is within the catchment area of the pond chains on Hampstead Heath. • There will be change in the proportion of hard-surfaced external areas. Slope Stability • The site includes slopes greater than 7 degrees. • Consequently, the changes in levels with the neighbouring properties would form equivalent slopes greater than degrees. • Trees are likely to be felled as part of the proposed development. • Moderate shrink-swell subsidence (due to the clays) is suspected in the area. • The site is located in a 'Secondary A' comprising the Claygate Member. • The site is within 5m of a pedestrian right of way Further details of the above are contained within the BIA by Chelmer. Surface Flow and Flooding • The site is within the catchment area of the pond chains on Hampstead Heath. • There may be a change in hardstanding which will affect the drainage of surface water. This will depend on the choice of covering to the rear basement.
Stage 2 – Scoping	The Scoping stage identifies in more detail the potential impacts of the basement and sets the parameters required for further study. Part of this was incorporated into the Screening stage. Areas of further study were identified, and subsequently examined by means of a desk study (refer to Section 1 of this document and also Section 3 of the BIA by Chelmer). This studied the physical setting of the site and the surrounding area. The most notable items are listed below. Subterranean flow (ground water) • Further study shows the presence of Claygate Member (an unproductive strata) below the site. • There are no groundwater abstraction licences or source protection zones within the site • There are no areas susceptible to ground water flooding within the site Slope Stability • Figure 17 of the GSD shows that there is a correlation with the

	presence of Claygate Member and landslide potential. However, there are no records of landslip within 500mm of the site and the hazard rating for the site is very low.
Stage 3 – Site Investigation and Study	The desk study was complemented by a site investigation. This included site visits by both Croft and Chelmer and also ground investigation works by Chelmer. The ground investigation is available as a separate report [Ref GENV/8522, dated May 2017] and is appended to the BIA produced by Chelmer. The most relevant site features identified during the site study are: <u>Subterranean flow (ground water)</u> • Claygate Member is present at the proposed formation level of the basement • Absolute ground water levels vary with the surface level of the site. Relative groundwater level readings include 3.4m bgl (below ground level) at the rear of the site and 1.72m bgl at the front of the site. • The formation level of the basement is likely to be below the ground water level. <u>Slope Stability</u> • Direct visual inspections confirmed the sloped ground within and surrounding the site. • The formation level of the basement will be within the Claygate Member. The BIA by Chelmer also includes a conceptual site model which was carried forward for the impact assessment. <u>Drainage & Surface Water Flow</u> No items of concern needed further study at this stage.
Stage 4 – Impact Assessment	<u>Land Stability</u> The BIA concluded that the basement will not make the area unstable. Chelmer completed a GMA [Ground Movement Analysis] for the proposed development. This included ground movements of properties nearby that have the potential to be affected by the development. This was followed through with a Damage Category Assessment of the areas considered to be affected the most. This concluded that the maximum damage category to any part of the neighbouring buildings is 0 (Negligible). Best practice construction methods will mitigate any potential damage. <u>Subterranean flow (ground water)</u> The BIA has concluded that the permanent basement structure is not anticipated to have any impact on the groundwater flow which would

	adversely affect the neighbouring properties. Monitoring and measures to control groundwater during construction are recommended. Drainage & Surface Water Flow No items of concern needed further study at this stage.

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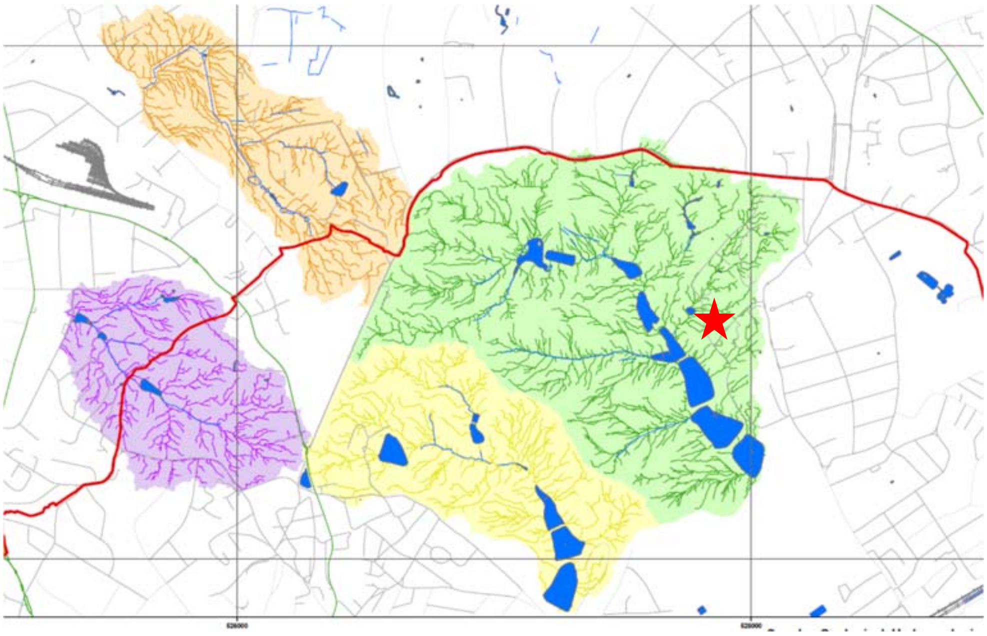
1. Screening Stage

	This stage identifies any areas for concern that should be investigated further.
Land Stability	Refer to the report on Land Stability [Appendix A of Chelmer report Ref BIA/8417, dated May 2017]
Subterranean Flow	Refer to the report on Groundwater [Appendix A of Chelmer report Ref BIA/8417, dated May 2017].
Surface Flow and Flooding	The questions below (taken from the Camden CPG 4 – Basements and Lightwells) and the responses by Croft form a standardised and structured approach to the Screening process.
	Question 1: Is the site within the catchment of the pond chains on Hampstead Heath? **Yes**. The site is within the Highgate chain catchment. The catchment is indicated by the area shaded in green on Figure 14 of the GSD. An extract of this is reproduced below.  *Figure 1: Extract from Figure 14 of the GSD (with approx. location of site indicated by the red star)*

	Question 2. As part of the proposed site drainage, will surface water flows (e.g. volume of rainfall and peak run-off) be materially changed from the existing route? **No** – The surface water that flows from the proposed development will be routed the same way as before: water collected hard surfaced areas will enter the existing drainage system; water on soft-landscaped areas will discharge to the ground.
	Question 3. Will the proposed basement development result in a change to the hard surfaced /paved external areas? **Unknown** – The Groundwater BIA by Chelmer [Ref BIA/8417] identifies a change in the hard-surfaced areas. Hard surfaces will be present above the smaller front basement, occupying areas already covered by paved areas. The rear basement will extend the Lower Ground floor area further into the rear garden. This may reduce the impermeable areas. Depending on the covering to the roof of this basement, it is possible that the hard surfaced areas may not change. Further study is required.
	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**. Granular backfill material will be provided behind the basement retaining walls. This will allow water to be transmitted around the basement structure. The inflows of water received by adjacent properties and downstream water courses will not be affected.
	Question 5. Will the proposed basement result in changes to the quality of surface water being received by adjacent properties or downstream watercourses? **No**. Water from the site that will discharge into the ground will be from the garden, 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?

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	No. The site does not lie in an area identified by EA floodplain maps as having a high risk of surface water flooding. Furthermore, the site is not on a street that was recorded as flooded in either 1975 or 2002
	Summary In this section, a positive and an ‘unknown’ answer are given to Questions 1 and 6 respectively. The assessment, with regards to Surface Water Flow, should therefore be carried forward to Scoping Stage for further studying of the potential impacts.

2. Scoping Stage

	This stage identifies the potential impacts of the areas of concern highlighted in the Screening phase.
Land Stability	Refer to Sections 3 and 4 of Land Stability & Groundwater BIA by Chelmer [Ref BIA/8417, dated May 2017]
Subterranean Flow	Refer to Sections 3 and 4 of Land Stability & Groundwater BIA by Chelmer [Ref BIA/8417, dated May 2017]
Surface Flow & Flooding	**Conceptual Model** A conceptual model of the ground is described in detail in Section 4 of the Land Stability & Groundwater BIA by Chelmer. This is complemented by the following: • Conventional drainage is likely to be present, which collects water from hard surfaces and directs it to the sewer system. • Rainwater on soft-landscaped areas surrounding the building discharges to the ground • Ground water levels are likely to vary with the sloped profile of the ground surface. • Groundwater levels are likely to be influenced by water discharging directly into the ground, within the site. The basement will be designed to allow for seepage. Terram-lined dimpled membranes or permeable backfill material can be placed behind the retaining walls. This will maintain hydraulic connectivity around the structure. The conveyance of groundwater in the catchment area of the Highgate Ponds will therefore not be affected. The front basement will be below an area that is currently hard-surfaced. There are no issues relating to surface water drainage in this area that need further studying. Initial inspection of the rear basement area identified the possibility of a changes in hard surfaced areas. Closer inspection of the Architect's drawings show that permeable ground is proposed above the roof of the rear basement. This will allow water to discharge into the ground as before. The development will therefore not affect surface flow. <u>Further site investigation and subsequent assessment is not required for surface flow and flooding.</u>

Ground Investigation

Ground Investigation Brief	A ground investigation is required. Croft considers that this should cover: • Two trial pits to confirm the extent of the existing foundations. • Two boreholes to a depth of 10m below ground level (i.e. more than twice the depth of the proposed basement). • Stand pipes to be inserted to monitor ground water; record initial strike and return for repeat readings. • Site testing to determine in-situ soil parameters. Pilcon Vane testing to be undertaken. • Laboratory testing to confirm soil make up and properties. • Report on soil conditions. • Calculation of bearing pressures • Indication of Ø (angle of friction) • Indication of soil type

3. Site Investigation and Desk Study

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

A aerial view of the property and the surrounding area is shown below

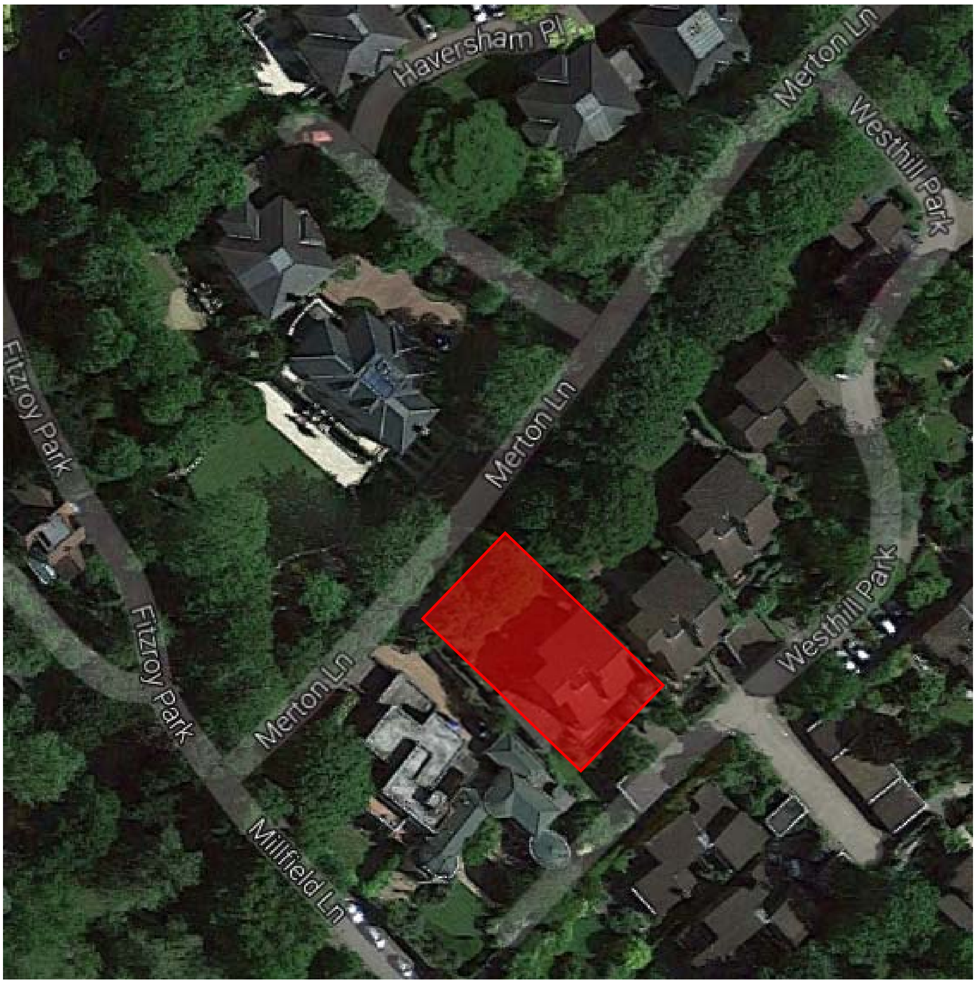

Figure 2: Aerial view with approx. site area indicated

Walkover Survey

A structural engineer from Croft visited the site on 22 December 2016.

The site comprises a three storey detached residential property with a front and a rear garden. The building is known to have been constructed in the latter half of the 20th century, from masonry and reinforced concrete. The main entrance is at ground floor level, above street level. The land within the site boundary is sloped. Due to this, the lowest floor (the lower ground floor) is at street level at the front and extends below the garden level at the rear.

The rear garden is terraced down from the north-east boundary to south-west boundary. Soft-landscaping occupies most of the rear garden and mature trees are present.

Figure 3: Partial view of rear garden looking towards Merton Lane

There is a detached garage and an adjoining driveway to the front of the main building, which joins directly onto West Hill Park. Most of the front yard is paved with areas of planting. The area behind the garage is occupied by soft landscaping.

Figure 4: View of front yard of property showing stairs up to main entrance at ground floor level

Merton Lane is to the north-west of the property and forms the rear boundary of the site. This road slopes downward from north-east to south-

	west. 25 West Hill Park is the neighbouring property to the north-east. Properties 23 and 25 Merton Lane are to the south-west of the site and are separated from 26 West Hill Park by a garden wall. This wall acts as a retaining wall due to the raised ground within the site boundary. This wall returns along the border with the public highway (Merton Lane).  *Figure 5: View of boundary wall with No 25 Merton Lane and neighbouring driveway.* No significant structural faults were noted; however, minor cracks in the boundary wall were noted by Chelmer in February 2017. The main building appeared to be in good condition. The land surrounding slopes downward from north-east to southwest. No significant watercourses or bodies of water were noted in the immediate vicinity.
Proposed Development	The proposed development involves extending the lower ground floor to the front and rear. The rear extension will include a swimming pool. Most of this extension will be below the level of the rear garden. The front extension will be below a paved area beyond the front entrance of the building. There will also be above-ground alterations. Plans showing the extent of the structural alterations from lower ground to ground floor level are presented in Appendix D. Architectural drawings that show the extent of the proposed alterations have been produced by London Development & Construction and are available separately. An aerial view of the area is shown below. This site is indicated. In addition to the basement area, this also includes areas that are likely to be temporarily occupied for construction purposes.

