99 FROGNAL

BASEMENT CONSTRUCTION STRUCTURAL REPORT

23020.R02.P2

30.11.2023

STRUCTURE WORKSHOP

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CONTENTS

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1 INTRODUCTION

The purpose of this report is to assess the proposed basement development at 99 Frognal, London, NW3 6XU. This report provides an overview of the Basement Impact Assessment (BIA) report by A2 Site Investigation (A2-S1) included in Appendix E, with additional structural commentary, preliminary structural drawings, and a proposed sequence of work. Refer to the BIA non-technical summary for a list of conclusions in line with the current planning guidance adopted by the London Borough of Camden

The property is located in Hampstead, within the London Borough of Camden. The existing property is a large three-storey detached house constructed in ~1740, with a two-storey L-shaped extension in the back garden constructed in the 1970s. The project, led by Hayhurst and Co. Architects, involves restoration of the main house extending upwards with construction of a new mansard roof, full demolition of existing extension buildings, and construction of a new extension and basement that integrates with the landscape. The proposals also include the construction of three additional housing units on the site. Two housing units will be located below the raised vegetable garden north of the main house, and the other will form part of the new extension to the main house.

A ground investigation has been carried out by A2-SI, which included extensive trial pits and exploratory boreholes across the site to provide quantitative data on the ground conditions. Their Interpretive Report, included in Appendix D, contains additional details of the geology, hydrogeology, and a geotechnical commentary on the proposals. Following this, A2-SI carried out a Ground Movement Assessment to assess the impact of the proposed works on existing structures and neighbouring properties. The full BIA report prepared by A2-SI goes through the screening and scoping process in accordance with local planning guidance, the findings of which are summarised within this report. See Appendix E for the full report.

A preliminary proposed sequence of construction has been developed for the safe construction of the basement, included in this report, together with preliminary Stage 3 structural drawings provided in Appendix A which provide additional structural information.

1.1 EXISTING DEVELOPMENT

The site is located in Hampstead, North London, just west of Hampstead Village and southwest of Hampstead Heath, within the London Borough of Camden. No. 99 is close to the northern end of Frognal, a steep road that runs from Finchley Road up to Branch Hill / West Heath.

The site is located within a wider hillside setting and generally slopes upwards towards the north and western extents. The site elevations range from approximately 110m AOD on the eastern side to around 116m AOD on the west, however the existing topography is stepped, dividing the site into three primary areas at different levels. At the main house the ground level is around 110m AOD. There is a central courtyard in front of the rear extension at 111.40m AOD. The garden to the rear of the property (west) has a lawn at around 116m AOD with raised flowerbeds stepping upwards to the northern and western boundary.

