71 GOLDHURST TERRACE

LONDON, NW6 3HA

BASEMENT IMPACT ASSESSMENT

ENGINEERING METHOD STATEMENT

Project Ref: J000958

March2018

Revision 0

Unit 5, Quayside, Sir William Morris Way, Fulham SW6 2UZ
Registered in England Number 06533911

REVISION HISTORY

Rev	Purpose	Date	Issued By	Approved
Rev 0	Initial report	15/02/2018	JS	

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1. INTRODUCTION

Green Structural Engineering (GSE) has been involved in the design of a significant number of successful basements in a number of London boroughs on behalf of private clients, developers and contractors. We also undertake the temporary works design and sequencing for many contractors who operate across London.

Basement projects previously undertaken successfully have been of a similar size to that proposed in this application and quite often on a much larger scale and complexity.

This experience has positioned GSE at the forefront of basement design and indeed temporary works design for basement construction. This experience has led to an in-depth understanding and appreciation of the design parameters that should be considered for all basement construction projects.

GSE holds £2million in professional indemnity insurance and is a member of the ACE.

This report has been prepared as part of the planning application for 71 Goldhurst Terrace (71 GT) on behalf of our client, Opera Architects, and is not to be used by any other parties or for any other purpose without the express written consent of GSE.

2. SCOPE OF REPORT

This report deals with the structural aspects of the proposed basement construction to 71 Goldhurst Terrace and is to be read in conjunction with the following reports:

- Geotechnical report by GabrielGeo Consulting.

This report is produced for submission to the London Borough of Camden as part of a planning application for works to 71 Goldhurst Terrace and should not be used for any other purposes, e.g. construction or Party Wall Awards.

3. SCOPE OF WORKS

The proposal includes new basement extension underneath the full footprint of the existing house with creation of the new front lightwell, side extension to the rear of the ground floor level as well as with some internal alterations on the ground floor.

Investigation works on site to confirm the existing arrangement of the ground floor and the detailed design of the new permanent structure to basement and ground floor will be carried out as part of the detailed design process and are not included within this BIA report.

4. DESCRIPTION OF EXISTING SITE

No.71 Goldhurst Terrace is a three-storey terraced house of traditional masonry and timber construction, situated within the South Hampstead Conservation Area, in the London Borough of Camden. This part of

Goldhurst Terrace extends from Finchley Road to the north-east, to Fairhazel Gardens to the south-west, beyond which Goldhurst Terrace extends westwards to combine with Aberdare Gardens, and then joins with Priory Road. As shown in Figure 1, No.71 is situated on the east side of Goldhurst Terrace, between the adjoining No.69 to the north and adjoining No.73 to the south. To the east, the site is bounded by the rear garden of No.39 Fairfax Place.

It was built between 1871 and 1894, when most of the houses in Goldhurst Terrace first appeared on the Ordnance Survey maps. The 1866 and 1871 maps indicate that the area was farmland prior to development.

Figure 1. 71 Goldhurst Terrace location

Originally built as a one family house, No.71 was subsequently divided into separate flats.

The bomb map for Hampstead shows no bombs landing on properties on Goldhurst Terrace, although one did fall near the northern end of Fairfax Place. The WW2 bomb map for the Borough of Hampstead shows the closest bomb to No.71 landing approximately 60m south-east of the site, onto No.26 Fairfax Place; another is recorded at the intersection of Fairfax Place and Fairhazel Gardens, some 200m south of No.71. A cluster of three bombs are recorded at the intersection between Greencroft Gardens and Fairhazel Gardens, and a further bomb was recorded as landing approximately 125m west of No.71 on Fairhazel Gardens.

Environmental search carried by GabrielGeo consulting confirmed that the nearest underground tunnel known is a Great Central Railway Company's tunnel which was completed in 1898 passes No 71 Goldhurst Terrace 175m to the east of the site.

The topography of the site is influenced by the one of the "lost" rivers of London River Westbourne.

Goldhurst Terrace is located on the east side of the valley of a former tributary of the Westbourne. The valley's position is between 40m and 50m contours from the river. Between the 40m contour, which passes just to the south of the site, and the 45m contour which passes further upslope to the north-east of the site, the overall slope angle has been calculated as around 1.0°; this overall slope angle reduces to less than 1° downslope of the 40m contour.

The property is not listed.

5. DESCRIPTION OF 71 GOLDHURST TERRACE AND ADJOINING PROPERTIES

The property is part of a terrace of 4 houses joined through brickwork arches to the larger terrace, spanning along Goldhurst Terrace. Most of the properties on the street, with exception of some new builds, constructed in the same period and of typical construction with timber floors and roof, supported off masonry walls. No.71 Goldhurst Terrace is a three storey Victorian terraced house arranged over split levels, with rear mansard roof, original cellar and rear conservatory extension.

Beneath the hallway there is a small cellar, accessed internally via a stairwell (probably a former coal store, as a blocked-up former chute remains in the front wall of the cellar and the adjoining No.73 still has an access hatch in the front path, close to the front wall of the house).

No 71 Goldhurst Terrace shares party walls with No 69 (north side) and No 73 (south side).

Externally, at the front of the property, there is a large parking area surfaced with concrete paving slabs which slopes gently towards the Goldhurst Terrace carriageway. This is bounded by a low brick boundary wall between No.69 and No.71, by a double metal gate at its access point with the Goldhurst Terrace footway, and the boundary with No.73 is marked by wooden posts with metal chain links attached. The section of the boundary between No.71 and No.69 closest to the Goldhurst Terrace footway consists of a small raised planting area, bounded with a low brickwork on the No.71 side, containing established shrubs. Between this paved area and the front bay of No.71 there is a small walled plot covered by concrete flagstones overlain by rounded gravel. There is a path leading from the Goldhurst Terrace footway to the front door of No.71, also surfaced with concrete paving slabs which is raised slightly above the parking area, and the two are separated by a single row of bricks.

The property is in a sound condition structurally. The adjoining properties are of similar construction and look to be in sound condition from an external non – intrusive visual examination.

There is no evidence of major crack damage, although some minor cracking and displaced brickwork was evident around some of the windows, particularly among the brickwork lintels of the front bays. To the rear of the property there was evidence of a leaking soil & vent pipe in the corner of the courtyard between the rear wall and the northern flank wall of No.71; water from that leak was flowing through the rear wall, into the area underneath the main part of the house.

The depth of the foundations of the existing building has been confirmed through trial pit excavation and found to be approximately 0.80m below ground floor level.

Figure 2. 71 Goldhurst Terrace front elevation

6. GEOLOGY AND HYDROLOGY CONDITIONS

The British Geological Survey website indicates the underlying ground condition to be London Clay. This has been confirmed by the site investigation carried out which has confirmed the ground conditions to comprise of firm to stiff brown clay immediately below the disturbed material found at the surface.

A copy of the site specific boreholes carried by GabrielGeo Consulting Investigations is included in the Appendices to this report.

The GabrielGeo BIA report covers the groundwater, surface water and slope stability issues more fully but the engineering related issues are summarised below.

Surface Water and Subterranean (Groundwater) Flow

Figure 3 below shows that Goldhurst Terrace was subject to surface water flooding in both the 1975 and 2002 flood events.

Figure 3. Extract from Figure 15 of the Camden GHHS (Arup, 2010) showing roads which flooded in 1975 (light blue), in 2002 (dark blue), and 'Areas with potential to be at risk of surface water flooding' (wide light blue bands).

Maps on the Environment Agency's website shows a 'Very Low' risk of surface water flooding for the entire site of No.71 Goldhurst Terrace, the neighbouring properties and along the Goldhurst Terrace carriageway outside the site. A 'Low' risk classification is given to the south-western end of the Goldhurst Terrace carriageway and at its intersection with Fairhazel Gardens, approximately 100m south-west of, and downslope from, No.71. A 'Low' risk of surface water flooding was also given to the Marston Close and Naseby Close carriageways upslope to the east of the property, and on the upslope side of No's 39/41/43 Fairfax Close which adjoin No.71's rear garden.

There are isolated pockets of 'High' risk areas at the site of Fairhazel Mansions, well downslope of No.71 to the east of the junction between Goldhurst Terrace and Fairhazel Gardens, and to the rear of the properties on the east side of the upper end of Fairfax Place. The latter is upslope of No.71, but there is no plausible flow route from there to No.71's garden.

The site Investigation did not encounter any ground water in boreholes, and subsequent monitoring found water at unusually low level. However the moisture contents measured in the cellar appeared unusually high. It is deemed that the leaking pipe have caused historical flood in the cellar of the adjacent property at No 69.

Perched groundwater would typically be expected in any overlying Made Ground, and possibly also in any Head Deposits which may be present, in at least the winter and early spring seasons.

An uplift pressure is to be allowed for in the basement slab design.

To allow for potential burst water mains, and as per GabrielGeo recommendations the retaining wall design will include ground water pressure to the ground level.

Slope and Ground Stability

GabrielGeo's BIA report covers the geotechnical aspects of slope and ground stability and report no issues as the slope of the site is less than 7deg.

With slope angles of approximately 1.0-3.0° upslope of this property, the proposed basement excavation raises no concerns in relation to slope stability.

The temporary condition during the works is dealt with in the temporary works section below.

7. STRUCTURAL CALCULATIONS

GSE have carried out an outline structural design for the new basement to confirm the feasibility and buildability of the scheme.

The new retaining walls are designed as cantilever walls to reduce the amount of propping required during construction.

On the party wall line the retaining wall sections only require a bottom prop to maintain stability against sliding as the weight of the wall above resists the overturning.

The lightwell retaining walls will require temporary propping at high level and low level. At high level this will provided during construction by Multiprops propped off the central berm and in the permanent condition by a reinforced concrete wall forming a box section with opening on one side tying all walls together.

See calculation sheets in Appendix B for the retaining wall calculations prepared as part of this report. Retaining wall design has been prepared using the following London Clay parameters:

Angle of internal friction φ' = 22 deg
Unit weight γ' = 20 kN/m^3
Cohesion - ignore

Intrusive opening up works to confirm the existing structural arrangement, the detailed design of the new basement will be undertaken at the start of works, once the house is unoccupied, to confirm that the existing structural arrangement are as allowed for in the outline design.

These operations will be carried out as part of the normal design process once planning has been obtained and will be submitted for checking by Building Control or an Approved Inspector.

8. STRUCTURAL DRAWINGS

The following structural drawings for the proposed basement are included in Appendix C:

J000958	/GA01	General arrangement plan of the proposed basement indicating the proposed construction method using a 'hit and miss' sequence.
	/S01	Typical section details through the party wall and external wall.

9. CONSTRUCTION METHOD AND TEMPORARY WORKS REQUIREMENTS

GSE have considered the outline temporary works design to confirm the feasibility of the proposed basement construction.

As normal on projects of this type, where basements are constructed under an existing property, the method used will be an underpinning approach, with the individual underpins constructed in sections no wider than 1000 mm, sequenced such that no adjacent underpins are constructed within a 48 hour period.

This method of construction mitigates the potential ground movement and so minimizes any effects of settlement on the adjacent structures.

10. CONSTRUCTION SEQUENCE OF THE NEW BASEMENT

1. Install basement/cellar floor waling frame and propping as required above the existing cellar floor slab, providing fixing details to the existing masonry wall
2. The cellar floor will be broken out locally and removed from site.
3. Batter back and reduce dig the across site and blind with an oversite concrete.
4. A conveyor belt will be set up in the cellar through the front room to convey the spoil from the excavation to the skip placed at the front of the property for disposal. The conveying will be done using a method that does not impair the safety of pedestrians.
5. Underpin front elevation and cast new retaining wall for the lightwell installing strip footing and vertical stem in a hit and miss underpinning sequence as per J000953 Basement Layout GA/01.
6. Once complete underpinning construction to party walls may commence.
7. Underpin the rear elevation and construct new rear retaining walls in underinning sequence and prop off berm .

Note: local needle and propping to wall will be required below the existing rear extensions and will comprise 152UC needles and Multiprops based on temporary footings.

Note: Reinforced concrete retaining walls will be formed as follows:

- ~ Excavate locally and shore excavation as required, installing sacrificial back board to external face. Excavated face to be propped off central berm behind.
- ~ Fix reinforcement to base and cast.
- ~ Fix reinforcement to wall and cast.
- ~ Dry pack between top of underpin and existing foundation
- ~ Reprop wall off berm.

8. Form local excavation to install pad foundations for the columns where required

9. Lower berm level and install propping to low level of new underpins. Back propping to adjacent underpin sections

10. As excavation progresses, any existing foundations discovered will be broken out and removed from site to make way for the new basement construction.

11. Where new columns are required to support structure above, needle and prop wall over, cast new base and install column ground floor steelwork.

12. Both high and low level propping will be required to the front lightwell and rear basement excavation.

    Initially this will comprise propping off the central berm with Multiprops at high level and RMD Slimshores (or similar designed by appointed Temporary Works Engineer) at low level. The high level props can be removed once the permanent reinforced concrete ring beam is cast to tie the top of the retaining wall sections together.

    At low level the propping is to remain in place until the basement slab is cast.

13. Reduce the depth of the berm to formation level and cast basement slab.

14. After the new basement slab has cured, a drained – cavity layer will be laid to the slab and walls.

15. A layer of insulation will be placed on top of the drained – cavity layer on the slab, and in front of the drained – cavity layer on the walls.

16. Finally a layer of screed will be laid to form the finished basement floor.

11. POTENTIAL IMPACT ON 69 AND 73 GOLDHURST TERRACE AND ADJOINING PROPERTIES

The construction of the new basement to 71 Goldhurst Terrace will affect No 69 and No 73 with which it shares a party walls. The zone of influence of the excavations will extend some distance but as set out in the GabrielGeo BIA report but the impact will be very slight.

The adjoining No. 69 and 73 do not appear to have modern basements, however No.67 had planning permission for a single storey basement extension granted in 2015. It is understood that the works have now been complete.

It is understood that both No 69 and No 73 are likely to have a cellar, similar to the existing cellar at No 71.

The damage assessment for the party walls, defined in geotechnical report by GabrielGeo Consulting, is within category 1, “very slight” and therefore the impact will be minimal provided a suitably experienced contractor is appointed and a designed temporary works methodology is developed and followed on site.

Accoriding to GabrielGeo report, the rear wall to No.73 (and No.75) was assessed to be the critical structure for displacements. A damage category assessment indicated that, provided best practice construction methods are employed, the worst case predicted deformation is likely to fall within Category 1, termed ‘very slight’. By inspection, it has been shown that No.69 is at a lower risk of potential damage from the excavation of the proposed basement.

BRE Digest 251 ‘Assessment of damage in low-rise buildings’ describes category 1 to be “Fine cracks which can be treated easily using normal decoration. Damage generally restricted to internal wall finishes; cracks rarely visible in external brickwork. Typical crack widths up to 1 mm.”

The critical stage of the works in relation to the effect on the neighbouring properties will be during the construction of the basement. The major risk of movement during this stage of the works can be reduced and controlled by the appointment of a contractor with previous experience of basement construction that follows the agreed method of working incorporating all necessary temporary works.

The contractor will be required to produce traffic management, detailed method statements and provide detailed temporary works proposals for approval prior to the start of any works.

The temporary works, in accordance with the outline temporary works intent, as described above, will maintain the stability of the new basement during the construction and prevent rotation or slipping of the retaining walls during this stage of the works.

One of the major sources of movement in basement construction is differential settlement of the new foundations when bearing onto different geological strata. The site investigations carried out reveals that the underlying ground strata comprises London Clay to depth, and any movement of the existing walls during the works will be governed by any settlement which occurs during the construction of the proposed underpinning.

The new RC retaining wall will be designed as free-standing cantilevered walled, ignoring propping from ground floor level.

In our experience on similar projects, we have been involved in over 100 basement projects across London including several in The London Borough of Camden, the movement may at most lead to some slight distortion and hairline cracking, but this can be dealt with by local redecoration.

The proximity of the proposed basement to the neighbouring properties means that Party Wall Agreements will be required and the Schedule of Conditions undertaken in this process will allow any inherent defects in the existing structures to be assessed and accommodated in the detailed design stage.

