HALSTEADS
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15 HOWITT ROAD
BELSIZE PARK
LONDON, NW3 4LT

STRUCTURAL METHODOLOGY STATEMENT

PREPARED FOR
Mr S Ioannou

Date: APRIL 2023
Revised: SEPT 2023

Ref: 19131 Rev A
Prepared by: DO
Checked by: DG

CONSULTING engineers
QUANTITY surveyors
PROJECT coordinators
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Contents

1 Brief

1.1 The Structural Engineering design brief was to produce a structural methodology statement and a feasibility study into creation of a new basement and rear extension to an existing two storey semi-detached house at 15 Howitt Road, Belsize Park, London NW11 4LT. The existing building is a two storey (ground and first) house. The house sits on a site which is raised slightly above the public highway to the front and which is roughly level between the front and rear of the site.

(Figure 1: Aerial view of site)

1.2 To the left side of the site, the house shares a party wall with 13 Howitt Road. Similarly, on the right hand side a party wall is shared with 17 Howitt Road.

1.3 The proposed works will involve forming a new full height basement under the footprint of the existing building along with internal restructuring at upper floor levels. A new lightwell to the front of the house will provide light into the new basement space, as well as giving access to the lower level from the public footpath. The works will require structural alterations to the superstructure and support of load-bearing walls and members at upper floor levels.

1.4 This report is to be read in conjunction with the following reports and drawings:

- Site Analytical Services, Ref. 23/36419-2, Basement Impact Assessment, March 2023
- Halstead Associates Drawing No. 19131/PL01, Basement Plan April 2023
- Halstead Associates Drawing No. 19131/PL02, Proposed Ground Floor Plan April 2023
- Halstead Associates Drawing No. 19131/PL03, Proposed Basement Sections April 2023
- Halstead Associates Drawing No. 19131/PL04, Suggested Construction Sequence April 2023

1.5 A cellar area exists in the basement under a part of the footprint of the existing building and is typical in houses of this age and layout. The height of cellar is approximately 1.8 m. In order to achieve the new floor-to-ceiling height in this area, the existing walls will be underpinned and extended down to the new floor level. The existing external walls are expected to be underpinned in reinforced concrete to a suitable level to form the new basement space.

2 Screening

2.1 Structural Stability Screening Assessment

I.	Does the proposed basement involve underpinning of the existing building?	Yes
II.	Does the proposed basement extend lower than the adjacent structure to the right?	Yes
III.	Does the proposed basement extend lower than the Party Wall to the left?	Yes
IV.	Does the proposed basement extend below the Party Wall footing level to the right?	Yes
V.	Does the proposed basement extend lower than the building structure to the left?	Yes
VI.	Does the proposed basement undermine the public highway?	Yes

3 Site Investigation

3.1 This assessment has been informed by the results of a site investigation report prepared by Site Analytical Services Ltd (SAS), dated March 2023, together with a Geotechnical and Hydrological Basement Impact Assessment. These have shown that the proposed basement will not affect the existing ground water regime, and that the existing groundwater levels are expected to be well below the level of the proposed basement floor with only localised pockets of surface water possible to appear following a heavy rainfall.

3.2 The British Geological Survey indicates that the site is directly underlain by solid deposits of the London Clay Formation. The geotechnical investigation confirmed the presence of London Clay, below a surface layer of Made Ground of approximately 1.3 metres in thickness.

BGS extract

3.3 London Clay is a generally stable material and not typically prone to collapse in short term excavations. Notwithstanding, in line with good construction practice, temporary shoring would be required in all underpinning excavations below the existing building.

3.4 It will be feasible to support the new proposed rear extension on conventional strip footings taken down below the layer of made ground and any weak superficial deposits or soils affected by seasonal moisture content changes. According to the site investigation report, the new substructure can be designed for the allowable net ground bearing pressure of 150-200kN/m2 at 2.5m below ground level

3.5 No adverse groundwater conditions would be expected to occur which would significantly affect either construction of the basement or the completed structure. Groundwater was encountered in the borehole at 7.34m below ground level. Any shallow groundwater encountered water encountered would be expected to be surface water trapped in pockets of the less cohesive ground/ made ground. The rate of flow of any ground water encountered would likely be low and slow moving owing to the cohesive nature of London clay. Excavations for the underpinning would not, therefore, be impacted by groundwater, with any minimal inflows being controlled by localised pumping.

3.6 Due to presence of overconsolidated soil with high volume change potential, a suspended floor slab is recommended at basement level. In the proposed arrangement, (refer to the drawings in the Appendix) the basement slab will need to be designed to span between the reinforced concrete foundations, and the heave pressures resulting from volume change of the soil will be allowed for in the design of the slab by calculating the net pressures acting to the underside of the concrete slab.

3.7 Given the proximity of the adjoining properties, there will be no scope for battering back excavations when forming the basement. A suitably robust temporary propping scheme will therefore need to be proposed by the Contractor and his appointed temporary works engineer.

3.8 The basement formation at 15 Howitt Road should not adversely impact the site, providing adequate measures are taken to protect the surrounding land and properties during construction. This will be achieved by utilising the progressive underpinning type construction in narrow sections and full temporary support of the stem of the wall against the central soil mass which shall be retained for propping. Refer to drawing 18332/PL04 for the suggested sequence of the underpinning works.

3.9 The proposed excavations will extend up to the back edge of the public footway. The cantilevering wall which forms the front lightwell will need to be designed to withstand vehicular surcharge loads.

3.10 The party walls on the left and right hand sides of the property are shared with No. 13 and No. 17 respectively and will need to be underpinned, with the design taking due account of the applied vertical loads from above as well as well as lateral forces from the earth which will be present under the (expected) suspended ground floor structure of the neighbouring property. No. 13 is expected to have a similar mirrored cellar area to No. 15 and it will therefore be possible to revert to mass concrete underpinning locally (refer to Section C-C on drg. 19131/PL03).

3.11 The retaining walls and the individual wall pins are expected to be designed as cantilever retaining walls to resist overturning and sliding in both temporary and permanent loading condition. Whilst groundwater levels are expected to be well below the basement formation level, an allowance should nevertheless be made for the water pressure from the retained ground (reduced in the temporary condition to allow for pumping any water out from the excavations during construction).

Stratum	Depth to top (mbgl)	Bulk Density (kN/m^2) (γ)	Effective Angle of Internal Friction (Φ)
Made Ground	-	16	28
London Clay Formation	0.50 – 1.30	20	24

Retaining wall design parameters

The Basement Impact Assessment has identified a suitable safe bearing pressure at basement level of 150-200kN/m^2. Both the reinforced concrete underpinning and mass concrete internal pad foundations will therefore be designed for the lower figure in this range. The attached calculations in Appendix B for the perimeter underpinning for the construction and permanent phases demonstrates the design.

3.12 According to the SI report, it is considered that deterioration of buried concrete due to sulphate or acid attack is likely to occur (SO_4>4g/l, corresponding to concrete class DS-4/ AC-4).

4 Basement Formation

4.1 Given the proximity to adjacent properties, it is expected that the walls of the new basement extension will be formed in an underpinning type sequence. This will involve carrying out local excavations of around 1.0 -1.2m in width and down to the formation level of the new basement, followed by fixing of reinforcement within the excavations and then casting of concrete to form individual retaining wall sections integral with their bases.

4.2 The sequencing of this work would be such that no more than 20% of a single wall elevation would be excavated at any given time. At the required excavation depth, suitable shoring would be required to provide a safe working area for site operatives. Typical sequencing for the excavation of a wall section is shown on Drawing No. 19131/PL04.

4.3 At the expected depth required for the excavation, it is likely that temporary shoring to the retaining wall sections will be required in the short term in order to prevent overturning and/or sliding, until the basement slab has been installed.

4.4 Given the site constraints, this underpinning will be carried out with access gained from inside the existing cellar and ground floor of the house. As a result, the existing floor structure will have to be locally removed and replaced. Consideration will be given to removal of the floor in discrete sections in order to retain any short-term lateral propping action which may be currently provided by the floor.

4.5 The works will involve the installation of supporting steelwork within the ground floor and first floor to support retained loadbearing elements above. On similar projects a successful sequencing of works has involved the installation of this steel grillage prior to excavating out for the new basement.

4.6 At an approximately 3.00m depth down to formation level, heave forces caused by the removal of overburden are not expected to be significant as long as there are no undue delays in the construction program. Nevertheless, any theoretical heave pressures will be accounted for in the detailed design by the inclusion of anti-heave boarding under the slab or alternatively by designing the rebar in the top surface of the slab to resist these forces.

4.7 The Contractor will provide a method statement prior to commencement of work on site in which full details of hours, site set up and method for the formation of reinforced underpinning sections will be detailed.

5 Construction sequence

5.1 The following construction sequence is envisaged, which will be agreed with the main contractor prior to any works commencing on site:

- Local excavations down to basement level to cast isolated concrete pad footings. Install steel columns up to ground floor level. Backfill excavation.
- Install temporary propping to ground floor loadbearing walls and install steel beams spanning between internal columns and perimeter walls. Remove existing ground floor structure to suit.
- Lower internal ground level to minimise depth of excavation for underpinning. Ground to be banked down at a maximum 30 degree angle from existing footings.
- Underpin the perimeter walls in reinforced concrete, making allowance for the front elevation pins to be linked to the new lightwell retaining wall along the front property line. Limit the width of the individual pin sections to maximum 1.2m in width. Suggested hit-and-miss sequence is shown on drawing 19131/PL01 in the Appendix. Shoring for each pin to be retained and propped against central earth mound.
- Install temporary propping across basement footprint to facilitate removal of central earth mound. Subject to detailed design, all perimeter RC underpins to be propped to eliminate risk of short term sliding/ overturning.
- Cast new RC slab to full footprint of basement. Slab to be tied into underpin sections to create a monolithic box.

6 Ground movement & predicted damage category

6.1 Any ground works pose an elevated risk to adjacent properties. The proposed works undermines the adjacent property along the Party Wall line.

6.2 With reference to the Site Analytical Services Basement Impact Assessment, the predicted level of damage to the adjoining properties is expected to be 'very slight' or less (assuming a high level of workmanship from a competent contractor). However, our experience informs us that there is a small risk of greater than anticipated movement to the neighbours.

