engineersHRW

LAND ADJOINING NO. 43 CAROL STREET, LONDON NW1 OHT

STRUCTURAL ENGINEER'S DESIGN STATEMENT FOR PLANNING

This report was written/compiled by Aoife Bloomer MIStructE and reviewed by Simon Robinson MIStructE of engineersHRW

Signed ..... Date 12.02.18 .

Job Number: 1402

This design statement report has been prepared for and on behalf of our client Make Some Space Ltd, based on the planning proposals by Lisa Shell Architects (drawing references listed in section 8.3.2). It is for the use of the client, the client's professional advisers and Camden Council and is for their use only. The report should not be used for any purposes other than for which it was considered. The report should be read in conjunction with Engineers HRW Structural drawings (drawing references listed in 8.3.1), and Basement Impact Assessment by Soiltechnics (September 2017).

1.0 Introduction

1.0.1 Engineers HRW have been asked to consider the structural issues surrounding the proposed construction works to support the planning application.

1.0.2 The proposal comprises of construction of a three storey mixed use dwelling with artist studios including a basement below and landscaped garden to the east and rear of the building. The existing site is currently undeveloped apart from a paved area and the playground.

1.0.3 This report has been prepared in compliance with the Camden Council's Planning Requirements for a new build dwelling with basement below. It includes a construction methodology statement prepared and signed off by a Chartered Structural Engineer (MIStructE) and includes proposals for temporary supports and sequence of construction. A Basement Impact Assessment has been prepared which includes the results of the site-specific soils investigation, the BIA report is included in this submission.

2.0 Site Information

The site is located on the south side of the bend of Carol Street, Camden. Access is gained from Carol Street only. There are warehouses to the west of the site at number 43 Carol Street which house various workshop units, including a dental laboratory, recording studio, musical instrument repair shop and several others. The rear of the site backs on to St Martins Gardens and to the east there is the end house of a residential terrace, No. 23 Carol Street. The site is approximately 290m^2. It is not situated within a conservation area and there are no listed buildings neighbouring the site.

2.1 Existing Building

There are currently no existing buildings on the site. There is a paved path, a paved area and a grass covered play area. There is a potential party fence wall at the rear of the site. The wall extents between 2.45m-3.28m above existing ground level, while the top of security fence is a further 1.05m high.

2.2 Geotechnical Ground Conditions

2.2.1 Geology

A Geotechnical Site Investigation has been carried out and the results are included in the BIA report attached. The exploratory borehole revealed that ground conditions are generally consistent with the geological records and known history of the area which is comprised of MADE GROUND approximately 1.5m deep above a stiff high strength slightly silty clay of LONDON CLAY FORMATION, this clay has occasional bands of brown fine sand from 8.5m depth. The LONDON CLAY FORMATION increases in stiffness and from 9.60m depth is described as stiff high strength dark grey silty clay, becoming stiff to very stiff from 10.40m depth extending to the full depth of the investigation of 15.0m.

2.2.2 Groundwater

A groundwater seepage was observed during the excavation of Borehole 1 at a depth of approximately 8.0m below ground level, this rose to 7.9m in 20 minutes. The nature of the strike was in the form of a light seepage, which is envisaged could relate to the presence of a claystone horizon around this depth.

A water level monitoring standpipe was installed in BH01 to a depth of 10m but no water was observed on the return visit.

The conclusions drawn from these findings are summarised below:

- Water was encountered only during the excavation of Borehole 1, not during monitoring and given the speed at which the site works will be undertaken there may well be insufficient time for water seepages to enter the excavations, particularly as the soil is cohesive.
- It is noted that groundwater observations relate to the time the investigations were undertaken (Sept 2015/Jan 2016) and variations could arise from seasonal effects or changes in drainage conditions.

2.2.3 Contamination

Please refer to Soiltechnics Ground Investigation Report (September 2017) for details of the contamination testing, assessment and remedial works required.

2.3 Trees

An Arboricultural Survey and Tree Root Investigation have been carried out by Marcus Foster Arboricultural Design consultancy. Please refer to the reports included in the planning submission. To summarise: the trees and vegetation within the site will be removed, the large trees in St Martins Gardens close to the boundary of the site are unlikely to be affected by the development because the deep foundations to the boundary wall appear to have prevented root spread into the site.

2.4 Flood Risk

2.4.1 Tidal Flood Risk

The site is not situated within a tidal flood zone as designated by the Environment Agencies Tidal Flood Map.

2.4.2 Surface Water Flood Risk

The site is situated within a surface flood zone as designated by the Environmental Agencies Surface Water Flood Map. The risk category for surface flooding is very low.

2.4.3 Reservoir Flood Risk

The site is not situated within a reservoir flood zone as designated by the Environment Agencies Reservoir Flood Map.

3.0 Proposed Structural Works

3.1 Introduction

The proposed development of the site involves the construction of a new three storey mixed use dwelling with single level basement below, a courtyard to the west side, and landscaping to the remainder of the site. Generally, the proposed depth of excavation below the existing ground level is approximately 3.85m, with a maximum of 4.85m considered for the lift area. This includes allowance for a generous blinding layer and a lift pit which may be not be required depending on the final choice of lift.

3.2 Demolition Works

There are no demolition works required, only the removal of the existing paving and the playground installations.

3.3 New Basement Structure

3.3.1 The proposed foundation solution is a ground bearing raft and the permanent basement box will consist of this in-situ reinforced concrete (RC) raft, perimeter RC retaining walls and an RC ground floor slab. The basement excavation will be formed using temporary sheet pile retaining walls. These will be propped near the top as the excavation progresses so that ground movements can be kept to a minimum. In the permanent case, the RC retaining walls will be propped by the ground floor slab to provide a stiff construction and avoid lateral movement of the top of the retaining wall. Temporary propping is proposed to be installed as per drawing 1402_CS_080 which shows the proposed construction sequence for the construction of the basement box.

3.3.2 Initial calculations for the proposed propped temporary sheet pile wall show that a toe depth of approximately 6m below ground level would be adequate to achieve equilibrium in passive and active pressures on the retaining wall. At this early stage a conservative toe depth of 7.5m has been assumed in the design to allow scope for design development. The piling type adopted is a Giken pile so that the Giken Silent Pile installation Method can be adopted, this allows the piles to be installed using a vibration-free, noise-free, static load press-in method with minimal influence on the surrounding environment. A preliminary sheet pile calculation is included in Appendix B. the final design of piles will be undertaken by a specialist contractor. It is not anticipated that any pre-augering or jetting would be required as the granular material in the made ground can be removed with shallow trenching if required before the sheet piles are installed. The neighbouring foundations are sufficiently deep to allow shallow trenches to the required depth without risk of undermining.

3.3.3 There is a Thames Water sewer in the road in front of the proposed site, please refer to the Thames Water asset search information contained in the Soiltechnics GI report and the survey drawing included in the Soiltechnics BIA report. Where non-impact piling works are carried out within 3 metres of a Thames Water sewer an asset protection study is required to make sure there is likely to be no structural impact on the assets. In this case the non-impact piling works on the site will be more than 3m from the Thames Water Asset in the road therefore the works are not likely to have an impact.

3.3.4 As set out in section 2.2.1 the ground below the basement raft is London clay formation. If clay is unloaded it tends to heave as the pressure removed allows an increase in moisture or rehydration of the clay resulting in a volume increase or heave. For the proposed structure the clay will only be unloaded for a relatively short period of time due to the excavation of ground to form the basement. Load will be re-applied to the ground as the new construction progresses. It is anticipated that the load from the new structure will be slightly lighter than the load removed due to excavation therefore the permanent movement will be a small heave of the ground. The basement raft will be designed to resist the upwards pressure from the ground like an upside-down slab spanning between vertical loadbearing elements.

3.3.5 Ground water was not observed in the monitoring standpipe installed in borehole 1 (see section 2.2.2) on the return visit. It is anticipated that the groundwater level does not sit within the proposed maximum excavation depth of 4.85m and the cohesive soil is not likely to promote seepage of water. However, it may be necessary to allow for pumping measures during construction should there be heavy rainfall during this period, due to the poor infiltration properties of the ground. In the permanent condition the reinforced concrete box be lined with waterproof tanking and will have a cavity wall system internally in grade 3 areas.