The design and construction methodology, as described above, deals with the potential risks and ensures that the excavation and construction of the proposed basement will not affect the structural integrity of the property and adjoining properties.

12. REDUCTION OF NOISE, DUST AND VIBRATION IMPACT ON NEIGHBOURING OCCUPIERS

The main environmental impacts are noise, vibration and dust. Contractors will always be expected to have considered noise and dust impacts related to their operations and to use Best Practicable Means (BPM) to minimise them, e.g. adjust working times, consider use of quieter methods.

The appointed contractor will be a member of the Considerate Contactors scheme.

The appointed contractor will comply with the following standards and practices.

- British Standard BS 5228 (noise and vibration control on construction and open sites).
- BS 6472:2008 (guide to evaluation of human exposure to vibration in buildings).
- Mayor's guidance on 'The control of dust and emissions during construction and demolition'.
- Principles set out within Section 61 of the Control of Pollution Act 1974.

Liaison with neighbors likely to be affected by works is an essential element of BPM and will be undertaken. The contractors will be expected to respond to complaints and resolve where practicable.

Impact on neighbors from vehicle movement will be addressed in the attached traffic management plan.

As residents are likely to be disturbed by noise, the permitted times of operation, including ancillary activities such as deliveries, will be restricted to standard hours:

- 8am – 6.00pm (Monday to Friday);
- 8am - 1pm (Saturday);
- No working is permitted on Sundays, bank holidays or other national holidays.

The appointed contractors will employ quiet working methods and noise generating equipment where practicable. Plant and activities to be employed should be reviewed to ensure that they are the quietest available for the required purpose e.g. 'super silenced' compressors. Work and sound reducing equipment should be regularly maintained to minimise noise emissions.

The contractors will make use of acoustic barriers or enclosures where there is likely to be significant disturbance to residents (subject to safety considerations).

The contractor's management team will employ the following actions to minimise the impact of noise, dust and vibration on the neighbours;

- All site operatives should be briefed and trained in the correct use of equipment and BPM measures in order to minimise noise impacts.
- Site surveys should take place to identify potential problems and facilitate work scheduling, the need for noise control measures, working hours and minimal delay and noise / dust impacts.
- Effective arrangements for the timely communication of site specific noise control measures to site teams should be in place.

To reduce air pollution the appointed contractors will be expected to employ the methods listed below.

- Ensuring that fumes and/or dust do not escape from the site to affect members of the public and the surrounding environment;

- Burning of materials on site is not permitted under any circumstances;
- Dusty activity should be undertaken away from sensitive receptors, with wind direction taken into consideration;
- The site should be regularly inspected for spillages of cement and other powders which should be removed to prevent off-site deposition;
- Dusty material and activities should be dampened down in dry weather. The use of groundwater should be investigated and water should be reused wherever possible.
- Rubber chutes should be used and drop heights minimised;
- Off-site fabrication, or cutting to size, shall be employed to avoid cutting materials on site whenever possible; and
- Careful consideration should be given to the location and temperature control of tar and asphalt burners.

13. POTENTIAL IMPACT ON EXISTING AND SURROUNDING UTILITIES, INFRASTRUCTURE AND MAN – MADE CAVITIES

Any local services on the property's land will be maintained during construction and rerouted if necessary. The exact location of these services will not be known until the works commence. However the impact will be negligible as these services will be maintained. If it is necessary to relocate or divert any utilities, the Contractor and Design Team will be under a statutory obligation to notify the utility owner prior to any works. This will be so that they can assess the impact of the works and grant or refuse their approval.

The method of constructing the front retaining wall, along with the presence of the front garden area means that services in the street should not be affected by these works.

14. POTENTIAL IMPACT ON DRAINAGE, SEWAGE, SURFACE AND GROUND WATER LEVELS AND FLOWS INCLUDING SUDS

All existing drainage and sewage connections will be maintained throughout the construction works and checked for new proposed use.

The new development will include creation of new accommodation below existing flats, which will increase a number of bathrooms. There will be a marginal increase in discharge into the existing drainage system which will have to be designed for increased use.

Surface water will not be greatly altered as the proposed works will be carried out in London Clay, which itself is a highly impermeable material, and the proposed lightwell extensions are within generally within existing hardstandings resulting in negligible change to the property's 'hard surfaces'.

The geotechnical investigations and research carried out confirm that the new formation will be into London Clay and ground water is not expected to be an issue.

15. POTENTIAL IMPACT ON EXISTING AND PROPOSED TREES

No existing trees will be felled during the construction of the proposed works.

There is an existing Ash tree in the rear garden of No 69, and arboriculturist should be asked to confirm whether the roots from the large Ash tree in No.69's garden will be affected by the proposed basement.

The basement will be founded sufficiently deep to be unaffected by the roots from the large Ash in No.69's rear garden. The tree's canopy does not reach the rear of the proposed basement and extension.

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BEng MSc CEng MIStructE

Green Structural Engineering Ltd

March 2018

APPENDICES

The following appendices are included with this report:

Appendix A	-	GSE Structural drawings for proposed basement
Appendix B	-	GSE Calculation sheets for design of basement retaining walls
Appendix C	-	GSE Underpinning Specification
Appendix D	-	Site Investigation Report (extract)

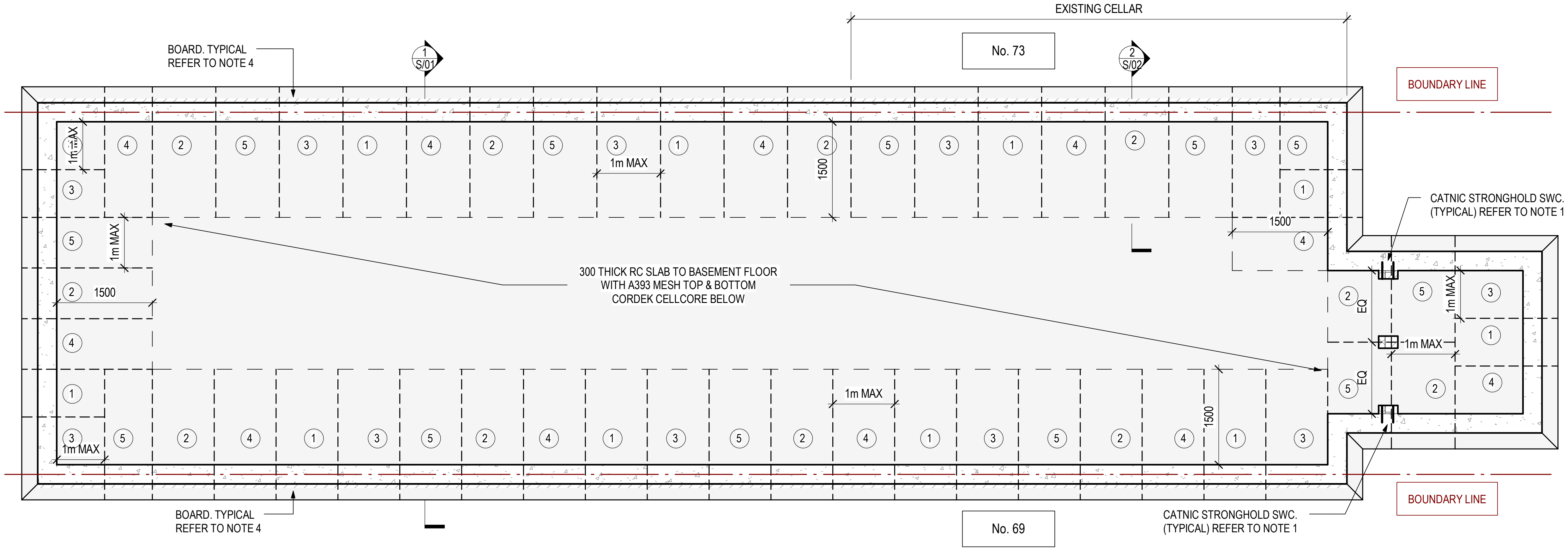
APPENDIX A

GSE STRUCTURAL DRAWINGS FOR PROPOSED BASEMENT

KEY:	
	EXISTING STRUCTURE
	NEW LOAD BEARING CONCRETE
	NEW LOAD BEARING BRICKWORK (20N/mm²)
	NEW LOAD BEARING BLOCKWORK (7N/mm²)
	NEW LOAD BEARING STUD PARTITION WALL
	NEW NON-LOAD BEARING STUD WALL
— — —	AREA TO BE UNDERPINNED

NOTES:

1. CATNIC STRONGHOLD SWC STAINLESS STEEL WALL STARTER KITS. POSITION AT JUNCTIONS OF EXISTING MASONRY WALL AND NEW MASONRY. INSTALL IN ACCORDANCE WITH THE MANUFACTURERS SPECIFICATION. FULLY EMBED TIES IN MORTAR JOINTS.
2. BELOW GROUND WATERPROOFING AND DRAINAGE BY OTHERS.
3. UNDERPINS WILL NOT BE STABLE WHILST UNDER CONSTRUCTION. CONTRACTOR MUST PROVIDE ADEQUATE LATERAL SUPPORT TO ALL PINS UNTIL BASEMENT SLAB HAS BEEN CAST.
4. NON COMPRESSIBLE WATER RESISTANT CEMENTITIOUS BOARD LINER TO BACK OF ALL UNDERPIN SUPPORTING PARTY WALLS.
5. RAISE RETAINING WALL LOCALLY (440 LONG x 100 WIDE) TO SUPPORT NEW STEEL WORK.



BASEMENT

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BASEMENT GA

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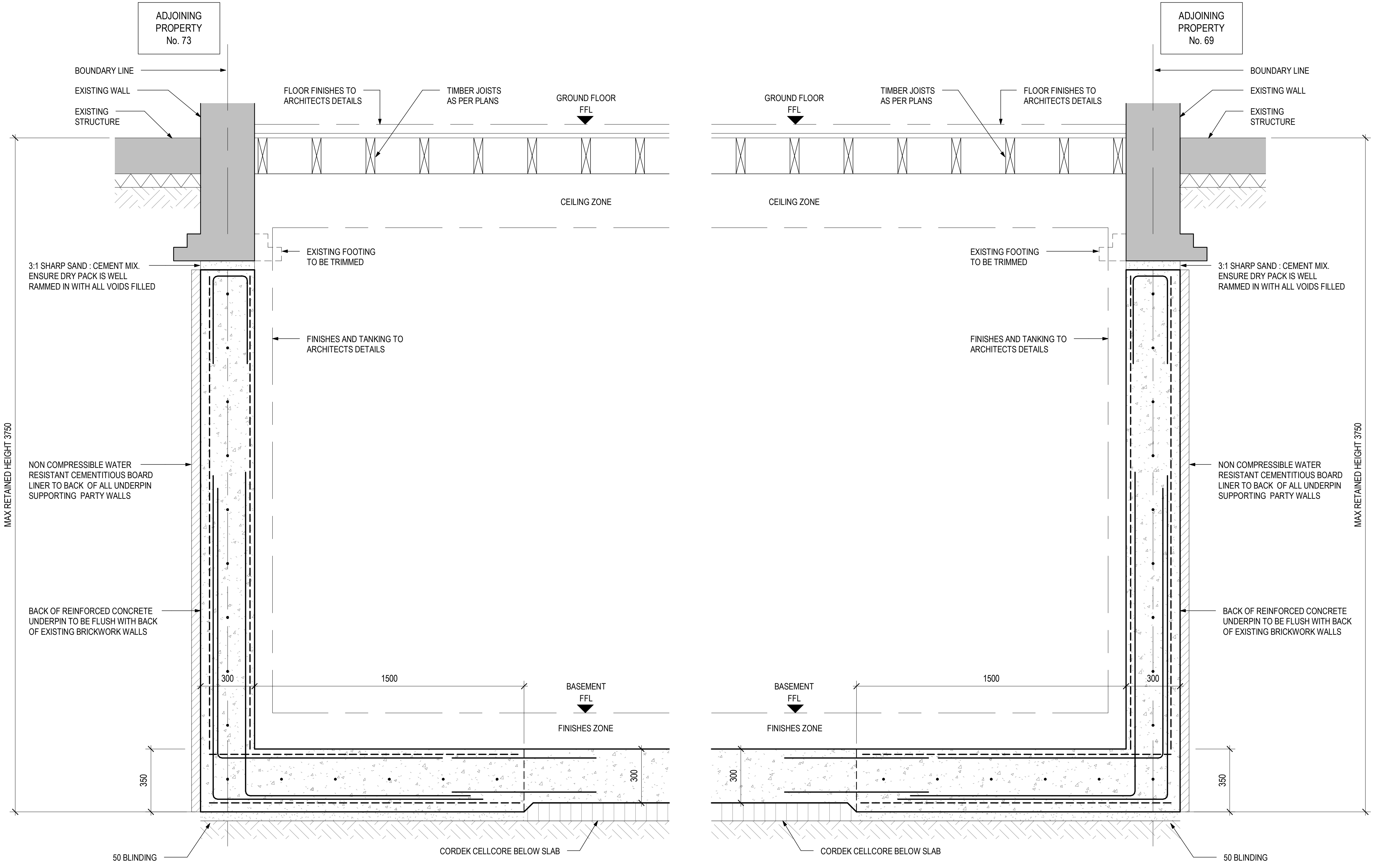

UNDERPIN SECTION 1

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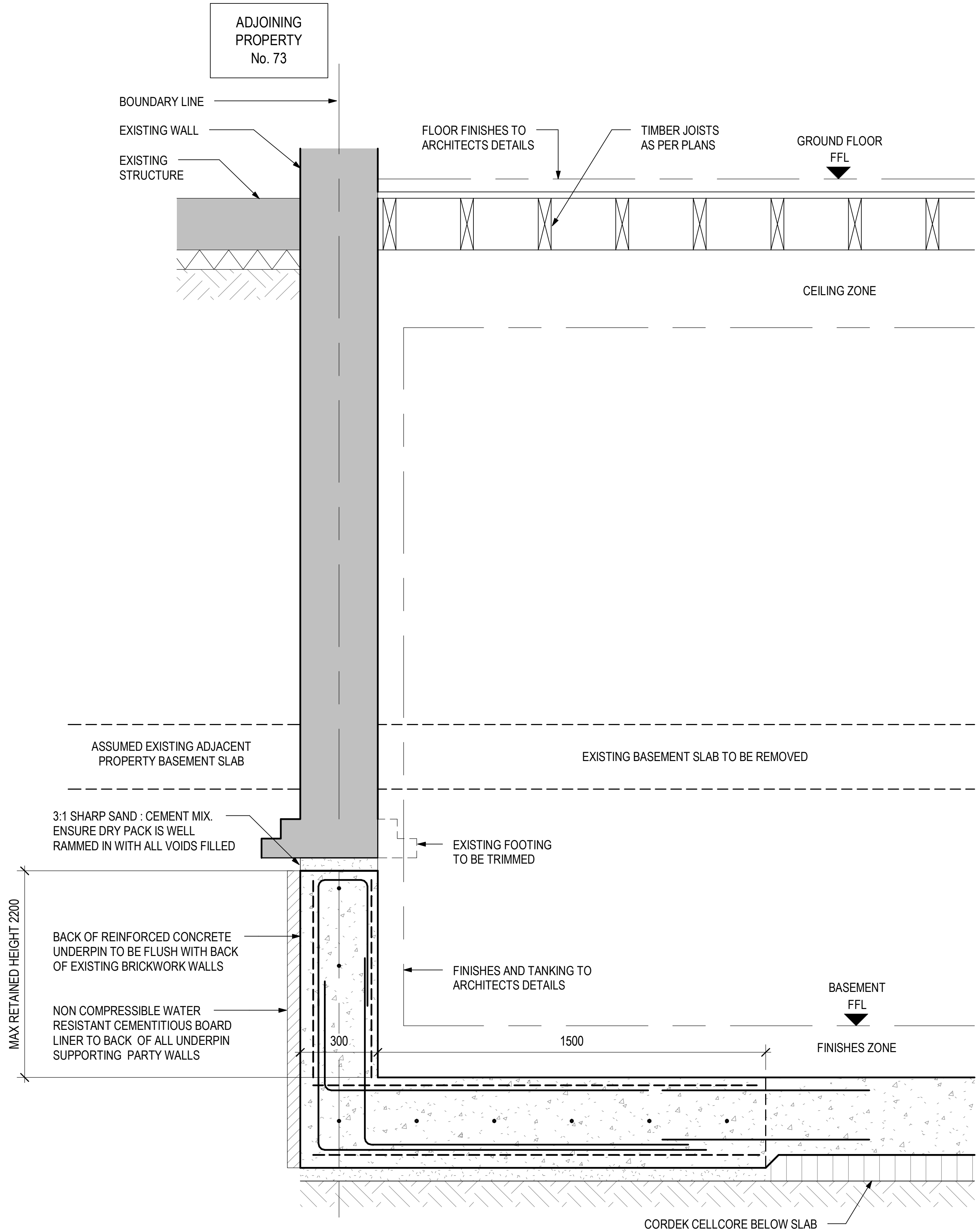