6.3 Whilst there is a level difference of approximate 3.0m between the foundations, the adjacent houses are in in excess of 100 years old and any settlement which may have occurred due to consolidation of the founding strata would have taken place during the early years of the life of the building.

6.4 To reduce the risk to the development:

- Employ a reputable firm for extensive knowledge of basement works.
- Employ suitably qualified Consultants. Halstead Associates have extensive experience with basement constructions.
- Design the underpins to be suitably propped during construction until permanent props are in place.
- Provide method statements for the Contractors to follow.
- Investigate the ground
- Record and monitor the external properties. This would be done by a condition survey under the Party Wall Act before and after the works are completed.

6.5 The maximum level of cracking anticipated is Hairline cracking which can be made good with decorative repairs by the appointed contractor. Under the Party Wall Act damage is allowed (although unwanted) to occur to a neighbouring property as long as repairs are suitably undertaken to rectify this. To mitigate this risk, the Party Wall Act is to be followed and Halstead Associates can be appointed to act in this respect.

6.6 Burland Scale:

Extract from The Institution of Structural Engineers "Subsidence of Low-Rise Buildings" Classification of visible damage to walls with particular reference to type of repair and rectification consideration.

Category of damage	Approximate crack width	Limiting tensile strain	Definitions of cracks & repair types / considerations
0	Up to 0.1	0.0 – 0.05	HAIRLINE – Internally cracks can be filled or covered by wall covering and redecorated. Externally, cracks rarely visible & remedial works rarely justified
1	0.2 to 2	0.05 – 0.075	FINE – Internally cracks can be filled or covered by wall covering, and redecorated. Externally, cracks may be visible, sometimes repairs required for weather tightness or aesthetics. NOTE: Plaster cracks may, in time, become visible again if not covered by a wall covering.

7 Monitoring

7.1 Visual movement monitoring, level of monitoring and reporting strategy required are to be agreed subject to consultation between the appointed Party Wall Surveyors for 13, 15 and 17 Howitt Road before the works commence on site.

8 Waterproofing

8.1 As this form of construction will not allow external damp proofing systems to be employed, it is envisaged that the Architect will opt for a proprietary drained cavity system to line the face of the retaining wall and slab. Any inflow of ground water which may result would then be directed to an internal sump and then pumped as necessary into the surface water system.

9 Party Walls

9.1 Given the proximity of adjacent buildings, Party Wall Agreements will be required with neighbouring home owners, particularly in light of the recommendations for monitoring during the works. Halstead Associates can be appointed to act on behalf of the Building Owner.

10 Temporary Works

10.1 It is critical that a competent Contractor who is experienced in this form of residential basement construction is employed for the works. Additionally, given the complex nature of the sequencing of the works, a Temporary Works Coordinator should be employed to ensure that the stability of the ground and adjoining buildings is maintained though out the construction process.

10.2 Significant propping of the existing structure will be required and as such will require careful consideration to ensure the safety of site operatives during construction.

10.3 Whilst suggestions have been provided with this document for the sequencing of the works, it will be the responsibility of the Contractor and Temporary Works co-ordinator to provide detailed proposals for the methodology for the Structural Engineer and design team to review.

David Oates CEng BEng (Hons) MIStructE

11 Appendix A - Drawings

Halstead Associates Drawing No:

- 19131/PL01 – Basement Plan
- 19131/PL02 – Ground Floor plan
- 19131/PL03 – Basement Sections
- 19131/PL04 – Suggested Sequencing of Works

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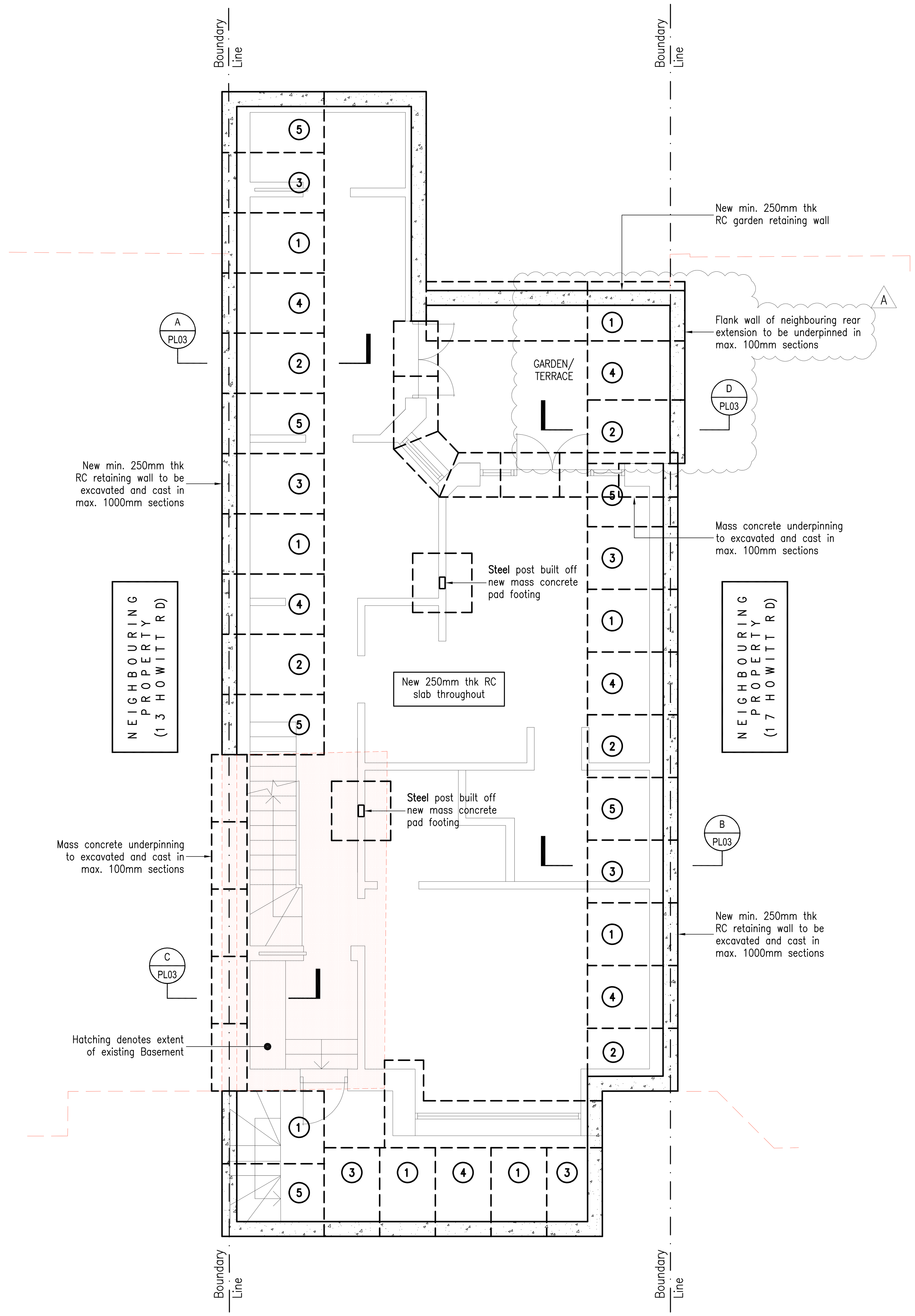
TEMPORARY WORKS
ALL TEMPORARY WORKS ARE TO THE CONTRACTORS DESIGN AND DETAIL

UNDERPINNING SEQUENCE
(X) DENOTES SUGGESTED UNDERPINNING SEQUENCE OF WORKS. FINAL UNDERPINNING SEQUENCE IS TO BE AGREED ON SITE WITH THE CONTRACTOR

ALL FINISHES, DPC, DPM AND VENTILATION ARE TO ARCHITECTS DETAILS AND SPECIFICATIONS

ALL WATERPROOFING AND TANKING DETAILS ARE TO BE PROVIDED BY WATERPROOFING SPECIALIST



BASEMENT FLOOR PLAN

SCALE 1:50

Rev.	Date	Revisions	By	Engineer
A	11.09.23	Underpinning to neighbouring extension flank wall added. Section mark D-D added. Revisions as clouded.	BA	DO

Notes:
1. The drawing is to be read in conjunction with all relevant Consultant's drawings and specifications.

Key:
1. Denotes Section — X
Denotes Drawing Number — XX

PRELIMINARY

Project:	15 HOWITT ROAD, LONDON, NW3 4LT
Title:	BASEMENT FLOOR PLAN
Client:	Mr Ioannou
Architect:	Jane Duncan Architects Ltd
Drawn by:	BA
Checked by:	DO
Date:	27th April 2023
Scale:	AS NOTED @ A1
Drawing No:	19131/PL01
Rev:	A