3.3.6 The concrete structure will be designed to EN1992 with full top and bottom reinforcement to all sections. The concrete in itself is not a watertight / waterproof construction and in order to achieve a Grade 3 'habitable' basement in accordance with BS8102 a combination of external tanking system with an internal drained cavity system will be provided. However, the final waterproofing system is yet to be agreed with the architect.

3.3.7 The RC basement structure is classified as a "robust" structure and any accidental lateral loading applied to the new basement structure can be resisted / absorbed by the new RC structure.

4.0 Control of Movement

The proposed basement scheme and method of construction are of a typical form for which we are confident that resulting ground movements can be controlled in both the temporary and permanent condition. The movements will be carefully monitored throughout the works and propping adjusted as required to keep movements within allowable limits. Refer to section 6.0.3 Monitoring.

4.0.1 Vertical Movement

The completed project will result in an overall reduction of load at the base of the foundation because the weight of the ground excavated to form the basement is slightly heavier than the load introduced due to the construction of the proposed building. This will result in a small heave of the site in the long term, which may take some 10 years to occur. This is well within the typically anticipated ground movements for projects of this scale and due to the timescale of the movement and the small movement anticipated this is not anticipated to cause any damage to neighbouring structures. Please refer to Soiltechnics Ground Investigation Report (September 2017).

4.0.2 Horizontal Movement

Horizontal deflection to the perimeter of the basement excavation will be limited by propping of the retaining walls in both the temporary and permanent conditions. In the temporary condition the sheet pile wall will be propped using pre-loaded adjustable steel props installed between walls as the excavation progresses. Used in conjunction with strict movement monitoring the props can be adjusted if required to keep movement within allowable limits. (Refer to item 4.0.3 for details on envisaged ground movements). In the permanent condition, the RC retaining walls will be propped by the ground floor slab to prevent movement.

4.0.3 Ground Movement Analysis

A ground movement analysis has been undertaken due to the presence of the neighbouring properties, this is included in the Soiltechnics BIA report. Anticipated movements have been calculated and used to assign 'damage criteria' categories in accordance with CIRIA Report C580 and C760, which use the Burland Scale of assessment. The findings of the analysis are that considering the small movements anticipated due to the construction of the basement adjacent to No. 23 Carol Street the work can be carried out without imposing more than 'negligible' damage to the adjacent property at No. 23 i.e. category 0. The adjacent property at No. 23 is assumed to be the most critical neighbouring structure due to its proximity to the basement therefore, the structure at No. 43 and the services in the road, e.g. Thames Water pipes, are also expected to be well within the 'negligible' category for damage, category 0.

In progressing with the detailed design of the scheme the ground movement assessment will be re-assessed at each stage due to the proximity of the adjacent structures. This assessment would

build on the current movement analysis model and account for final design proposals, sequencing and temporary works. Values of envisaged displacements can then be used to inform boundaries on allowable movements to ensure damage criteria of the adjacent properties in accordance with CIRIA Report C580 does not exceed agreed limits.
The Camden Council guidance also uses the Burland scale for the assessment of damage categories and maintains that as Burland states; "it is a major objective of design and construction to maintain a level of risk to buildings no higher than category 2, where there is only risk of aesthetic damage to buildings". The council requires that for any anticipated damage of 'very slight' or higher the BIA should include mitigation measures for the proposed scheme and a re-assessment of the consequences. The anticipated damage category for this project does not go beyond negligible damage therefore this is well within the council's required limits.

5.0 New Superstructure

5.1 Superstructure – Structure

5.1.1 A reinforced concrete frame structure is proposed for the superstructure with flat slab floors forming the horizontal structure and a combination of walls and columns providing the vertical structure. The roof will be a steel frame with timber infill. The external reinforced concrete walls and internal walls up to roof level will provide stability to the building. The concrete floor slabs and the steel and timber roof will transmit lateral loads back to the walls through diaphragm action.

5.1.2 The reinforced concrete walls and columns will carry the vertical loads down to basement level where the ground bearing raft will transfer these loads to the ground.

5.2 Superstructure - Disproportionate Collapse

5.2.1 The Building Regulations require that the building shall be constructed so that in the event of an accident the building will not suffer collapse to an extent disproportionate to the cause. The new building will be mixed use therefore, rather than a solely residential Consequence Class 1, the structure will be classified as Consequence Class 2A based on the building type and occupancy.

The requirements of the regulations will be met by designing the structure to provide effective horizontal ties or effective anchorage of suspended floors and roofs to walls.

6.0 Temporary Works

6.0.1 Temporary Works
The contractor will be responsible for the design, erection and maintenance of all temporary works in accordance with all relevant Eurocodes and British Standards. The contractor will be contractually obligated to appoint a qualified temporary works engineer to provide adequate temporary works and supervision to ensure that the stability of the excavations and surrounding structures are maintained at all times.

6.0.2 Submissions
The contractor will be required to submit full proposals, method statements and calculations to the engineer and all appropriate parties (party wall surveyors, etc.) for approval prior to the start of any works on site. The contractor will also be required to appoint a Temporary Works Co-ordinator for the duration of the contract in accordance with the specification and BS 5975.

6.0.3 Monitoring
All items of temporary works and surrounding structures should be monitored in a manner and frequency commensurate with the construction activity taking place. As a minimum the monitoring should include a daily full visual survey of all temporary works and surrounding structures and a

weekly measured survey using fixed survey points during the main basement works, subject to proposed construction sequence, party wall agreement, etc.
The final monitoring strategy will be developed by the Contractor however, due to the proximity of neighbouring buildings, a strict monitoring regime will be required, and the propping will be adjusted as required to keep any movements within allowable limits.
Anticipated trigger levels are shown in the table below for monitoring of the retaining wall, please refer to Soiltechnics BIA report section 5.2 Ground Movement Analysis for explanation of the anticipated movements that these trigger levels relate to and the limited damage category that these movements represent.

	Vertical Movement		Horizontal Movement	
	Trigger Level	Action Level	Trigger Level	Action Level
Monitoring during the works	5mm	8mm	7mm	10mm

Trigger Level: Submit proposals for ensuring action values are not exceeded

Action Level: Stop work and inform Structural Engineer and CA immediately, await further instruction.

7.0 Construction Method Statement

The outline construction sequence and temporary works assumed in the design is described below and on drawing 1402_CS_080. These will be superseded by the contractor's proposals.

Basement construction sequence

- Install temporary sheet piles, using a silent piling method to avoid vibration, with top level just below underside of proposed ground floor slab
- Excavate to below the propping position and install temporary waling beams and horizontal props to prop top of sheet pile wall
- Excavate to formation level
- Construct the in-situ reinforced concrete basement box; raft and retaining walls
- Retaining walls are to be constructed up to underside of the temporary props
- Install a second layer of temporary waling beams and props to the top of the RC retaining walls
- Remove the original layer of props to the sheet pile walls and complete the basement box construction i.e. the remaining height of retaining wall and the ground floor slab
- Once the ground floor slab is in place this provides a permanent prop to the RC retaining walls so the remaining temporary props can be removed

8.0 Design Criteria

8.1 Code of Practice

Basis of Structural Design EN1990
Actions on Structures EN1991 (BS6399 – Part 1,2 &3)
Design of Concrete Structures EN1992 (BS8110)
Design of Steel Structures EN1993 (BS5950)
Design of Timber Structures EN1995 (BS 5268)
Geotechnical / Design of Concrete Building and Civil Engineering Structures EN1997 (BS 8004)

8.2 Loading – Imposed loadings to BS 6399

Domestic areas = 1.5 kN/m²
Artist Workshop = 25 kN/m²
Artist Studio = 7.5 kN/m²
External areas = 3.0 kN/m²
Roof (flat with access) = 0.75 kN/m²
Roof (pitched) = 0.6 kN/m²

8.3 List of relevant drawings

8.3.1 eHRW Sketches (Appendix A):