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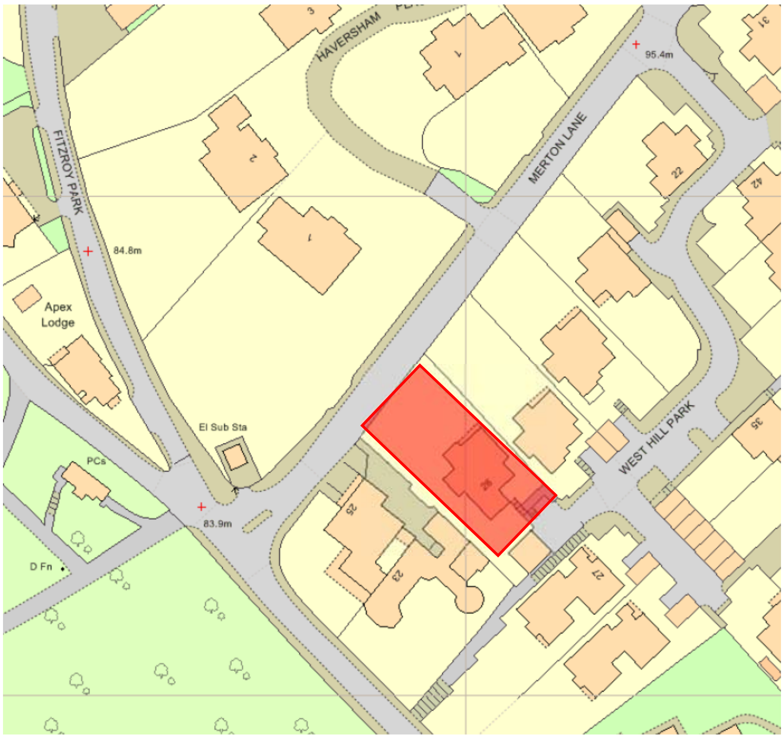
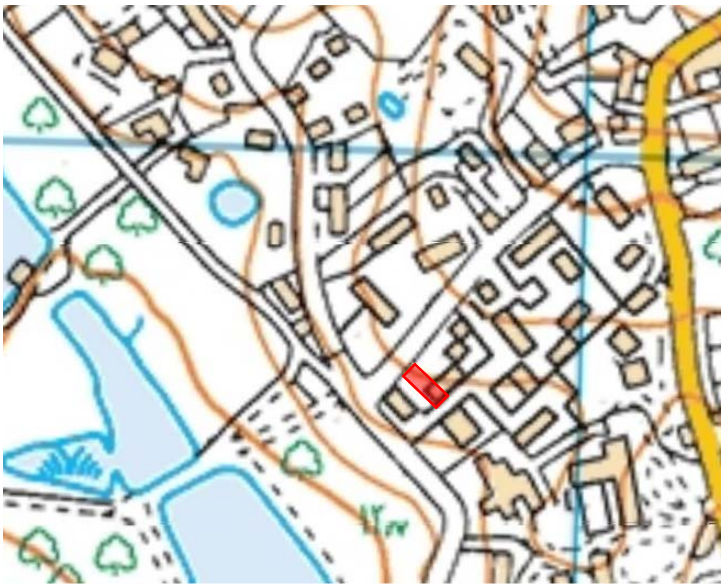
	 *Figure 6: Plan view of local area with approx. site boundary indicated* A proposed outline construction sequence is appended to this report.
Local topography & external features not noted from walk-over survey	Inspection of OS maps show that there are no water courses, ponds, water courses or similar open water features within 50m of the site. The Highgate ponds are over 100m away  *Figure 7: Extract from OS map, with location of site indicated.*

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 8: Extract showing listed buildings* The site is in the Highgate Village Conservation Area.
Geology & Ground Conditions	Site is underlain with made ground. Clay is present below this. More details are presented in the Ground Investigation report and the Hydrogeological and Land Stability assessment.
Highways & public footpaths	The site is within 5m of a public highway.
London Underground and Network Rail	The site is more than 100m away from the nearest national rail line and the nearest subterranean train line. No train lines are likely to be affected by the development. These are unlikely to be affected by the new basement.
UK Power Networks	There is an electrical substation to the south-west of the site. This is over 25m away and is on ground that is at a lower level than the proposed basements.
Underground water services	Record drawings of the drainage network show drain runs in the area of the proposed basement at the front. An extract is shown below.

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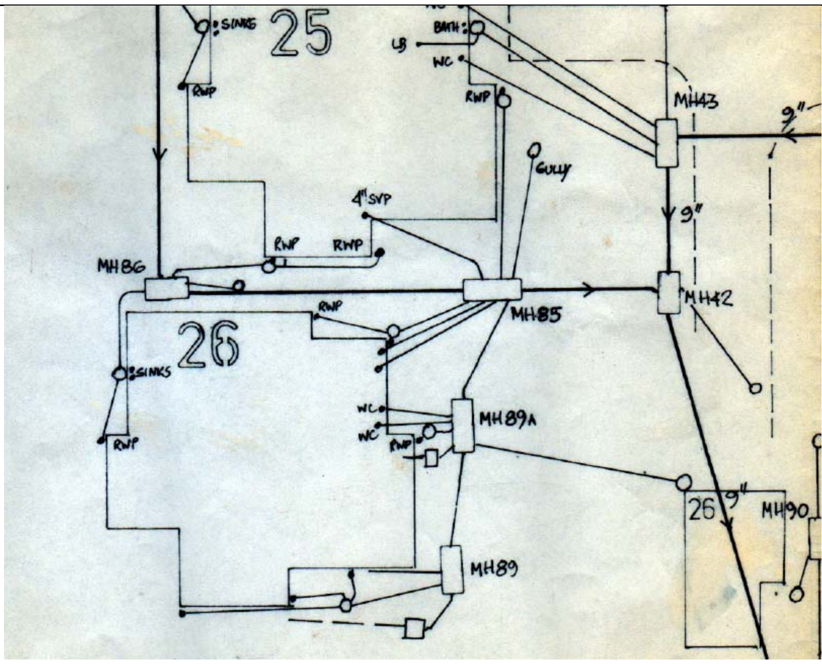

Figure 9: Record drawing of drainage

After planning permission is granted, and before construction, the contractor should carry out a survey to determine the locations of the drains and other services below ground level. At detailed design stage, the drain runs will have to be re-located and the design of these should be suitably co-ordinated with the design of the basement structure.

Proximity of Trees

Mature trees are present within the site boundary. This includes a mature oak, about 4.6m away from the basement proposed at the rear. This has been surveyed and is described in detail in a report by a chartered arboriculturalist. This is a separate report (Ref TH 1408, dated April 2017).

Adjacent Properties

The external facades of the neighbouring properties were inspected.

The location of the neighbouring properties in relation to the new basements are shown below:

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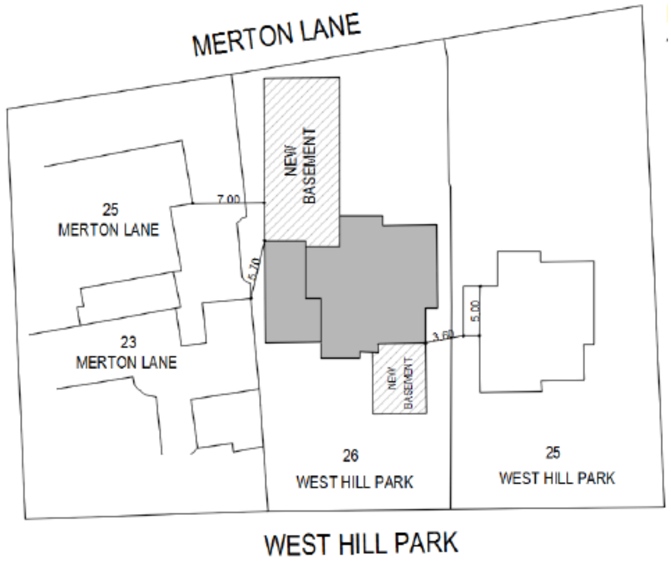

Descriptions of the properties below are given in an anti-clockwise order starting from the neighbouring land to the north-east. Handed descriptions in relation to the location of the subject property are given as if facing the front of the property from West Hill Park.

25 West Hill Park – Property to Right	25 West Hill Park is a detached house, of a similar age and construction to No 26. From observing the external façade of the building, there were no visible signs of movement. A search on Camden Council's website has shown that no basements have been proposed since the original construction. There is a garden to the rear, slightly larger than the garden to No 26. The rear basement is unlikely to have any significant impact on the building. The proposed front basement is significantly closer and this should be accounted for in a ground movement assessment (GMA).
No. 25 Merton Lane– Property to Left	25 Merton Lane is a detached house, of a similar age and construction to 26 West Hill Park. No signs of movement were noted to the main building from the outside. A search on Camden Council's website has shown that no basements have been proposed since the original construction. The driveway to this property is adjacent to the rear garden of 26 West Hill Park. The driveway is separated from the garden by a retaining wall. The construction of the rear basement will reduce the difference in ground level between the two properties in this area. The front basement is unlikely to have any significant impact on the building. The proposed rear basement is significantly closer and this should be accounted for in a ground movement assessment (GMA).

No. 23 Merton Lane– Property to Left	23 Merton Lane is a detached house, of a similar age and construction to 26 West Hill Park. No signs of movement were noted to the main building from the outside. A search on Camden Council's website has shown that no basements have been proposed since the original construction. Neither of the proposed basements are likely to have any significant impact on the building. This will be confirmed in the GMA.
	Monitoring, Reporting and Investigation The ground investigation report, which has data from initial site investigations and data from subsequent monitoring, is available as a separate report [Ref GENV/8522, dated May 2017].

4. Basement Impact Assessment

Impacts relating to Land Stability and Groundwater are described within the BIA produced by Chelmer. Proposed measures to mitigate these, which should be developed further at detailed design stage, are presented in this section.

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).

The ground movement assessment (GMA) is contained within the Land Stability BIA [Chelmer report Ref BIA/8417, dated May 2017].

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Mitigation Measures: Limiting Ground Movement

The BIA by Chelmer emphasised the requirement for best practice construction methods to limit any ground movements and associated damage to the neighbouring properties.

The design and construction methodology described in this report aims to limit damage to acceptable levels. For this development, suitable temporary propping during the construction phase will limit the amount of movement due to the basement works. This is described in the Basement Method Statement (appended). The procedures described in this 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.
- Where practicable (ie, for the front basement), provide additional temporary support at the head of the retaining walls. This will give a

	‘high stiffness’ propping model, as identified under CIRIA C580; this will limit the movements even further than those predicted in the GMA by Chelmer, which assumed a worst case ‘low support stiffness’.

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Monitoring of Structures

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

Risk Assessment

Monitoring Level proposed	Type of Works.
Monitoring 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).

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Basement Design & Construction Impacts and Initial Design Considerations

Design Concept	The foundation of the rear basements will consist of reinforced concrete cantilevered retaining walls. These will be designed to resist the lateral loads around the perimeter of the basement. Retaining walls will also be present within the perimeter of the rear basement. These will form the internal edges of a swimming pool. The basement floor structure will comprise reinforced concrete slabs spanning between the retaining wall structures. There will also be internal foundation strips to support these. The front basement will comprise reinforced a reinforced concrete retaining wall along the north-east edge (the side closest to 25 West Hill Park). The internal walls will be part of the existing building. These are already present. The retaining wall will be propped at the head by a reinforced ceiling slab. The lateral load applied to the walls will be transferred along the basement slab (and also by the ceiling slab) and will be resisted by the existing structure. For both basements, the RC walls will also transfer vertical loads to the ground. The investigations highlight that water is present. The walls will be designed to resist the hydrostatic pressure. Design of retaining walls should account for the anticipated worst case scenario for ground water levels. 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 1m from the top of the wall. This will be applied to the front basement which is likely to be in proximity of the incoming water mains. The retaining wall for the rear basement is not considered likely to encounter this scenario. 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. The central slab of the basement should be designed to resist local uplift. The stability of the walls should be designed using K_a & K_p values. The Land Stability and Groundwater BIA predicts heave below the basement. This will be less than 10mm and can be accommodated by installing compressible material or a void former (Clayboard or similar) between the basement slab and the ground. Trees roots are known to cause volumetric changes in cohesive soils. This has

	the potential to affect building foundations. The basement will be founded at a level which will be outside the zone of influence of any trees. Drawing showing the structural scheme design are appended. Similar drawings are also appended to the BIA produced by Chelmer. (The drawings appended to Chelmer's BIA are superseded by the drawings appended to this document but the dimensions and the extent of the proposals shown in them are still valid of the information contained in Chelmer's report.)

Additional loading requirements	The lateral earth pressure exerts a horizontal force on the retaining walls. The retaining walls will be checked for resistance to the overturning force this produces. Lateral forces will be applied from: • Soil loads • Hydrostatic pressures • Surcharge loading from behind the retaining walls <u>Surcharge Loading</u> The following will be applied as surcharge loads to the retaining walls: • Garden surcharge 2.5kN/m^2 + 1m of soil (present above basement ceiling) 20kN/m^2 As noted previously, the both basements are within 5m of a highway or a pedestrian right of way. The road level near the rear basement is lower than the basement level; the driveway at the front of the property is at the same level as the floor of the basement proposed at the front. Surcharge loading from vehicles are therefore not applicable to either. <u>Adjacent Properties</u> A line at 45º from the foundation of the neighbours' wall flank wall would not intersect the basement retaining wall. Dispersed loading from neighbouring foundations of the main building will therefore not be applicable. The nearest structure that is likely to apply any dispersed loads is the garden wall at the front which separates the two properties (refer to Section C-C in appended drawing SD-11). This should be accounted for at the detailed design stage. The appended calculations show the design of the most heavily loaded retaining walls. The most critical parameters have been used for this.
Mitigation Measures - Internal Flooding	To mitigate the risks associated with utility failure, Croft would recommend the following measures to reduce damage associated with flooding: • A pumping system 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. • The pumping system should be a dual mechanism to maintain operation in the event of a failure. This should include a battery backup and a suitable alarm system for warning purposes.