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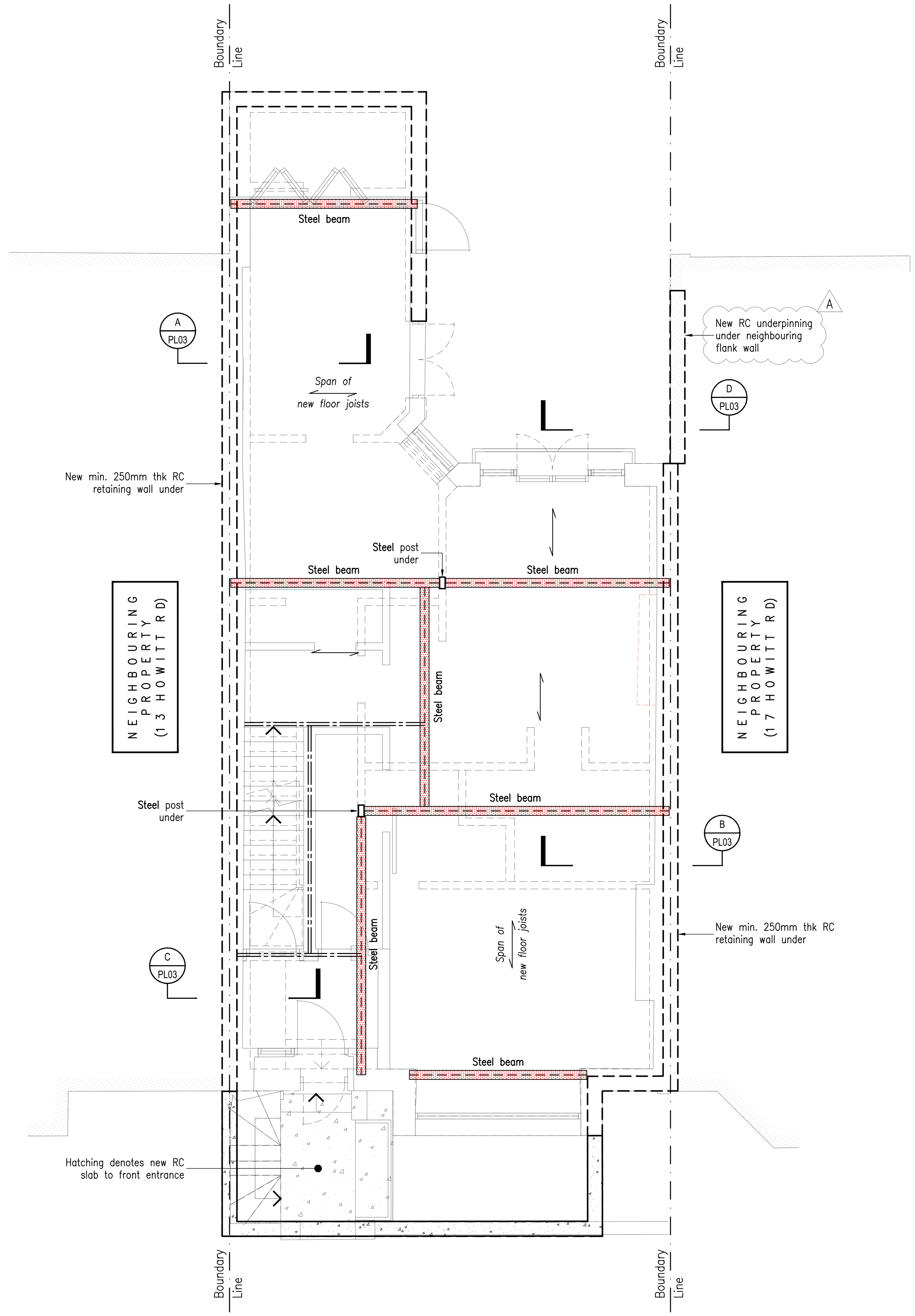

GROUND FLOOR PLAN

SCALE 1:50

Rev.	Date	Revisions	By	Engineer
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Notes:
1. The drawing is to be read in conjunction with all relevant Consultant's drawings and specifications.

Key:
1. Denotes Section — X
Denotes Drawing Number — XX

PRELIMINARY

Project:	15 HOWITT ROAD, LONDON, NW3 4LT
Title:	GROUND FLOOR PLAN
Client:	Mr Ioannou
Architect:	Jane Duncan Architects Ltd
Drawn by:	BA
Checked by:	DO
Date:	27th April 2023
Scale:	AS NOTED @ A1
Drawing No:	19131/PL02
Rev:	A

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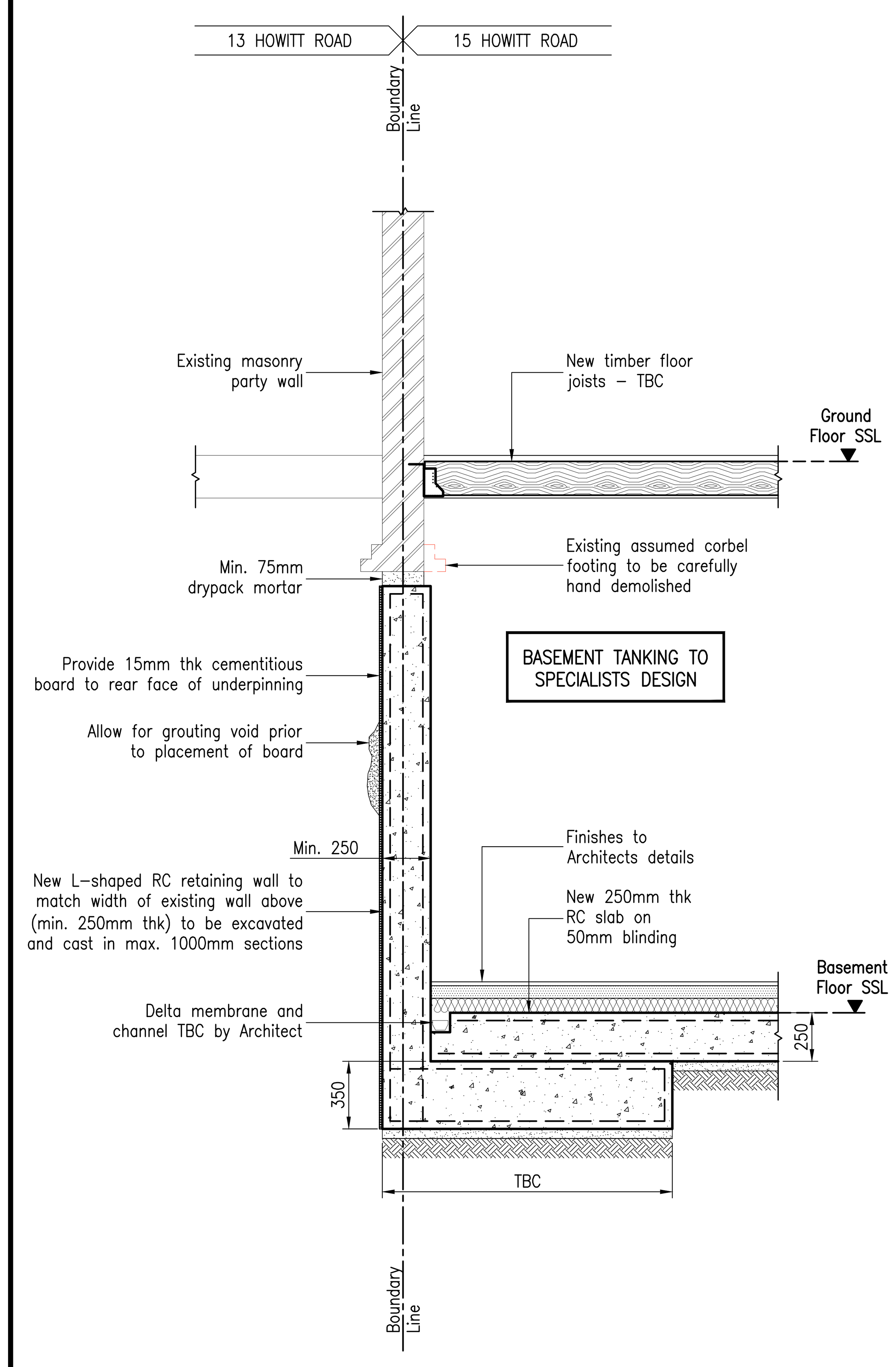

SECTION A-A

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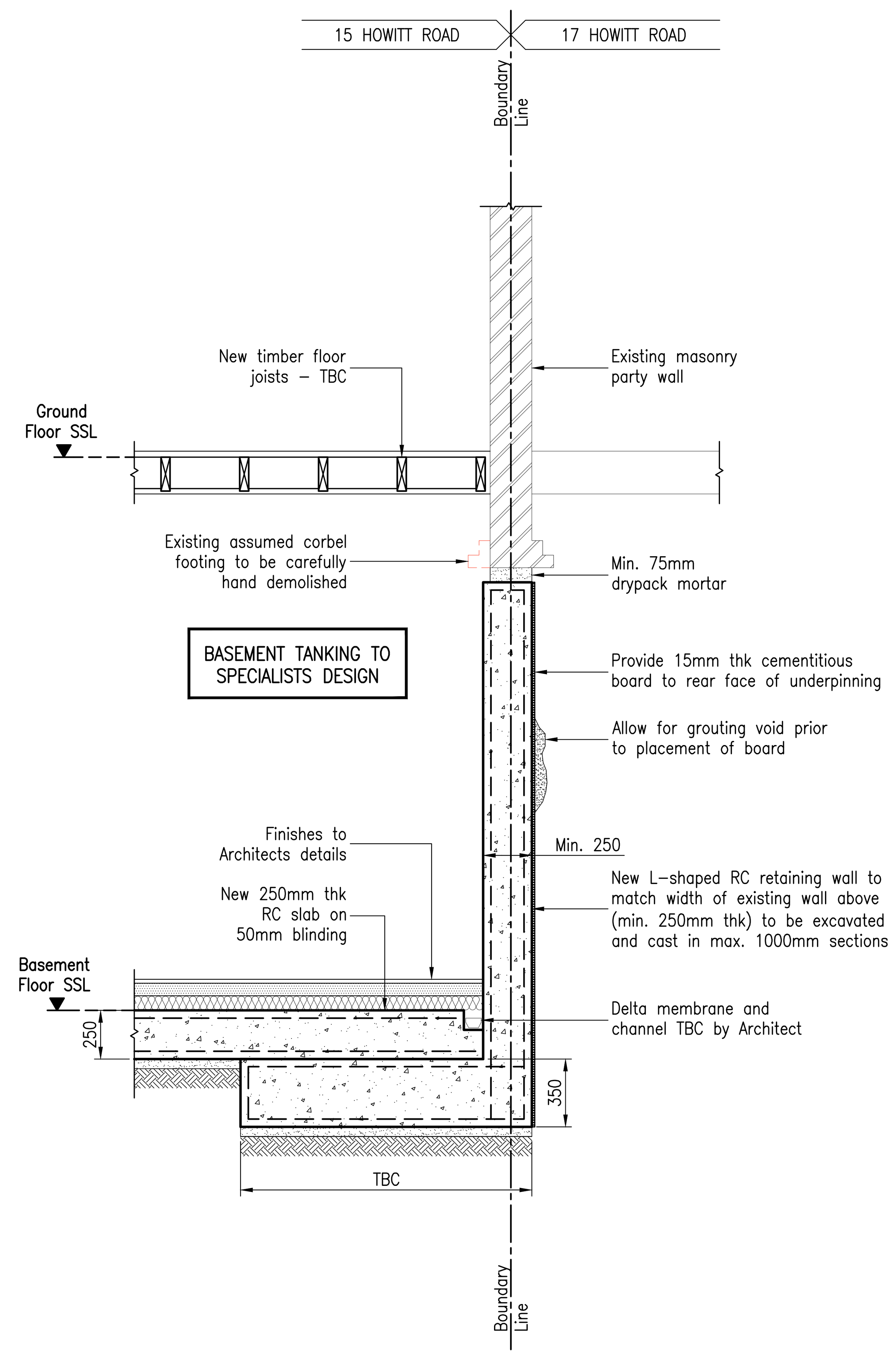