1402_GA_002
1402_GA_003
1402_GA_004
1402_GA_005
1402_GA_006
1402_SE_010
1402_SE_011
1402_CS_080

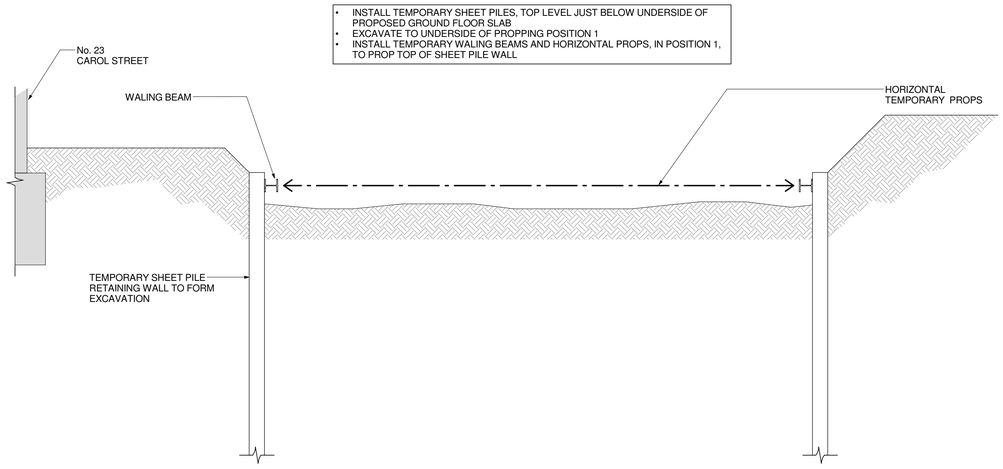
8.3.2 Architects Drawings (not included in report):

CRL GA000S BASEMENT
CRL GA001S GROUND FLOOR
CRL GA002S FIRST
CRL GA003S SECOND
CRL GA004H ROOF
CRL GA101K FRONT ELEVATION
CRL GA102M REAR ELEVATION
CRL GA103H FLANK WEST ELEVATION
CRL GA104F FLANK EAST ELEVATION

9.0 Conclusion

A preliminary feasibility assessment of the proposed scheme has been undertaken although detailed calculation checks, investigations and full design will need to be completed. At this stage, we are satisfied that the proposed scheme is viable and that if carried out in a carefully defined sequence, similar to that noted above, it can be completed without compromising the structural stability of any adjacent properties or structures.

APPENDIX A - eHRW Sketches



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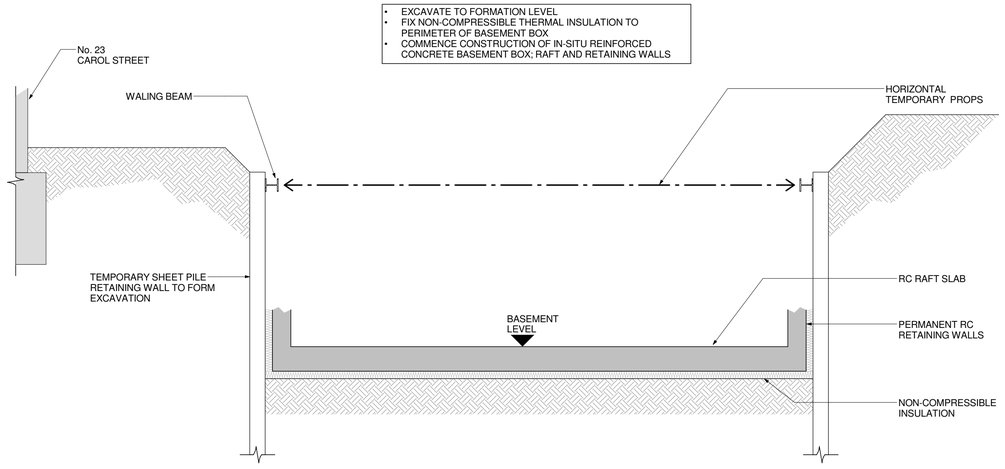

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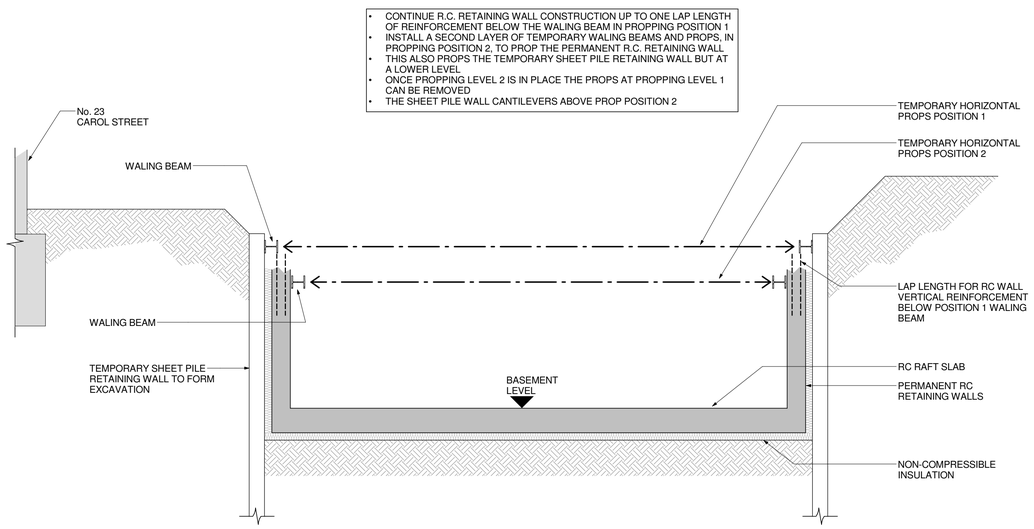

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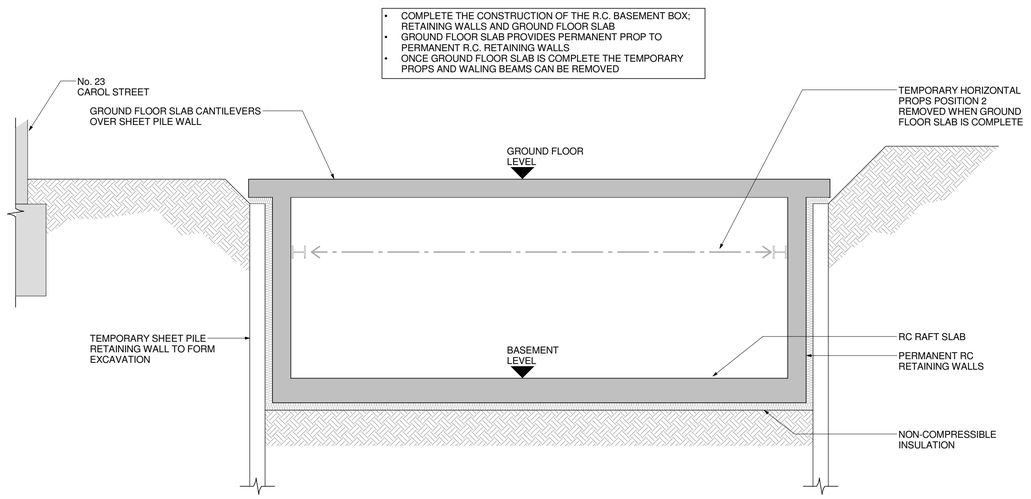

Stage 4
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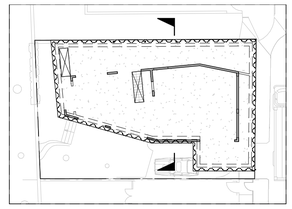
NOTES

1. DO NOT SCALE FROM THIS DRAWING
2. THESE DRAWINGS ARE TO BE READ IN CONJUNCTION WITH ARCHITECTS AND OTHER CONSULTANTS INFORMATION