	• Install all electrical wiring at high level
Mitigation Measures - Drainage and Damp-proofing	The design of drainage and damp-proofing is not within the scope of this assessment and would not normally be expected to be part of the structural engineer's remit at detailed design stage. A common and anticipated detailed design stage approach is to use internal membranes (Delta or similar). These will be integral to the waterproofing of the basement. Any water from this will enter a drainage channel below the slab. This will be pumped and discharged into the exiting sewer system. 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
SUDS Considerations	As described previously, the basement will not have any noteworthy impacts on surface flow. Section 11 of CPG3 draws attention to the SUDS hierarchy of drainage solutions, which promotes the use of infiltration techniques above others. There is plentiful soft landscaping in the rear garden which allow and will continue to allow rainwater to discharge into the ground. This mechanism will be maintained above the rear basement by means of a layer of soil above the ceiling structure. As described in Section 2, either permeable backfill of dimpled membranes can be placed behind the retaining walls. This will ease the conveyance of ground water around the basement.

	The external ground, which is in the location of the roof of the basement proposed at the front, includes hard surfaces. There is little allowance for water to infiltrate into the ground at present. The inclusion of the new basement at the front is therefore not likely to make the area less permeable. However, when reinstating the ground-level paving above the new basement, the design team may consider the use of permeable paving, which would allow rainwater to infiltrate into the ground.
Temporary Works	Temporary propping details will be required. This must be provided by the contractor. Their details should be forwarded to the design stage engineer. Water levels should be monitored for at least one month prior to starting on site and throughout the construction process. Localised dewatering to pin excavations may be necessary. To demonstrate the feasibility of the works, a proposed basement construction method statement is appended. <u>Protection of trees</u> As mentioned previously, there is a mature oak in the rear garden. This is understood to have a tree preservation order. The construction of the basement should aim to limit the damage to any of the tree's roots. Further details of the necessary construction proposals are presented in the arboriculturalist's report (Ref TH 1408, dated April 2017). This should be incorporated into the contractor's construction method statement at detailed design stage. <u>Construction Management</u> The site is in a conservation area. Camden Council will require a management plan for construction, construction traffic and demolition. This has been produced under a separate cover. An outline construction programme is appended.

Appendix A: Structural Calculations

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

The design must resist:

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

The final proposed scheme must:

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

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

1. Retaining wall for rear basement

2. Uplift calculations for rear basement

The most critical retaining walls are those for the rear basement. Two separate analysis calculations are presented in this section. One for the retaining wall of the basement that does not contain the pool (closest to the main building). The other is for the retaining wall where the pool is present.

RETAINING WALL ANALYSIS REAR BASEMENT (NON-POOL AREA)

For the rear basement, the following parameters are used, as advised in the ground investigation (ref GENV.8522) and noted in the Land Stability and Hydrogeology BIA (ref BIA/ 8417):

- Firm clay at formation level
- Allowable bearing pressure no greater than 100 kN/m^2
- Water level should not be lower than 3.4m bgl

The base of the wall will be considered as propped. This will be achieved by tying the side edges of the base to the basement slabs either side (ie pool basement structure and existing lower ground floor structure).

RETAINING WALL ANALYSIS

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

Tedds calculation version 2.6.08

Retaining wall details

Stem type Cantilever

Stem height h_{stem} = **3900** mm

Stem thickness t_{stem} = **350** mm

Angle to rear face of stem α = **90** deg

Stem density γ_{stem} = **25** kN/m^3

Toe length l_{toe} = **7550** mm

Heel length l_{heel} = **750** mm

Base thickness t_{base} = **350** mm

Base density γ_{base} = **25** kN/m^3

Height of retained soil h_{ret} = **3900** mm Angle of soil surface β = **0** deg

Depth of cover d_{cover} = **0** mm

Height of water h_{water} = **1900** mm

Water density γ_w = **9.8** kN/m^3

Retained soil properties

Soil type Firm clay

Moist density γ_{mr} = **18** kN/m^3

Saturated density γ_{sr} = **18** kN/m^3

Characteristic effective shear resistance angle $\phi'_{r.k}$ = **18** deg

Characteristic wall friction angle $\delta_{r.k}$ = **9** deg

Base soil properties

Soil type Firm clay

Soil density γ_b = **18** kN/m^3

Characteristic effective shear resistance angle $\phi'_{b.k}$ = **18** deg

Characteristic wall friction angle $\delta_{b.k}$ = **9** deg

Characteristic base friction angle $\delta_{bb.k}$ = **12** deg

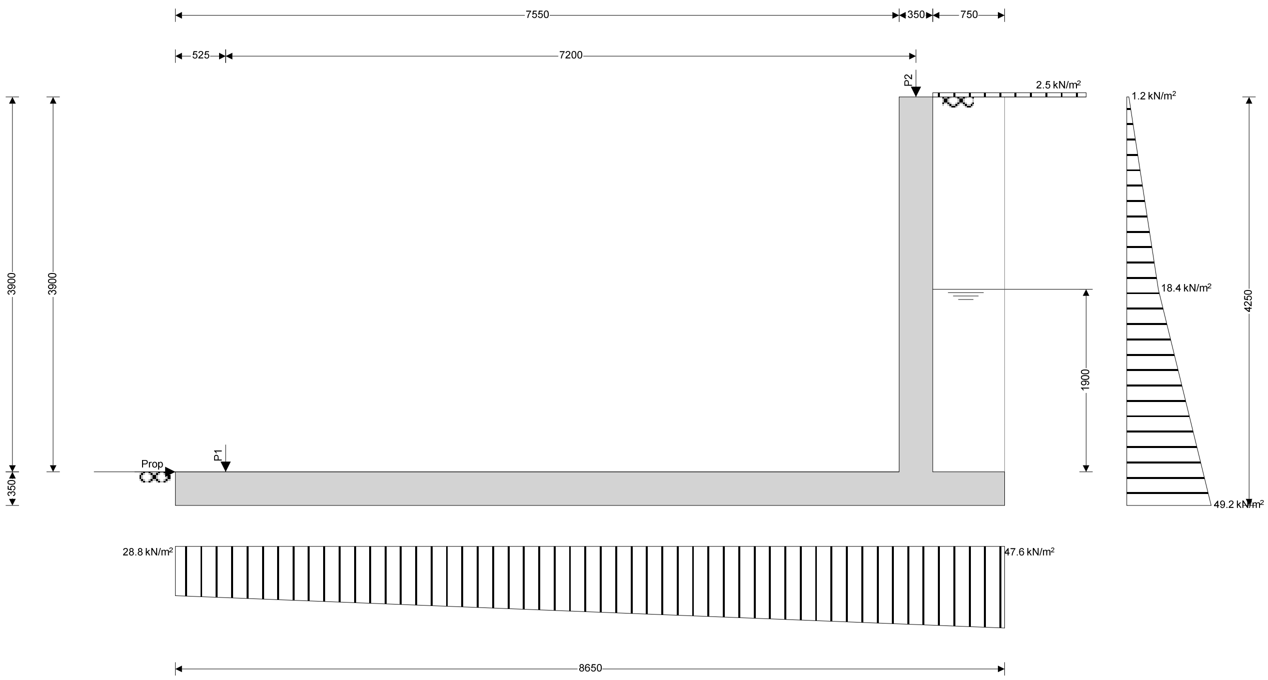
Presumed bearing capacity $P_{bearing}$ = **100** kN/m^2

Loading details

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

Vertical line load at 525 mm P_{G1} = **90** kN/m

Vertical line load at 7725 mm P_{G2} = **76** kN/m



General arrangement

Calculate retaining wall geometry

Base length	l_{base} = **8650** mm		
Saturated soil height	h_{sat} = **1900** mm		
Moist soil height	h_{moist} = **2000** mm		
Length of surcharge load	l_{sur} = **750** mm		
Vertical distance	x_{sur_v} = **8275** mm		
Effective height of wall	h_{eff} = **4250** mm		
Horizontal distance	x_{sur_h} = **2125** mm		
Area of wall stem	A_{stem} = **1.365** m^2	Vertical distance	x_{stem} = **7725** mm
Area of wall base	A_{base} = **3.028** m^2	Vertical distance	x_{base} = **4325** mm
Area of saturated soil	A_{sat} = **1.425** m^2	Vertical distance	x_{sat_v} = **8275** mm
		Horizontal distance	x_{sat_h} = **750** mm
Area of water	A_{water} = **1.425** m^2	Vertical distance	x_{water_v} = **8275** mm
		Horizontal distance	x_{water_h} = **750** mm
Area of moist soil	A_{moist} = **1.5** m^2	Vertical distance	x_{moist_v} = **8275** mm
		Horizontal distance	x_{moist_h} = **1676** mm

Using Coulomb theory

Active pressure coefficient K_A = **0.483** Passive pressure coefficient K_P = **2.359**

Croft Structural Engineers Ltd Clockshop Mews Rear of 60 Saxon Rd SE25 5EH	Project 26 West Hill Park	Job Ref. 161206
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Bearing pressure check

Vertical forces on wall

Total $F_{total\_v} = F_{stem} + F_{base} + F_{sat\_v} + F_{moist\_v} + F_{water\_v} + F_{sur\_v} + F_{P\_v} =$ **330.3** kN/m

Horizontal forces on wall

Total $F_{total\_h} = F_{sat\_h} + F_{moist\_h} + F_{pass\_h} + F_{water\_h} + F_{sur\_h} =$ **93** kN/m

Moments on wall

Total $M_{total} = M_{stem} + M_{base} + M_{sat} + M_{moist} + M_{water} + M_{sur} + M_P =$ **1546.1** kNm/m

Check bearing pressure

Propping force $F_{prop\_base} =$ **93** kN/m

Bearing pressure at toe $q_{toe} =$ **28.8** kN/m^2 Bearing pressure at heel $q_{heel} =$ **47.6** kN/m^2

Factor of safety $FoS_{bp} =$ **2.101**

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

<u>RETAINING WALL DESIGN</u>

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

Tedds calculation version 2.6.08

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

Concrete strength class C30/37

Char.comp.cylinder strength $f_{ck} =$ **30** N/mm^2 Mean axial tensile strength $f_{ctm} =$ **2.9** N/mm^2

Secant modulus of elasticity $E_{cm} =$ **32837** N/mm^2 Maximum aggregate size $h_{agg} =$ **20** mm

Design comp.concrete strength $f_{cd} =$ **17.0** N/mm^2 Partial factor $\gamma_C =$ **1.50**

Reinforcement details

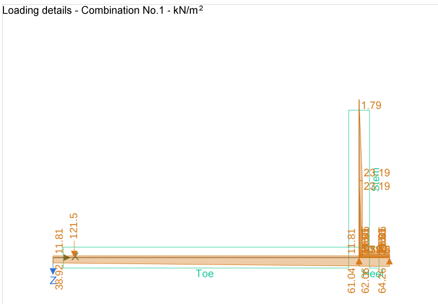
Characteristic yield strength $f_{yk} =$ **500** N/mm^2 Modulus of elasticity $E_s =$ **200000** N/mm^2

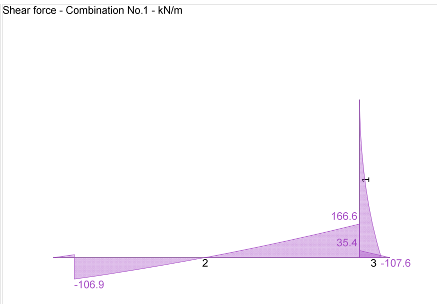
Design yield strength $f_{yd} =$ **435** N/mm^2 Partial factor $\gamma_S =$ **1.15**

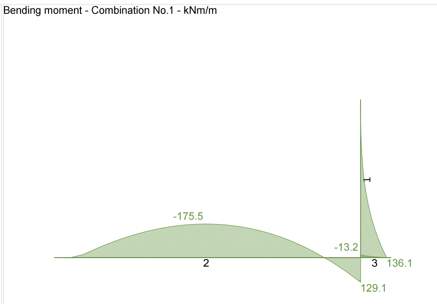
Cover to reinforcement

Front face of stem $c_{sf} =$ **40** mm Rear face of stem $c_{sr} =$ **50** mm

Top face of base $c_{bt} =$ **50** mm Bottom face of base $c_{bb} =$ **75** mm







Check stem design at base of stem

Depth of section h = **350** mm

Rectangular section in flexure - Section 6.1

Design bending moment M = **136.1** kNm/m K = **0.053** K' = **0.207**

K' > K - No compression reinforcement is required

Tens.reinforcement required $A_{sr.req} =$ **1129** mm^2/m

Tens.reinforcement provided 16 dia.bars @ 125 c/c Tens.reinforcement provided $A_{sr.prov} =$ **1608** mm^2/m

Min.area of reinforcement $A_{sr.min} =$ **440** mm^2/m Max.area of reinforcement $A_{sr.max} =$ **14000** mm^2/m

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

Deflection control - Section 7.4

Limiting span to depth ratio 15.6 Actual span to depth ratio 13.4

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

Crack control - Section 7.3

Limiting crack width w_{max} = **0.3** mm Maximum crack width w_k = **0.231** mm

PASS - Maximum crack width is less than limiting crack width**Rectangular section in shear - Section 6.2**

Design shear force V = **107.6** kN/m Design shear resistance $V_{Rd.c}$ = **163.1** kN/m

PASS - Design shear resistance exceeds design shear force

Horizontal reinforcement parallel to face of stem - Section 9.6

Min.area of reinforcement $A_{sx.req}$ = **402** mm²/m Max.spacing of reinforcement s_{sx_max} = **400** mm

Trans.reinforcement provided 12 dia.bars @ 200 c/c Trans.reinforcement provided $A_{sx.prov}$ = **565** mm²/m

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

Check base design at toe

Depth of section h = **350** mm

Rectangular section in flexure - Section 6.1

Design bending moment M = **129.1** kNm/m K = **0.061** K' = **0.207**

K' > K - No compression reinforcement is required

Tens.reinforcement required $A_{bb.req}$ = **1189** mm²/m

Tens.reinforcement provided 20 dia.bars @ 100 c/c Tens.reinforcement provided $A_{bb.prov}$ = **3142** mm²/m

Min.area of reinforcement $A_{bb.min}$ = **399** mm²/m Max.area of reinforcement $A_{bb.max}$ = **14000** mm²/m