SECTION B-B

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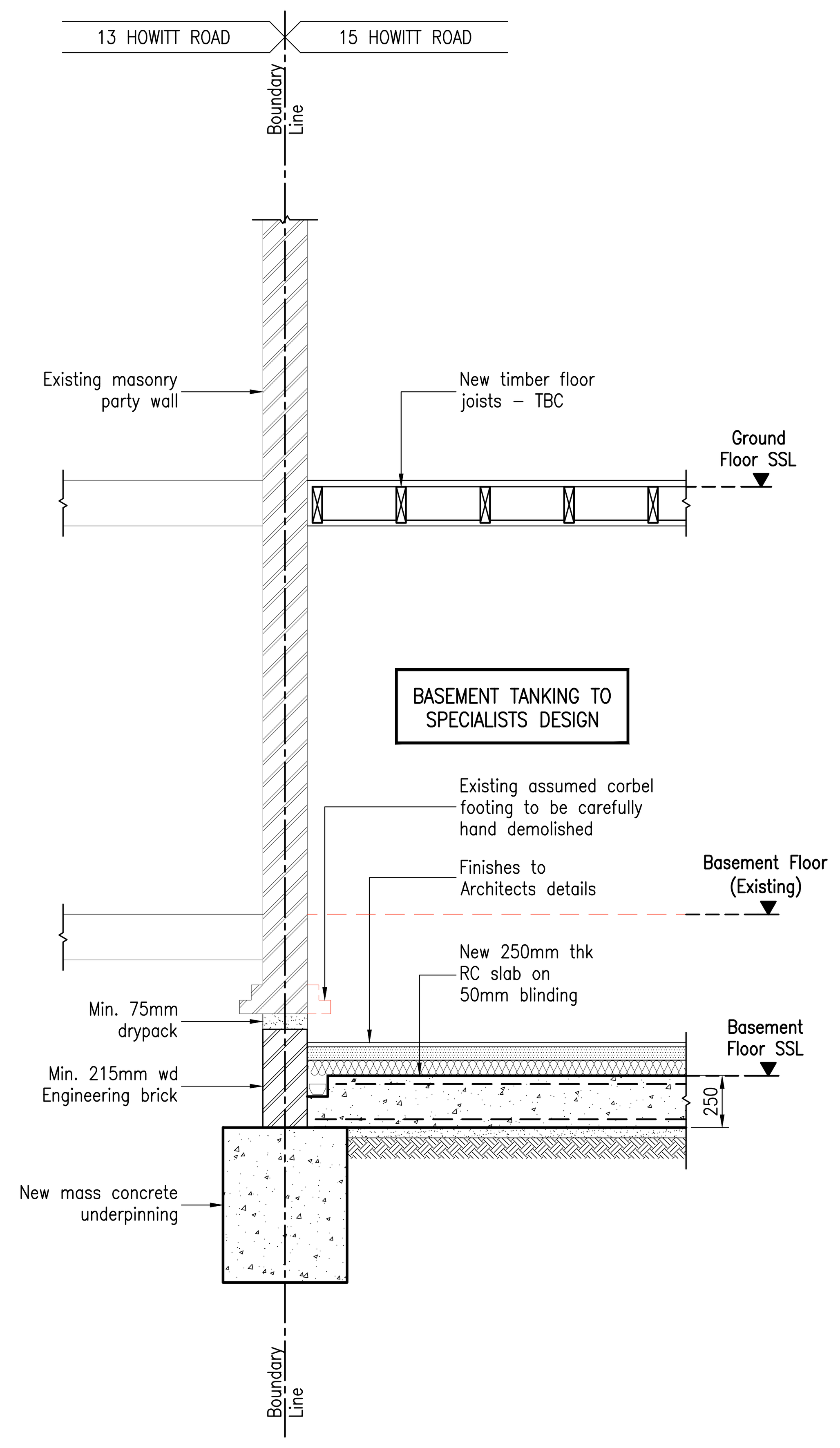

SECTION C-C

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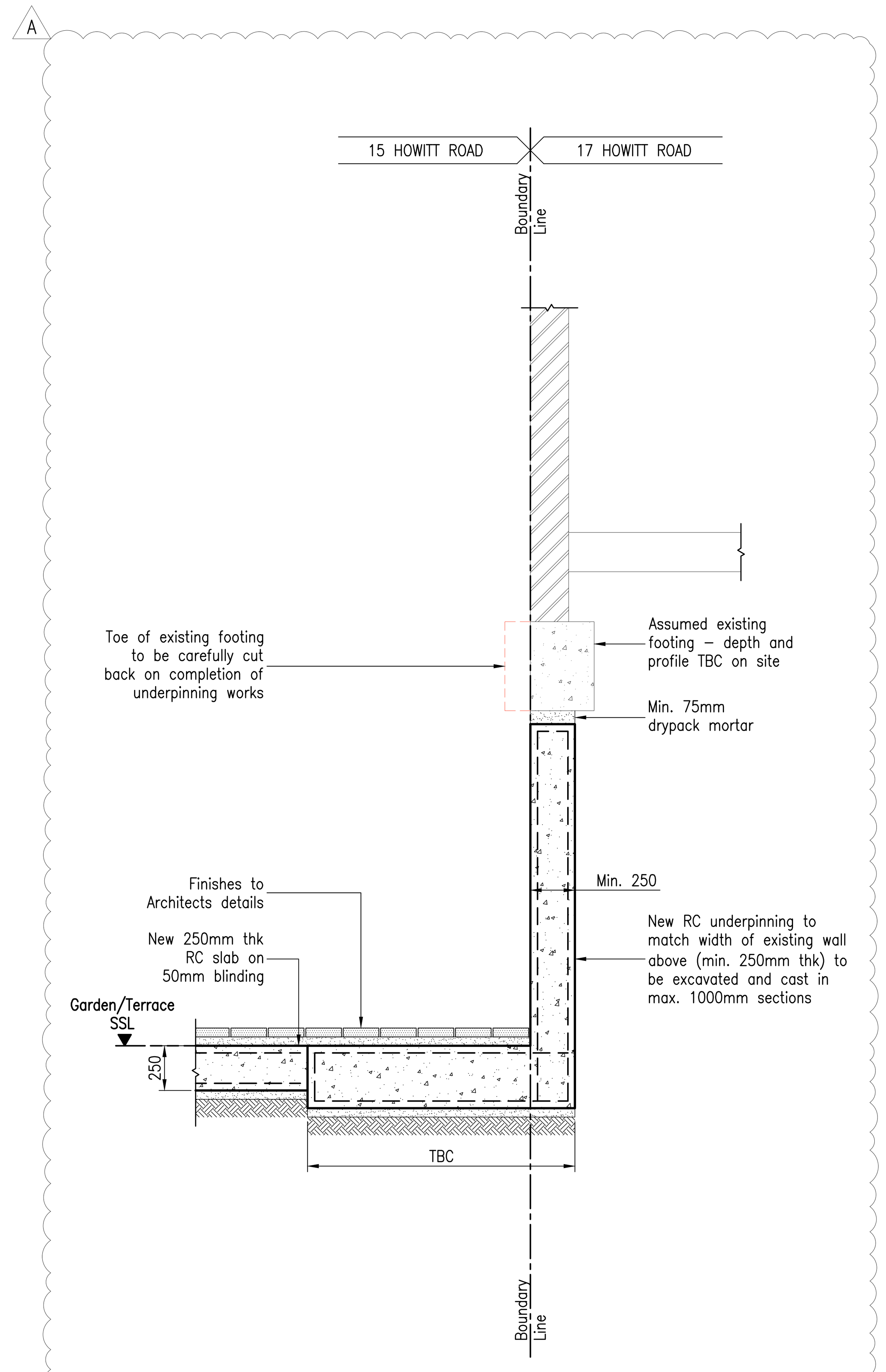

SECTION D-D

SCALE 1:25

Rev.	Date	Revisions	By	Engineer
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Notes:
1. The drawing is to be read in conjunction with all relevant Consultant's drawings and specifications.