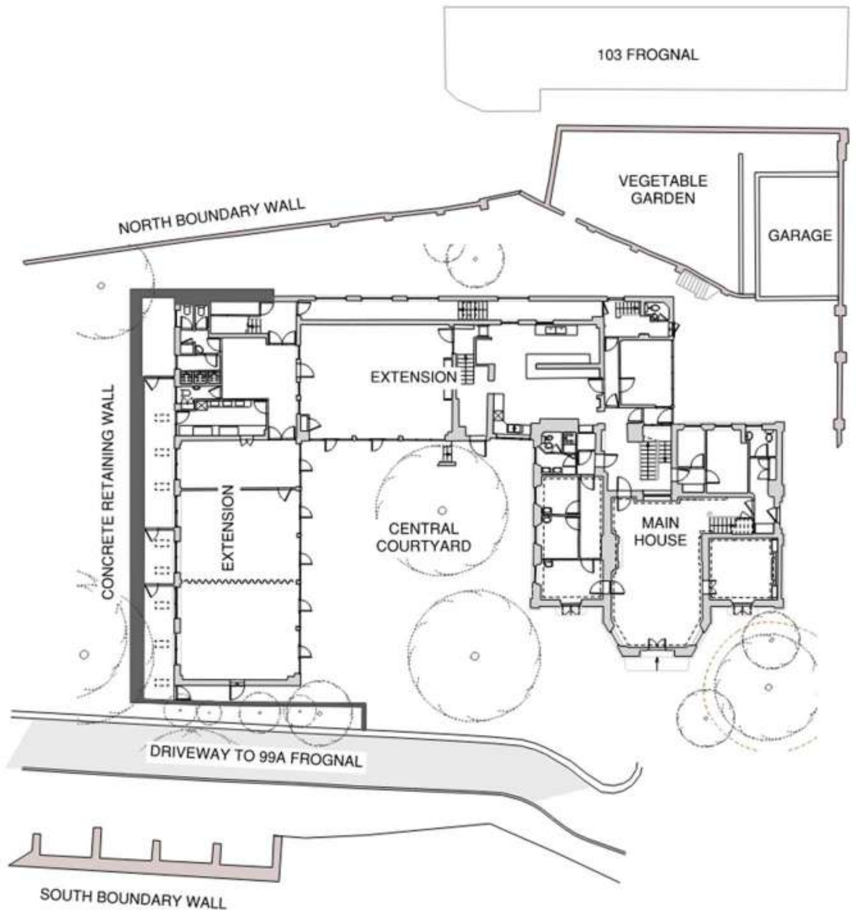
The existing property is a large three-storey detached house with a roof terrace and small basement, constructed in ~1740. Historic records show there was previously a mansard roof level which is thought to have been removed in the 1930s. The main house is built of solid load-bearing brick walls, with timber floors and a timber roof. It is understood to have originally been built with a rectangular plan, with the canted bay on the south elevation added later in the 18th century. Some of the brickwork on the main house was refaced in 1890. The reinforced concrete art deco style staircase and glazed bay was added as part of the renovations undertaken in the 1930s.

A large L-shaped two-storey extension to the north and west of the main house was constructed in phases in the 1970s-80s. This brick faced structure is framed in reinforced concrete with concrete slabs, columns and foundations. There is a reinforced concrete wall retaining a level change of approximately 4m on the north, west and south sides of the western wing.

There are some nearby Listed properties, known to be 103 Frognal to the immediate north, and Grove Cottage and 108 Frognal on the other side of Frognal.

A description of the site boundaries is provided in section 2.7.

ARIAL VIEW OF SITE



SITE BUILDING PLAN

SW

1.2 PROPOSED DEVELOPMENT

The proposal involves restoring the main house for its original use as a single-family dwelling, undoing the various alterations, removing 20th century partition walls and non-original staircases, and reinstating the original plan. The proposal for the main house also includes construction of a new mansard roof, providing an additional level with a roof terrace.

The 1970s L-shaped extension to the west of the house is to be carefully demolished and a new extension built in its place that integrates with the landscape. The new extension includes a large basement to be constructed roughly within the footprint of the existing 1970s building. The basement will contain a pool, sauna, utilities and plant space.

The proposals also include the construction of three additional housing units on the property. Two housing units will be located below the raised vegetable garden north of the main house, and the other will form part of the new extension to the main house.

Preliminary Stage 3 structural proposals for the areas with significant excavations are provided in Appendix A.

BASEMENT

The basement formation level is approximately 6.5 metres below existing ground level due to the added depth for the swimming pool (not including localised sumps). The rear garden to the west of this building is approximately 4m above the existing ground floor level, so it is proposed that the existing concrete retaining wall remains in place during the works so the basement can be constructed from the lower level. Site inspections have revealed that this existing retaining wall does not rely on support from the building itself but will likely require additional stabilising measures prior to breaking out the concrete base slab. It is proposed that this could take the form of ground anchors to free up working space, which would be designed for temporary loading but become redundant once the final structure and landscaping is in place. To batter back behind the existing wall for basement construction would require a ~13.6m wide berth, and with spatial limitations due to the north boundary wall and the driveway to 99a this was not considered a practical option.

Due to high measured groundwater levels in this location, a secant piled wall is proposed to the perimeter of the basement to control groundwater during construction. In the permanent case water-resistant concrete lining walls are also proposed around the perimeter in addition to an internal drained cavity for waterproofing.