ALLOW FOR GROUND WATER DEWATERING SYSTEM DURING BASEMENT CONSTRUCTION. GROUND INVESTIGATION REVISED GROUND WATER LEVEL - 1.23m BELOW EXISTING GROUND LEVEL.
GIVEN THE PRESENCE OF A NON-AQUIFER BELOW THE SITE IT IS LIKELY THAT THE GROUNDWATER RECORDED WITHIN THESE SOILS RELATES TO PERCHED WATER WITHIN THE MADE GROUND AND WATER WITHIN MORE PERMEABLE POCKETS IN THE CLAY AND IS RECHARGED VIA INTERMITTENT SEEPAGES FROM SURFACE WATER ASSOCIATED WITH WEATHER CONDITIONS RATHER THAN ANY LARGE SCALE SUBTERRANEAN GROUNDWATER FLOW

ALLOW FOR SUPER BRACING STRUTS (SBS) SYSTEM BY MABEY HIRE SERVICES OR SIMILAR APPROVED. THE STRUTS TO BE USED IN COMBINATION WITH MABEY HIRE SERVICES SUPER STRUCTURE (WALING). EACH STRUT TO HAVE ADJUSTABLE HYDRAULIC UNIT. ALTERNATIVELY ALLOW FOR TEMPORARY PROPPING TO BE CONSTRUCTED WITH STEEL HOT ROLLED SECTIONS (MIN. 118kg/m). FINAL TEMPORARY WOKS DESIGN TBC BY TEMPORARY WORKS SPECIALISTS



kEY PLAN

WORK IN PROGRESS

Rev	Date	Amendments	By	Chk'd
P1	03.08.17	ISSUED FOR INFORMATION	EP	AB

engineersHRW
London 0207 407 9575 Oxford 01865 251 206 www.ehrw.co.uk

Project:
Carol Street N1

Drawing title:
Construction Sequence

Scale at A1:	Drawn by:	Date:	Chk'd by:
As indicated	EP	July 2017	AB

INFORMATION

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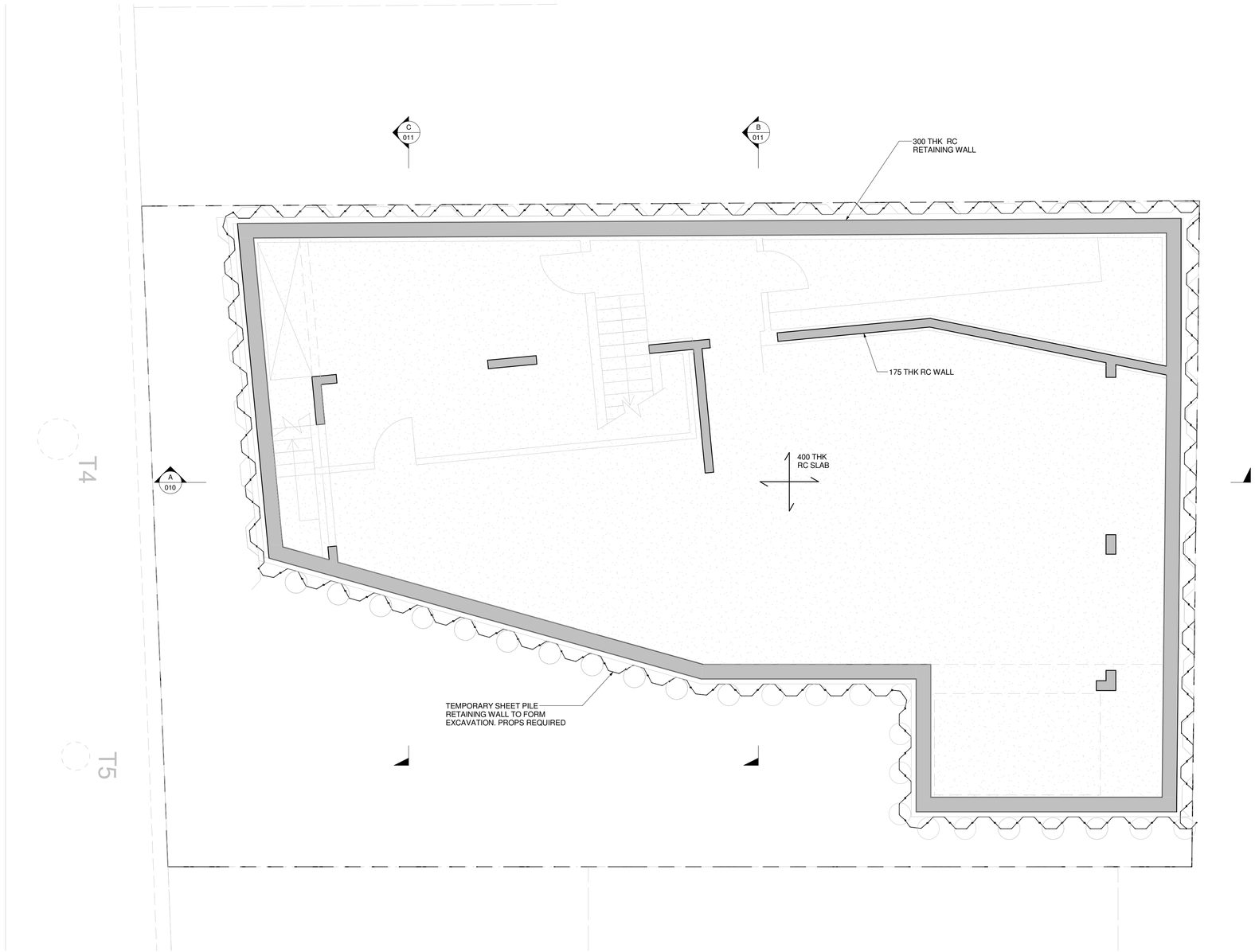
1402	CS	080	P1



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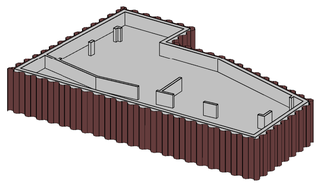

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WORK IN PROGRESS

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Project:
Carol Street N1

Drawing title:
Basement Plan

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INFORMATION

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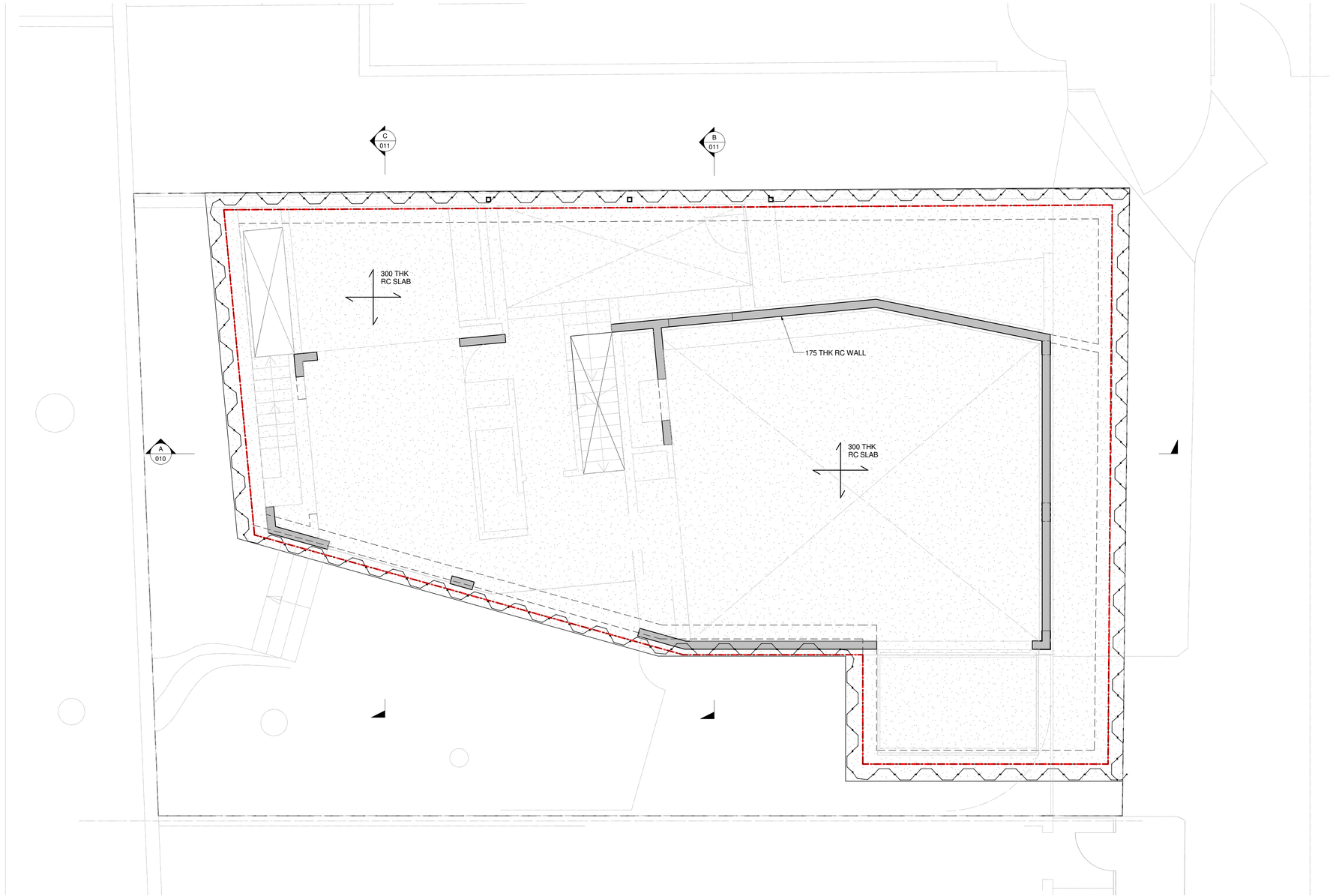