Key:
1. Denotes Section — X
Denotes Drawing Number — XX

PRELIMINARY

Project:	15 HOWITT ROAD, LONDON, NW3 4LT
Title:	PROPOSED SECTIONS
Client:	Mr Ioannou
Architect:	Jane Duncan Architects Ltd
Drawn by:	BA
Checked by:	DO
Date:	27th April 2023
Scale:	AS NOTED @ A1
Drawing No:	19131/PL03
Rev:	A

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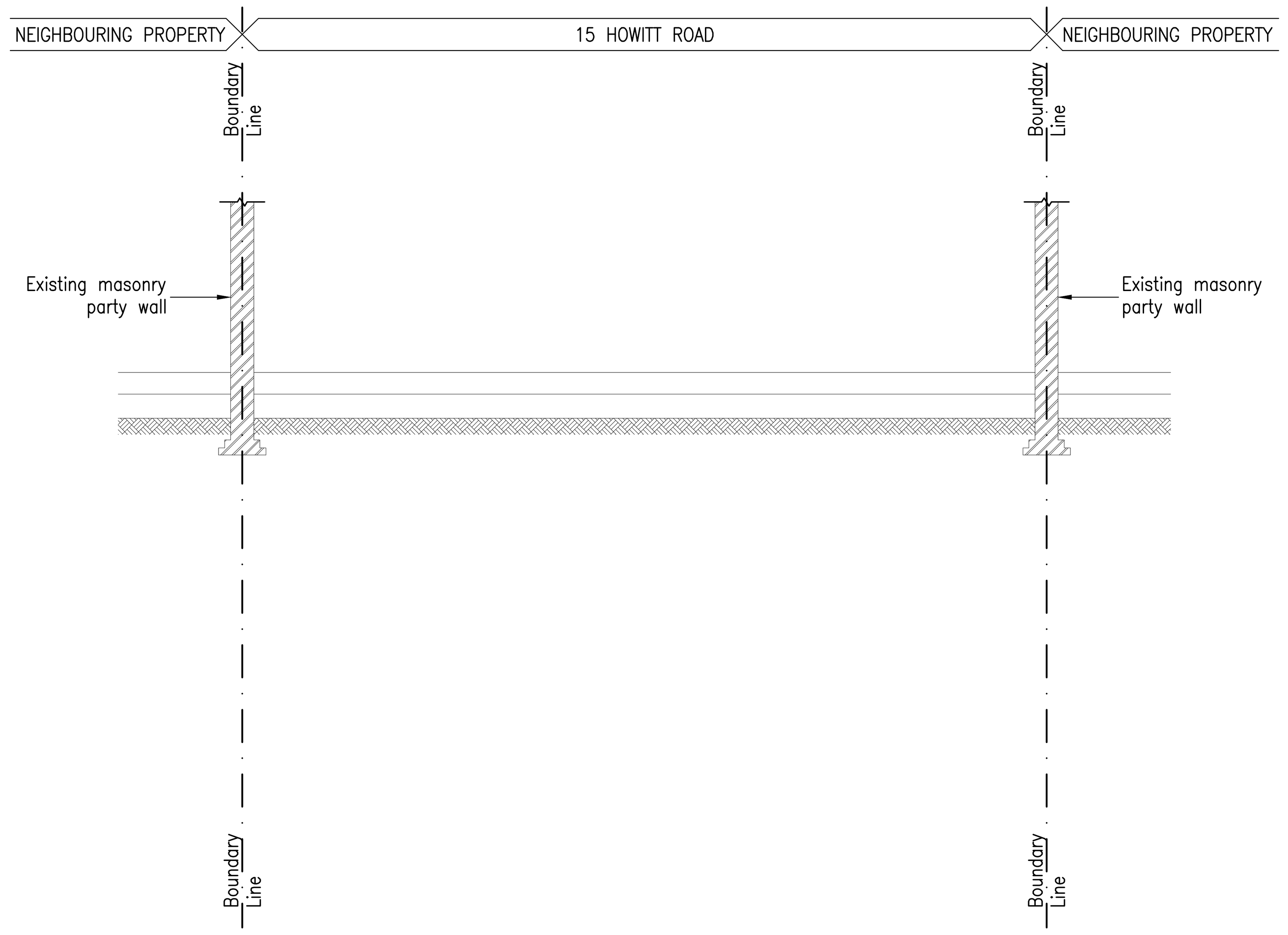

UNDERPINNING SECTION - AS EXISTING

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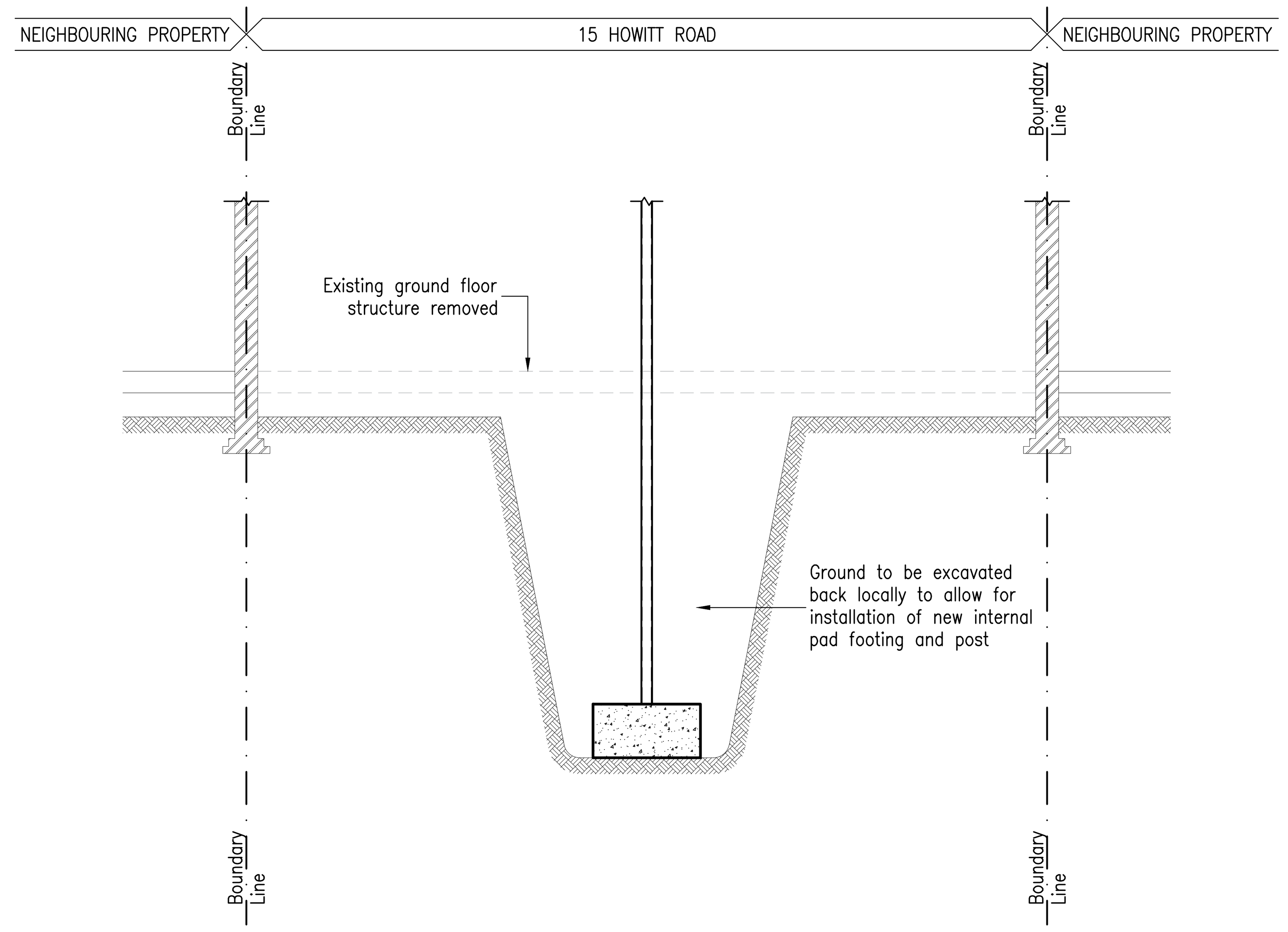
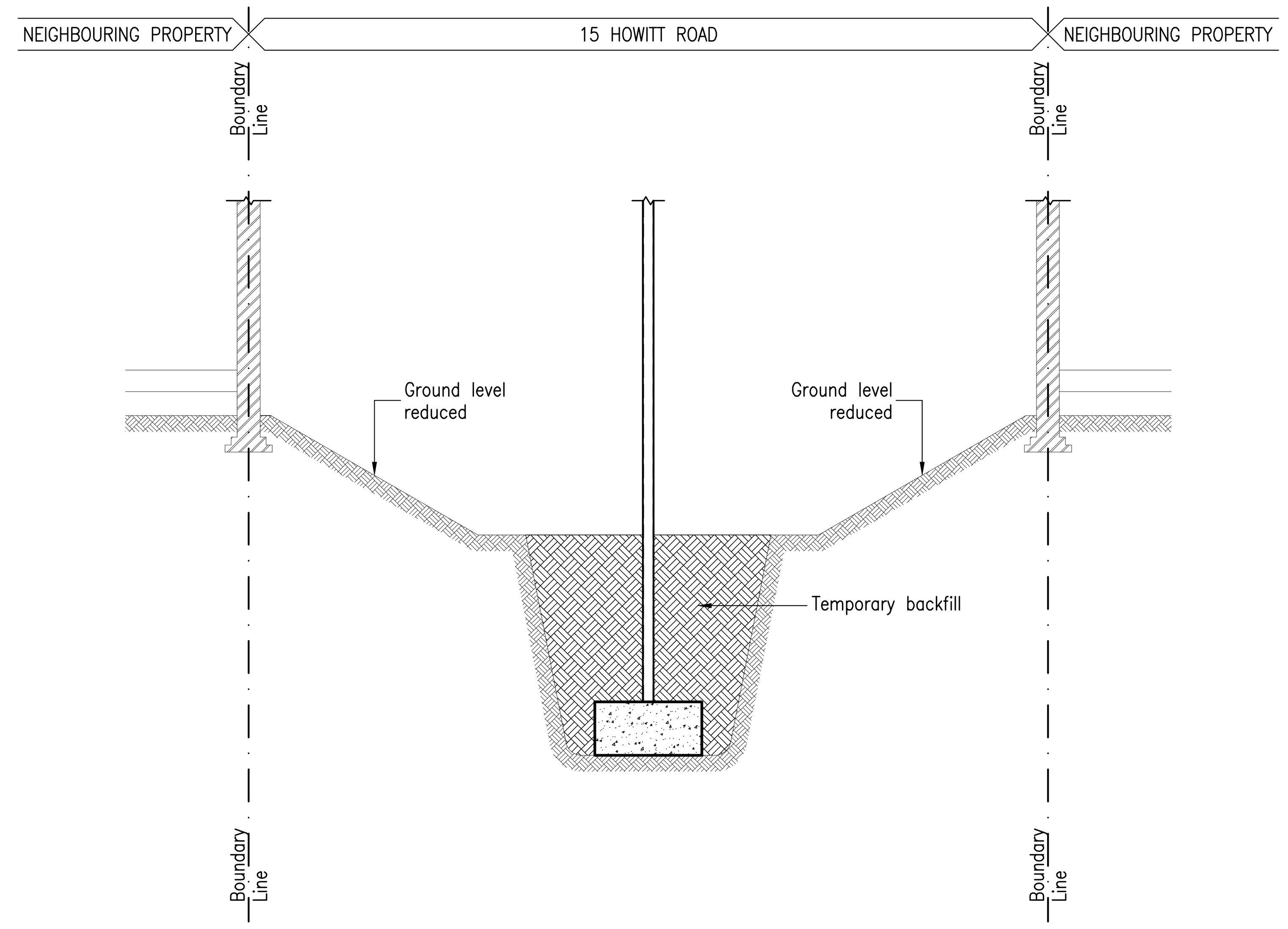