UNDERPIN SECTION 2

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SECTION SHEET 2

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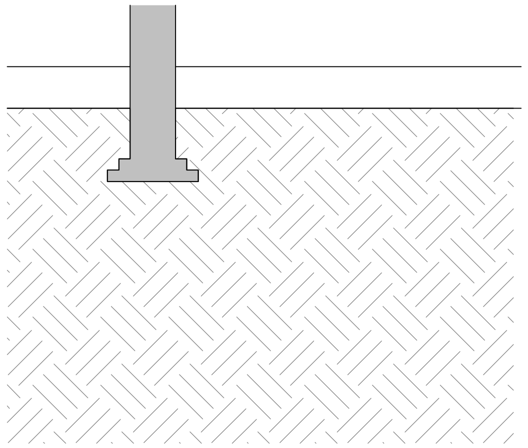
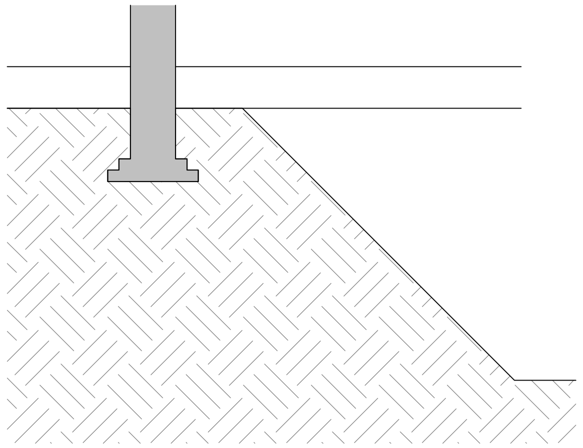


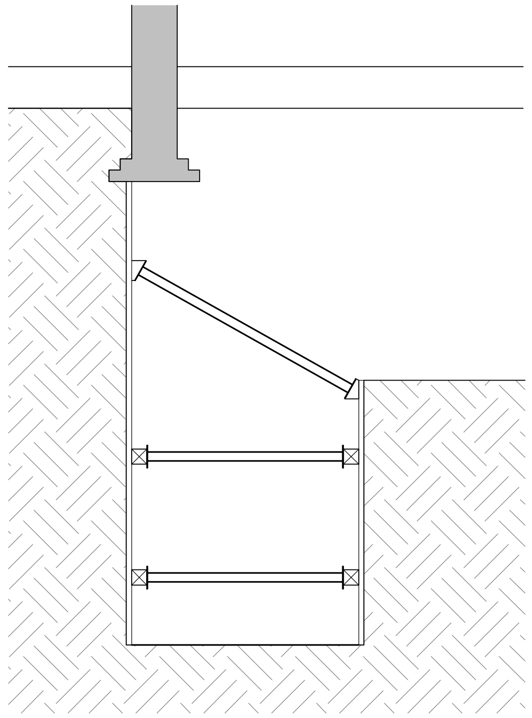
STAGE 0

EXISTING CONDITION



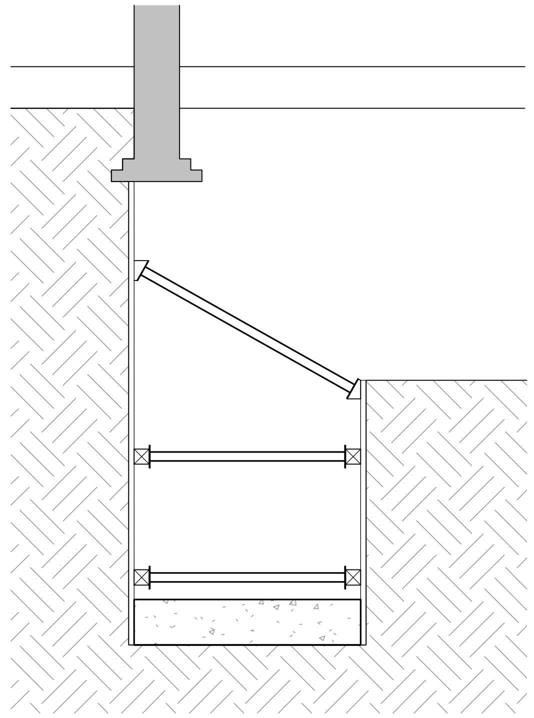
STAGE 1

GENERAL LEVEL REDUCTION



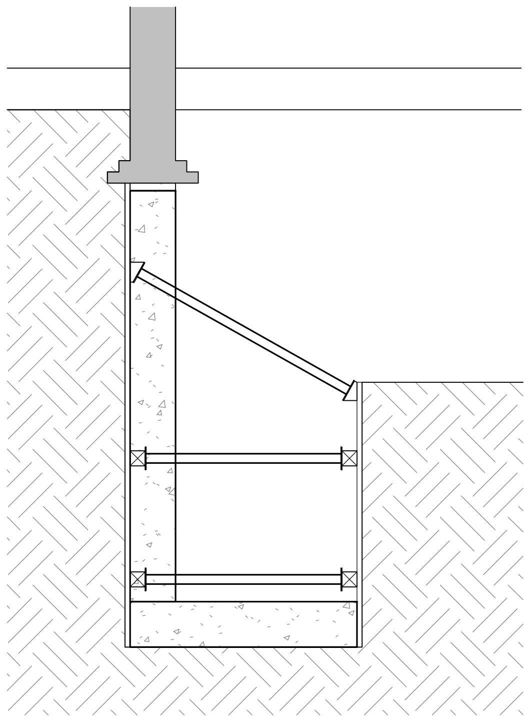
STAGE 2

EXCAVATE TO FORM UNDERPIN



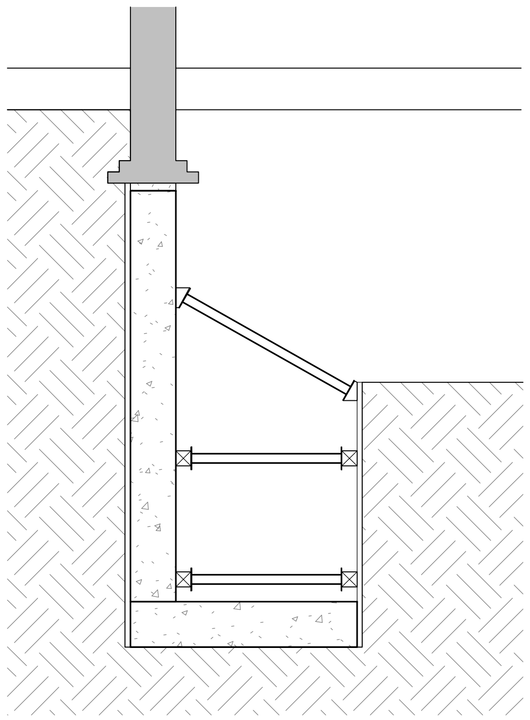
STAGE 3

CONCRETE BASE OF UNDERPIN



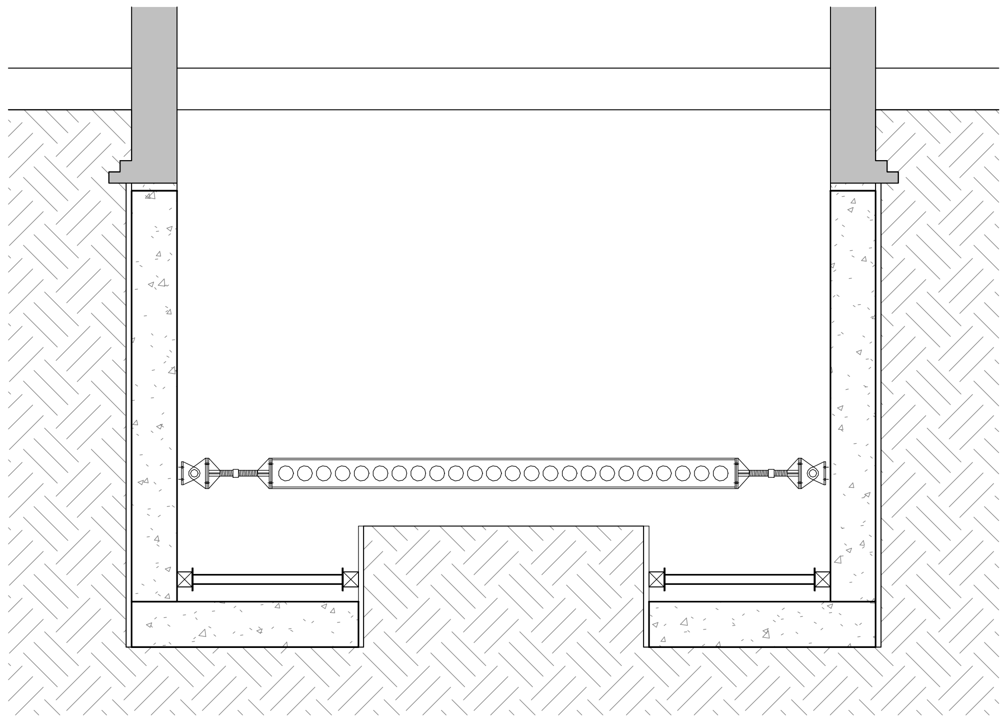
STAGE 4

ERECT SHUTTER
CONCRETE STEM OF UNDERPIN



STAGE 5

STRIKE SHUTTER WHEN CONCRETE HAS GAINED SUFFICIENT STRENGTH, DRYPACK, TRIM - OFF PROJECTING FOOTING, RE-PROP UNTIL BASEMENT SLAB IS CAST.



STAGE 6

COMMENCE EXCAVATION OF CENTRAL BERM.
ONCE EXCAVATION IS 500mm ABOVE FORMATION LEVEL
INSTALL SUPER SLIM SOLDIER ACROSS SITE AT LOW LEVEL.

ALL DIMENSIONS IN mm UNLESS OTHERWISE NOTED.
ALL DIMENSIONS AND LEVELS TO BE CONFIRMED BY ARCHITECT.
SETTING OUT TO BE CONFIRMED ON SITE.

J000958

71 GOLDHURST TERRACE

P1	22.03.18	INITIAL ISSUE

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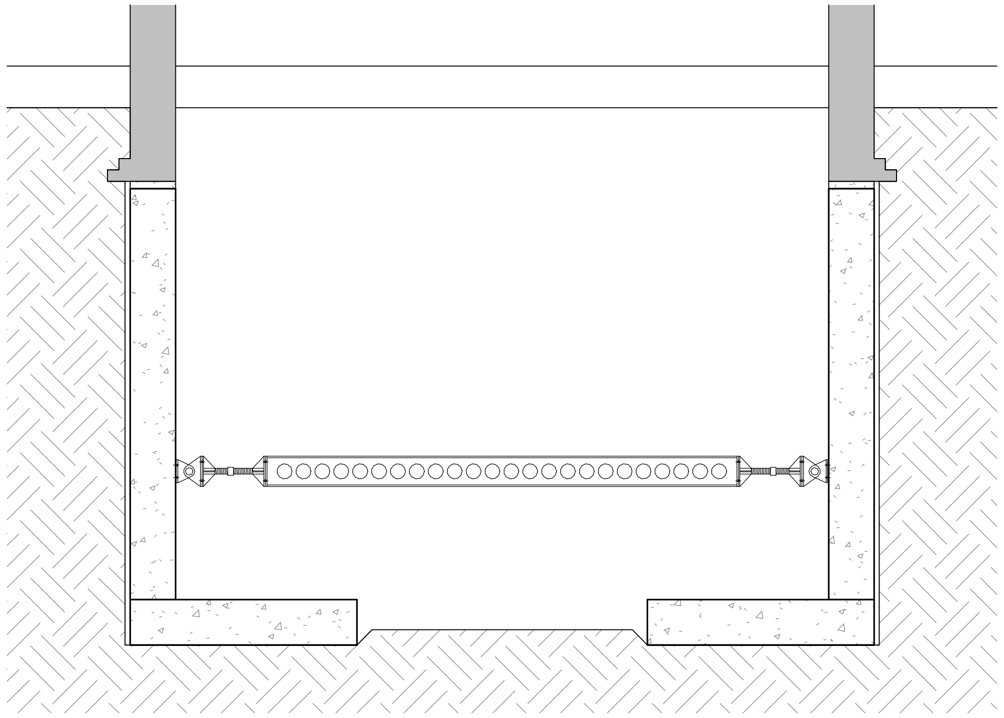
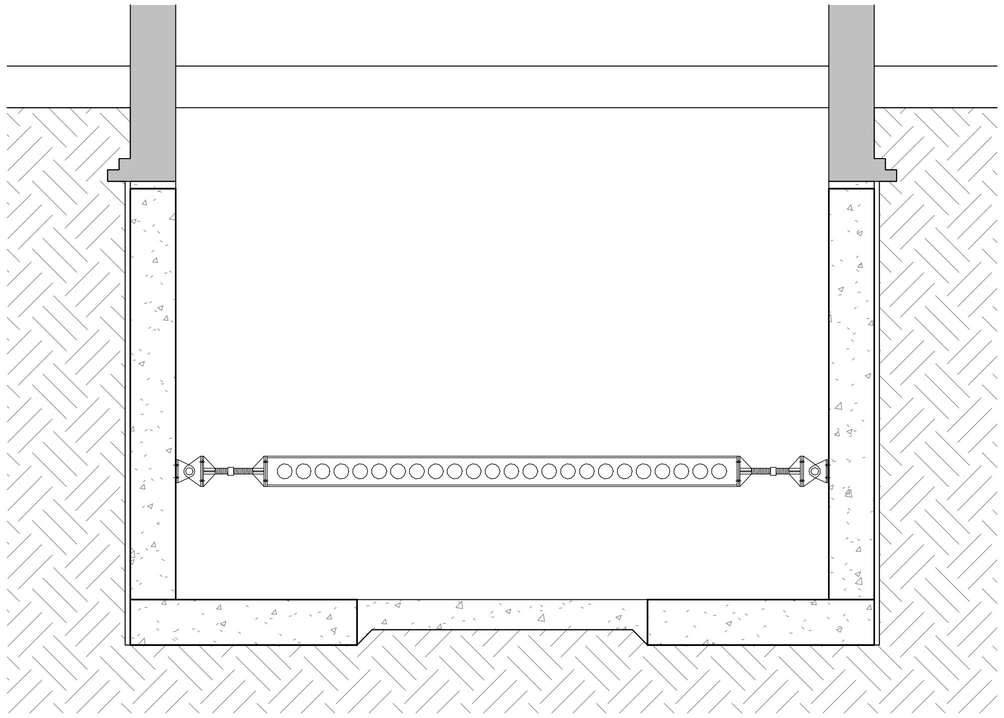
CONST. SEQ. FOR TYP. UNDERPIN SECTION