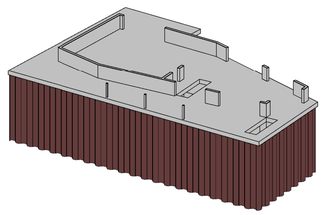

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P1	03.08.17	ISSUED FOR INFORMATION	EP	AB

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Project:
Carol Street N1

Drawing title:
Ground Floor Plan

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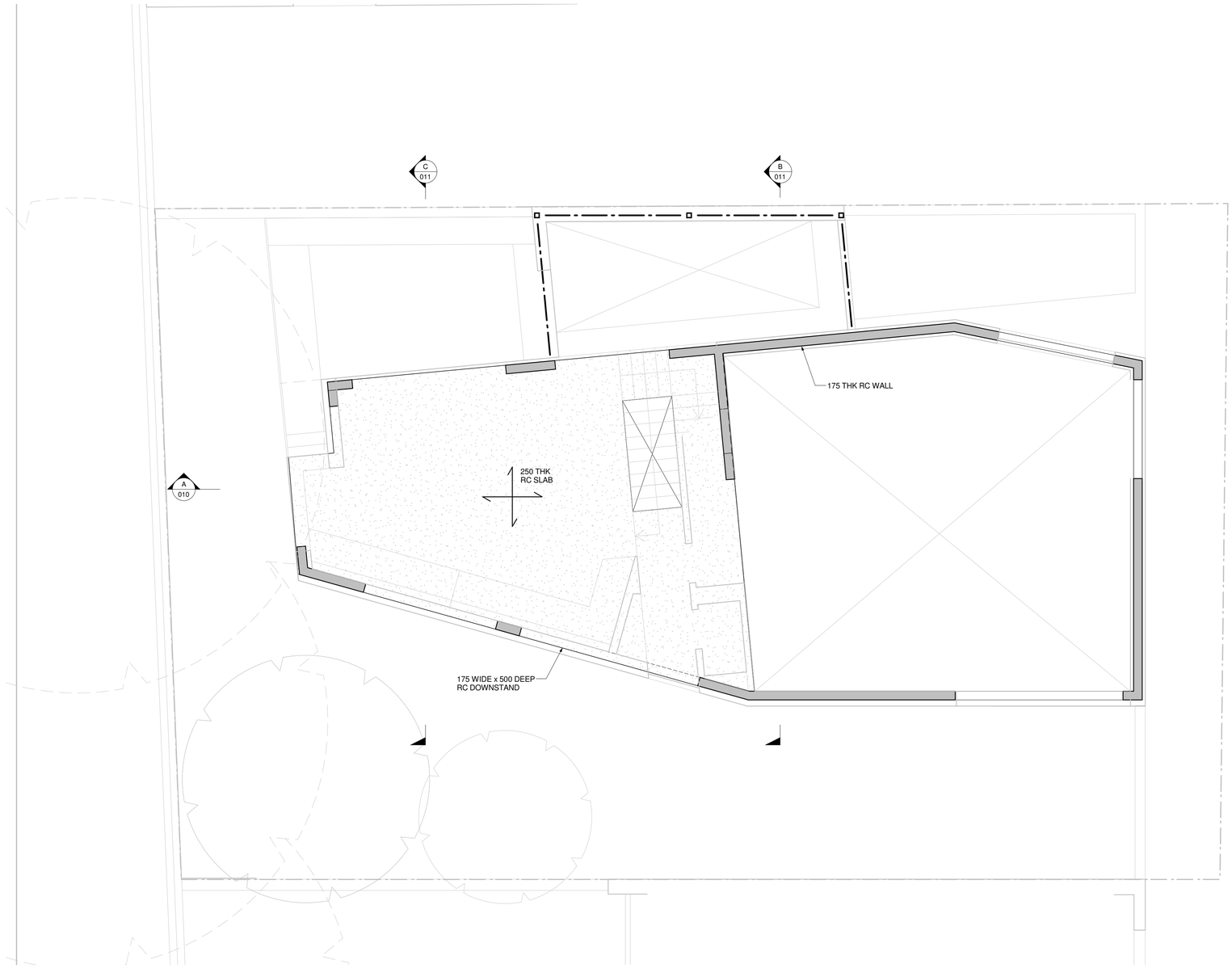

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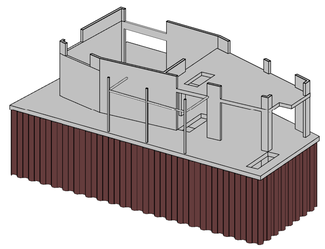

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WORK IN PROGRESS

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engineersHRW
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Project:
Carol Street N1