UNDERPINNING SECTION - STAGE 1

SCALE 1:50



UNDERPINNING SECTION - STAGE 2

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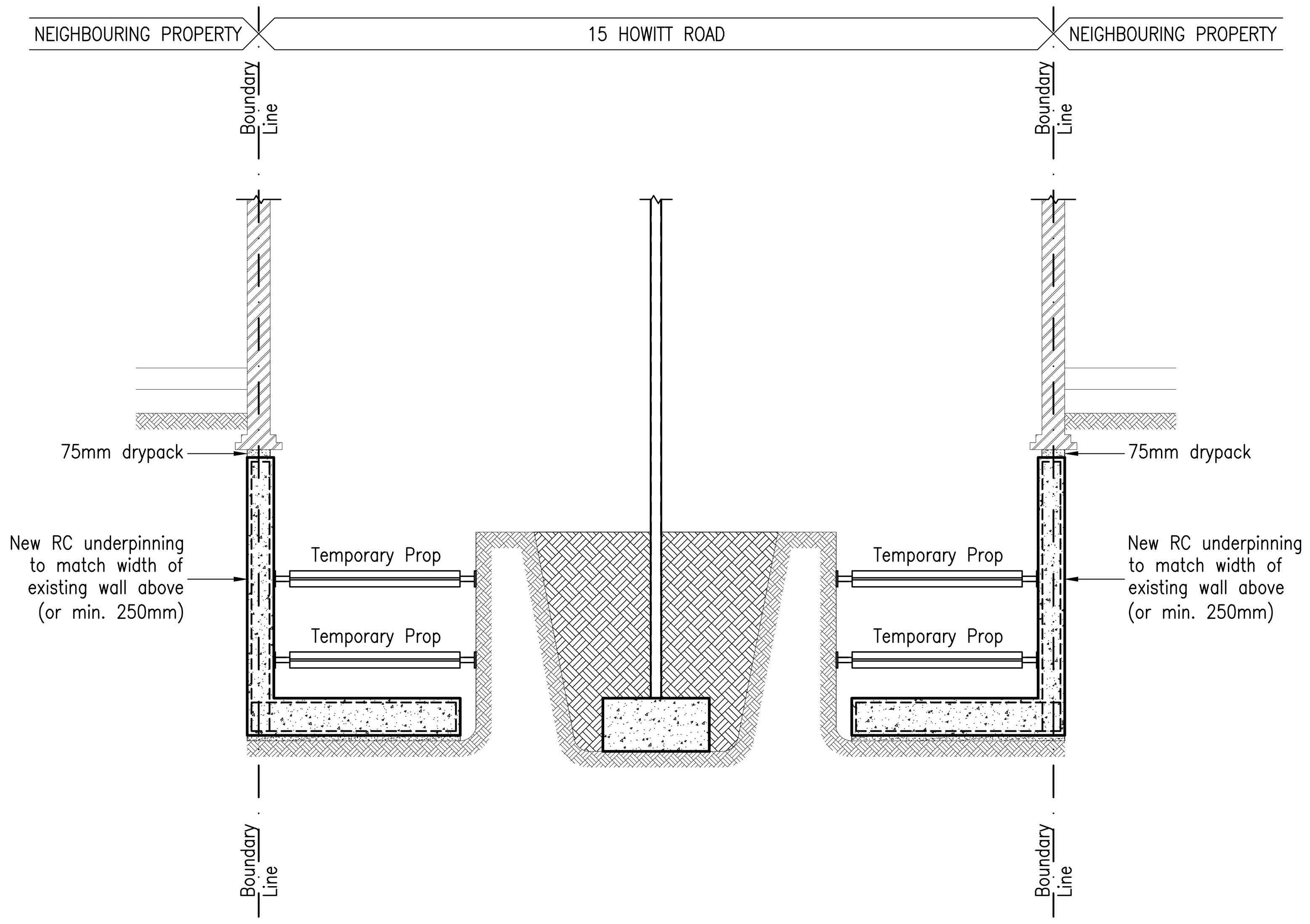

UNDERPINNING SECTION - STAGE 3

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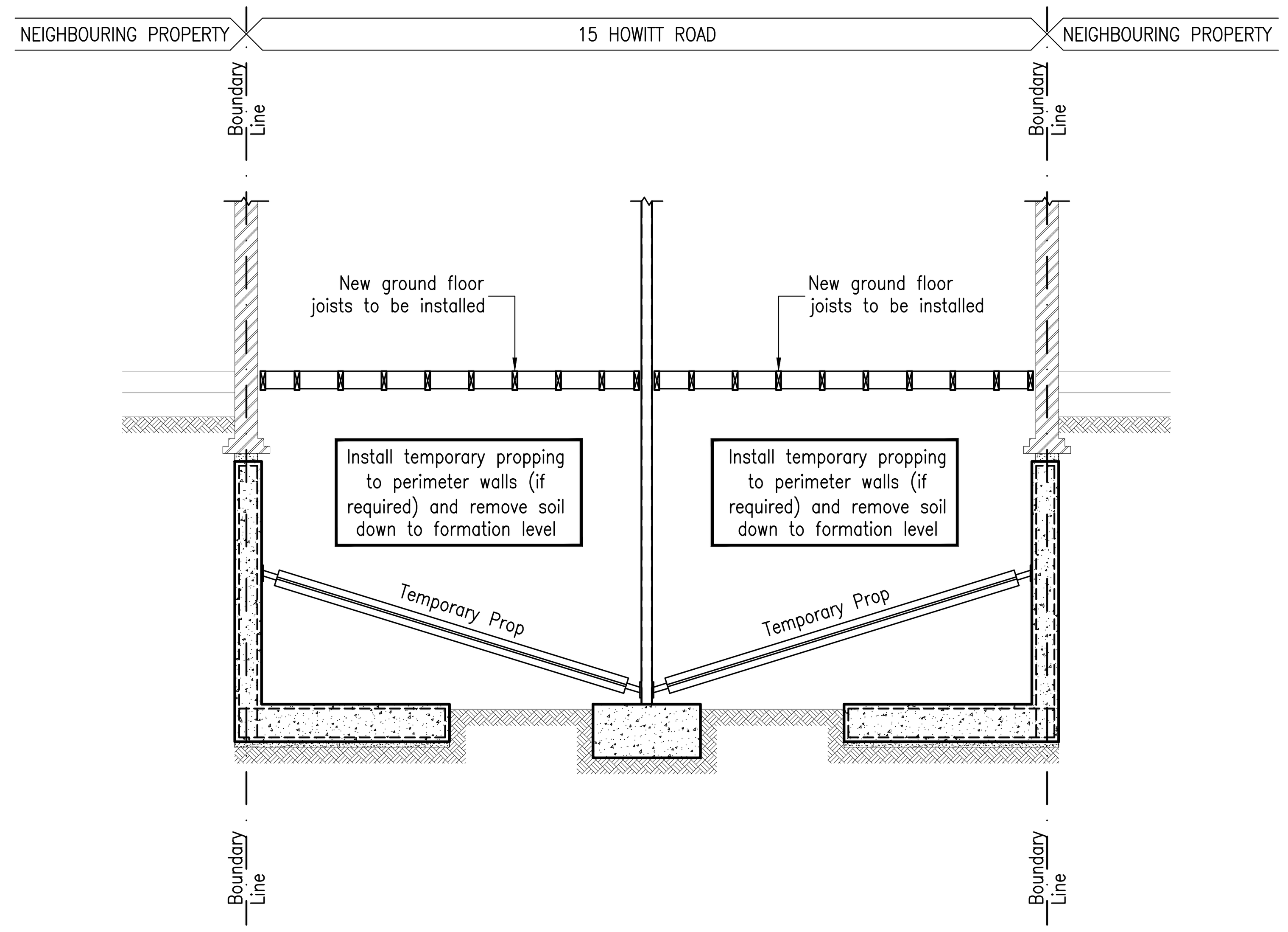