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

Crack control - Section 7.3

Limiting crack width w_{max} = **0.3** mm Maximum crack width w_k = **0.222** mm

PASS - Maximum crack width is less than limiting crack width**Rectangular section in shear - Section 6.2**

Design shear force V = **166.6** kN/m Design shear resistance $V_{Rd.c}$ = **195.4** kN/m

PASS - Design shear resistance exceeds design shear force

Check base design at toe

Depth of section h = **350** mm

Rectangular section in flexure - Section 6.1

Design bending moment M = **175.5** kNm/m K = **0.069** K' = **0.207**

K' > K - No compression reinforcement is required

Tens.reinforcement required $A_{bt.req}$ = **1478** mm²/m

Tens.reinforcement provided 16 dia.bars @ 125 c/c Tens.reinforcement provided $A_{bt.prov}$ = **1608** mm²/m

Min.area of reinforcement $A_{bt.min}$ = **440** mm²/m Max.area of reinforcement $A_{bt.max}$ = **14000** mm²/m

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

Crack control - Section 7.3

Limiting crack width w_{max} = **0.3** mm Maximum crack width w_k = **0.022** mm

PASS - Maximum crack width is less than limiting crack width**Rectangular section in shear - Section 6.2**

Design shear force V = **35.4** kN/m Design shear resistance $V_{Rd.c}$ = **163.1** kN/m

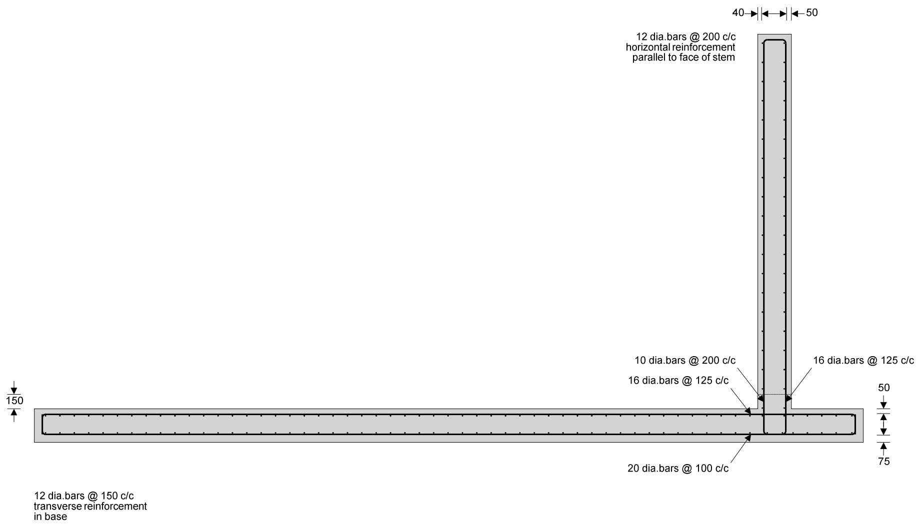
PASS - Design shear resistance exceeds design shear force

Secondary transverse reinforcement to base - Section 9.3

Min.area of reinforcement $A_{bx.req}$ = **628** mm²/m Max.spacing of reinforcement s_{bx_max} = **450** mm

Trans.reinforcement provided 12 dia.bars @ 150 c/c Trans.reinforcement provided $A_{bx.prov}$ = **754** mm²/m

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



Reinforcement details

Horizontal force on wall is under 100kN/m. Half of the non-pool basement (ie 3m) will transfer a horizontal load to the pool basement. 300kN/m should be applied as a horizontal load in the following analysis (conservative because sliding resistance is not accounted for).

RETAINING WALL ANALYSIS FOR REAR BASEMENT (POOL AREA)

For the rear basement, the following parameters are used, as advised in the ground investigation (ref GENV.8522) and noted in the Land Stability and Hydrogeology BIA (ref BIA/ 8417):

- Firm clay at formation level
- Allowable bearing pressure no greater than 100 kN/m2
- Water level should not be lower than 3.4m bgl

RETAINING WALL ANALYSIS

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

Tedds calculation version 2.6.08

Retaining wall details

Stem type Cantilever

Stem height h_{stem} = **5000** mm

Stem thickness t_{stem} = **400** mm

Angle to rear face of stem α = **90** deg
Stem density γ_{stem} = **25** kN/m^3
Toe length l_{toe} = **7550** mm
Heel length l_{heel} = **750** mm
Base thickness t_{base} = **350** mm
Base density γ_{base} = **25** kN/m^3
Height of retained soil h_{ret} = **5000** mm Angle of soil surface β = **0** deg
Depth of cover d_{cover} = **0** mm
Height of water h_{water} = **2000** mm
Water density γ_w = **9.8** kN/m^3

Retained soil properties

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

Base soil properties

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

Loading details

Variable surcharge load $Surcharge_Q$ = **2.5** kN/m^2
Vertical line load at 7725 mm P_{G1} = **76** kN/m
Vertical line load at 600 mm P_{G2} = **18** kN/m
Horizontal line load at 1500 mm P_{G3} = **300** kN/m

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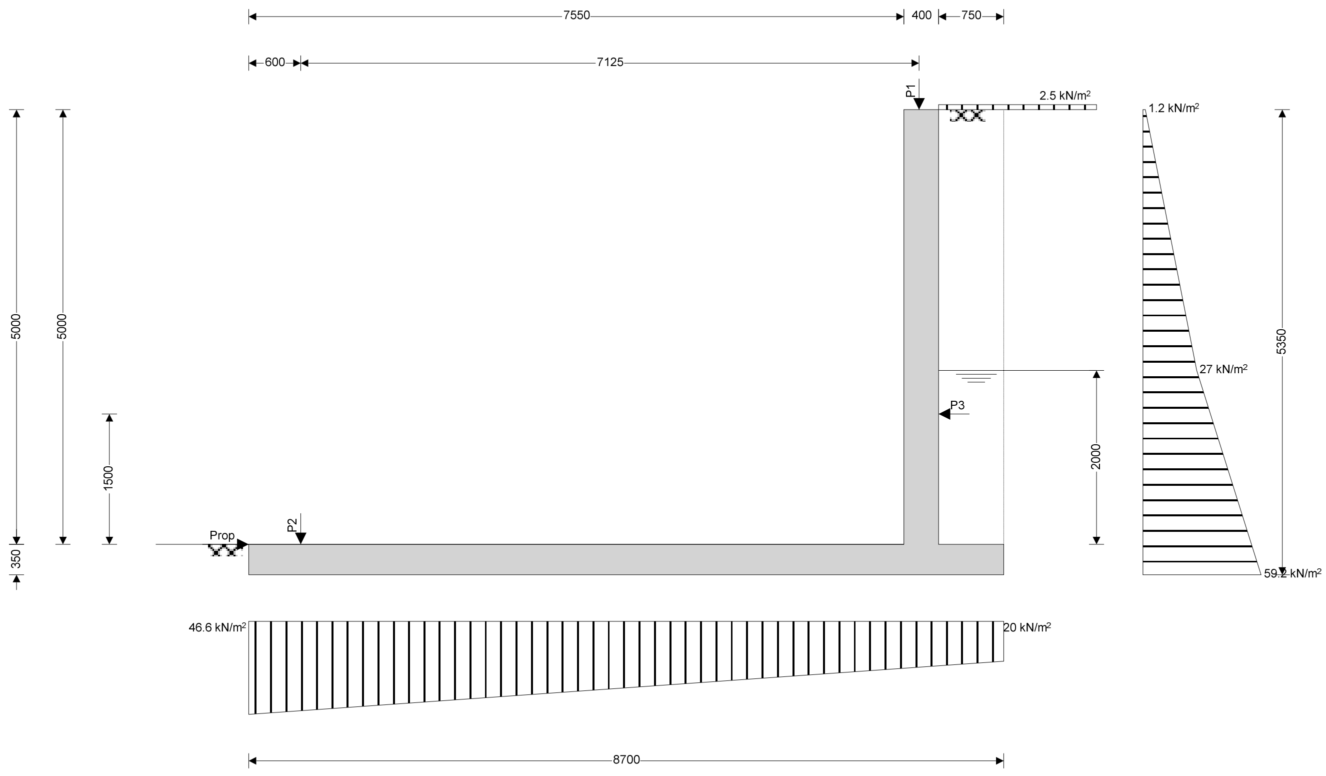
	Section Planning stage calculations			Sheet no./rev. 7	
	Calc. by GW	Date 04/06/2017	Chk'd by	Date	App'd by	Date



General arrangement

Calculate retaining wall geometry

Base length l_{base} = **8700** mm

Saturated soil height h_{sat} = **2000** mm

Moist soil height h_{moist} = **3000** mm

Length of surcharge load l_{sur} = **750** mm

Vertical distance x_{sur_v} = **8325** mm

Effective height of wall h_{eff} = **5350** mm

Horizontal distance x_{sur_h} = **2675** mm

Area of wall stem A_{stem} = **2** m^2 Vertical distance x_{stem} = **7750** mm

Area of wall base A_{base} = **3.045** m^2 Vertical distance x_{base} = **4350** mm

Area of saturated soil A_{sat} = **1.5** m^2 Vertical distance x_{sat_v} = **8325** mm

Horizontal distance x_{sat_h} = **783** mm

Area of water A_{water} = **1.5** m^2 Vertical distance x_{water_v} = **8325** mm

Horizontal distance x_{water_h} = **783** mm

Area of moist soil A_{moist} = **2.25** m^2 Vertical distance x_{moist_v} = **8325** mm

Horizontal distance x_{moist_h} = **2022** mm

Using Coulomb theory

Active pressure coefficient K_A = **0.483** Passive pressure coefficient K_P = **2.359**

Bearing pressure check

Vertical forces on wall

Total $F_{total\_v} = F_{stem} + F_{base} + F_{sat\_v} + F_{moist\_v} + F_{water\_v} + F_{sur\_v} + F_{P\_v}$ = **289.5** kN/m

Horizontal forces on wall

Total $F_{total\_h} = F_{sat\_h} + F_{moist\_h} + F_{pass\_h} + F_{water\_h} + F_{sur\_h} + F_{P\_h} = \mathbf{440.9}$ kN/m

Moments on wall

Total $M_{total} = M_{stem} + M_{base} + M_{sat} + M_{moist} + M_{water} + M_{sur} + M_{P} = \mathbf{1091.7}$ kNm/m

Check bearing pressure

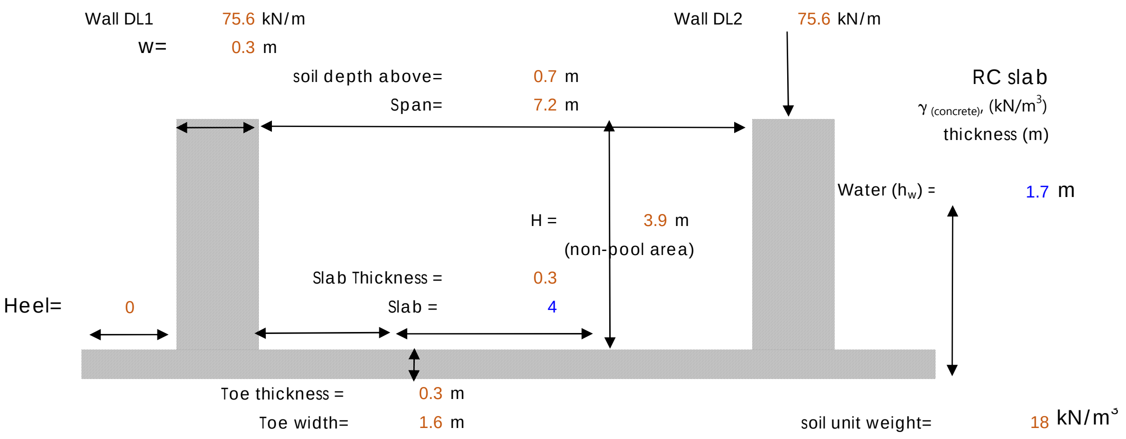
Propping force $F_{prop\_base} = \mathbf{440.9}$ kN/m

Bearing pressure at toe $q_{toe} = \mathbf{46.6}$ kN/m^2 Bearing pressure at heel $q_{heel} = \mathbf{20}$ kN/m^2

Factor of safety $FoS_{bp} = \mathbf{2.148}$

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

UPLIFT CALCULATIONS



Global Uplift Calc

Total Dead Load =	Slab=	30.0 kN/m	= slab thickness x slab weight x 25kN/m^3
	Toe and heel =	28.5 kN/m	= (heel length + wall thickness + toe length) x slab thickness x 25kN/m^3 x 2No
			(heel + weight of soil above heel ignored, which is a more conservative approach)
	RC Wall =	58.5	= wall height above heel x wall thickness x 25kN/m^3 x 2No
	Weight above wall =	151.2	= weight applied from ground floor and structure above (DL1+DL2)
	Soil=(	0 +	0) x 2 + 90.72 = 90.72 28.04
	Total Dead load =	358.9 kN/m	
Total Uplift Force=		132.6 kN/m	= (wall thickness + span + wall thickness) x h_w x 10kN/m^3

F.o.S.= **2.71 No Global Uplift**

Slab Uplift

Slab = 7.5 kN/m Uplift = h_w x 10kN/m^3 = 17 kN/m

Service Moment = (net uplift)*(span)^2 / 8 -61.6 kNm/m

Factored Design moment= -77.4 kNm/m

Factored Design shear = -43.0 kN/m

[At Detailed Design stage, the slab should be designed to resist these forces]

Slab, main reinforcement

ULS moment (approx)	M = 78 kNm
Overall depth	h = 200mm
Cover	c = 75mm
Bar diameter	D = 16mm

Effective depth d = h – c – D/2 = **117.000** mm

Width b = 1m

Concrete strength f_{cu} = 35N/mm^2

Ratio k = M/(f_{cu}*b*d^2) = **0.163**

Assuming redistribution does not exceed 10 % (this implies a limitation of the neutral axis depth to d/2),

k' = 0.156

Compression re-bar required? check = if(k<k',"No","Yes") = **"Yes"**

Lever arm (assuming no comp steel req'd) z = min(d*(0.5 + √(0.25-k/0.9)),0.95*d) = **89.258** mm