A piled ground beam within the basement footprint will break up the span of the basement ground slab and, together with the perimeter walls, resist uplift forces. The slab is to be cast on a void former to mitigate against heave forces on the underside of the basement slab being transmitted to the building.

The RC roof slab will provide a propping force to the top of the secant piles. An internal upper basement slab provides a services zone underneath for storage of pool-associated plant, which is proposed to be precast hollowcore panels suspended on blockwork walls, for ease of construction.

The perimeter and internal piles will be installed from existing ground level, and the pile capping beam and basement roof slab cast in-situ will provide lateral propping at the top of the piles. There is a large opening proposed in the roof slab at the south end of the basement, which will provide access and egress between the basement and gardens at ground level, and which can also be used to facilitate a ‘top-down’ construction sequence.

Refer to section 6.2 and Appendix B of this report for the assumed sequence of work and further details.

GARAGE HOUSES

The two housing units proposed in the north-east corner of the site are to be at ground level to match the driveway and existing garage. This will require excavation of the existing raised vegetable garden. This means that the perimeter walls must be designed as retaining structures to maintain stability of the neighbouring property and adjacent land.

The existing garden walls here are proposed to be retained in the interest of heritage protection, therefore these will be underpinned with mass concrete and stabilised with temporary internal lateral propping prior to excavation works. Underpinning is proposed in two vertical lifts to reduce the depth of excavations, to be carried out in sequence with the temporary lateral propping.

The ground slab will be suspended on piled ground beams, similar to the proposed basement construction. Permanent lateral stability to the existing walls and adjacent retained earth will be provided by reinforced concrete walls that are propped in the permanent case by the ground and roof slabs.

Refer to section 6.2 and Appendix B for the assumed sequence of work and further details.