DRAWN	CHECKED	DATE	PAPER SIZE	SCALE	DRAWING NO.	REV.
IB	GG	22.03.2018	A3	1 : 50	MS/01	P1



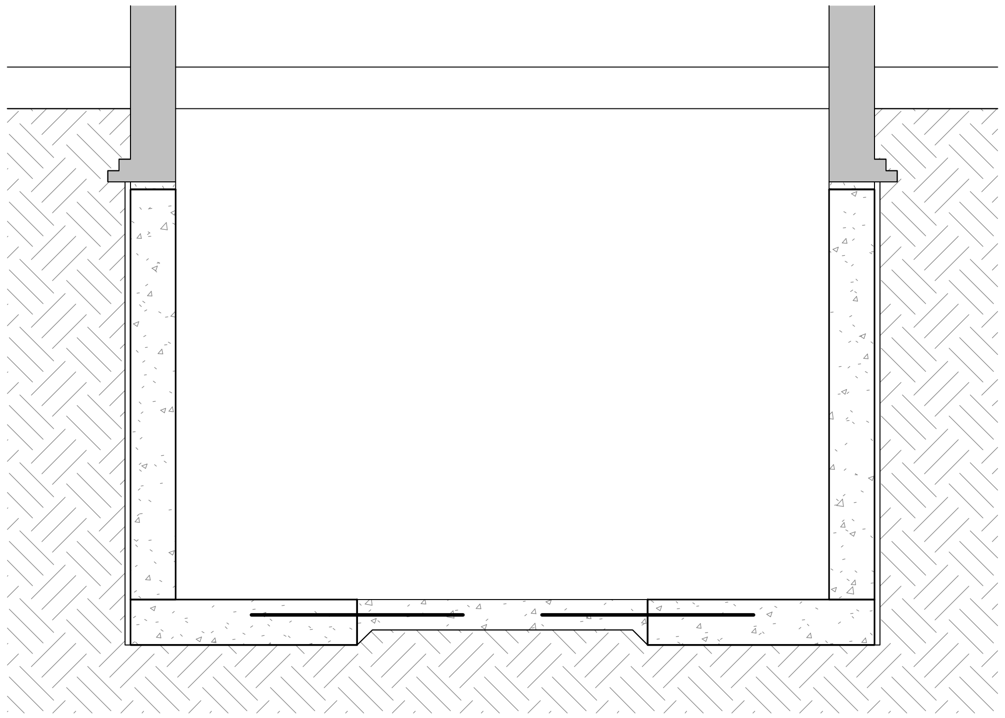
STAGE 7

COMPLETE EXCAVATION TO FORMATION LEVEL



STAGE 8

CAST BASEMENT SLAB AND LET CURE



STAGE 9

ALL PROPS REMOVED

DO NOT SCALE FROM THIS DRAWING THIS DRAWING IS SUBJECT TO COPYRIGHT.
THE CONTRACTOR IS RESPONSIBLE FOR VERIFYING ALL SITE DIMENSIONS BEFORE COMMENCING ANY WORK.
ALL DIMENSIONS IN mm UNLESS OTHERWISE NOTED.
ALL DIMENSIONS AND LEVELS TO BE CONFIRMED BY ARCHITECT.
SETTING OUT TO BE CONFIRMED ON SITE.

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CONST. SEQ. FOR TYP. UNDERPIN SECTION

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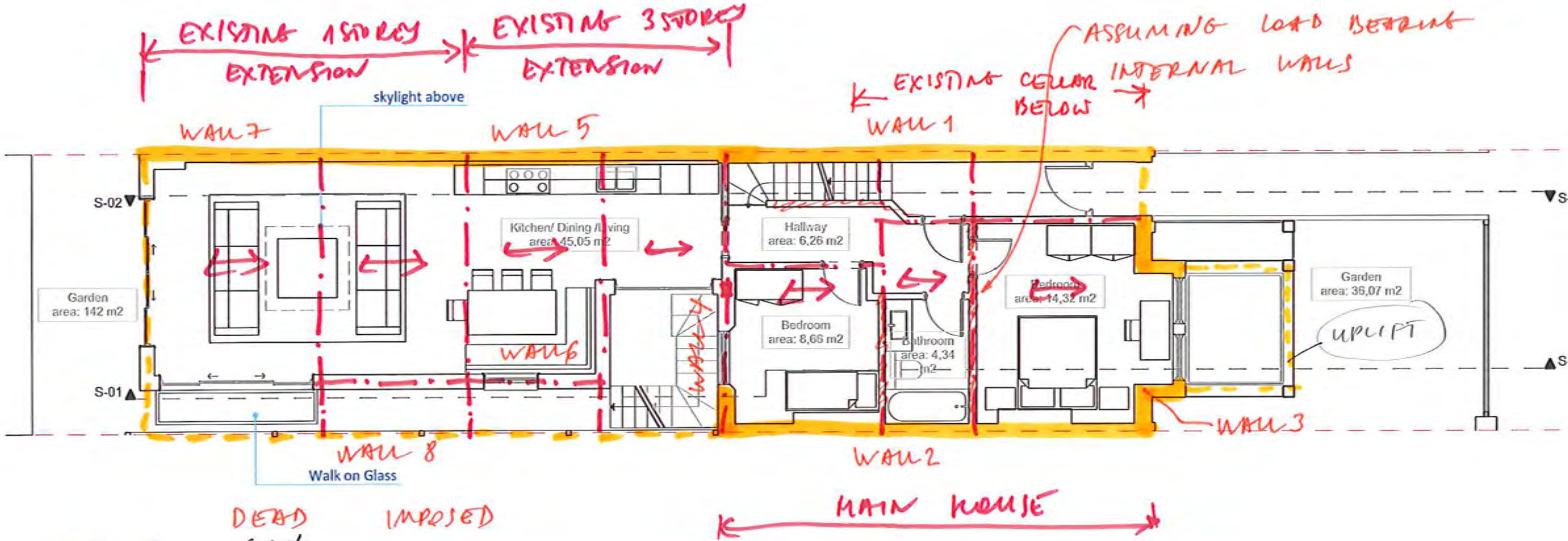
APPENDIX B

GSE CALCULATIONS FOR DESIGN OF BASEMENT RETAINING WALLS

Proposed Ground Floor Plan
1:100

ALL LOADS ARE UNFACTORED

LOAD TAKEN DOWN @ 0.5 M BELOW GROUND FLOOR LEVEL.



	DEAD	IMPOSED
WALL 1	60 kN/m	
WALL 2	60 kN/m	
WALL 3	54 kN/m	14 kN/m
WALL 4	ASSUME UNDERPINNED. SEE LOADS FOR WALL 3	
WALL 5	50 kN/m	16 kN/m
WALL 6		
WALL 7	25 kN/m	12 kN/m
WALL 8	16 kN/m	6 kN/m

LOAD TAKE DOWN

PROJECT DETAILS:

71 Goldhurst Terrace
NW6 3HA
London

N.DOC.:17_27_PR_1

TITLE: **Proposed Set**
Ground Floor

SCALE:	1:100 @A3
PHASE:	Planning
REVISION:	00
DATE:	18/08/2017

NOTE:

RevID	ChID	Change Name	Date
01			26/05/2017
02			05/06/2017

N 0 1 2 3

GREEN STRUCTURAL ENGINEERING

Project: 71 GOLDHURST TERRACE
Title:
By: J. SOKOLENKO

Project No: J000958
Date: 19/02/2018

	Project 71 GOLDHURST TERRACE		Job Ref J000958	
GSE GREEN STRUCTURAL ENGINEERING	Drawing Ref	Calculations by J.S.	Checked by	Sheet No. 1
	Part of Structure LOAD TAKE DOWN		Date FEB '18	

WALL 1 + WALL 2 (MAIN HOUSE)

@ BOTTOM OF EXISTING FOOTINGS (ASSUMED -0,5m)

DEAD: BRICKWORK:

9.6m × 0,33m × 19 kN/m³ = 60,2 kN/m

WALL 3 + WALL 4 (MAIN HOUSE)

DEAD: BRICKWORK

9.6m × 0,33m × 19 kN/m³ - 33% FOR WINDOWS = 40 kN/m

+ FLOOR LOAD (FLOOR SPAN FRONT-BACK ASSUMED)

3 FLOOR LEVELS + ROOF

ASSUME CENTRAL SPINE WALL. FLOOR SPAN: 4,5M

FLOOR DEAD LOAD:

1,5 kN/m² (INCLUDING PARTITIONS)

FLOOR IMPOSED LOAD:

1,5 kN/m²

LOAD TO FRONT / REAR ELEVATION:

4.5m × 1,5 / 2 = 3,4 kN/m PER LEVEL × 4 = 14 kN/m

TOTAL WALL 3 & 4 DEAD:

40 kN/m + 14 = 54 kN/m

IMPOSED: 14 kN/m

	Project		Job Ref	
GSE GREEN STRUCTURAL ENGINEERING	71 GOLDHURST TERRACE		J000958	
	Drawing Ref	Calculations by J.S.	Checked by	Sheet No. 2
	Part of Structure: LOAD TAKE DOWN		Date: FEB'18	

WALL 5

DEAD: BRICKWORK:

8,2m × 0,22 × 19 kN/m³ = 34 kN/m

FLOOR LOAD:

DEAD: 1,5 kN/m² × 3m = 4,5 kN/m PER LEVEL INCL NEXT DOOR

IMPOSED: -"- 4,5 kN/m PER LEVEL

× 4 LEVELS (INC ROOF) =

D: 4,5 × 3,5 = 15,5 kN/m

I: -"- 15,5 kN/m

TOTAL DEAD: 34+15,5 = 49,5 kN/m (conservative)

IMPOSED: 15,5 kN/m

WALL 6 – NOT GOING TO BASEMENT (SUPPORTED ON BEAMS, TRANSFERRING LOAD TO WALL 8)

WALL 7

DEAD: BRICKWORK

3m × 0,22 × 19 kN/m³ = 12,5 kN/m

FLOORS (TIMBER) + ROOF

1,5 kN/m² × 2,8m × 2 SIDES +

0,75 kN/m² × 2,3m × 2 SIDES = 11,85 kN/m

IMPOSED: 12 kN/m

TOTAL DEAD: 24,5 kN/m
IMPOSED: 12 kN/m

GSE GREEN STRUCTURAL ENGINEERING	Project: 71 GOLDHURST TERRACE		Job Ref: J0000958	
	Drawing Ref:	Calculations by: J.S.	Checked by:	Sheet No. 3
	Part of Structure: LOAD TAKE DOWN		Date: FEB '18	

WALL 8

DEAD: BRICKWORK:

3m × 0,22 × 19 kN/m³ − 20% WINDOWS = 10 kN/m

FLOORS:

1,5 kN/m² × 2,8 m + ROOF

0,75 kN/m² × 2,3 m = 6 kN/m

IMPOSED: 6 kN/m

TOTAL DEAD: 16 kN/m

IMPOSED: 6 kN/m

GSE GREEN STRUCTURAL ENGINEERING	Project: 71 GOLDHURST TERRACE		Job Ref: J000958	
	Drawing Ref:	Calculations by: J.S.	Checked by:	Sheet No.
	Part of Structure: UNDERPINNING DESIGN		Date:	

MAIN HOUSE AND REAR EXTENSION (SECTION R1)
UNDERPINNING (WALLS 2 & 5)

LOADS:

DEAD: 50kN/m IMPOSED: 16 kN/m

SOIL: CLAY
UNIT WEIGHT: 20kN/m^3
ANGLE OF INT. FRICTION: 22°
$K_0 = 1,0 - 1,5$

ALLOWABLE BEARING PRESSURE: 100 kN/m^2

HEIGHT OF THE WALL: 3,4m

WALL 8 UNDERPINNING (SECTION R2)

DEAD: 16 kN/m IMPOSED: 6 kN/m

WALL 1 UNDERPINNING:

ADD 2m OF MASONRY LOAD:

$2 \times 0{,}33 \times 19 kN/m^3 = 12{,}5$ kN/m

TOTAL DEAD: $50 + 12{,}5 = 62{,}5$ kN/m
IMPOSED: 16 kN/m

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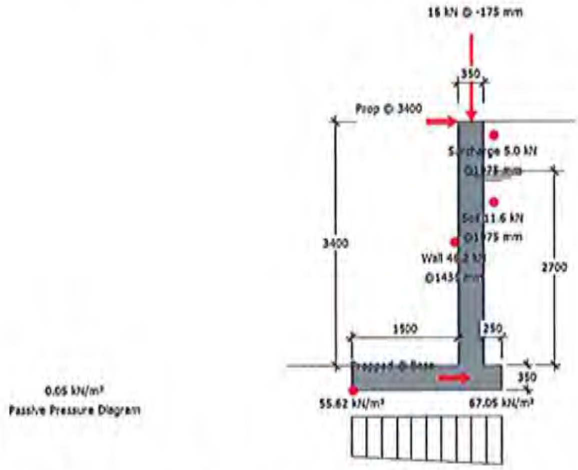
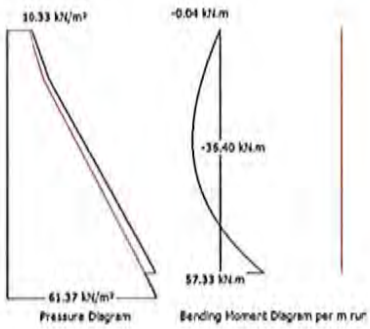
Checked	:
Approved	:

MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall 03 - L/C 1
Reinforced Concrete Retaining Wall with Reinforced Base





Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 20.00 kN/m², Water table level 2700 mm
Unplanned excavation depth	Front of wall 375 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 3.4 m
Vertical Line Loads	50 kN/m @ X -175 mm and Y 0 mm - Load type Dead
	16 kN/m @ X -175 mm and Y 0 mm - Load type Live
† Dimensions	All props are measured from the top of the base
	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 100.00 kN/m², @ back 100.00 kN/m²
Back Soil Friction and Cohesion	ϕ = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	$1.00\ G_{Soil}+1.00\ G_{Wall}+1.00\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}$
Case 2: Structural Ultimate Design	$1.40\ G_{Soil}+1.40\ G_{Wall}+1.60\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	171.401/310.843	0.551	OK

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Date : 20 February 2018 / Ver. 2017.10
Checked :
Approved :

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(32.524+0.000)	0.000	OK
Prop Reactions Case 2 (Service)	98.8 kN @ Base, 27.0 kN @ 3.750 m		

Soil Pressure

Virtual Back (No uplift)	Max(55.616/100, 67.051/100) kN/m²	0.671	OK
Wall Back (No uplift)	Max(64.827/100, 57.840/100) kN/m²	0.648	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\sin(\phi)) \times \sqrt{OCR} = (1+\sin(18.61) \times \sqrt{1}$	1.32

Prop Reactions

Maximum Prop Reactions (Ultimate)	140.2 kN @ Base, 40.1 kN @ 3.400 m

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 57.3 kN.m, Mr 160.7 kN.m	0.357	OK
Shear Capacity Check	F 113.1 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.63	OK

Wall Design (Outer Steel)

Critical Section	Critical @ 1838 mm from base, Case 2		
Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	315 mm, 1000 mm, 524 mm², 500 N/mm², 40.0 N/mm²	299 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	68.2 kN.m	
Moment Capacity Check (M/Mr)	M 36.4 kN.m, Mr 68.2 kN.m	0.534	OK
Shear Capacity Check	F 0.8 kN, vc 0.431 N/mm², Fvr 135.9 kN	0.01	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1608 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 0.4 kN.m, Mr 63.8 kN.m	0.007	OK
Shear Capacity Check	F 3.5 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.03	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1608 mm², 500 N/mm², 40 N/mm²	272 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 44 mm, 0.15	190.6 kN.m	
Moment Capacity Check (M/Mr)	M 81.2 kN.m, Mr 190.6 kN.m	0.426	OK
Shear Capacity Check	F 110.9 kN, vc 0.656 N/mm², Fvr 191.4 kN	0.58	OK