Drawing title:
First Floor Plan

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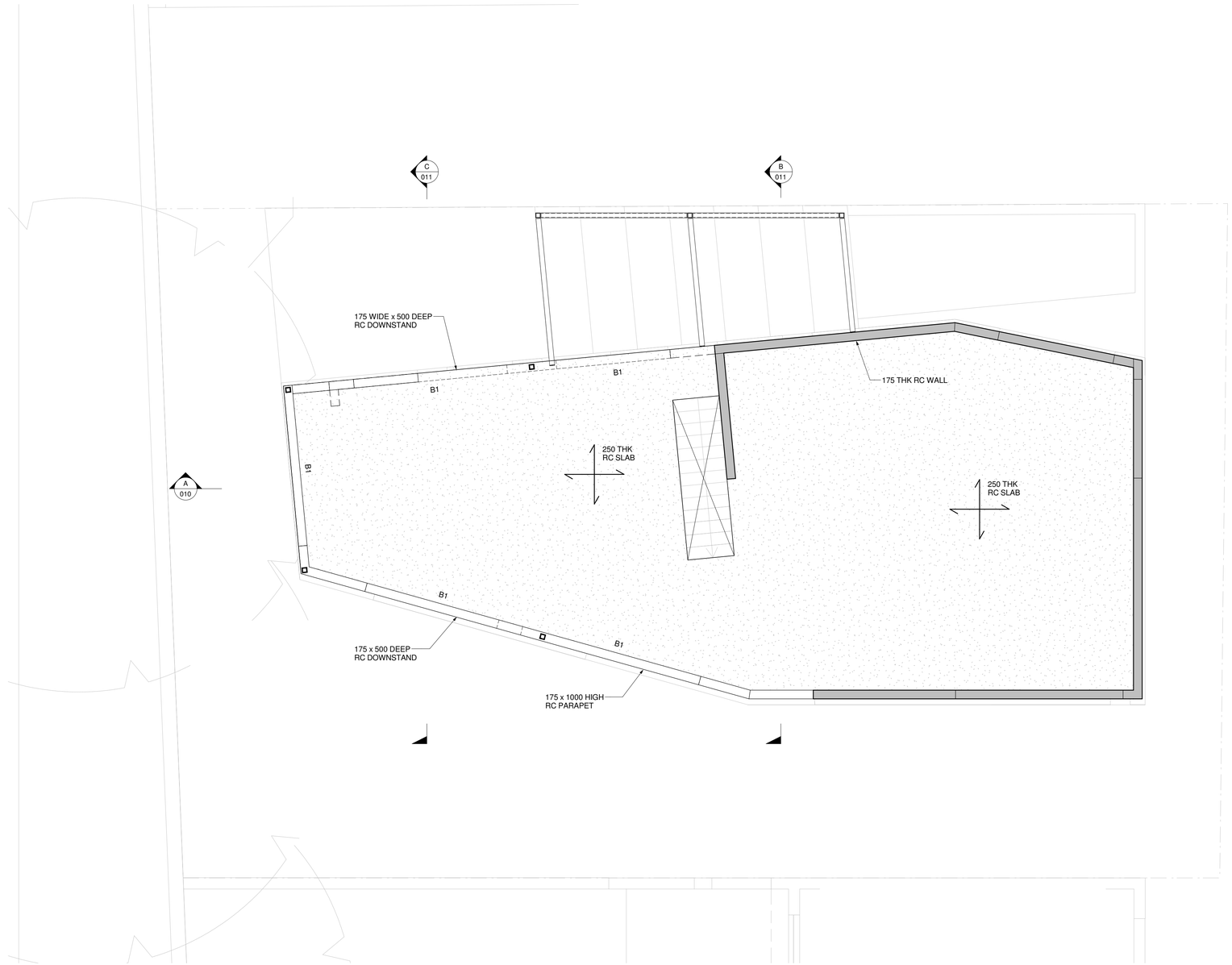

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RC Beam Schedule

REF	SIZE
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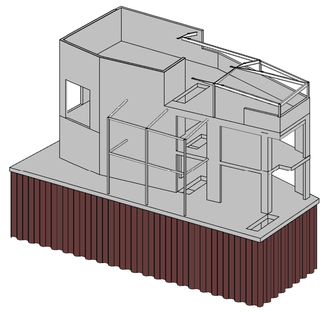

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WORK IN PROGRESS

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engineersHRW
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Project:
Carol Street N1

Drawing title:
Second Floor Plan

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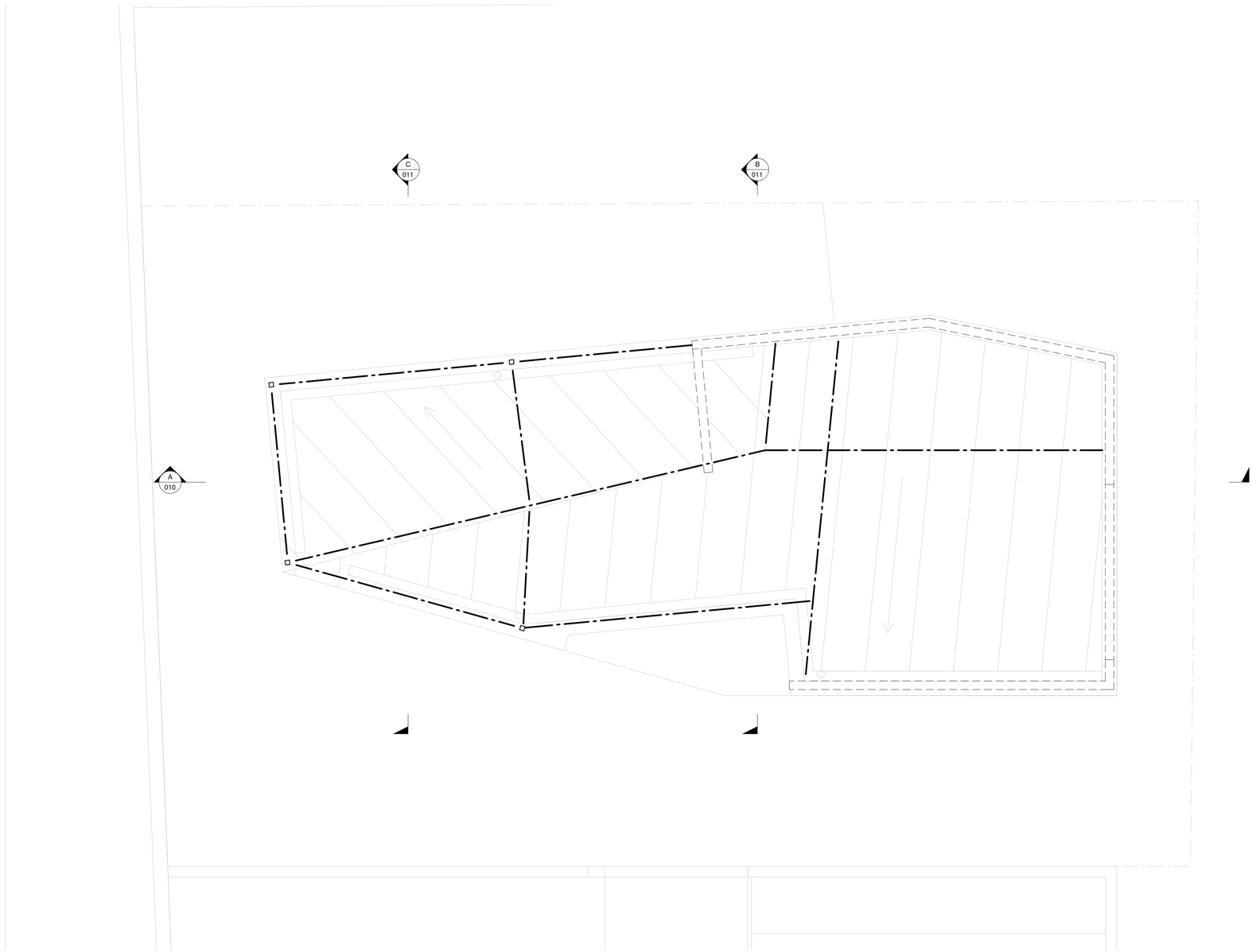