Steel strength f_y = 500N/mm^2

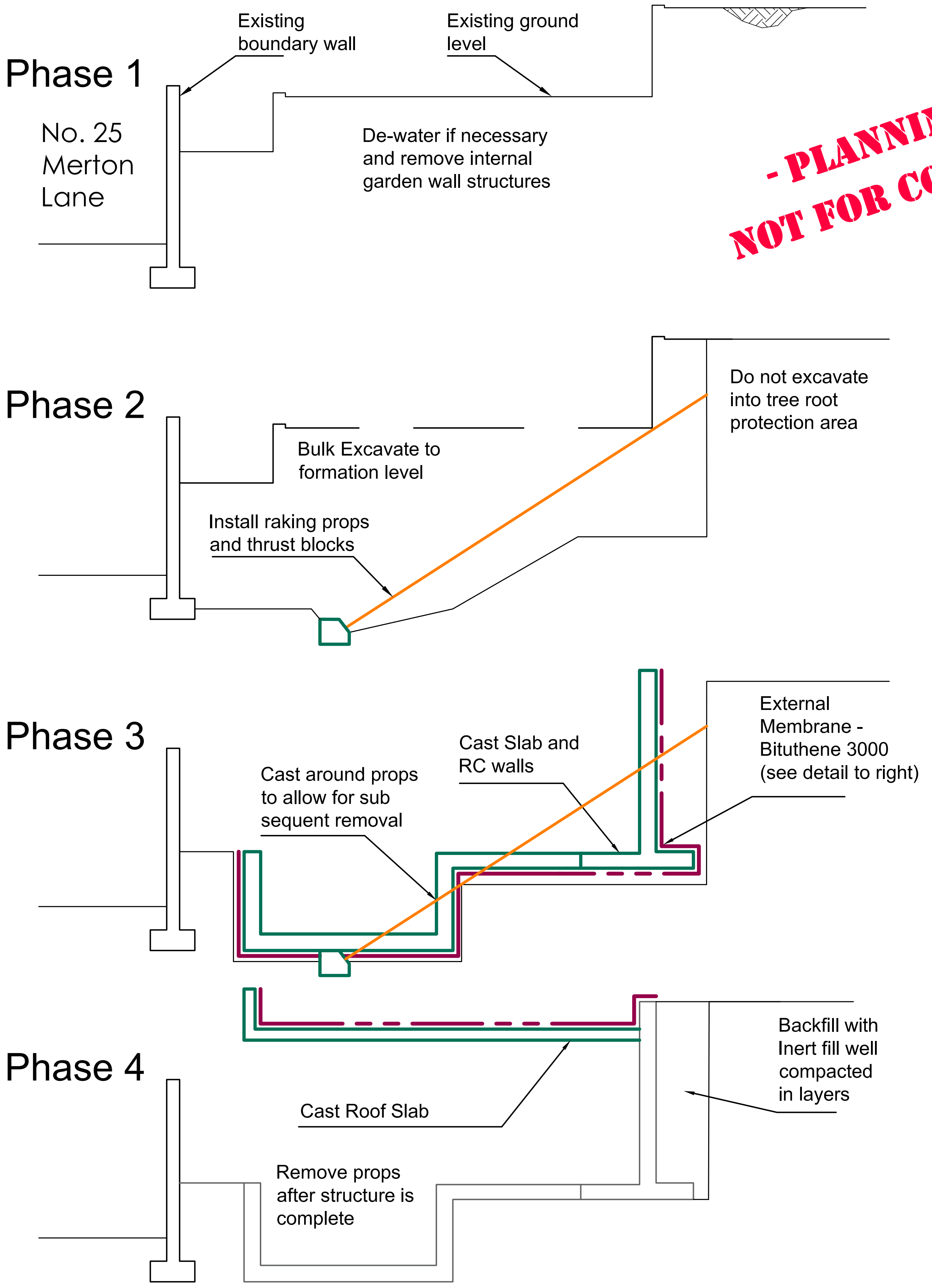
Area of steel required A_s = M/(0.95*f_y*z) = **1839.727** mm^2

H16s @ 100cc (2011mm/m) will suffice

Appendix B: Construction Method

USE IN CONJUNCTION WITH BASEMENT CONSTRUCTION METHOD STATEMENT

- PLANNING ISSUE -
NOT FOR CONSTRUCTION

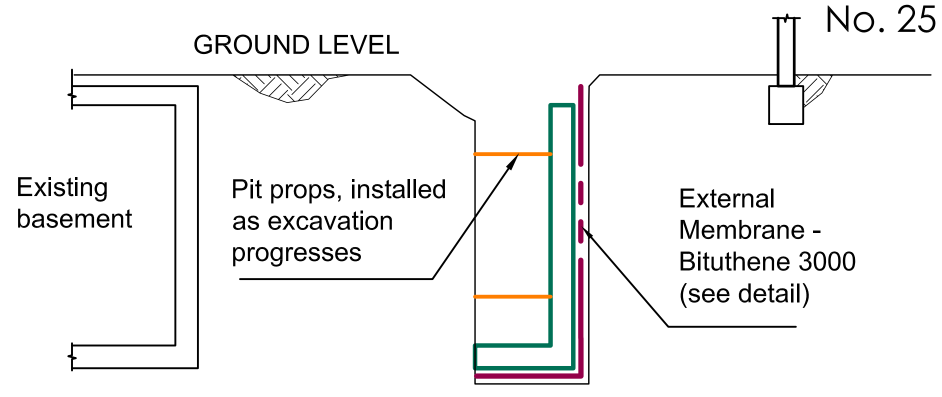


Typical section through rear basement showing construction sequence

(1:100)

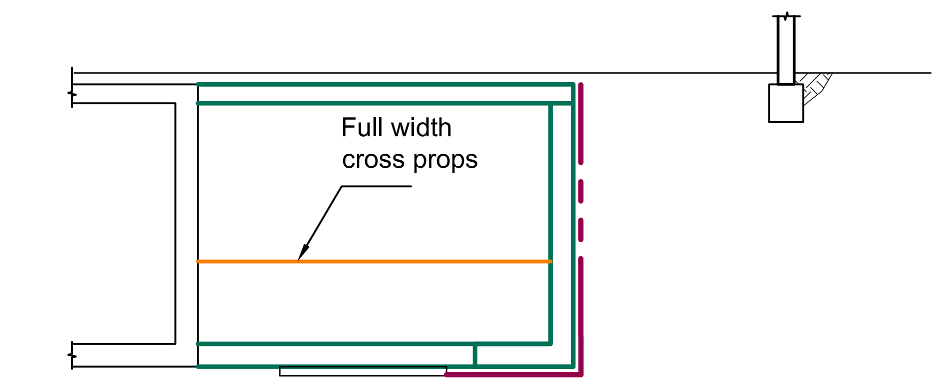
Phases 1 - 3

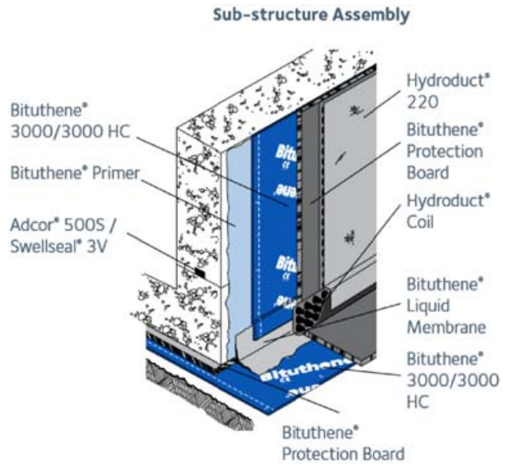
1. De-water if required and remove existing paving slabs
2. Carefully excavate retaining walls in segments shown in plan
3. Install RC retaining wall and base. Excavate remaining soil in basement after retaining walls are cast. Install full width cross props.



Phase 4

4. Construct floor slab then ceiling slab then remove props





Typical section through front basement showing construction sequence

(1:100)

Job No.	Drawn	Scale
161206	GW	As shown @ A3
	Chk'd -	
Dwg No. TW-10	Rev. 1	Date April 2017

Rev	Date	Amendments
1	04.06.2017	For Planning submission
-	21.04.2017	First issue for comment

Client: Nadia Gobova

Project: 26 West Hill Park

Title : Temporary Works Scheme Design

Croft Structural Engineers
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Job Number: 161206

Basement Construction Sequence for 26 West Hill Park

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Contents

1. Preamble

1.1. This method statement provides an approach that will allow the basement to be safely constructed. This statement is for planning purposes only. Once planning and Building Control has been completed, the responsibility for the temporary works will transfer to the Contractor during works on site.

1.2. This method has been produced to demonstrate the feasibility of the works at planning and for inclusion in the Basement Impact Assessment at Planning for Camden.

1.3. The site is to be hoarded to prevent unauthorised public access.

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

1.5. Prior to construction, the contractor should review the construction traffic management plan. Traffic routes and deliveries to and from the site should be agreed beforehand between the contractor and the client.

1.6. The contractor should review the arboricultural method statement and ensure that all necessary tree protection is installed before the start of works.

1.7. 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.

1.8. For the rear and front basement, props will be provided to the excavations and the retaining walls in the temporary condition.

2. Sequencing

The rear and front basement may be constructed simultaneously. The sequencing is shown illustratively on drawing TW-10. The general procedures is as follows:

2.1. Phase I – Enabling Works

2.1.1. It is possible that water may be encountered on site during the works.

2.1.1.1. Localised removal of water may be required to deal with rain from perched water or localised water. This is to be dealt with by localised pumping. Typically achieved by a small sump pump in a bucket.

2.1.2. Remove paving slabs and internal garden walls in the construction area

2.2. Phase II – Initial Excavation and Propping

2.2.1. Excavate soil

2.2.1.1. Excavate in segments

2.2.1.2. Install props as excavations progress

2.3. Phase III – Wall and Floor Construction

2.3.1. Construct reinforced concrete (RC) retaining walls

2.3.1.1. For front basement, remove remaining soil and install horizontal props to wall of existing basement

2.3.2. Place below-slab drainage. Croft recommends that all drainage is encased in concrete below the slab and cast monolithically with the slab.

2.3.3. Construct basement floor slab (including pool slab for rear basement) and internal foundation strips

2.3.4. After wall and floor structure is complete, props may be removed

2.4. Phase IV – Roof Construction

2.4.1. Construct roof to complete the basement structures.

3. 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 1000c/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.

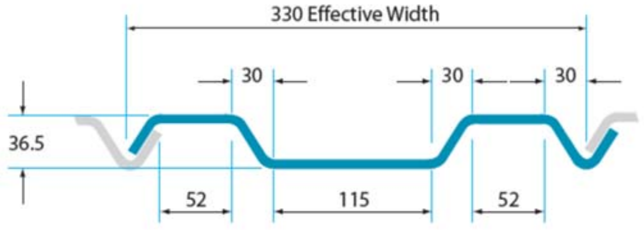
Soil and ground conditions are variable. Typically one finds that, in the temporary condition, clays are more stable and the C_u (cohesive) values in clay reduce the risk of collapse. It is this cohesive nature that allows clays to be cut into a vertical slope. For these calculations, weak sand and gravels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

Trench Sheet Design

Soil Depth	Dsoil = 3000mm	
Surcharge	sur = 5kN/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	= **24.352**kN/m^2
Surcharge pressure	surcharge = sur * k_a	= **2.029** kN/m^2

STANDARD LAP

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



CROFT STRUCTURAL ENGINEERS

Technical Information

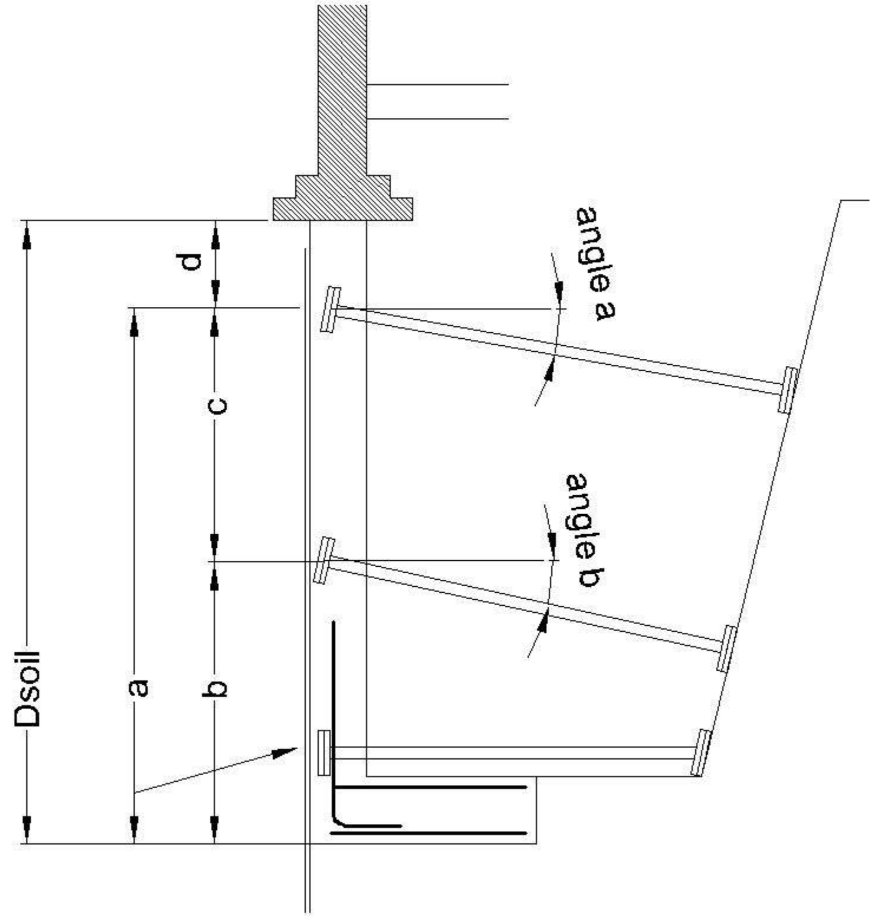
Effective width per sheet (mm)	330
Thickness (mm)	3.4
Depth (mm)	35
Weight per linear metre (kg/m)	10.8
Weight per m² (kg)	32.9
Section modulus per metre width (cm³)	48.3
Section modulus per sheet (cm³)	15.9
I value per metre width (cm⁴)	81.7
I value per sheet (cm⁴)	26.9
Total rolled metres per tonne	92.1