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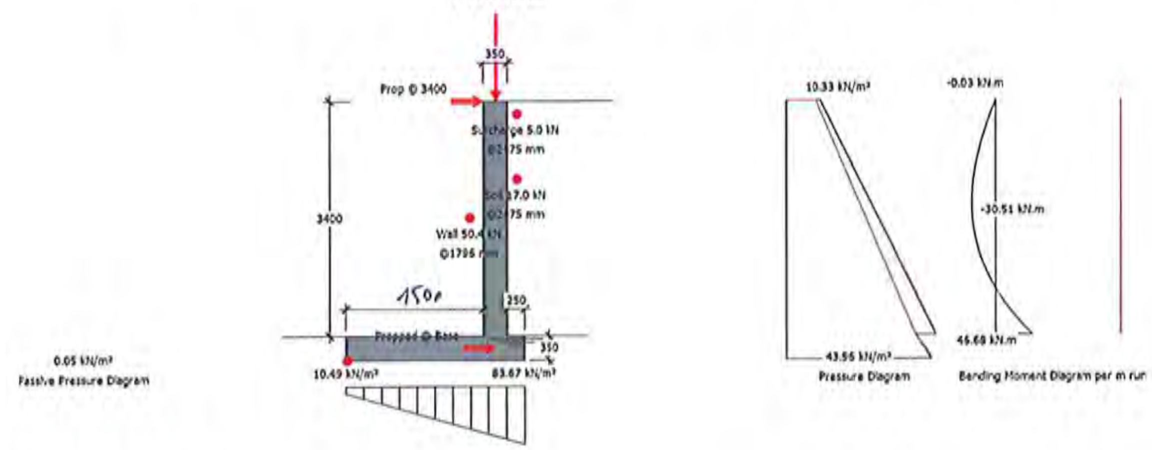
Date	: 20 February 2018 / Ver. 2017.10
Checked	:
Approved	:

MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall 03 - L/C 2
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 20.00 kN/m², Water table level 0 mm
Unplanned excavation depth	Front of wall 375 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 3.4 m
Vertical Line Load	50 kN/m @ X -175 mm and Y 0 mm - Load type Dead
† Dimensions	All props are measured from the top of the base
	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 100.00 kN/m², @ back 100.00 kN/m²
Back Soil Friction and Cohesion	ϕ = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	$1.00\ G_{Soil}+1.00\ G_{Wall}+1.00\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}$
Case 2: Structural Ultimate Design	$1.40\ G_{Soil}+1.40\ G_{Wall}+1.60\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	140.829/341.176	0.413	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(30.908+0.000)	0.000	OK

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Prop Reactions Case 2 (Service)	72.8 kN @ Base, 23.3 kN @ 3.750 m		

Soil Pressure

Virtual Back (No uplift)	Max(10.485/100, 83.668/100) kN/m²	0.837	OK
Wall Back (No uplift)	Max(17.765/100, 76.389/100) kN/m²	0.764	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	(1+Sin(ϕ)) x√OCR = (1+Sin(18.61)x√1		1.32

Prop Reactions

Maximum Prop Reactions (Ultimate)	108.4 kN @ Base, 35.7 kN @ 3.400 m		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 46.7 kN.m, Mr 160.7 kN.m	0.290	OK
Shear Capacity Check	F 89.2 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.50	OK

Wall Design (Outer Steel)

Critical Section	Critical @ 1900 mm from base, Case 2		
Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	315 mm, 1000 mm, 524 mm², 500 N/mm², 40.0 N/mm²	299 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	68.2 kN.m	
Moment Capacity Check (M/Mr)	M 30.5 kN.m, Mr 68.2 kN.m	0.448	OK
Shear Capacity Check	F 0.1 kN, vc 0.431 N/mm², Fvr 135.9 kN	0.00	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 0.9 kN.m, Mr 63.8 kN.m	0.014	OK
Shear Capacity Check	F 7.7 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.06	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 63.8 kN.m, Mr 160.7 kN.m	0.397	OK
Shear Capacity Check	F 87.6 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.49	OK

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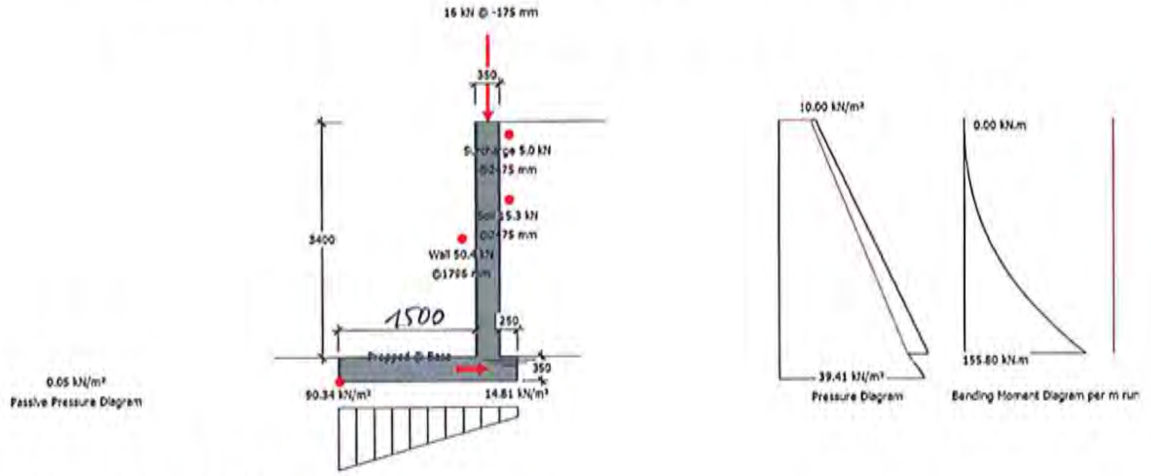
Job Ref	:
Sheet	: /10004
Made by	:
Date	: 20 February 2018 / Ver. 2017.10
Checked	:
Approved	:

MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall 03 - L/C 3
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Dry Soil 18.00, Saturated Soil 20.80, Submerged Soil 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 20.00 kN/m², Water table level 0 mm
Unplanned excavation depth	Front of wall 375 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Vertical Line Loads	50 kN/m @ X -175 mm and Y 0 mm - Load type Dead
	16 kN/m @ X -175 mm and Y 0 mm - Load type Live
† Dimensions	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 100.00 kN/m², @ back 100.00 kN/m²
Back Soil Friction and Cohesion	ϕ = Atn(Tan(23)/1.2) = 19.48°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(23)/1.2))) = 14.86°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	$1.00\ G_{Soil}+1.00\ G_{Wall}+1.00\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}$
Case 2: Structural Ultimate Design	$1.40\ G_{Soil}+1.40\ G_{Wall}+1.60\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	128.167/284.302	0.451	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+ Rx_{Passive})$	0.000/(36.266+0.000)	0.000	OK
Prop Reaction Case 2 (Service)	86.7 kN @ Base		

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Soil Pressure

Virtual Back (No uplift)	Max(71.726/100, 33.428/100) kN/m²	0.717	OK
Wall Back (No uplift)	Max(90.344/100, 14.810/100) kN/m²	0.903	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\text{Sin}(\phi)) \times \sqrt{OCR} = (1+\text{Sin}(19.48) \times \sqrt{1}$		1.33

Prop Reaction

Maximum Prop Reaction (Ultimate)	131.9 kN @ Base

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	OK
Compression Steel Provided (Cover)	Main H10@300 (30 mm) Dist. H10@300 (40 mm)	262 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1608 mm², 500 N/mm², 40.0 N/mm²	272 mm	
Mr=fn(above,As',d',x,x/d)	262 mm², 35 mm, 44 mm, 0.15	190.6 kN.m	
Moment Capacity Check (M/Mr)	M 155.8 kN.m, Mr 190.6 kN.m	0.818	OK
Shear Capacity Check	F 114.6 kN, vc 0.656 N/mm², Fvr 191.4 kN	0.60	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1608 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 2.9 kN.m, Mr 63.8 kN.m	0.045	OK
Shear Capacity Check	F 22.7 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.17	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1608 mm², 500 N/mm², 40 N/mm²	272 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 44 mm, 0.15	190.6 kN.m	
Moment Capacity Check (M/Mr)	M 166.4 kN.m, Mr 190.6 kN.m	0.873	OK
Shear Capacity Check	F 145.6 kN, vc 0.656 N/mm², Fvr 191.4 kN	0.76	OK

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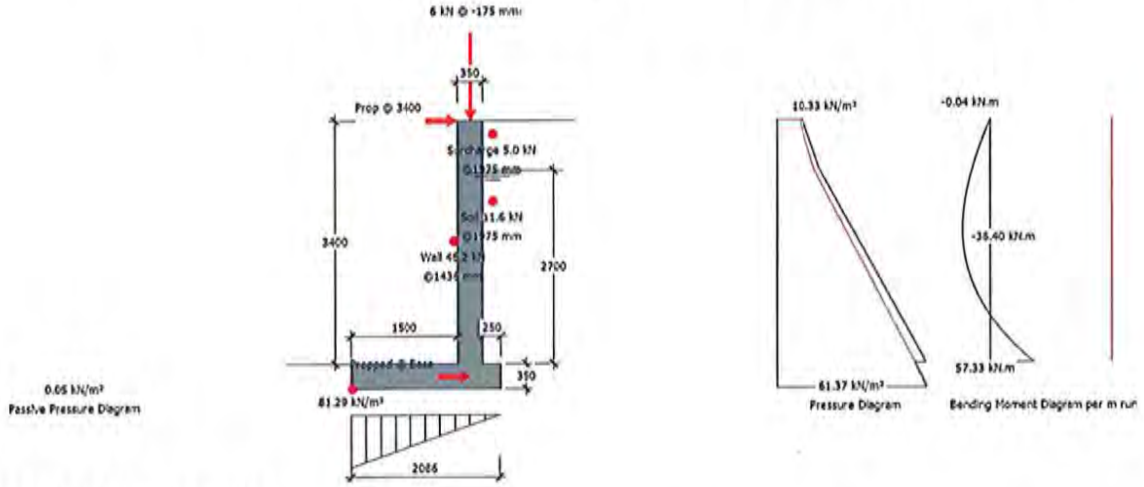
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall 03 - L/C 1
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 20.00 kN/m², Water table level 2700 mm
Unplanned excavation depth	Front of wall 375 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 3.4 m
Vertical Line Loads	16 kN/m @ X -175 mm and Y 0 mm - Load type Dead
	6 kN/m @ X -175 mm and Y 0 mm - Load type Live
† Dimensions	All props are measured from the top of the base
	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 100.00 kN/m², @ back 100.00 kN/m²
Back Soil Friction and Cohesion	ϕ = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	$1.00\ G_{Soil}+1.00\ G_{Wall}+1.00\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}$
Case 2: Structural Ultimate Design	$1.40\ G_{Soil}+1.40\ G_{Wall}+1.60\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	171.401/237.143	0.723	OK

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Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(21.413+0.000)	0.000	OK
Prop Reactions Case 2 (Service)	98.8 kN @ Base, 27.0 kN @ 3.750 m		

Soil Pressure

Virtual Back (No uplift)	Max(72.078/100, 8.684/100) kN/m²	0.721	OK
Wall Back	81.293/100 kN/m², Length under pressure 2.086 m	0.813	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\sin(\phi))\times\sqrt{OCR} = (1+\sin(18.61)\times\sqrt{1}$		1.32

Prop Reactions

Maximum Prop Reactions (Ultimate)	140.2 kN @ Base, 40.1 kN @ 3.400 m		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 57.3 kN.m, Mr 160.7 kN.m	0.357	OK
Shear Capacity Check	F 113.1 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.63	OK

Wall Design (Outer Steel)

Critical Section	Critical @ 1838 mm from base, Case 2		
Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	315 mm, 1000 mm, 524 mm², 500 N/mm², 40.0 N/mm²	299 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	68.2 kN.m	
Moment Capacity Check (M/Mr)	M 36.4 kN.m, Mr 68.2 kN.m	0.534	OK
Shear Capacity Check	F 0.8 kN, vc 0.431 N/mm², Fvr 135.9 kN	0.01	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1608 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 2.9 kN.m, Mr 63.8 kN.m	0.046	OK
Shear Capacity Check	F 23.0 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.17	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1608 mm², 500 N/mm², 40 N/mm²	272 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 44 mm, 0.15	190.6 kN.m	
Moment Capacity Check (M/Mr)	M 79.0 kN.m, Mr 190.6 kN.m	0.414	OK
Shear Capacity Check	F 88.7 kN, vc 0.656 N/mm², Fvr 191.4 kN	0.46	OK

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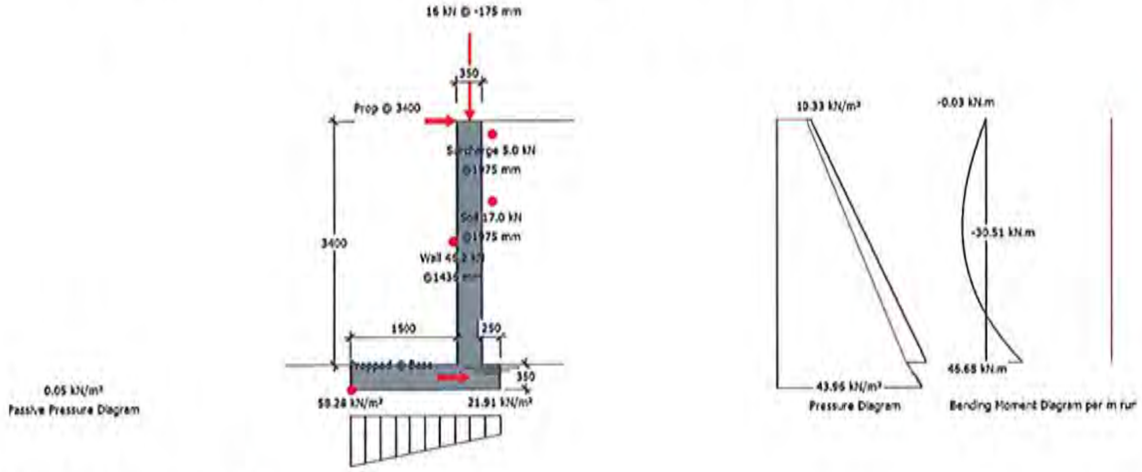
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall 03 - L/C 2
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 20.00 kN/m², Water table level 0 mm
Unplanned excavation depth	Front of wall 375 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 3.4 m
Vertical Line Load	16 kN/m @ X -175 mm and Y 0 mm - Load type Dead
† Dimensions	All props are measured from the top of the base
	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 100.00 kN/m², @ back 100.00 kN/m²
Back Soil Friction and Cohesion	ϕ_b = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	$1.00\ G_{Soil}+1.00\ G_{Wall}+1.00\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}$
Case 2: Structural Ultimate Design	$1.40\ G_{Soil}+1.40\ G_{Wall}+1.60\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	140.829/224.076	0.628	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(21.262+0.000)	0.000	OK

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Prop Reactions Case 2 (Service)	72.8 kN @ Base, 23.3 kN @ 3.750 m		

Soil Pressure

Virtual Back (No uplift)	Max(47.120/100, 33.070/100) kN/m²	0.471	OK
Wall Back (No uplift)	Max(58.279/100, 21.912/100) kN/m²	0.583	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\mathrm{Sin}(\phi))\ \mathrm{x}\sqrt{\mathrm{OCR}} = (1+\mathrm{Sin}(18.61)\mathrm{x}\sqrt{1}$		1.32

Prop Reactions

Maximum Prop Reactions (Ultimate)	108.4 kN @ Base, 35.7 kN @ 3.400 m		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 46.7 kN.m, Mr 160.7 kN.m	0.290	OK
Shear Capacity Check	F 89.2 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.50	OK

Wall Design (Outer Steel)

Critical Section	Critical @ 1900 mm from base, Case 2		
Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	315 mm, 1000 mm, 524 mm², 500 N/mm², 40.0 N/mm²	299 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	68.2 kN.m	
Moment Capacity Check (M/Mr)	M 30.5 kN.m, Mr 68.2 kN.m	0.448	OK
Shear Capacity Check	F 0.1 kN, vc 0.431 N/mm², Fvr 135.9 kN	0.00	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 3.1 kN.m, Mr 63.8 kN.m	0.048	OK
Shear Capacity Check	F 24.4 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.18	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 60.7 kN.m, Mr 160.7 kN.m	0.378	OK
Shear Capacity Check	F 74.7 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.41	OK