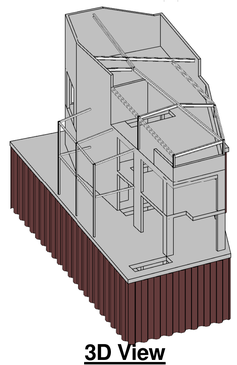

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WORK IN PROGRESS

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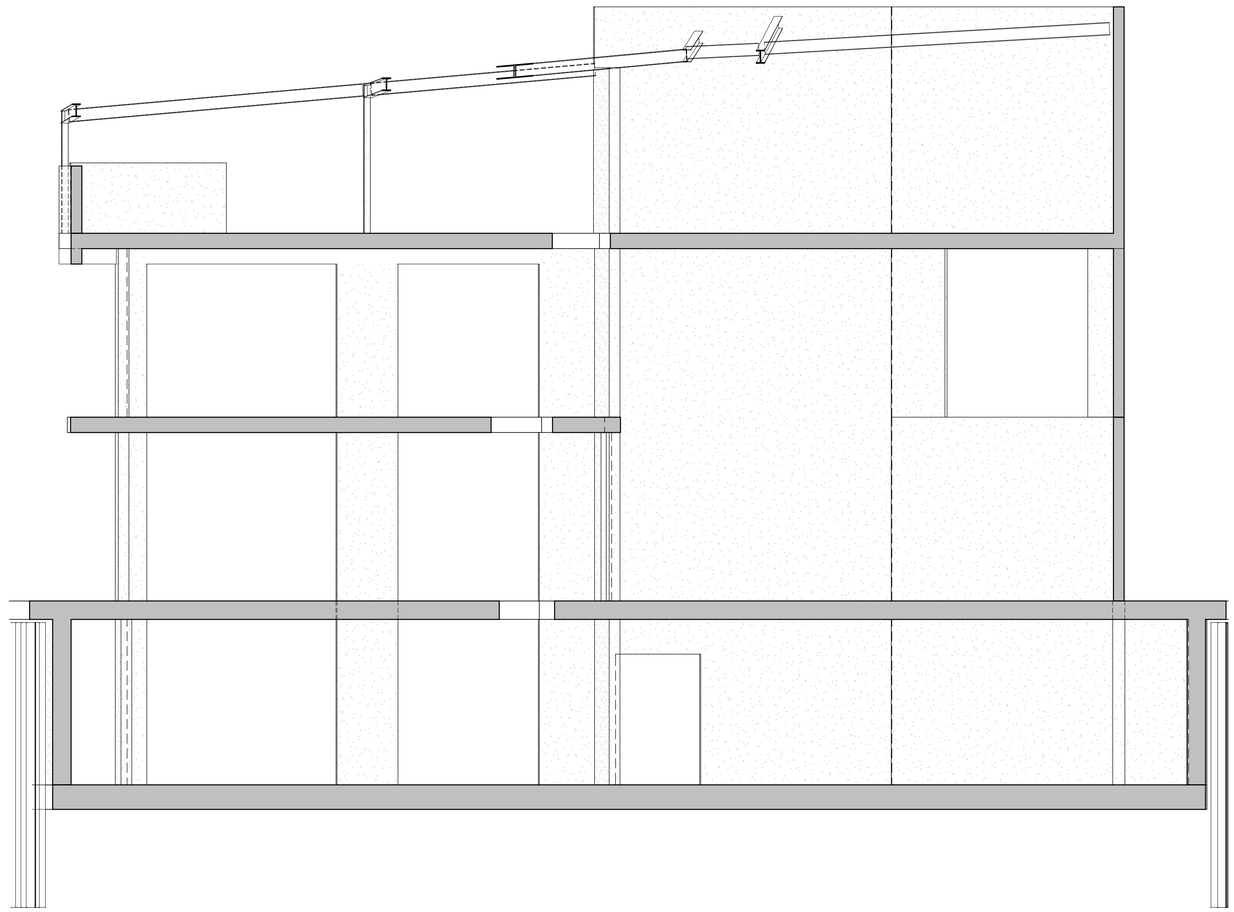
Project:
Carol Street N1

Drawing title:
Roof Plan

Scale at A1:	Drawn by:	Date:	Chk'd by:
1 : 50	EP	July 2017	AB

INFORMATION

Project Number:	Drawing Type:	Drawing No:	Revision:
1402	GA	006	P1



Section A - A
Scale 1 : 50

1:50 0 1000 2000 3000 4000 5000

NOTES

1. DO NOT SCALE FROM THIS DRAWING
2. THESE DRAWINGS ARE TO BE READ IN CONJUNCTION WITH ARCHITECTS AND OTHER CONSULTANTS INFORMATION

WORK IN PROGRESS

Rev	Date	Amendments	By	Chk'd
P1	03.08.17	ISSUED FOR INFORMATION	EP	AB

engineersHRW
London 0207 407 9575 Oxford 01865 251 206 www.ehrw.co.uk

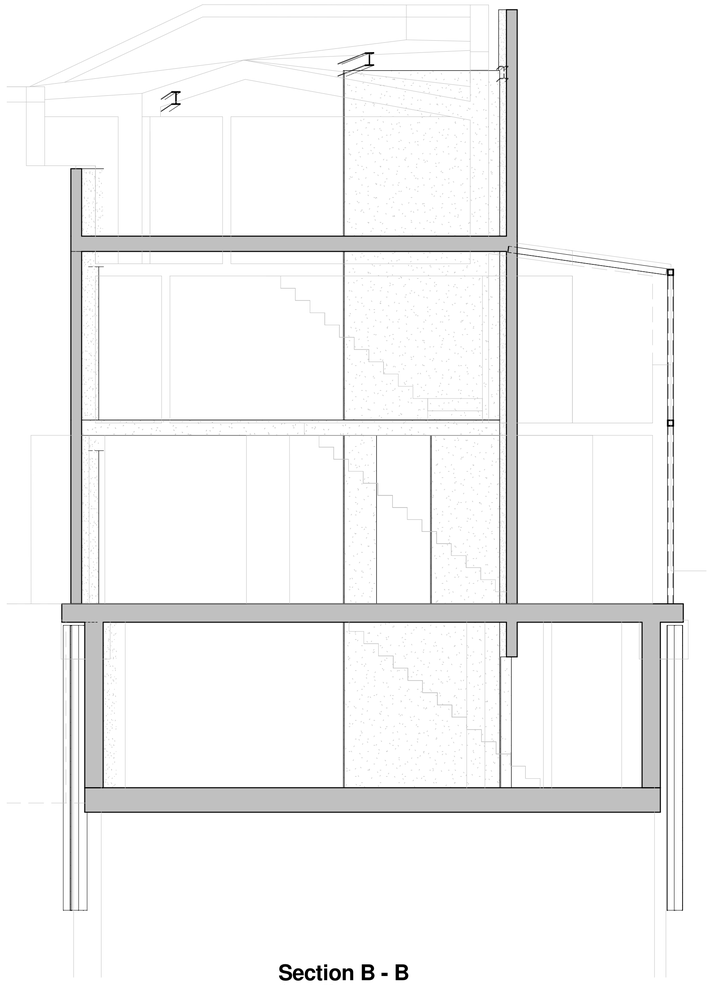
Project:
Carol Street N1

Drawing title:
Section A - A

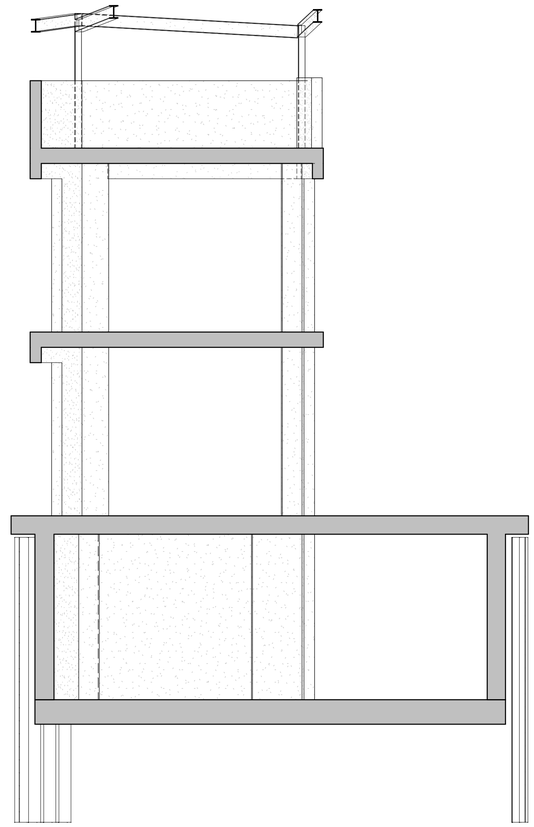
Scale at A1:	Drawn by:	Date:	Chk'd by:
1 : 50	EP	July 2017	AB

INFORMATION

Project Number:	Drawing Type:	Drawing No:	Revision:
1402	SE	010	P1



Section B - B
Scale 1 : 50



Section C - C
Scale 1 : 50

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NOTES

1. DO NOT SCALE FROM THIS DRAWING
2. THESE DRAWINGS ARE TO BE READ IN CONJUNCTION WITH ARCHITECTS AND OTHER CONSULTANTS INFORMATION

WORK IN PROGRESS

Rev	Date	Amendments	By	Chk'd
P1	03.08.17	ISSUED FOR INFORMATION	EP	AB

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Project:
Carol Street N1

Drawing title:
Section B - B

Scale at A1:	Drawn by:	Date:	Chk'd by:
1 : 50	EP	July 2017	AB

INFORMATION

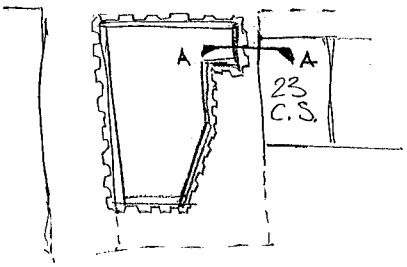
Project Number:	Drawing Type:	Drawing No:	Revision:
1402	SE	011	P1

APPENDIX B – Preliminary Propped Temporary Sheet Pile Calculation

engineersHRW	Job No. 1406	Sheet No. 1	Revision
	Member Location		
Job Title Carol Street.	Drawing Ref.		
Section Sheet Pile - Temporary Retaining Wall	Made by AB	Date 09/02/18	Checked

Temporary Sheet Pile Wall

Preliminary Design Summary

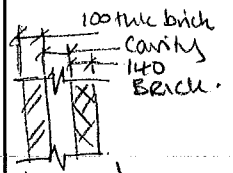


Key Plan.