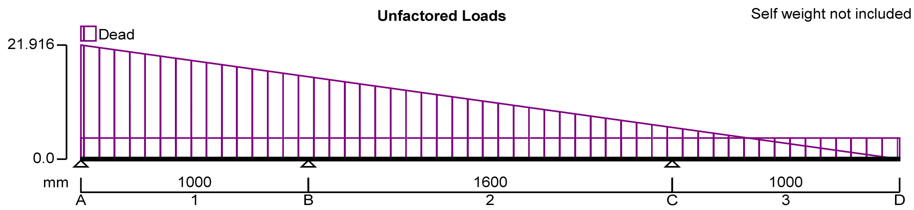
S_{xx} = 15.9 cm^3

py = 275N/mm^2

I_{xx} = 26.9cm^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 = **$269.\times10^3$** mm^4
Span 2	Length = **1600** mm	Cross-sectional area = **4245** mm^2	Moment of inertia = **$269.\times10^3$** mm^4
Span 3	Length = **1000** mm	Cross-sectional area = **4245** mm^2	Moment of inertia = **$269.\times10^3$** 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

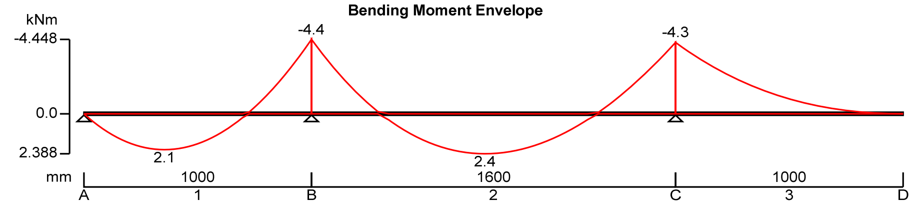
Support A	Max react = **-12.3** kN	Min react = **-12.3** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support B	Max react = **-38.5** kN	Min react = **-38.5** kN	Max mom = **0.0** kNm	Min mom = **0.0** kNm
Support C	Max react = **-24.8** kN	Min react = **-24.8** kN	Max mom = **0.0** kNm	Min mom = **0.0**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

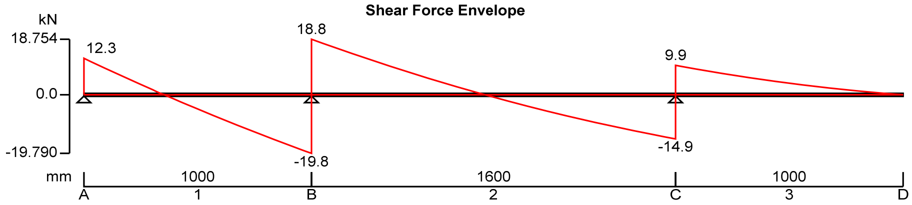
Beam Max/Min results - Combination Summary

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

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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 = 5kN/m^2

Soil Density — γ = 19kN/m^3

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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 = **34.701**kN/m

Surcharge Force Surchargeforce = k_a * sur * Dsoil = **6.088**kN/m

Place Props every other pin spacing = 2m

Propforce Propforce = spacing * (soilforce + Surchargeforce) = **81.578**kN

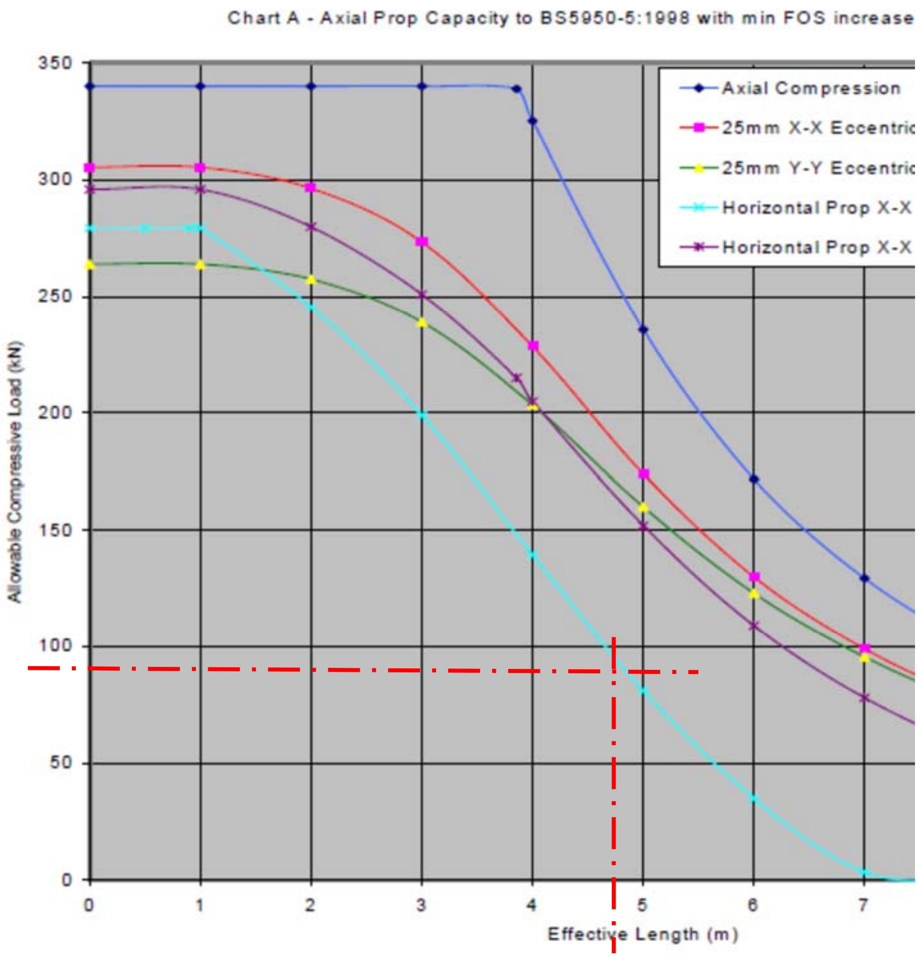

Figure 1 Mabey Mass 25 Load Chart

For rear basement, props will be placed at 30 degrees.

Applied horizontal force per metre will be 81kN. Accounting for props spaced 2m apart, applied load will be:

Force in prop at 30 degrees $P_{\_raking\_prop}$ = 2*81kN/cos(30°) = **187.061** kN

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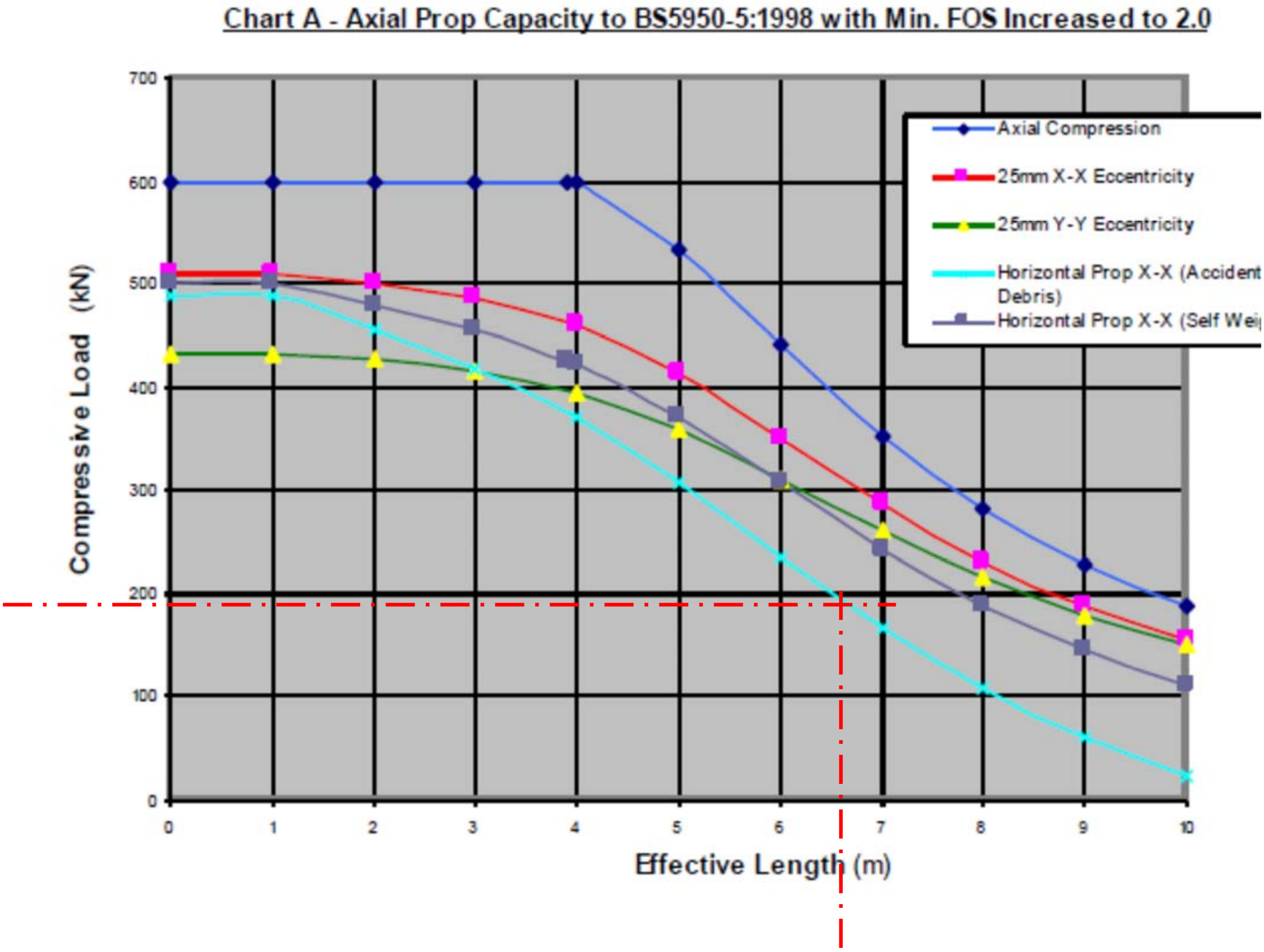

Figure 2 Mabey Mass 50 Load Chart

Provide Mabey Mass 50 at 2m centres

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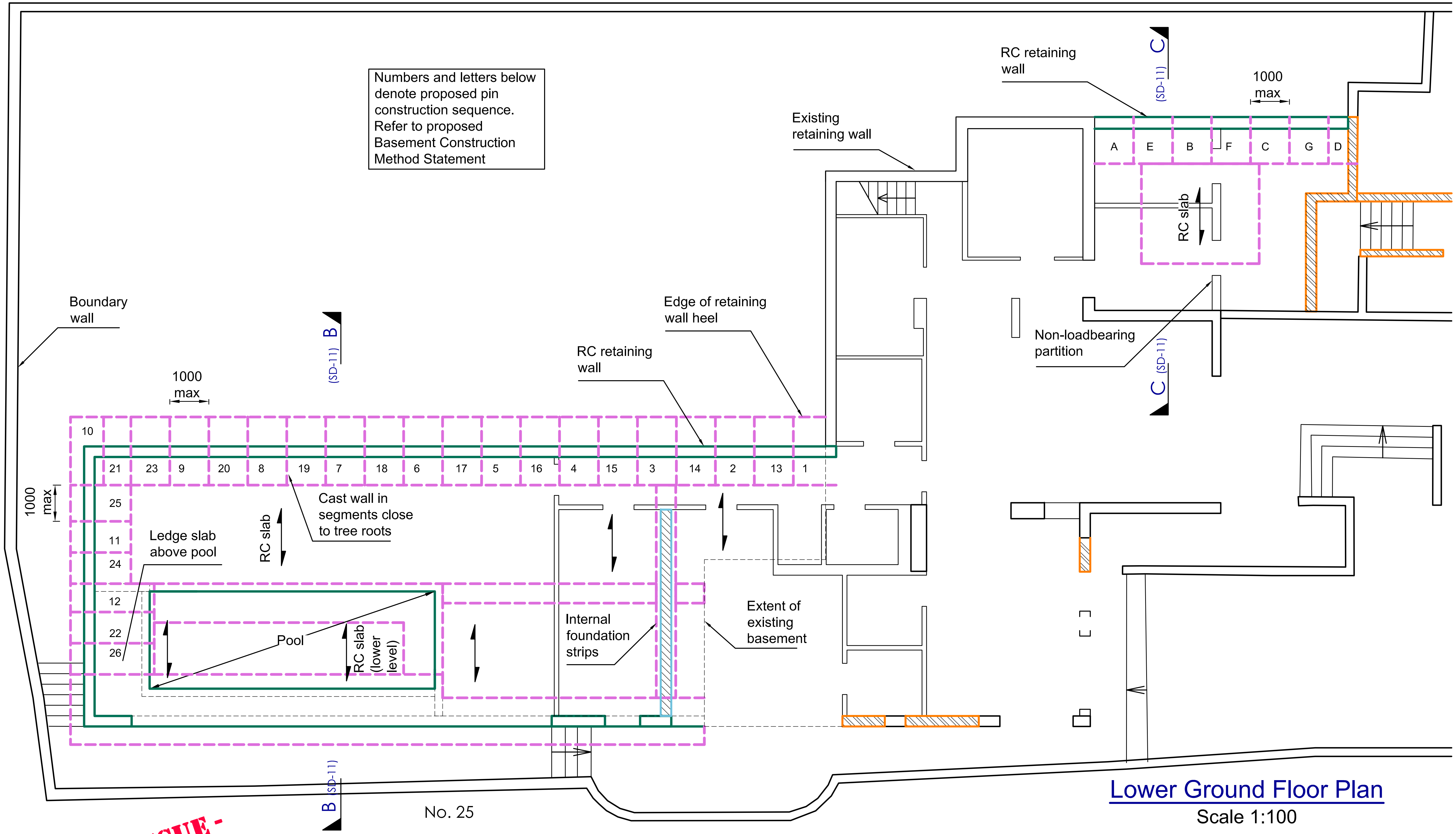
Appendix C: Structural Drawings



Lower Ground Floor Plan

Scale 1:100

- PLANNING ISSUE -
NOT FOR CONSTRUCTION

Rev	Date	Amendments
1	05.06.2017	Pin numbers/letters added
-	21.04.2017	First issue for comment

Job No. 161206	Drawn GW	Scale As shown @ A3
	Chk'd -	
Dwg No. SL-10	Rev. 1	Date April 2017