PLAN VIEW, HAYHURST & CO ARCHITECTS

2 DESK STUDY

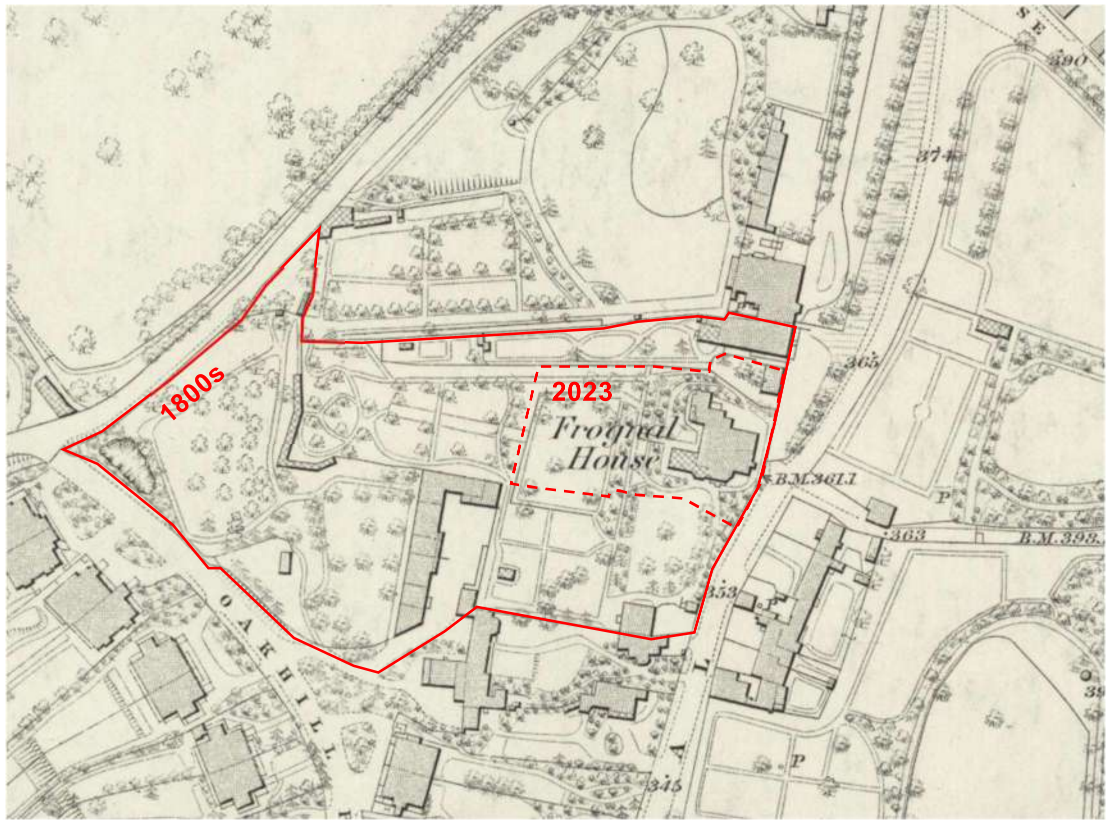
2.1 SITE HISTORY

‘Frognal House’ (now 99 Frognal) is thought to have been constructed in circa 1740, and the estate to have originally included Upper Frognal Lodge (No. 103) and a small mews terrace to the south west. The main house was used as a private residence for many years, between the years of 1862 to 1869 it housed the Sailors’ Orphan Girls’ School and Home, between the years of 1942 and 1944 it was a wartime residence to General Charles de Gaulle, and between the years of 1968 and 2021 it was home to the Sisters of St Dorothy convent.

Historic maps indicate that there was previously an extension on the south west corner of the main house that has since been removed. To the north east of the house, an existing garage exists bounded by a series of stepped brick walls that resolve the changes in ground level and also form the boundary with no. 103 Frognal. There are no other known historic building structures in the gardens of the main house that fall within the current site boundary, which is much smaller than it once.

The existing house is three storeys with a roof terrace and small basement. Historic records show there was previously a mansard roof level which is thought to have been removed in the 1930s. The main house is built of solid load-bearing brick walls, with timber floors and a timber roof. It is understood to have originally been built with a rectangular plan, with the canted bay on the south elevation added later in the 18th century. Some of the brickwork on the main house was refaced in 1890. The reinforced concrete art deco style staircase and glazed bay was added as part of the renovations undertaken in the 1930s.

A large L-shaped two-storey extension to the north and west of the main house was constructed in phases in the 1970s-80s, purpose-built for student accommodation. This brick faced structure is framed in reinforced concrete with concrete slabs, columns and foundations. There is a reinforced concrete wall retaining a level change of approximately 4m on the north, west and south of the western wing.



ORDNANCE SURVEY MAP 1866


PHOTOGRAPH OF FROGNAL HOUSE ESTATE, 1940

SW

2.2 TOPOGRAPHY

A topographic survey has been undertaken which covers all areas within the property boundary including the adjacent footpath and road. The overall gradient of the land is sloping up to the north and west, from a level of 110m AOD at the eastern extent up to around 116m AOD on the west. Behind the northern wall of the extension building the land slopes up from a level of around 112.5m AOD to a level of 114m AOD at the boundary wall.

99 FROGNAL TOPOGRAPHIC SURVEY MAP

2.3 GEOLOGY

The British Geological Survey (BGS) mapping shows that site is underlain by Bagshot Formation, with no superficial deposits. The Claygate Member and the London Clay Formation are also shown in close proximity to the site and are thought to underlay the Bagshot Formation.

A number of historic borehole record on the BGS website within the surrounding area show the presence of made ground in the top layers.

A desk study has been carried out by A2-SI which covers the initial geological findings in further detail. Please refer to the ‘Phase I Desk Study’ report included in Appendix E.