UNDERPINNING SECTION - STAGE 4

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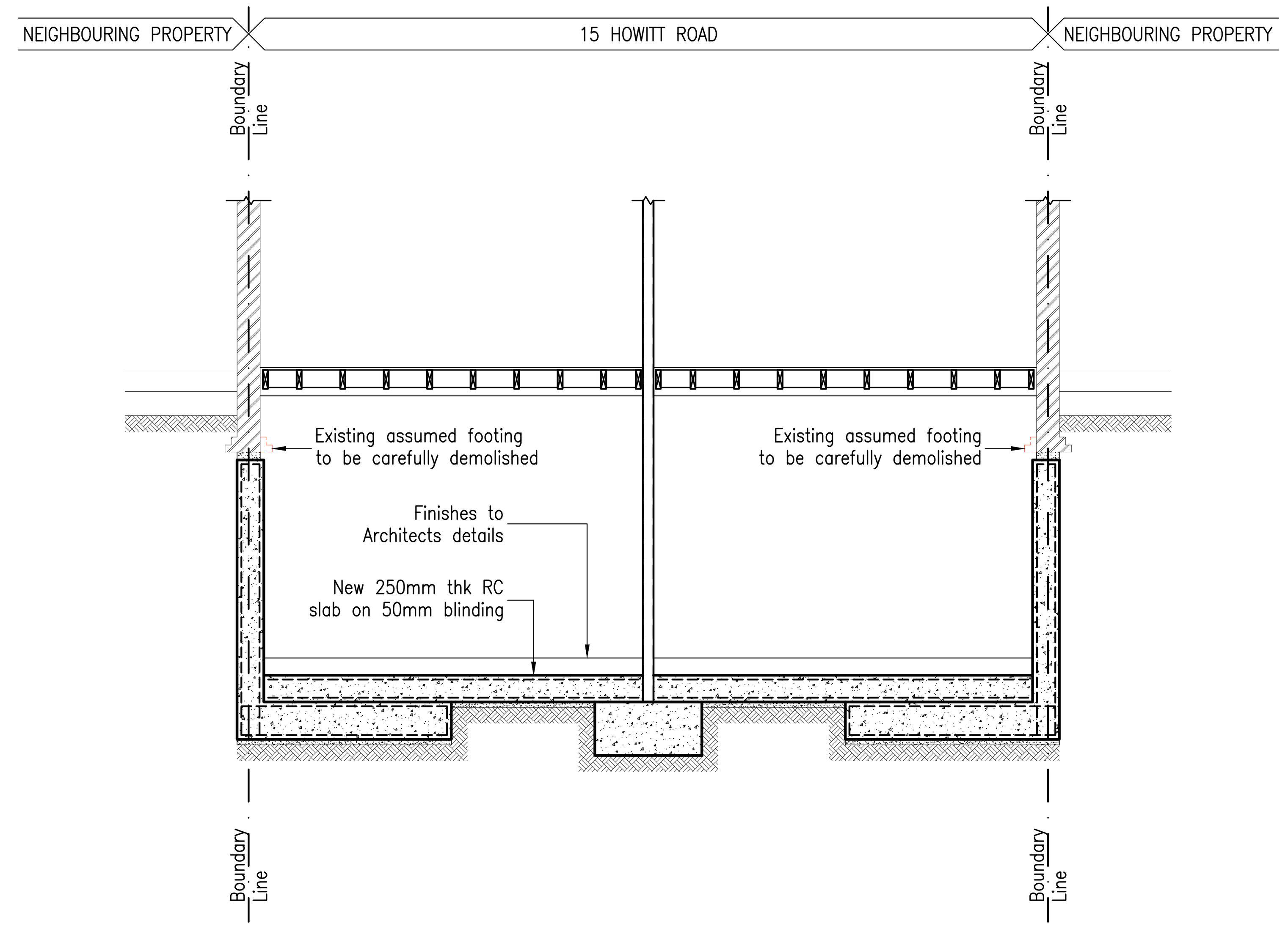

UNDERPINNING SECTION - AS PROPOSED

SCALE 1:50

Rev.	Date	Revisions	By	Engineer

Notes:
1. The drawing is to be read in conjunction with all relevant Consultant's drawings and specifications.

Key:
1. Denotes Section — X
Denotes Drawing Number — XX

PRELIMINARY

Project:	15 HOWITT ROAD, LONDON, NW3 4LT	Drawn by:	BA
Title:	SUGGESTED SEQUENCE OF WORKS	Checked by:	DO
Client:	Mr Ioannou	Date:	27th April 2023
Architect:	Jane Duncan Architects Ltd	Scale:	AS NOTED @ A1
		Drawing No:	19131/PL04

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12 Appendix B - Calculations

Retaining Wall Design

The retaining wall will be calculated for the temporary condition (during construction) as a cantilever. At Permanent condition the base of retaining wall will be tied into the main basement slab and therefore will act monolithically.

Geometry of the retaining wall is as shown below Figure 1.

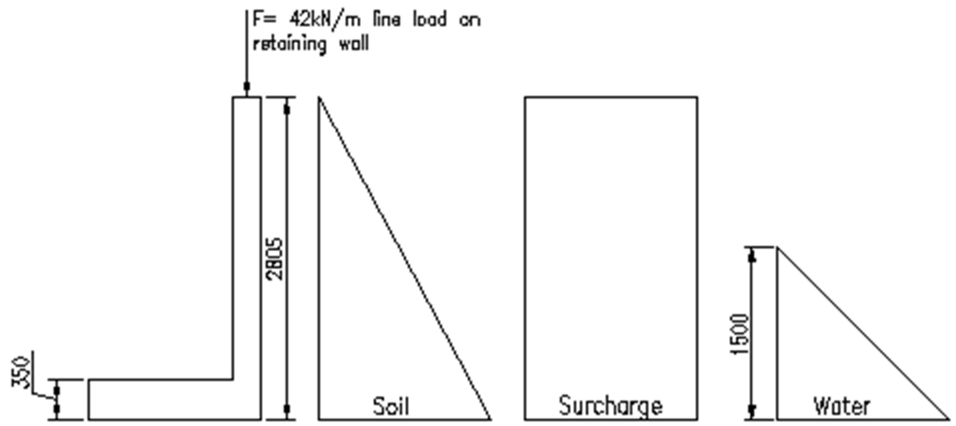


Figure 1

Parameters which were used for the design of the retaining wall is as follows.

Allowable gross Bearing Pressure: 150 - 200 kN/m^2 the value was taken from the Site Investigation Report. Conservatively the value which will be used will be 150kN/m^2.

Surcharge load : 5kN/m^2

Soil : 18 kN/m^3

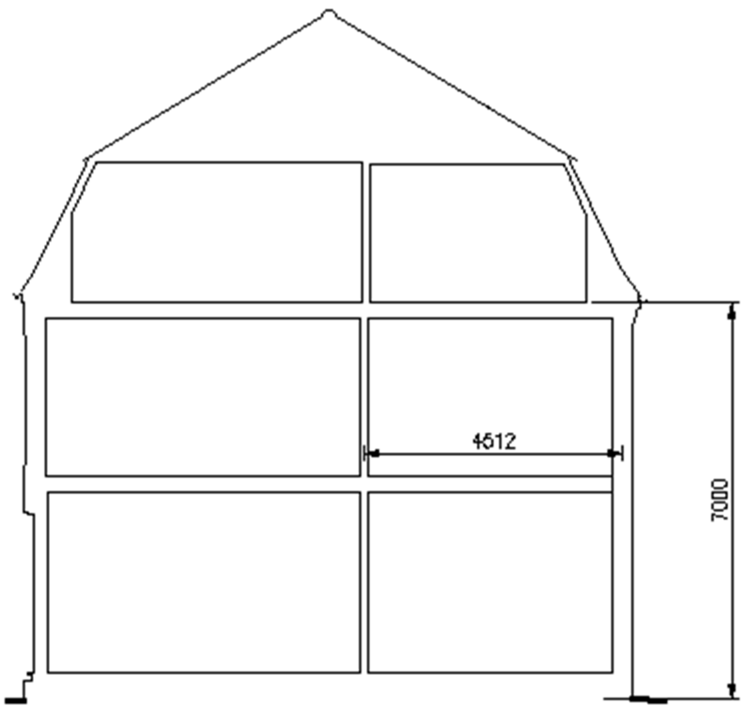
Water : 9.81kN/m^3

Angle of friction : 24^0 (Value obtained from Site Investigation Report)

γ_m concrete : 1.5

γ_m steel : 1.1

The line load applied on the retaining wall is calculated below:



- s/w of 9'' wall: 7m (Average height) x 5.03 kN/m^2 x 0.80 (openings) =
  = 28.2 kN/m

- 1st Floor : $\frac{4.4}{2}$ x (0.5 + 1.5) = 4.4kN/m

- 2st Floor : $\frac{4.4}{2}$ x (0.5 + 1.5) = 4.4kN/m

- Roof : $\frac{4.4}{2}$ x (1.20 + 0.75) = 4.3kN/m

  Total load : 42kN/m

Full analysis and design of the wall to follow from RC spreadsheet.

In conclusion, as it can be seen from the provided calculation the retaining wall can be independently stand (cantilever) without any need of propping during construction.

Project	15 Howitt Road		The Concrete Centre		
Client	Mr. Ioannou		Made by SD	Date 08-Sep-2023	Page 1
Location	Retaining Wall		Checked DO	Revision -	Job No 19131

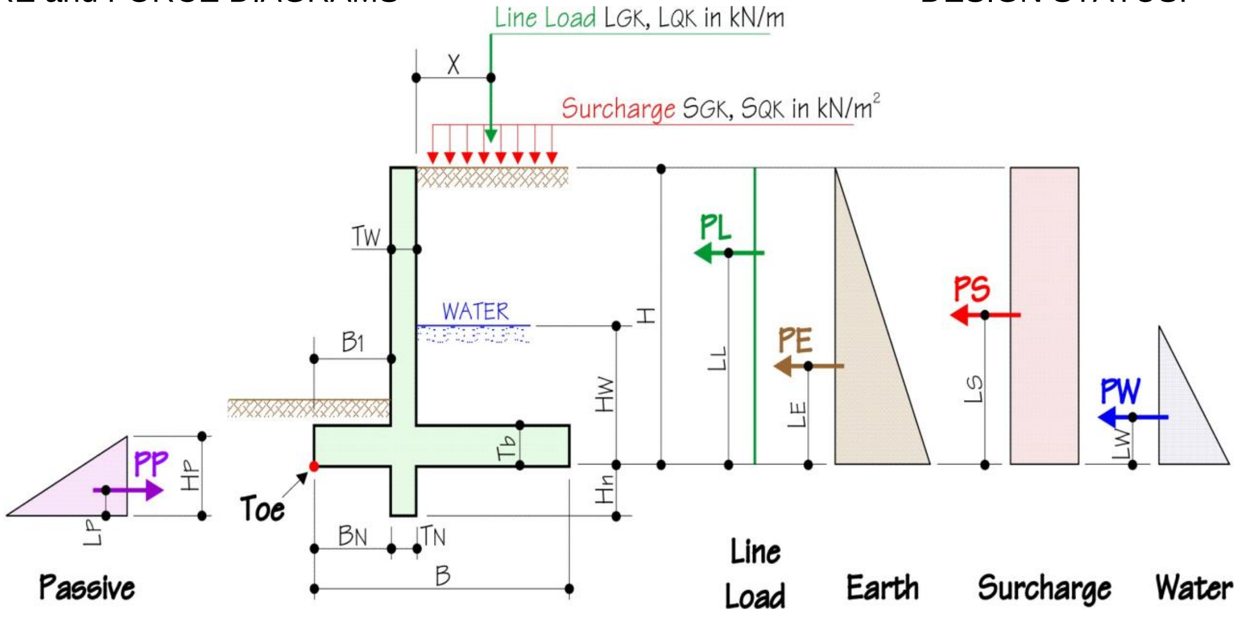
RETAINING WALL design to BS 8110:2005

Originated from 'RC062.xls' v4.2 © 2006 TCC

IDEALISED STRUCTURE and FORCE DIAGRAMS

DESIGN STATUS: **VALID**

WARNING :
Passive pressure should only be considered if it can be guaranteed that there will be no future excavation in front of the wall.