Croft Structural Engineers
Clockshop Mews,
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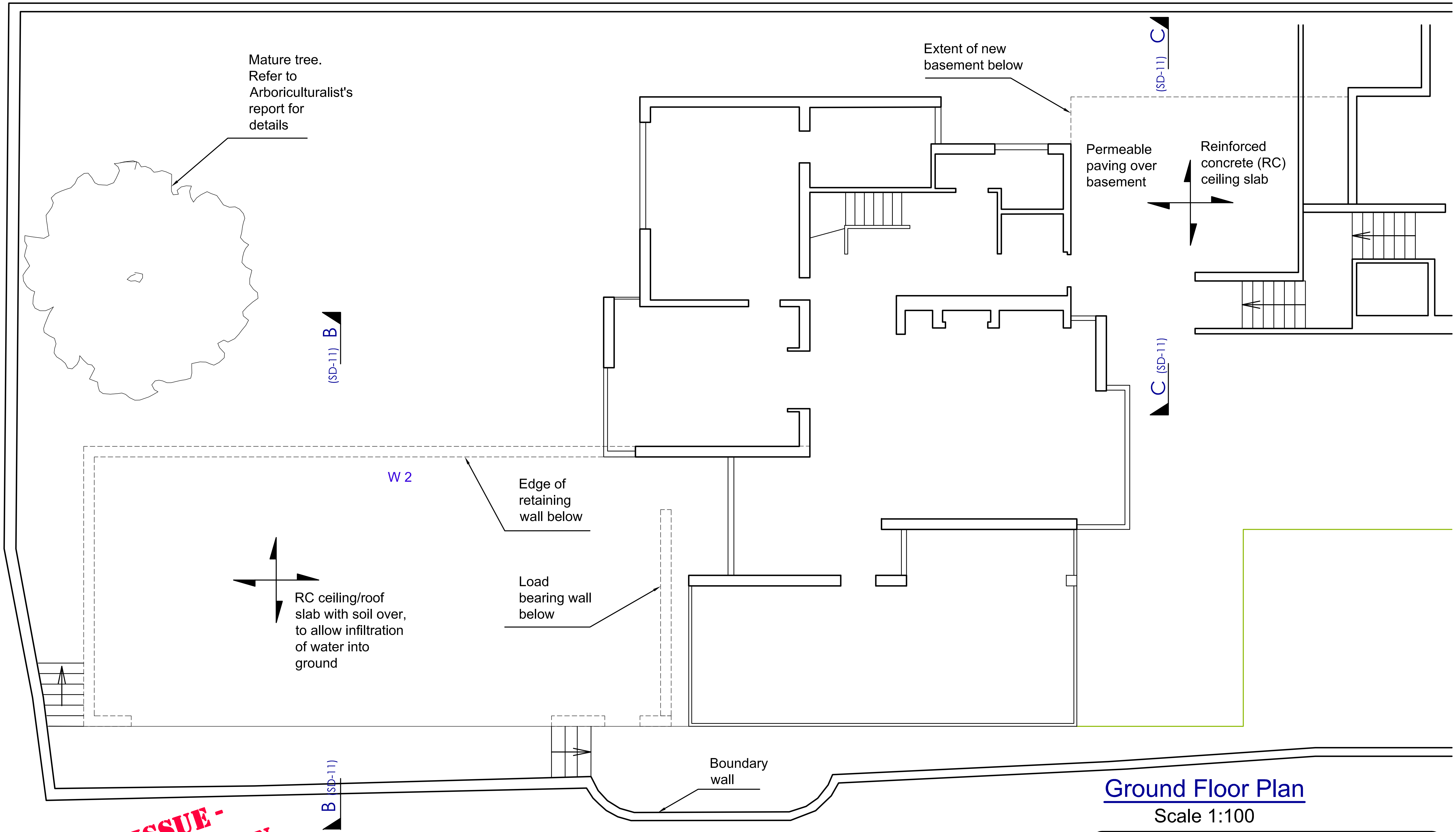
London, SE25 5EH.
020 8684 4744
www.croftse.co.uk

Client: Nadia Gobova

Project: 26 West Hill Park

Title : Structural Scheme Design - Lower Ground Floor Plan

No. 25 West Hill Park



Ground Floor Plan

Scale 1:100

- PLANNING ISSUE -
NOT FOR CONSTRUCTION

Rev	Date	Amendments
1	05.06.2017	Battered soil proposal removed
-	21.04.2017	First issue for comment

Job No. 161206	Drawn GW	Scale As shown @ A3
	Chk'd -	
Dwg No. SL-20	Rev. 1	Date April 2017

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Clockshop Mews, r/o 60 Saxon Rd, London, SE25 5EH.
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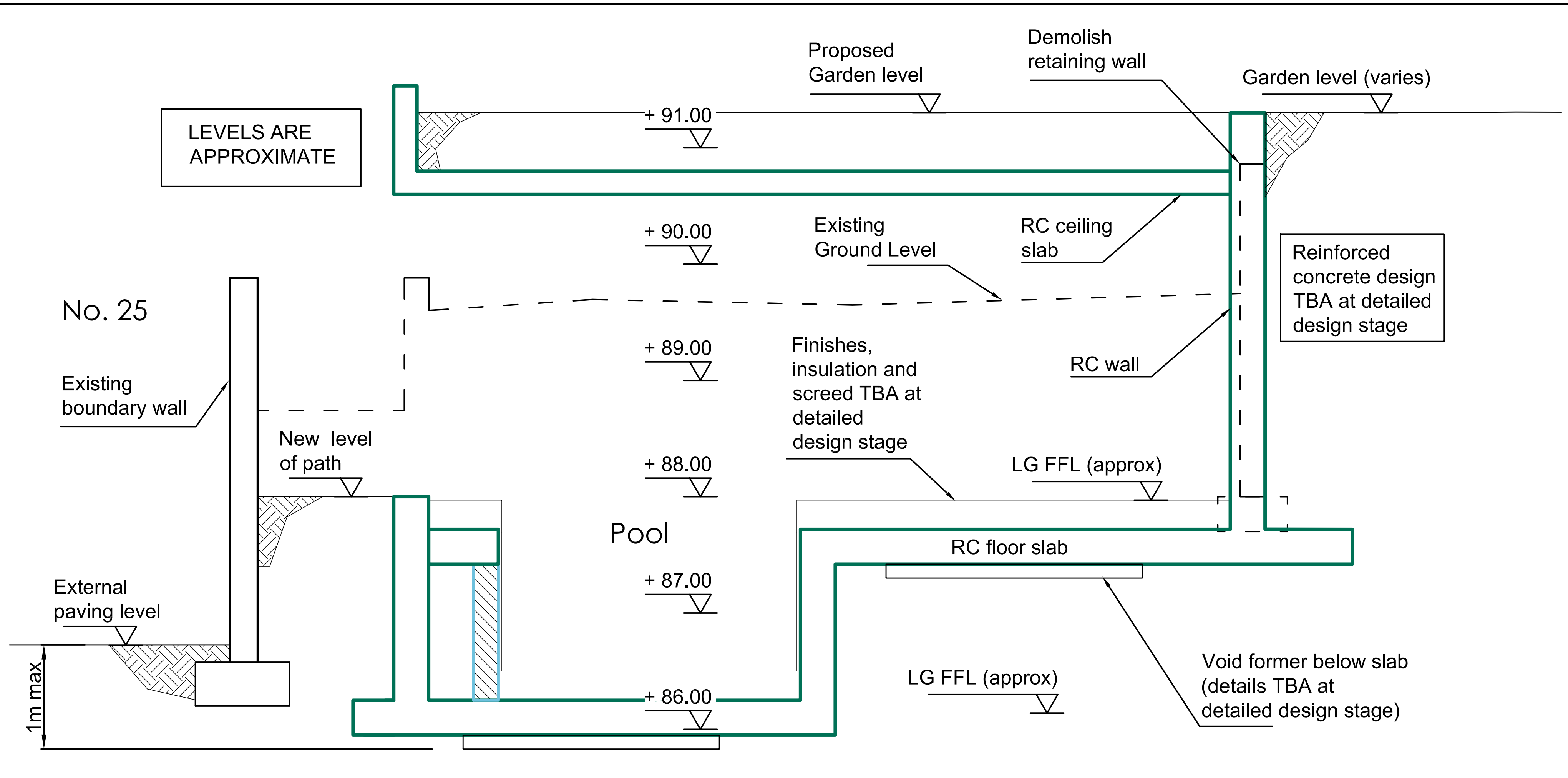
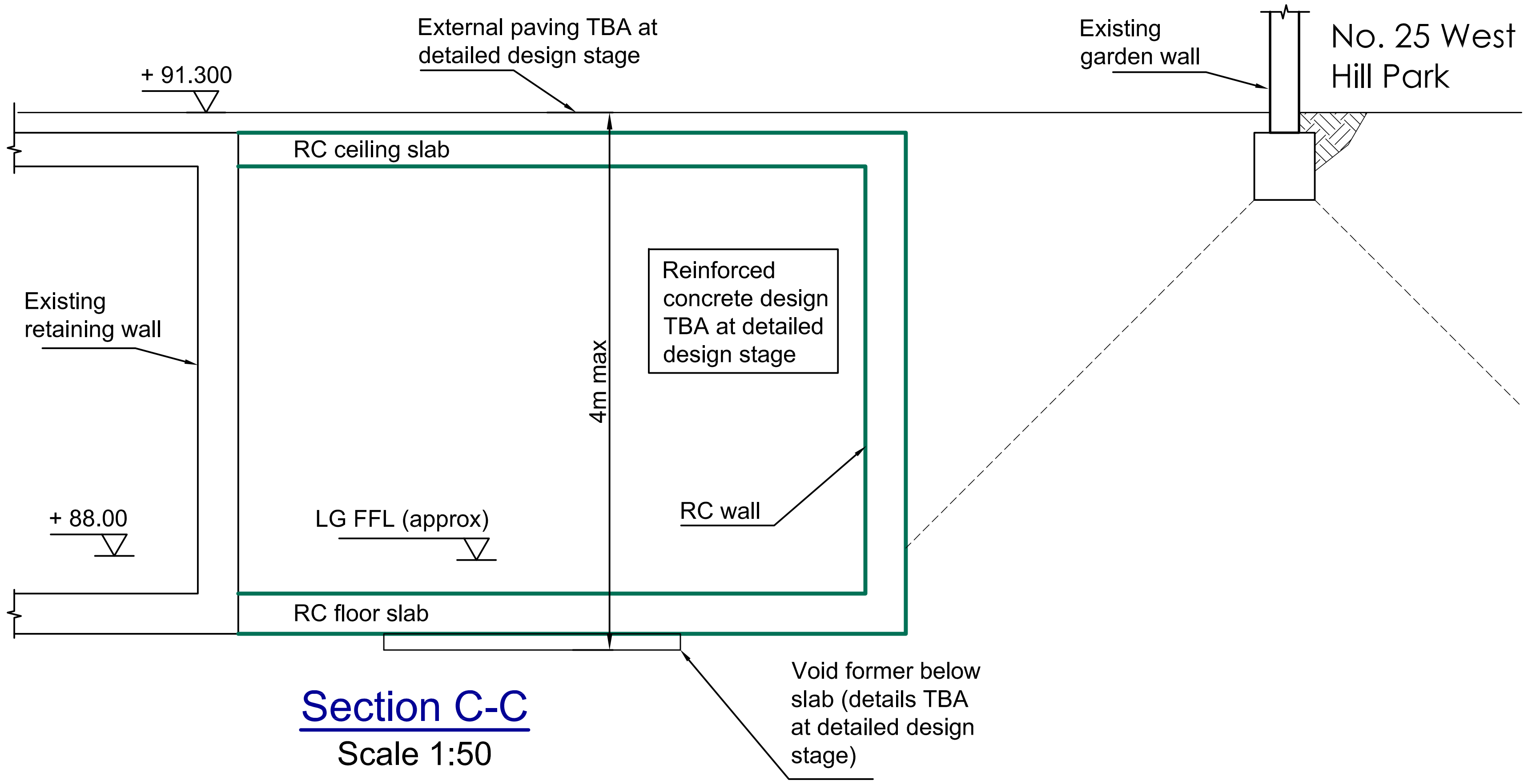
www.croftse.co.uk

Client: Nadia Gobova
Project: 26 West Hill Park
Title : Structural Scheme Design - Ground Floor Plan



Section B-B (Through Pool)

(1:50)



Section C-C

Scale 1:50

- PLANNING ISSUE -
NOT FOR CONSTRUCTION

Rev	Date	Amendments
1	05.06.2017	For Planning submission
-	21.04.2017	First issue for comment

Job No. 161206	Drawn GW / Chk'd -	Scale As shown @ A3
Dwg No. SD-11	Rev. -	Date April 2017

Croft Structural Engineers
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www.croftse.co.uk

Client: Nadia Gobova

Project: 26 West Hill Park

Title : Structural Scheme Design - Sections

Appendix D: Monitoring Proposals

Job Number: 161206

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

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E: enquiries@croftse.co.uk
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Structural Monitoring Statement

Site:

26 West Hill Park
Camden
N6 6ND

Client:

Mrs Konopleva
c/o
Nadia Gobova

Revision	Date	Comment
-	05.06.2017	First Issue

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The Institution of Structural Engineers

Contents

1. Introduction

Basement works are intended at 26 West Hill Park. 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 rear boundary wall and the flank wall of the neighbouring building (ie the flank wall of No 25 West Hill Park, closest to the front basement). 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 new basement at the front and rear of the existing building.

Scope of Works

The works comprise:

- Visual monitoring of the rear boundary wall with No 25 Merton Lane and the closest wall of 25 West Hill Park.
- 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
Boundary and flank wall	
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 boundary wall and neighbour's flank wall and any pre-existing cracking
b) Settlement of the boundary 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 (Total Stations for similar). 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:

Wall settlement	$\pm$1.5mm
Crack monitoring	$\pm$0.75mm

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 walls of nearby buildings.

The trigger limits are shown in the following table.

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

MOVEMENT		CATEGORY	ACTION
Vertical	Horizontal		
0mm-3mm	0-5mm	Green	No action required
3mm-6mm	5-8mm	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
6-8mm	8-10mm		Implement remedial measures review method of working and ground conditions
>8mm	>10mm	RED	Implement structural support as required; Cease works with the exception of necessary works for the safety and stability of the structure and personnel; Review monitoring data and implement revised method of works

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

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

Standard Reporting

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

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

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

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

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

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

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

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.

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

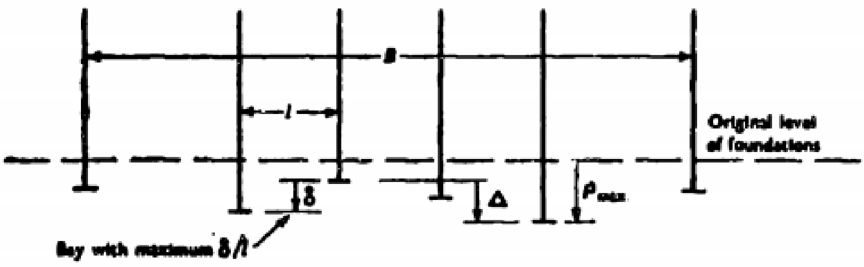

Figure 2.1 – Diagram illustrating the definitions of maximum angular distortion, δ/l, maximum settlement, ρ_{max}, and greatest differential settlement, Δ, for a building with no tilt (Skempton and MacDonald, 1956).