BGS MAPS – BEDROCK GEOLOGY

KEY

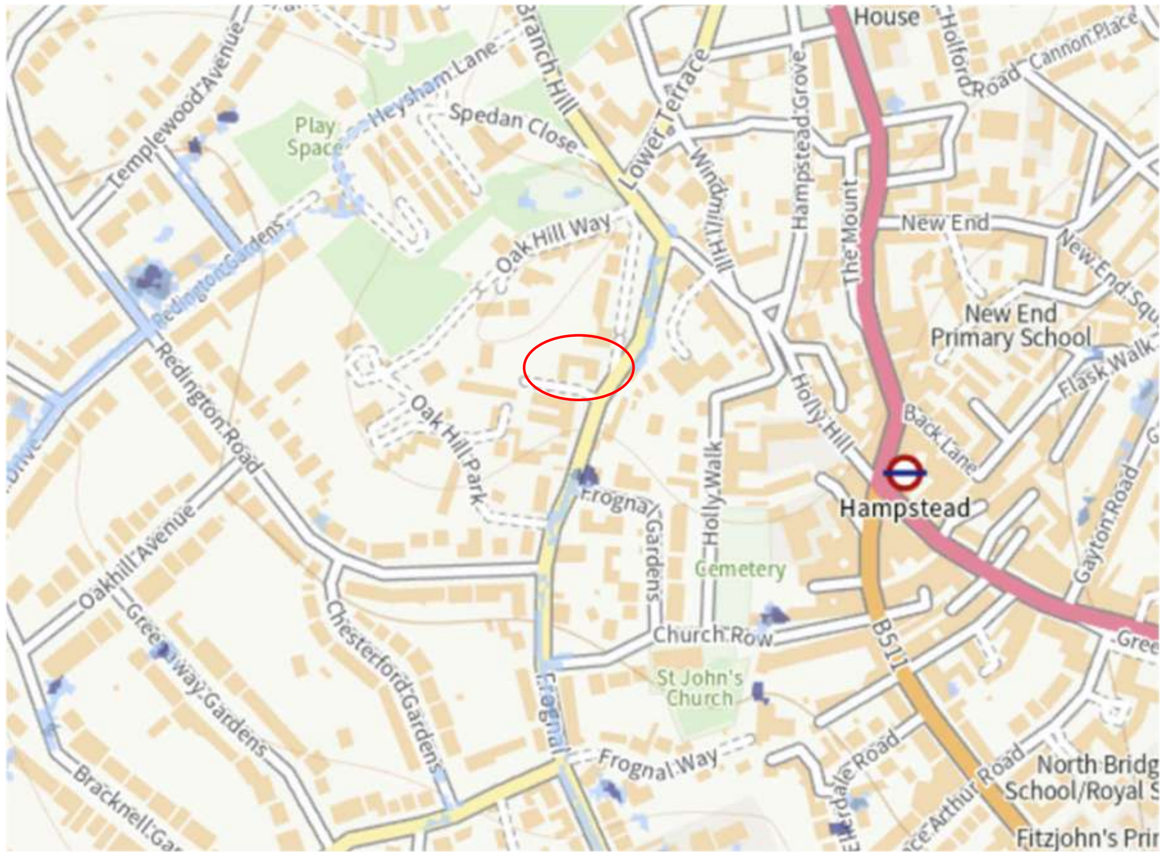
- BAGSHOT FORMATION - SAND
- CLAYGATE MEMBER – CLAY, SILT AND SAND
- LONDON CLAY FORMATION – CLAY, SILT AND SAND

2.4 HYDROGEOLOGY

The desk study carried out by A2-SI includes a high-level hydrogeological assessment, which indicates the likelihood of a perched aquifer beneath the site. Refer to Appendix E for full details.

2.5 HYDROLOGY, DRAINAGE AND FLOOD RISK

The property is at very low risk of fluvial flooding and very low risk of surface water flooding, meaning there is less than 0.1% (1 in 1000) annual probability of flooding.