The retaining wall is in closest proximity to a neighbouring bldg at the front corner beside no. 23 Carol St. A trial pit was carried out to this neighbouring wall showing that the footing is based approx. 1.9 m below ground level.
This is the worst case location ∴ critical calc.

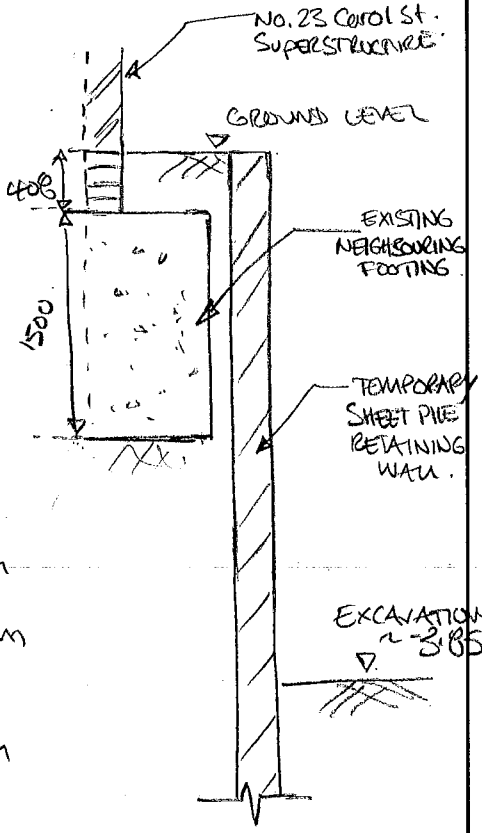
No. 23 Carol St
3 storey terrace house

assume typical domestic construction, joists span front-to-back.



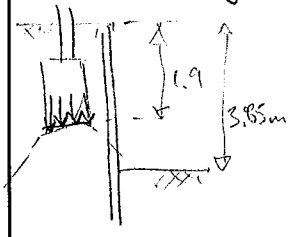
walls. 2 leaf cavity wall.
self wt wall:
$0.1 \times 20 + 0.14 \times 18 = 4.5\ kN/m^2$
$\times$ 9.4m high = 43 kN/m

Load to base of footing?
Footing width - projection ~ 600mm from trial pit.
∴ full width of footing
600mm each side + width of wall.
≈ 1500 mm.
∴ Load at base of footing:
≈ 29 kN/m²
include self-wt concrete footing = $59\ kN/m^2$



Section A-A
scale ~ 1:50.
temporary case.

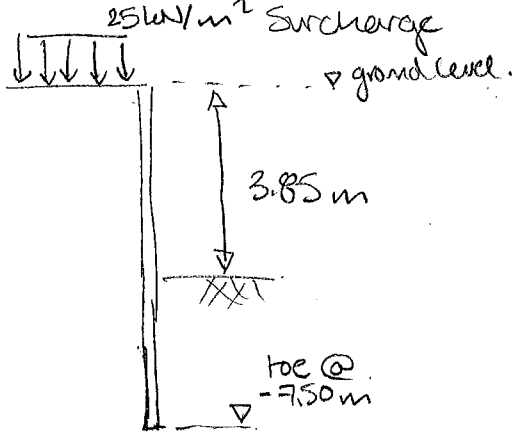
Using Tedds calc. to estimate forces in retaining wall.



need to model as retaining wall with a surcharge ∴ approximate this design scenario

Load from existing wall footing loads approx. 1/2 height of retaining wall.
Load from an applied surcharge loads full height of retaining wall.
Estimate surcharge load that would result in similar effect on wall so similar pressure at −1.9 m.
weight of soil $1.9\ m \times 18\ kN/m^3 = 34.2\ kN/m^2$
∴ use surcharge at top of $25\ kN/m^2$

Equivalent analysis model to be used



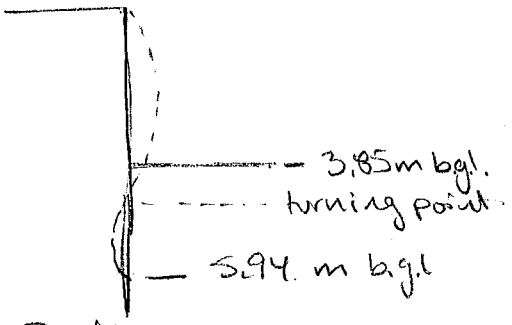
Excavated depth = 3.85m

Propped at 0.3m bgl.

Surcharge = 25kN/m²

Toe depth assumed = 7.5m b.g.l.

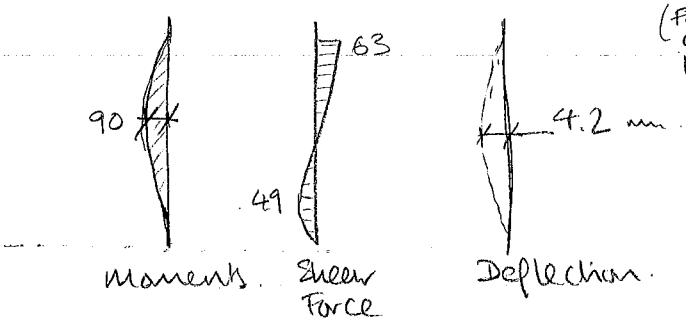
From analysis:



Deflected shape diagram.

Max. moment in pile = 90 kNm/m.
Min. required section modulus = 399 cm³/m.
Tie/prop load = 68.4 kN/m.

Minimum required length of sheet pile
5.94m < 7.5m provided ∴ ok.
Turning point estimate = 4.90m b.g.l.



(Force diagram opposite direction to excavation diagram!)

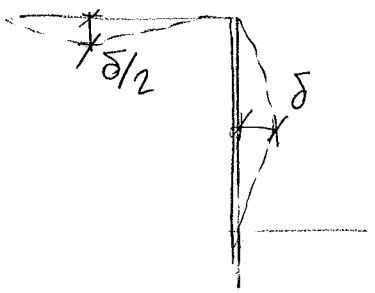
Pile adopted. Given U-pile IV

Silent piling method.

Section width = 400
Section hight = 340
Sectional area = 242.5 cm²/m
Moment of inertia = 38,600 cm⁴/m
Section modulus = 2,270.0 cm³/m > min required modulus 399 ∴ ok.

moment capacity of pile = 615 kN/m. >> max. moment = 90 ∴ ok.

Pile design adequate.
Consider deflections...



Using CIRIA C580 guidance on movement of ground behind a retaining wall in stiff ground note we have London Clay below top layer of Made Ground.

Relationship: vertical movement of ground behind retaining wall is approximately half of the lateral movement of the retaining wall.

$\delta_{horizontal} = 4.2\,mm$

$\therefore \quad \delta_{vertical} = 2.1\,mm$

These are less than the movements estimated and discussed in the Soiltechnics BIA Ground Movement Analysis therefore please refer to this document for estimate of strains and damage categories for the neighbouring masonry walls.