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

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

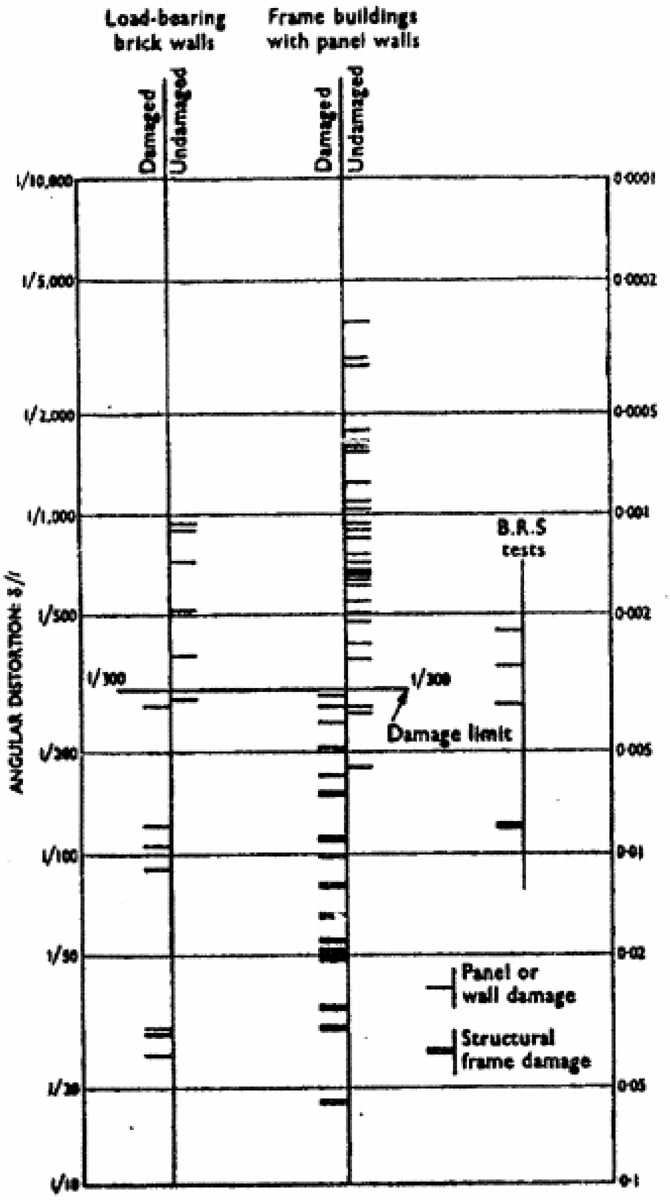

Figure 2: Skempton and MacDonald's analysis of field evidence of damage on traditional frame buildings and loadbearing brick walls

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

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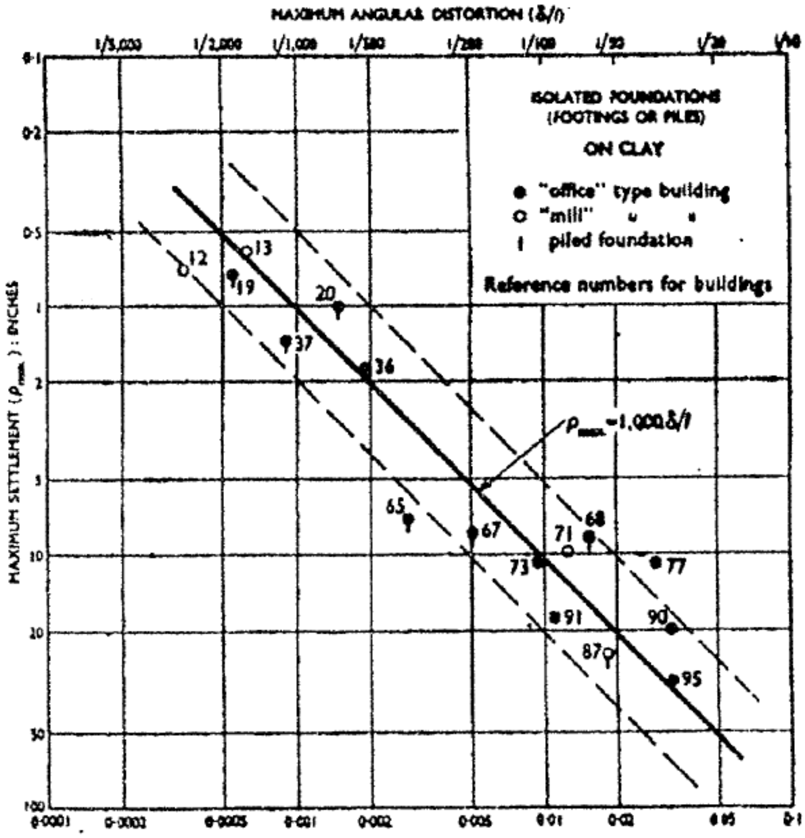
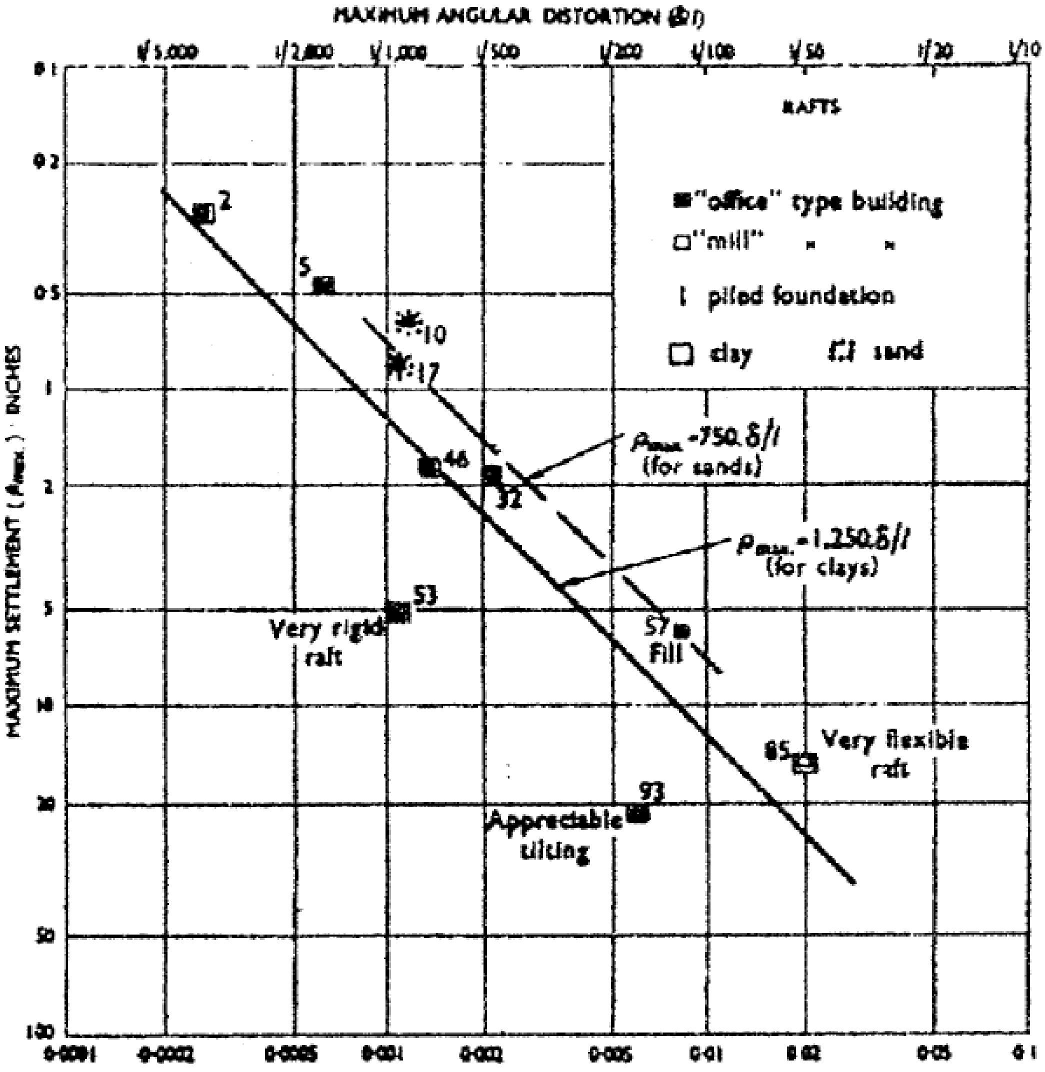
Other key findings by Skempton and MacDonald include limiting values of δ/l for structure, and a relationship between maximum settlement, ρ_{max} and δ/l for structures founded on sands and clays. The charts below show these relations for raft foundations and isolated footings.





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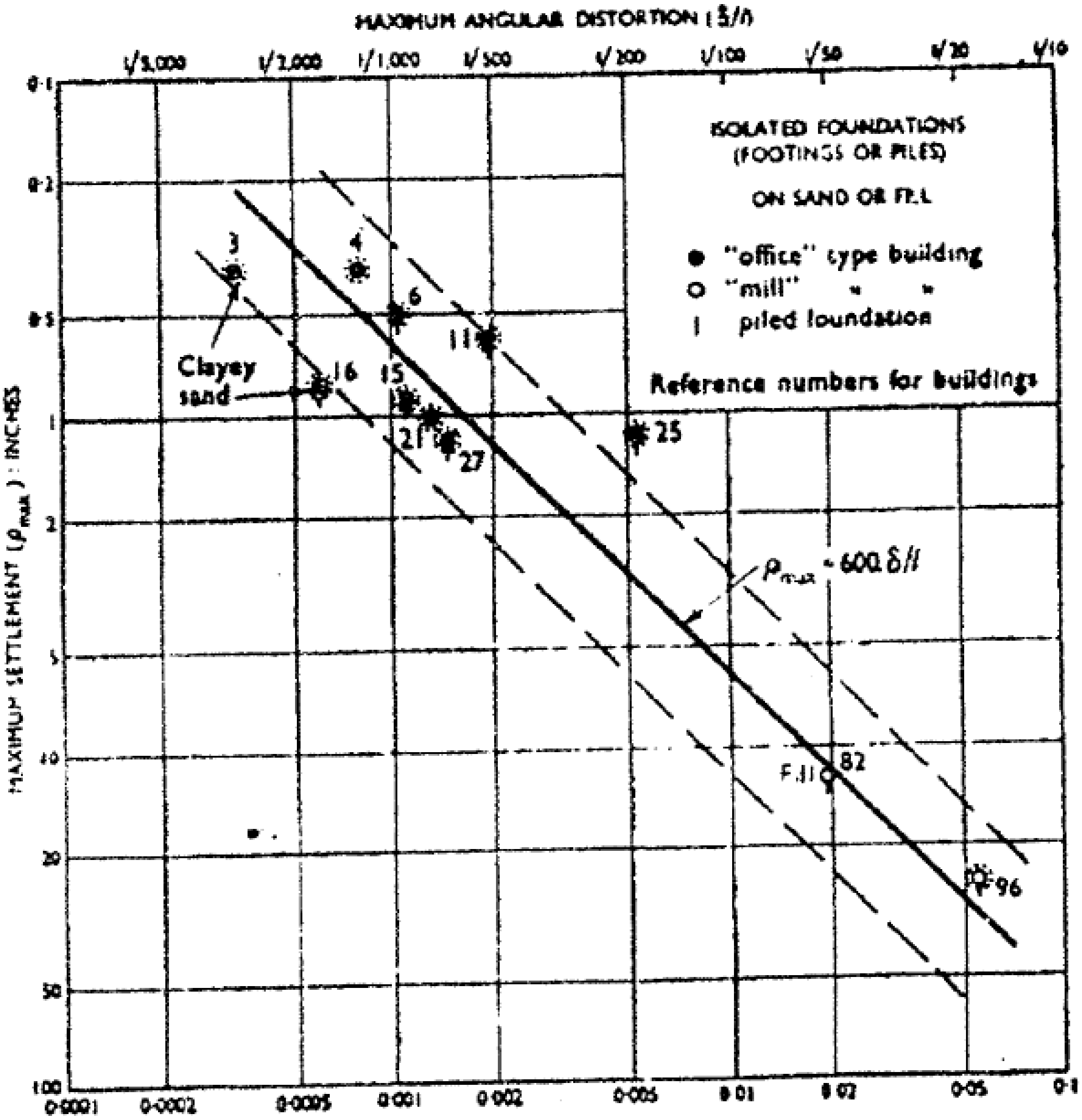

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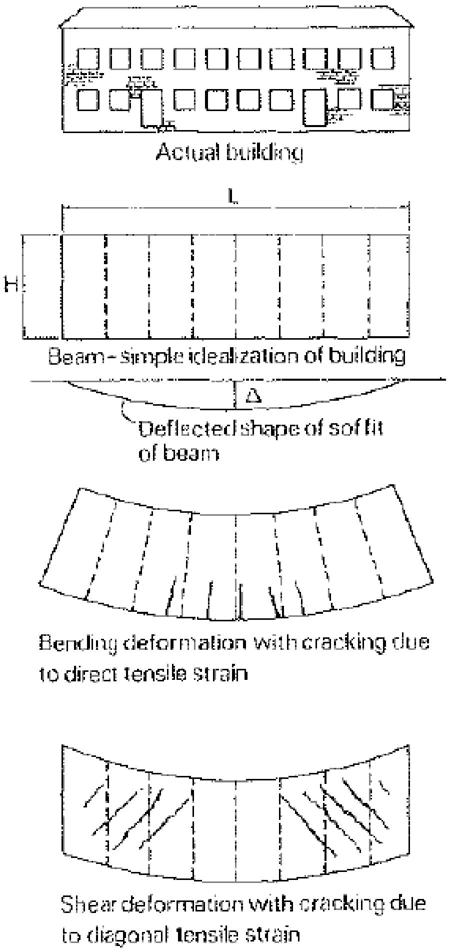

TABLE I

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 E: Outline Construction Programme

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

Task	**Month**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Monitoring of adjacent structures											
Enabling works											
Demolition											
Bulk excavation											
Basement construction											
Superstructure construction											