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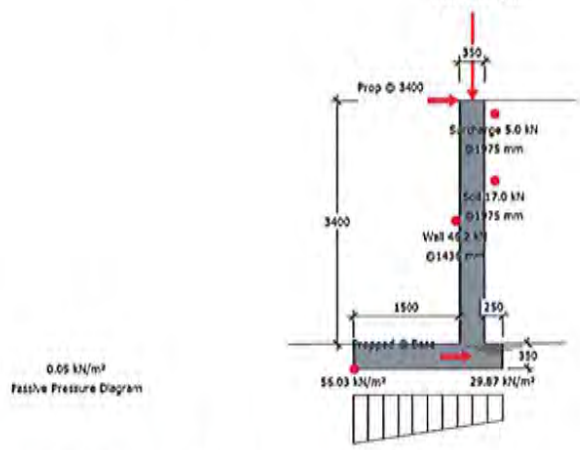
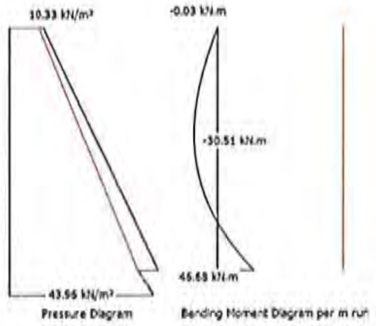
MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall 03 - L/C 3
Reinforced Concrete Retaining Wall with Reinforced Base





Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 20.00 kN/m², Water table level 0 mm
Unplanned excavation depth	Front of wall 375 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 3.4 m
Vertical Line Loads	16 kN/m @ X -175 mm and Y 0 mm - Load type Dead
	6 kN/m @ X -175 mm and Y 0 mm - Load type Live
† Dimensions	All props are measured from the top of the base
	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 100.00 kN/m², @ back 100.00 kN/m²
Back Soil Friction and Cohesion	ϕ = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge

Case 1: Geotechnical Design	$1.00\ G_{Soil}+1.00\ G_{Wall}+1.00\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}$
Case 2: Structural Ultimate Design	$1.40\ G_{Soil}+1.40\ G_{Wall}+1.60\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	140.829/234.126	0.602	OK

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Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(22.777+0.000)	0.000	OK
Prop Reactions Case 2 (Service)	72.8 kN @ Base, 23.3 kN @ 3.750 m		

Soil Pressure

Virtual Back (No uplift)	Max(44.876/100, 41.029/100) kN/m²	0.449	OK
Wall Back (No uplift)	Max(56.034/100, 29.871/100) kN/m²	0.560	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\sin(\phi)) \times \sqrt{OCR} = (1+\sin(18.61) \times \sqrt{1}$		1.32

Prop Reactions

Maximum Prop Reactions (Ultimate)	108.4 kN @ Base, 35.7 kN @ 3.400 m		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 46.7 kN.m, Mr 160.7 kN.m	0.290	OK
Shear Capacity Check	F 89.2 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.50	OK

Wall Design (Outer Steel)

Critical Section	Critical @ 1900 mm from base, Case 2		
Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	315 mm, 1000 mm, 524 mm², 500 N/mm², 40.0 N/mm²	299 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	68.2 kN.m	
Moment Capacity Check (M/Mr)	M 30.5 kN.m, Mr 68.2 kN.m	0.448	OK
Shear Capacity Check	F 0.1 kN, vc 0.431 N/mm², Fvr 135.9 kN	0.00	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 2.7 kN.m, Mr 63.8 kN.m	0.042	OK
Shear Capacity Check	F 21.5 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.16	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 61.1 kN.m, Mr 160.7 kN.m	0.380	OK
Shear Capacity Check	F 78.1 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.43	OK

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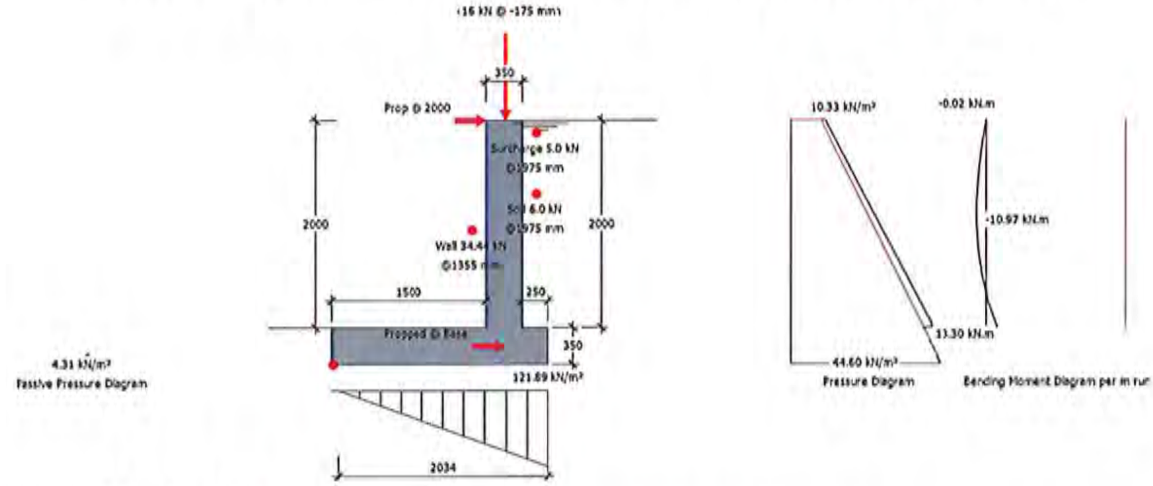
25612

Job Ref	:
Sheet	: /10012
Made by	:
Date	: 22 March 2018 / Ver. 2017.10
Checked	:
Approved	:

MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall 03 - L/C 1
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 20.00 kN/m², Water table level 2000 mm
Unplanned excavation depth	Front of wall 235 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 2.0 m
Vertical Line Loads	62.5 kN/m @ X -175 mm and Y 0 mm - Load type Dead
	16 kN/m @ X -175 mm and Y 0 mm - Load type Live
† Dimensions	All props are measured from the top of the base
	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 150.00 kN/m², @ back 150.00 kN/m²
Back Soil Friction and Cohesion	ϕ = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge, P_p- Passive Earth Pressure

Case 1: Geotechnical Design	$1.00\ G_{Soil}+1.00\ G_{Wall}+1.00\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}+1.00\ P_p$
Case 2: Structural Ultimate Design	$1.40\ G_{Soil}+1.40\ G_{Wall}+1.60\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}+1.00\ P_p$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	57.789/234.044	0.247	OK

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Sheet	: /10013
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Approved	:

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(31.297+0.250)	0.000	OK
Prop Reactions Case 2 (Service)	48.7 kN @ Base, 14.5 kN @ 2.350 m		

Soil Pressure

Virtual Back	121.886/150 kN/m², Length under pressure 2.034 m	0.813	OK
Wall Back	119.226/150 kN/m², Length under pressure 2.079 m	0.795	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\sin(\phi))\times\sqrt{OCR} = (1+\sin(18.61))\times\sqrt{1}$		1.32

Prop Reactions

Maximum Prop Reactions (Ultimate)	68.0 kN @ Base, 21.2 kN @ 2.000 m		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 13.3 kN.m, Mr 160.7 kN.m	0.083	OK
Shear Capacity Check	F 48.6 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.27	OK

Wall Design (Outer Steel)

Critical Section	Critical @ 1099 mm from base, Case 2		
Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	315 mm, 1000 mm, 524 mm², 500 N/mm², 40.0 N/mm²	299 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	68.2 kN.m	
Moment Capacity Check (M/Mr)	M 11.0 kN.m, Mr 68.2 kN.m	0.161	OK
Shear Capacity Check	F 0.3 kN, vc 0.431 N/mm², Fvr 135.9 kN	0.00	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1608 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 0.5 kN.m, Mr 63.8 kN.m	0.007	OK
Shear Capacity Check	F 4.7 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.04	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@125 (50 mm) Dist. H10@150 (66 mm)	1608 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1608 mm², 500 N/mm², 40 N/mm²	272 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 44 mm, 0.15	190.6 kN.m	
Moment Capacity Check (M/Mr)	M 28.3 kN.m, Mr 190.6 kN.m	0.149	OK
Shear Capacity Check	F 70.2 kN, vc 0.656 N/mm², Fvr 191.4 kN	0.37	OK

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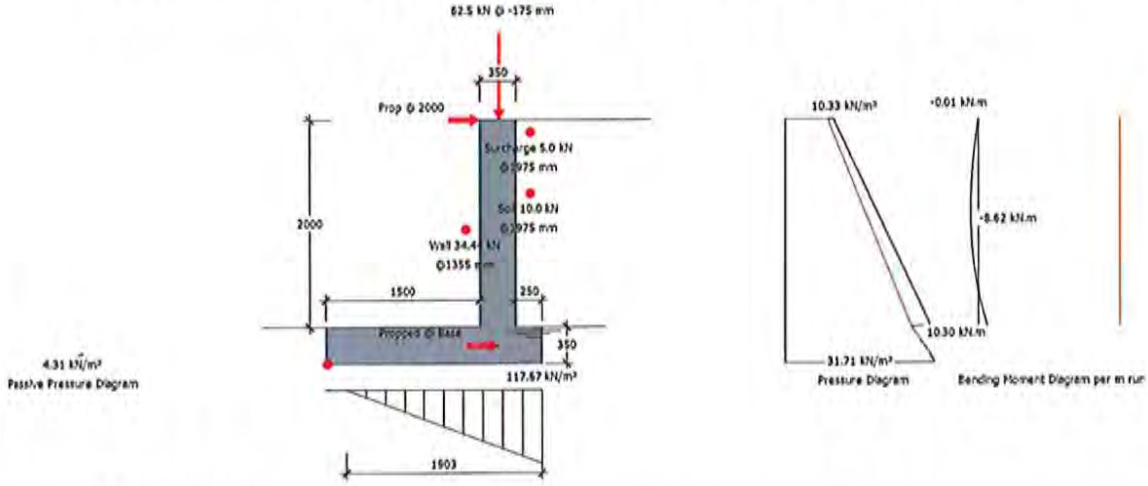
Job Ref	:
Sheet	: /10014
Made by	:
Date	: 22 March 2018 / Ver. 2017.10
Checked	:
Approved	:

MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall 03 - L/C 2
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00
	Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 20.00 kN/m², Water table level 0 mm
Unplanned excavation depth	Front of wall 235 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 2.0 m
Vertical Line Load	62.5 kN/m @ X -175 mm and Y 0 mm - Load type Dead
† Dimensions	All props are measured from the top of the base
	Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 150.00 kN/m², @ back 150.00 kN/m²
Back Soil Friction and Cohesion	ϕ_b = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge, P_p- Passive Earth Pressure

Case 1: Geotechnical Design	$1.00\ G_{Soil}+1.00\ G_{Wall}+1.00\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}+1.00\ P_p$
Case 2: Structural Ultimate Design	$1.40\ G_{Soil}+1.40\ G_{Wall}+1.60\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}+1.00\ P_p$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	43.854/207.935	0.211	OK

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(28.267+0.250)	0.000	OK

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Job Ref	:
Sheet	: /10015
Made by	:
Date	: 22 March 2018 / Ver. 2017.10
Checked	:
Approved	:

Prop Reactions Case 2 (Service) 34.3 kN @ Base, 11.5 kN @ 2.350 m

Soil Pressure

Virtual Back	117.670/150 kN/m², Length under pressure 1.903 m	0.784	OK
Wall Back	113.792/150 kN/m², Length under pressure 1.967 m	0.759	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\sin(\phi)) \times \sqrt{OCR} = (1+\sin(18.61) \times \sqrt{1}$		1.32

Prop Reactions

Maximum Prop Reactions (Ultimate)	50.3 kN @ Base, 17.6 kN @ 2.000 m		

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 10.3 kN.m, Mr 160.7 kN.m	0.064	OK
Shear Capacity Check	F 36.8 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.20	OK

Wall Design (Outer Steel)

Critical Section	Critical @ 1099 mm from base, Case 2		
Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	315 mm, 1000 mm, 524 mm², 500 N/mm², 40.0 N/mm²	299 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	68.2 kN.m	
Moment Capacity Check (M/Mr)	M 8.6 kN.m, Mr 68.2 kN.m	0.126	OK
Shear Capacity Check	F 0.2 kN, vc 0.431 N/mm², Fvr 135.9 kN	0.00	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 1.0 kN.m, Mr 63.8 kN.m	0.016	OK
Shear Capacity Check	F 8.4 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.06	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 19.9 kN.m, Mr 160.7 kN.m	0.124	OK
Shear Capacity Check	F 57.2 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.32	OK

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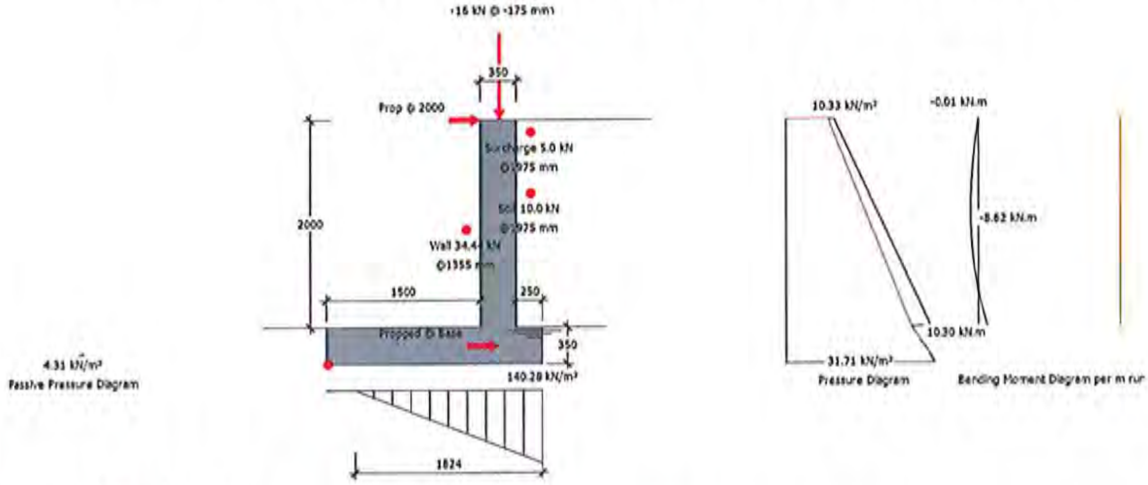
Job Ref	:
Sheet	: /10016
Made by	:
Date	: 22 March 2018 / Ver. 2017.10
Checked	:
Approved	:

MasterKey : Retaining Wall Design to BS 8002 and BS 8110 : 1997
Wall 03 - L/C 3
Reinforced Concrete Retaining Wall with Reinforced Base



Summary of Design Data

Notes	All dimensions are in mm and all forces are per metre run
Material Densities (kN/m³)	Back Soil - Dry 20.00, Saturated 22.00, Submerged 12.00 Front Soil - Dry 18.00, Saturated 20.80, Submerged 10.80, Concrete 24.00
Concrete grade	fcu 40 N/mm², Permissible tensile stress 0.250 N/mm²
Concrete covers (mm)	Wall inner cover 50 mm, Wall outer cover 30 mm, Base cover 50 mm
Reinforcement design	fy 500 N/mm² designed to BS 8110: 1997
Surcharge and Water Table	Surcharge 20.00 kN/m², Water table level 0 mm
Unplanned excavation depth	Front of wall 235 mm

† The Engineer must satisfy him/herself to the reinforcement detailing requirements of the relevant codes of practice

Additional Loads

Wall Propped at Base Level	Therefore no sliding check is required
Additional Wall Prop	Prop @ 2.0 m
Vertical Line Loads	62.5 kN/m @ X -175 mm and Y 0 mm - Load type Dead 16 kN/m @ X -175 mm and Y 0 mm - Load type Live
† Dimensions	All props are measured from the top of the base Ties, line loads and partial loads are measured from the inner top edge of the wall

Soil Properties

Soil bearing pressure	Allowable pressure @ front 150.00 kN/m², @ back 150.00 kN/m²
Back Soil Friction and Cohesion	ϕ_b = Atn(Tan(22)/1.2) = 18.61°
Base Friction and Cohesion	δ = Atn(0.75xTan(Atn(Tan(22)/1.2))) = 14.17°
Front Soil Friction and Cohesion	ϕ = Atn(Tan(30)/1.2) = 25.69°