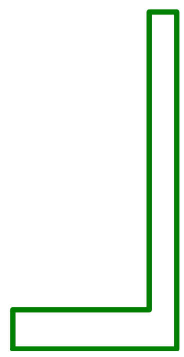
DIMENSIONS (mm)

H =	3000	B =	1500	Tw =	250
Hw =	1500	Bl =	1250	Tb =	350
Hp =	0	BN =	0	TN =	0
Hn =	0				

MATERIAL PROPERTIES

			steel class	A	
fcu =	40	N/mm²	γm =	1.5	concrete
fy =	500	N/mm²	γm =	1.15	steel
			cover to tension steel =	50	mm
			Max allowable design surface crack width (W) =	0.3	mm
			Concrete density =	24	kN/m³

(0.2 or 0.3 mm only)



Wall Geometry

SOIL PROPERTIES

Design angle of int'l friction of retained mat'l (Ø) =	24	degree	
Design cohesion of retained mat'l (C) =	0	kN/m²	(Only granular backfil considered, "C" = zero)
Density of retained mat'l (q) =	18	kN/m³	
Submerged Density of retained mat'l (qs) =	5.00	kN/m³	[default =2/3*q (only apply when Hw> 12.00
Design angle of int'l friction of base mat'l (Øb) =	26	degree	ASSUMPTIONS
Design cohesion of base material (Cb) =	50	kN/m²	a) Wall friction is zero
Density of base material (qb) =	18	kN/m³	b) Minimum active earth pressure = 0.25qH
Allowable gross ground bearing pressure (GBP) =	150	kN/m²	c) Granular backfill
			d) Does **not** include check of rotational slide/slope failu

LOADINGS

Surcharge load -- live (SQK) =	5	kN/m²	e) Does **not** include effect of seepage of ground water beneath the wall.
Surcharge load -- dead (SGK) =	0		
Line load -- live (LQK) =	13	kN/m	f) Does **not** include deflection check of wall due to lateral earth pressures
Line load -- dead (LGK) =	30	kN/m	
Distance of line load from wall (X) =	-125	mm	h) Design not intended for walls over 3.0 m high
			i) Does **not** include check for temp. or shrinkage effect

LATERAL FORCES (unfactored)

Ka =	0.42	[default ka = (1-SIN Ø)/(1+SIN Ø)]	0.42
Kp =	2.56	[default kp = (1+SIN Øb)/(1-SIN Øb)]	2.56
Kpc =	3.20	[default kpc = 2kp$^{0.5}$] =	3.20
Kac =	1.30	[2ka$^{0.5}$]	

	Force (kN)	Lever arm (m)	Moment about TOE (kNm)	γ_f	F_{ult} (kN)	M_{ult} (kNm)
PE =	27.99	LE = 1.110	31.08	1.40	39.19	43.51
PS(GK) =	0.00	LS = 1.50	0.00	1.40	0.00	0.00
PS(QK) =	6.33	LS = 1.50	9.49	1.60	10.12	15.18
PL(GK) =	12.65	LL = 3.00	37.96	1.40	17.71	53.14
PL(QK) =	5.48	LL = 3.00	16.45	1.60	8.77	26.32
PW =	11.25	LW = 0.50	5.63	1.40	15.75	7.88
Total	63.70		100.59		91.55	146.02
PP =	0.00	(LP-HN) = 0.00	0.00	1.00	0.00	0.00

Project	15 Howitt Road	The Concrete Centre		
Client	Mr. Ioannou	Made by	Date	Page
Location	Retaining Wall	SD	08-Sep-2023	2
	RETAINING WALL design to BS 8110:2005	Checked	Revision	Job No
	Originated from 'RCC62.xls' v4.2 © 2006 TCC	DO	-	19131

EXTERNAL STABILITY

STABILITY CHECKS : OK

OVERTURNING about TOE

(using overall factor of safety instead of partial safety factor)

F.O.S = 1.50

LOADING OPTION

(select critical load combination)

√EARTH

☑ PS(GK)
☑ PS(QK)
☑ PL(GK)
☑ PL(QK)
☑ PW

Warning:

Overturning Moments

Lateral FORCE (kN)	Lever arm (m)	Moment (kNm)
PE = 27.99	LE = 1.00	27.99
PS(GK) = 0.00	LS = 1.50	0.00
PS(QK) = 6.33	LS = 1.50	9.49
PL(GK) = 0.00	LL = 3.10	0.00
PL(QK) = 0.00	LL = 3.10	0.00
PW = 11.25	LW = 0.50	5.63
∑ **P** = 45.57		
Pp = 0.00	(LP-HN) = 0.00	0.00
		∑ **Mo** = 43.11

Restoring Moments

Vertical FORCE (kN)	Lever arm (m)	Moment (kNm)
Wall = 15.90	1.38	21.86
Base = 12.60	0.75	9.45
Nib = 0.00	0.00	0.00
Earth = 0.00	1.50	0.00
Water = 0.00	1.50	0.00
Surcharge = 0.00	1.50	0.00
Line load = 43.00	1.38	59.13
∑ **V** = 71.50		∑ **Mr** = 90.44

Warning:

☐ ALLOW BUOYANCY OF BASE

Factor of Safety, Mr / Mo = 2.10 > 1.50 OK

SLIDING

(using overall factor of safety instead of partial safety factor)

F.O.S = 1.50

Sum of LATERAL FORCES, **P** = 45.57 kN

PASSIVE FORCE, Pp x Reduction factor (1) = 0.00 kN

Red'n factor for passive force = 1.00

BASE FRICTION (∑ **V** TANØb + 0.75 B Cb) = -91.12 kN

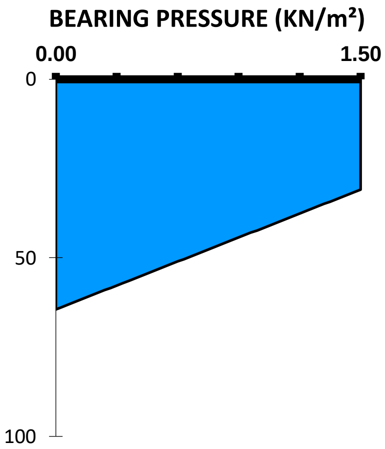
Sum of FORCES RESISTING SLIDING, **Pr** = -91.12 kN

Factor of Safety, Pr / P = 2.00 > 1.50 OK

GROUND BEARING F

Taking moments about centre of base (anticlockwise "+") :

Vertical FORCES (kN)	Lever arm (m)	Moment (kNm)
Wall = 15.90	-0.63	-9.94
Base = 12.60	0.00	0.00
Nib = 0.00	0.75	0.00
Earth = 0.00	-0.75	0.00
Water = 0.00	-0.75	0.00
Surcharge = 0.00	-0.75	0.00
Line load = 43.00	-0.63	-26.88
∑ **V** = 71.50		∑ **Mv** = -36.81



Moment due to LATERAL FORCES, **Mo** = 43.11 kNm

Resultant Moment , **M** = **Mv** + **Mo** = 6.29 kNm

Eccentricity from base centre, **M** / **V** = 0.09 m

Therefore, MAXIMUM Gross Bearing Pressure (**GRP**) = 64 kN/m² < 150 OK

BASE - unloaded side (per metre length)

BS8110 reference

γ_f = **145** (default = ult mt / non-factored m 145

Vult = 83.29 kN

Mult = 52.06 kNm ('+' TENSION AT BOTTOM FACE)

BOTTOM REINFORCEMENT :

Min. As =	455	mm^2			Table 3.25
ϕ =	**16**	mm			
centres =	**200**	mm	< 766	OK	3.12.11.2.7(b)
Asprov =	1005	mm^2	> 455	OK	

MOMENT of RESISTANCE :

d =	292	mm			
z =	277.40	mm			3.4.4.4
As' =	0	mm^2			
Mres =	121.25	kNm	> 52.06	OK	

SHEAR RESISTANCE:

100 As/bd =	0.34%				
vc =	0.56	N/mm^2			Table 3.8
Vres =	163.66	kN	> 83.29	OK	3.5.5.2

CHECK CRACK WIDTH TO BS8110/BS8007 (Temperature and shrinkage effects not included)

X=	77.87	mm	ε_m =	0.0003				BS8007
Acr =	107.60	mm	W=	0.06	mm	< 0.30	OK	App. B.2

BASE - loaded side (per metre length)

Vult = 62.42 kN

Mult = -7.80 kNm (TENSION - TOP FACE)

TOP REINFORCEMENT :

Min. As =	455	mm^2			Table 3.25
ϕ =	**12**	mm			
centres =	**200**	mm	< 762	OK	3.12.11.2.7(b)
Asprov =	565	mm^2	> 455	OK	

MOMENT RESISTANCE :

d =	294	mm			
z =	279.30	mm			3.4.4.4
As' =	0	mm^2			
Mres =	68.67	kNm	> 52.06	OK	

SHEAR RESISTANCE:

100 As/bd =	0.19%				
vc =	0.46	N/mm^2			Table 3.8
Vres =	135.49	kN	> 62.42	OK	3.5.5.2

CHECK CRACK WIDTH to BS8100/ BS8007 (Temperature and shrinkage effects not included)

X=	60.93	mm	ε_m =	-0.0013				BS8007
Acr =	108.61	mm	W=	-0.29	mm	< 0.30	OK	App. B.2

REINFORCEMENT SUMMARY for BASE

	Type	ϕ mm	Centers mm	As mm^2	Min. As mm^2	
TOP (DESIGN)	H	12	200	565	455	OK
BOTTOM (DESIGN)	H	16	200	1005	455	OK
TRANSVERSE	H	**12**	**200**	565	455	OK