Loading Cases

G_{Soil}- Soil Self Weight, G_{Wall}- Wall & Base Self Weight, Fv_{Heel}- Vertical Loads over Heel,
P_a- Active Earth Pressure, $P_{surcharge}$- Earth pressure from surcharge, P_p- Passive Earth Pressure

Case 1: Geotechnical Design	$1.00\ G_{Soil}+1.00\ G_{Wall}+1.00\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}+1.00\ P_p$
Case 2: Structural Ultimate Design	$1.40\ G_{Soil}+1.40\ G_{Wall}+1.60\ Fv_{Heel}+1.00\ P_a+1.00\ P_{surcharge}+1.00\ P_p$

Geotechnical Design

Wall Stability - Virtual Back Pressure

Case 1 Overturning/Stabilising	43.854/234.735	0.187	OK

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Job Ref :
Sheet : /10017
Made by :
Date : 22 March 2018 / Ver. 2017.10
Checked :
Approved :

Wall Sliding - Virtual Back Pressure

$Fx/(Rx_{Friction}+Rx_{Passive})$	0.000/(32.307+0.250)	0.000	OK
Prop Reactions Case 2 (Service)	34.3 kN @ Base, 11.5 kN @ 2.350 m		

Soil Pressure

Virtual Back	140.276/150 kN/m², Length under pressure 1.824 m	0.935	OK
Wall Back	136.045/150 kN/m², Length under pressure 1.881 m	0.907	OK

Structural Design

At Rest Earth Pressure

At rest earth pressures magnification	$(1+\mathrm{Sin}(\phi)) \times \sqrt{OCR} = (1+\mathrm{Sin}(18.61) \times \sqrt{1}$		1.32

Prop Reactions

Maximum Prop Reactions (Ultimate)	50.3 kN @ Base, 17.6 kN @ 2.000 m

Wall Design (Inner Steel)

Critical Section	Critical @ 0 mm from base, Case 2		
Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40.0 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 35 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 10.3 kN.m, Mr 160.7 kN.m	0.064	OK
Shear Capacity Check	F 36.8 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.20	OK

Wall Design (Outer Steel)

Critical Section	Critical @ 1099 mm from base, Case 2		
Steel Provided (Cover)	Main H10@150 (30 mm) Dist. H10@150 (40 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	315 mm, 1000 mm, 524 mm², 500 N/mm², 40.0 N/mm²	299 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	68.2 kN.m	
Moment Capacity Check (M/Mr)	M 8.6 kN.m, Mr 68.2 kN.m	0.126	OK
Shear Capacity Check	F 0.2 kN, vc 0.431 N/mm², Fvr 135.9 kN	0.00	OK

Base Top Steel Design

Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	OK
Compression Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	295 mm, 1000 mm, 524 mm², 500 N/mm², 40 N/mm²	280 mm	
Mr=fn(above,As',d',x,x/d)	1340 mm², 58 mm, 14 mm, 0.05	63.8 kN.m	
Moment Capacity Check (M/Mr)	M 1.4 kN.m, Mr 63.8 kN.m	0.022	OK
Shear Capacity Check	F 11.4 kN, vc 0.448 N/mm², Fvr 132.2 kN	0.09	OK

Base Bottom Steel Design

Steel Provided (Cover)	Main H16@150 (50 mm) Dist. H10@150 (66 mm)	1340 mm²	OK
Compression Steel Provided (Cover)	Main H10@150 (50 mm) Dist. H10@150 (60 mm)	524 mm²	
Leverarm z=fn(d,b,As,fy,Fcu)	292 mm, 1000 mm, 1340 mm², 500 N/mm², 40 N/mm²	276 mm	
Mr=fn(above,As',d',x,x/d)	524 mm², 55 mm, 37 mm, 0.13	160.7 kN.m	
Moment Capacity Check (M/Mr)	M 21.0 kN.m, Mr 160.7 kN.m	0.131	OK
Shear Capacity Check	F 65.4 kN, vc 0.617 N/mm², Fvr 180.1 kN	0.36	OK

APPENDIX C

GSE UNDERPINNING SPECIFICATION

Specification: **Underpinning**

Project: **71 Goldhurst Terrace NW6 3HA**

Date of issue: **28 February 2018**

Prepared by: **JS**

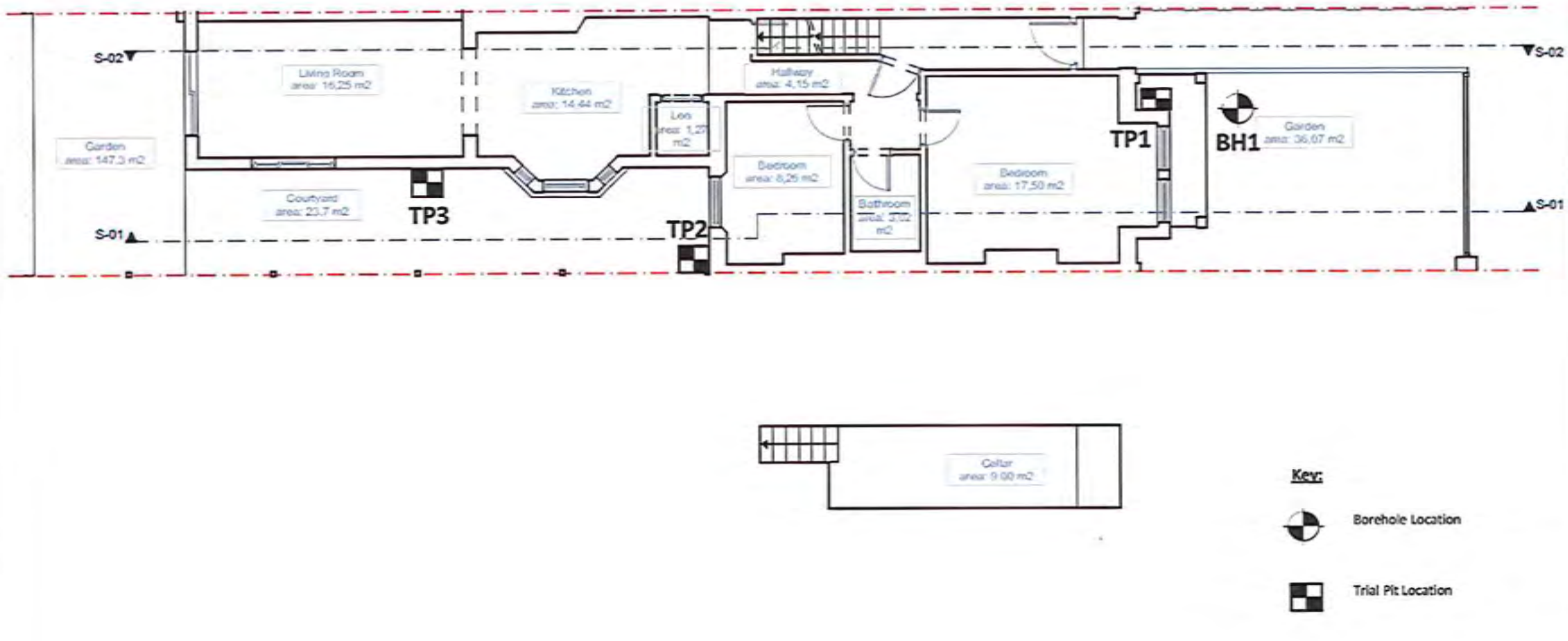
Revision: **0**

General Underpinning Specification

1. The walls to the perimeter of the new basement shall be underpinned in reinforced concrete. The underpins shall take the vertical loads from the walls and horizontal loads from the earth.
2. Underpinning bases shall be excavated in short sections not exceeding 1000mm in width.
3. The sequence of the underpinning shall be such that any given underpin will be completed, drypacked and a minimum period of 48 hours lapsed before an adjacent excavation commenced to form another underpin.
4. In the event that the existing foundations to the wall are found to be unstable, sacrificial steel jacks shall be installed underneath the foundation to prop the bottom few courses of bricks. These steel jacks shall be left in place and shall be incorporated into the concrete stem.
5. In the event that the ground is unstable, lateral propping shall be provided as required to the rear of the excavation and to the sides of the excavated working trench. The front and side faces of the excavation shall be propped using trench sheeting or plywood, timber boards and acrow props as appropriate. Sacrificial back – shutters shall be used to the rear face of the excavation (i.e. underneath the wall) if required. Cementitious grout will be poured behind the back – shutters to fill up the voids behind the back – shutters.
6. Excavation for an underpin section shall be dug in a day, and the concrete to the base shall be poured by the end of the same day.
7. The concrete to the stem of the underpin shall be poured the following day. This shall be poured up to within 50 – 75mm of the underside of the existing wall foundations.
8. On the following day, the gap between the concrete and the underside of the existing foundation shall be drypacked with C35 concrete using 5 – 10mm coarse aggregate and "Combex 100" expanding admixture by Fosroc UK Ltd in accordance with their instructions.
9. Once the drypack has gained sufficient strength, any protrusions of the footings into our site shall be carefully trimmed back using hand tools to avoid causing any damage to the foundation. The protrusions shall be trimmed back to be flush in-line with the face of the wall above.
10. A minimum of 48 hours shall be allowed before adjacent sections are excavated to form a new underpin.
11. Adjacent underpins shall be connected using T12 dowel bars 600mm long, 300mm embedment each side, at 300mm vertical centres.
12. Concrete cover to reinforcement shall be 35mm for cast against shutter or the top surface of the basement slab, 40mm for cast against blinding and 75mm for cast against earth.
13. Grade of concrete shall be C35 with minimum cement content 300kg/m^3, maximum free water to cement ratio 0.60, slump 100mm.

APPENDIX D

SITE INVESTIGATION REPORT (extract)



Ground and Cellar Floor Plan
Plan taken from Opera Architects' 'Existing Set: Ground Floor/Cellar' (Drg No. 17_27//1 Rev.02)

Project: 71 Goldhurst Terrace, London NW6 3HA	Title: Borehole & Trial Pit Location Plan			Figure: GI-01	GabrielGeo Consulting
18672	Date: February 2018	Checked: HB	Approved: KRG	Scale: NTS	

GabrielGeo Consulting	www.gabrielgeo.co.uk T: 01580 241044		Site 71 Goldhurst Terrace, London NW6 3HA	Number 1
Excavation Method Drive-in Windowless Sampler	Dimensions	Ground Level (mOD)	Client Mr J Parihar	Job Number 18672
	Location Front Parking Area of No.71	Dates 07/02/2018	Engineer Green Structural Engineering Ltd	Sheet 1/2

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
					0.05 (0.10)	CONCRETE PAVING SLABS		
					0.15 (0.10)	SAND BEDDING		
					0.25	BRICK RUBBLE		
0.50-0.60	D1				(0.45)	MADE GROUND: Soft to firm, dark brown, slightly sandy, slightly gravelly CLAY. Gravel consists of brick fragments (<10mm) with occasional slate (<55mm) and rare flint (<5mm). Also contains occasional half bricks. Dead roots (1mm thick) and rootlets.		
0.80-0.90	D2				0.70 (0.30)	Soft to firm, brown to light brown with some grey and orange mottling, slightly gravelly CLAY. Gravel consists of flint (<15mm). Clay has a 'chewed up' appearance, with occasional polished, gleyed shear surfaces. Decaying roots (<1mm) with grey discolouration to the surrounding clay. (HEAD/SOLIFLUCTED LONDON CLAY) Transition to...		
1.00-1.45 1.00	SPT N=6 D3		1,1/1,2,1,2		1.00			
1.35-1.40	D4		PP@1.30m=1.9, 1.8, 1.6 PP@1.40m=2.2, 1.8, 2.0			Firm becoming stiff with depth, brown and grey mottled CLAY. Decaying roots, with grey discolouration to surrounding clay. (WEATHERED LONDON CLAY) At 1.00 - 1.20m: Soft to firm.		
1.55-1.60	D5					Below 1.60m: Occasional fine sand partings. At 1.60 - 1.70m: Brown mottled orange, with very rare flint gravel.		
			PP@1.70m=2.2, 2.5, 2 2		(1.50)			
1.80-1.90	D6							
			PP@1.95m=2.1, 2.3, 2.1					
			PP@2.10m=2.0, 2.2, 2.4			At 2.15m: Fine to medium, orange and yellow sand parting (20mm thick). Below 2.20m: Mid-brown to orange brown, with blue-grey staining on/around fissures. Below 2.35m: Closely fissured, with white fine sand on fissure surfaces.		
2.30-2.40	D7		PP@2.40m=2.2, 2.3, 2.4		2.50			
			PP@2.65m=2.6, 2.4, 2.6			Stiff becoming very stiff with depth, fissured, brown to orange brown CLAY, with partings of fine sand and pockets of selenite crystals. Preferred horizontal alignment of clay minerals. Fissures closely spaced. Decaying rootlets to 5.70m, with blue-grey discolouration to the surrounding clay. (WEATHERED LONDON CLAY) Between 2.50 - 3.40m: White fine sand present on fissure surfaces.		
2.70-2.80	D8		PP@2.80m=2.9, 2.8, 3.3					
3.00-3.45	SPT N=12		1,2/2,3,3,4					
			PP@3.20m=3.2, 3.0, 3.1					
3.30-3.40	D9					Between 3.40 - 3.70m: Abundant selenite crystals		
3.50-3.60	D10		PP@3.50m=3.0, 3.5, 3.3					
3.70-3.80	D11					At 3.65m: Fine to medium yellow sand parting (50mm thick) Between 3.70 - 3.90m: Abundant decaying rootlets with gleying in surrounding clay.		
			PP@3.90m=4.1, 4.1, 3.9					
4.00-4.45	SPT N=15		2,2/3,4,4,4			Below 4.00m: Mid-brown with rare blue-grey staining on/around fissures.		
			PP@4.10m=3.7, 3.7, 3.6					
4.20-4.35	D12				(3.50)	Pockets of selenite crystals, concentrated at 4.20m, 4.45m, 4.65m, 4.80m, 5.48m and 5.74m.		
			PP@4.50m=3.5, 3.6, 3.9			At 4.50m: Decaying root (2mm in diameter)		
4.75-4.85	D13							
			PP@4.90m=4.5, 4.6, 4.3					

Remarks
PP = Pocket Penetrometer Readings (kPa)
1. Hand dug inspection pit to 1.00m bgl.
2. No live roots observed but dead roots observed to 5.70m bgl.
3. No groundwater entry occurred.
4. Borehole 'dry' and open on completion.
5. Standpipe installed to 4.00m bgl. Slotted pipe with pea gravel response zone = 4.00 - 1.00m, plain pipe 1.00m to ground level (GL), and bentonite seal above 1.00m. Stopcock cover at surface.

Scale (approx)	Logged By
1:25	HB
Figure No.	
GI-02	

GabrielGeo Consulting	www.gabrielgeo.co.uk T: 01580 241044		Site 71 Goldhurst Terrace, London NW6 3HA	Number 1
Excavation Method Drive-in Windowless Sampler	Dimensions	Ground Level (mOD)	Client Mr J Parihar	Job Number 18672
	Location Front Parking Area of No.71	Dates 07/02/2018	Engineer Green Structural Engineering Ltd	Sheet 2/2

Depth (m)	Sample / Tests	Water Depth (m)	Field Records	Level (mOD)	Depth (m) (Thickness)	Description	Legend	Water
5.00-5.10	D14					Continued from Sheet 1		
			PP@5.10m=4.3, 4.5, 4.2					
			PP@5.50m=4.4, 4.7, 4.7					
			PP@5.90m=4.5, 3.5, 3.6					
5.98-6.00	D15				6.00	Complete at 6.00m		
6.00-6.45	SPT N=18		2,2/3,5,5,5					

Remarks	Scale (approx)	Logged By
See Sheet 1	1:25	HB
	Figure No. GI-02	

GabrielGeo Consulting

www.gabrielgeo.co.uk
T: 01580 241044

Standard Penetration Test Results

Site : 71 Goldhurst Terrace, London NW6 3HA

Client : Mr J Parihar

Engineer: Green Structural Engineering Ltd

Job Number 18672

Sheet 1 / 1

Borehole Number	Base of Borehole (m)	End of Seating Drive (m)	End of Test Drive (m)	Test Type	Seating Blows per 75mm		Blows for each 75mm penetration				Result	Comments
					1	2	1	2	3	4		
1	1.00	1.15	1.45	SPT	1	1	1	2	1	2	N=6	
1	3.00	3.15	3.45	SPT	1	2	2	3	3	4	N=12	
1	4.00	4.15	4.45	SPT	2	2	3	4	4	4	N=15	
1	6.00	6.15	6.45	SPT	2	2	3	5	5	5	N=18	

GabrielGeo Consulting	www.gabrielgeo.co.uk T: 01580 241044	Site 71 Goldhurst Terrace, London NW6 3HA	Borehole Number 1
Installation Type Single Installation	Dimensions Internal Diameter of Tube [A] = 50 mm	Client Mr J Parihar	Job Number 18672
	Location Front Parking Area of No.71 / Ground Level (mOD)	Engineer Green Structural Engineering Ltd	Sheet 1/1

Legend	Water	Instr (A)	Level (mOD)	Depth (m)	Description
				0.20	Concrete
				1.00	Bentonite Seal
				4.00	Slotted Standpipe

Groundwater Strikes During Drilling

Date	Time	Depth Struck (m)	Casing Depth (m)	Inflow Rate	Readings 5 min	10 min	15 min	20 min	Depth Sealed (m)

Groundwater Observations During Drilling

Date	Start of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)	End of Shift Time	Depth Hole (m)	Casing Depth (m)	Water Depth (m)	Water Level (mOD)

Instrument Groundwater Observations

Inst. [A] Type : Slotted Standpipe

Date	Instrument [A] Time	Depth (m)	Level (mOD)	Remarks

Remarks

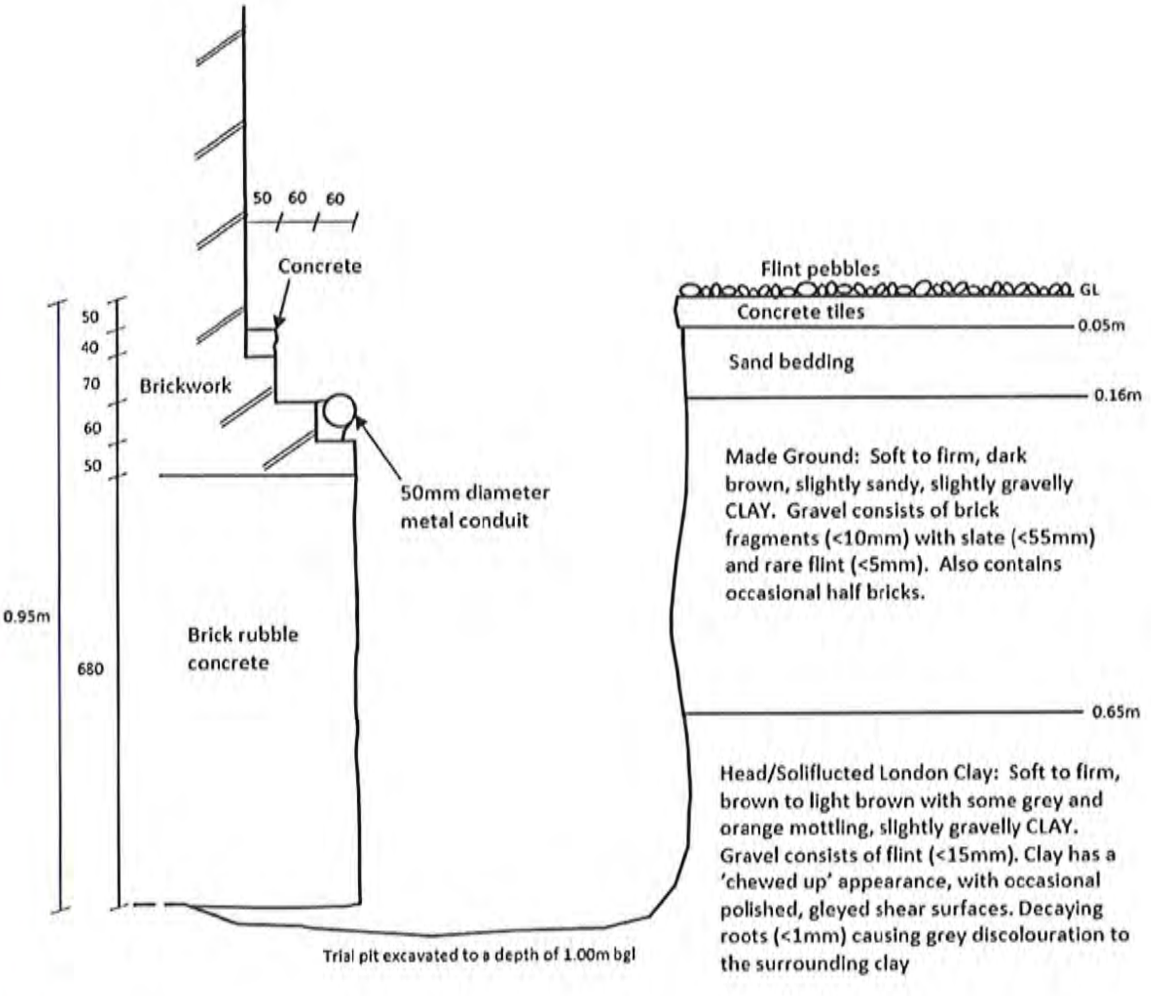
Project:

71 Goldhurst Terrace, London NW6 3HA

GabrielGeo Consulting

18672

TP1: Side Wall of the Front Bay



Notes
- No live roots observed

Samples
- D @ 0.30 - 0.60m
- D @ 0.70 - 0.80m

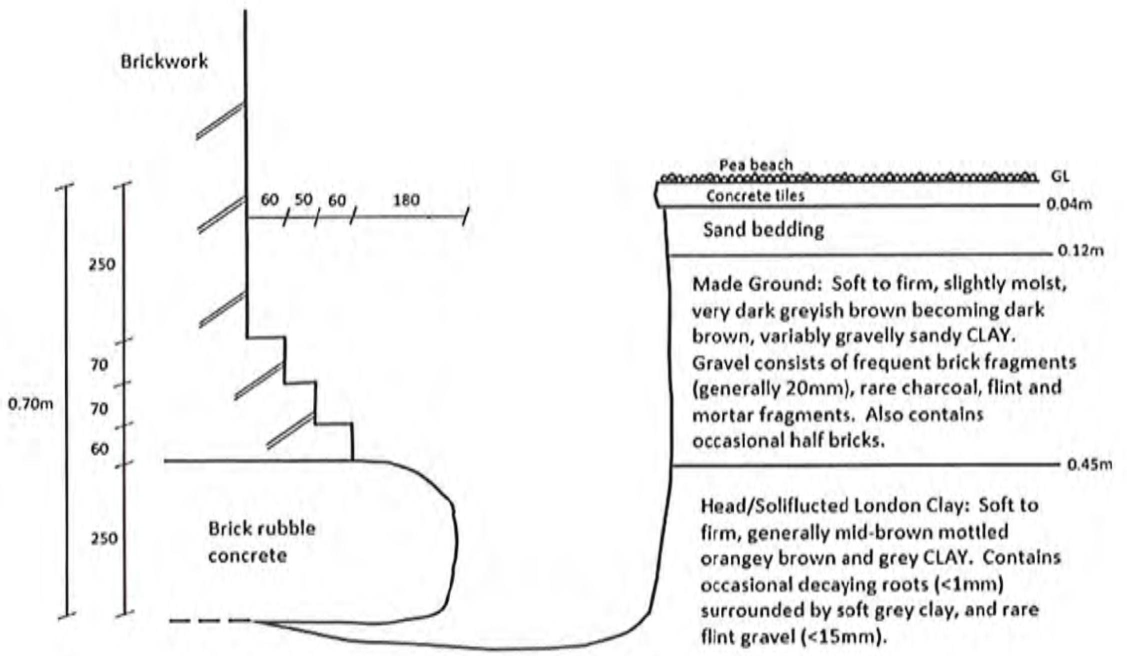
Title:	Trial Pit 1			Figure:	GI-03
Date:	7th February 2018	Checked: AG	Approved: KRG	Scale :	NTS

Project:

71 Goldhurst Terrace, London NW6 3HA

18672

TP2: Rear Wall



Trial pit excavated to a depth of 0.75m bgl

Notes
- No live roots observed

Samples
- D @ 0.30 - 0.40m
- D @ 0.65 - 0.75m

Title:	Trial Pit 2					Figure:	GI-04
Date:	7th February 2018	Checked:	AG	Approved:	KRG	Scale :	NTS

Project:

71 Goldhurst Terrace, London NW6 3HA

GabrielGeo Consulting

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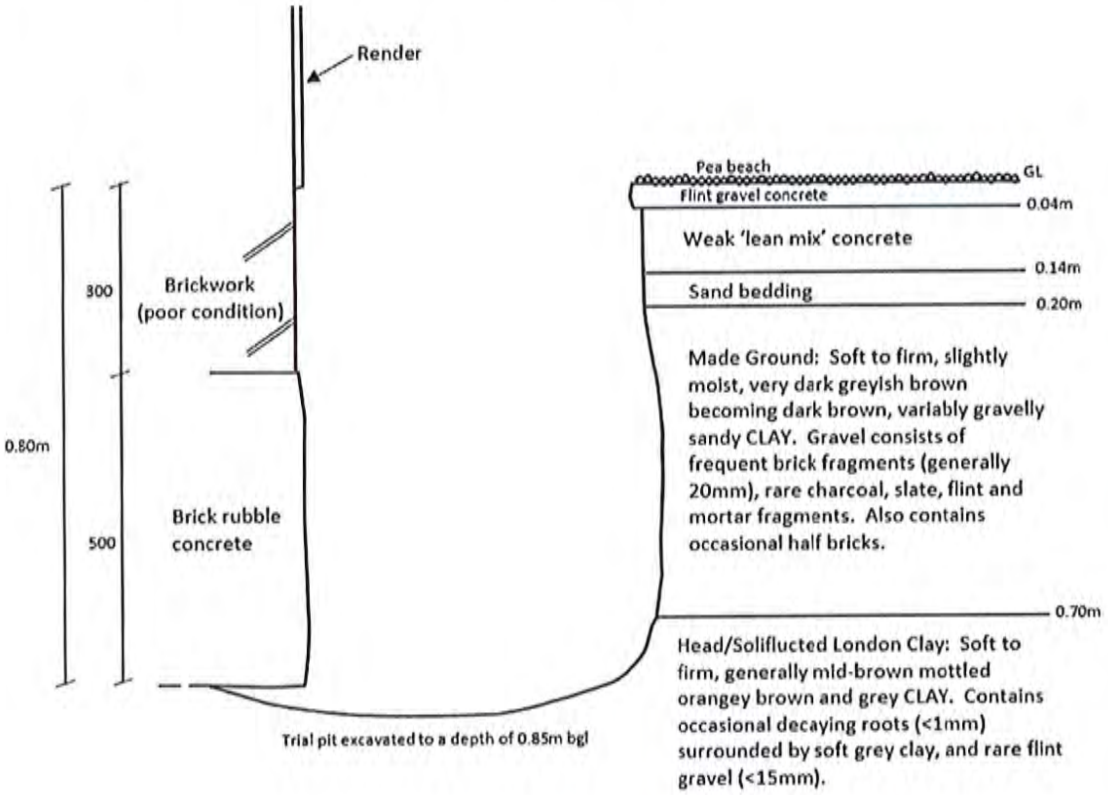
TP3: Flank Wall of Rear Extension



Notes
- Slight groundwater seepage in Made Ground, opposite wall
- No live roots observed

Samples
- D @ 0.40 - 0.50m
- D @ 0.70 - 0.80m

Title:	Trial Pit 3					Figure:	GI-05
Date:	7th February 2018	Checked:	AG	Approved:	KRG	Scale :	NTS

SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression			Chemical Tests			Other tests and comments
Borehole / Trial Pit	Sample Ref	Depth (m)	Type	Description	WC (%)	LL (%)	PL (%)	PI (%)	<425 µm (%)	Bulk Mg/m^3	Dry Mg/m^3	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 (g/L)	W/S Mg (mg/L)	
BH1		0.50-0.60	D															Chemical
BH1	SPT	1.00	D	Yellowish brown mottled greyish brown CLAY.	33.8													
BH1		1.35-1.40	D	Greyish brown CLAY.	33.1	78	26	52	100									
BH1		1.55-1.60	D	Greyish brown mottled light brown CLAY with rare fine gypsum.	32.3													
BH1		1.80-1.95	D	Greyish brown mottled yellowish brown and grey CLAY with rare rootlets.	33.0													
BH1		2.30-2.40	D	Greyish brown mottled grey CLAY with rare fine sand pockets and rootlets.	34.0													Chemical
BH1		2.70-2.80	D	Greyish brown mottled grey CLAY with rare fine gypsum.	33.8													
BH1		3.30-3.40	D	Greyish brown mottled grey CLAY with rare fine gypsum.	32.5													
BH1		3.50-3.60	D	Greyish brown mottled grey CLAY with rare fine to medium gravel.	33.2													Chemical
BH1		3.70-3.80	D	Greyish brown mottled grey CLAY with rare rootlets.	32.3	80	29	51	100									

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

S Burke

S Burke - Senior Technician
02/03/2018

Project Number: GEO / 27117

Project Name: 71 GOLDHURST TERRACE, LONDON, NW6 3HA
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SUMMARY OF GEOTECHNICAL TESTING

Sample details					Classification Tests					Density Tests		Undrained Triaxial Compression			Chemical Tests			Other tests and comments
Borehole / Trial Pit	Sample Ref	Depth (m)	Type	Description	WC (%)	LL (%)	PL (%)	PI (%)	<425 µm (%)	Bulk Mg/m³	Dry Mg/m³	Cell Pressure kPa	Deviator Stress kPa	Shear Stress kPa	pH	2:1 W/S SO4 (g/L)	W/S Mg (mg/L)	
BH1		4.20-4.35	D	Greyish brown mottled grey CLAY with rare fine gypsum.	28.7													
BH1		4.75-4.85	D	Greyish brown mottled grey CLAY with rare fine gypsum and rootlets.	29.6													
BH1		5.00-5.10	D	Greyish brown CLAY with grey pockets and rare gypsum.	30.8													
BH1		5.90-6.00	D	Greyish brown CLAY with grey pockets and rare gypsum and fine siltstone.	29.1													
TP3		0.70-0.80	D	Greyish brown mottled grey CLAY with black staining and rare fine gravel including slag.	37.0	85	29	56	99									

Sample type: B (Bulk disturb.) BLK (Block) C (Core) D (Disturbed) LB (Large Bulk dist.) U (Undisturbed)

Checked and Approved by

S Burke

S Burke - Senior Technician
02/03/2018

Project Number: GEO / 27117

Project Name: 71 GOLDHURST TERRACE, LONDON, NW6 3HA
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SUMMARY OF CHEMICAL TESTS ON SOIL

Borehole / Trial Pit	Depth m	Sample Ref	Sample Type	pH Value	Total Acid Soluble Sulphate as SO4 %	Water Soluble Sulphate as SO4 2:1 Water:Soil Extract g/l	Total Sulphur %	Water Soluble Chloride g/l	Water Soluble Nitrate g/l	Magnesium g/l	Organic Content %	Mass Loss on Ignition %	Carbonate Content %
BH1	0.50-0.60		D	7.6	0.09	0.08	0.08						
BH1	2.30-2.40		D	7.5	1.50	2.00	0.41						
BH1	3.50-3.60		D	8.0	0.29	0.96	0.09						

Tested by Chemtest Ltd : UKAS No 2183

Checked and Approved by:

S Burke

S Burke - Senior Technician
02/03/2018

Project Number:

GEO / 27117

Project Name:

71 GOLDHURST TERRACE, LONDON, NW6 3HA

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