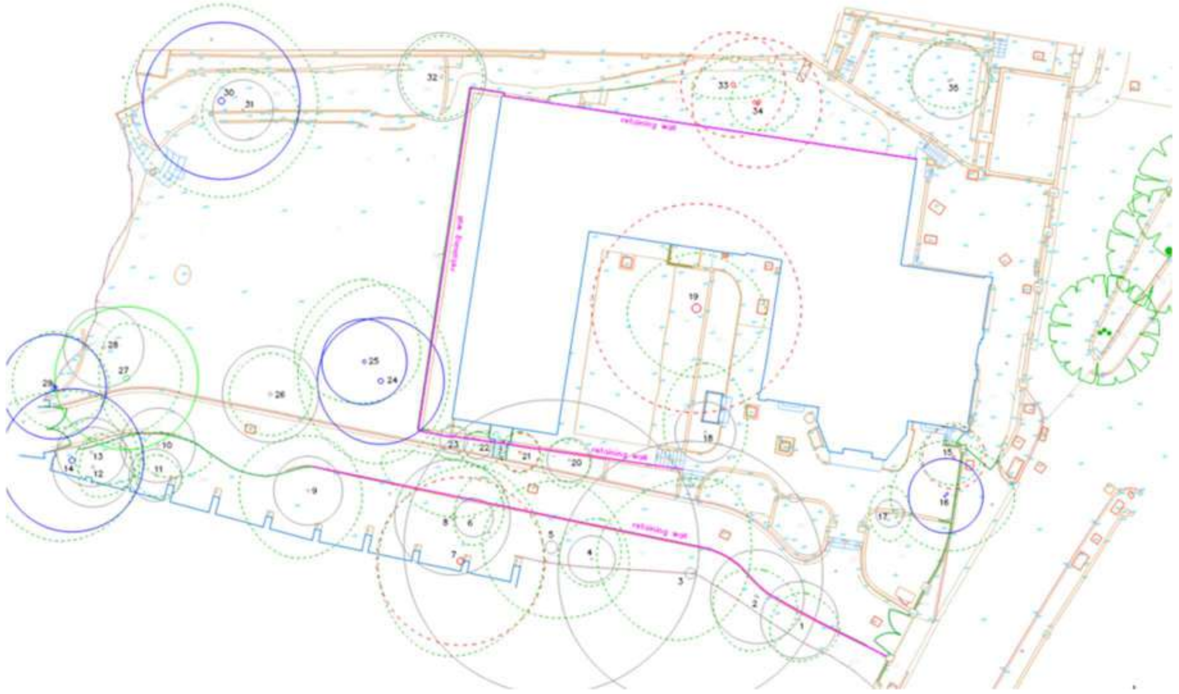
ENVIRONMENT AGENCY SURFACE WATER FLOOD MAP

2.6 SURROUNDING VEGETATION

Refer to the Architect's plan for the locations of existing vegetation and root protection areas.

The arboriculturist's survey was undertaken in February 2022. At the time of survey there was a total of 35 trees recorded on the property, most of which were located towards the south along the driveway, and mostly all sound and healthy. 5 of the 35 were found to be in poor condition and recommended for removal: one large Beech along the southern boundary wall; one Winter cherry between the driveway and the concrete retaining wall; one Goat willow in the central courtyard, and two Cherry trees behind the north wall of the extension. These are indicated in red in the figure below.

There are several trees in close proximity to the concrete retaining wall which may be affected by any proposed construction works here. However, given that the trees are at a raised ground level approximately 4m above the ground level at the top of the excavation, and given that the existing concrete retaining wall is not being removed as part of the works, it is not expected that works will clash with any root protection areas. The proposed basement foundations will extend below the influence of any existing and future planting.



99 FROGNAL ARBORICULTURIST SURVEY PLAN, 2022

2.7 SITE BOUNDARIES

There is a large freestanding brick wall along the property's southern boundary, built in 1896 by the owner at the time to shield his view of the adjacent flats being built. It was claimed to be 'the highest independent wall in London, 42ft high and 6ft thick at the bottom". This wall has large chamfered buttresses and is partially concealed by vegetation. Adjacent to this wall is a driveway within the property boundary that provides access to 99A Frognal to the west.

Along the northern boundary there is a historic brick retaining wall that separates 99 Frognal from no.103. The top of the wall is 2-3m above ground level on the 99 Frognal side. This boundary wall retains the neighbouring land, with the closest point of the neighbouring building being approximately 2m away. The wall is bulging in areas, has been previously extended upwards and has some buttresses toothed in.

At the eastern boundary is Frognal (the road) and a driveway up to no.103, separated from 99 Frognal with a freestanding brick wall with piers and black-painted railing along the frontage.

At the western boundary there is a low brick garden wall with wooden fencing above to separate the property from 99A.


SOUTHERN BOUNDARY WALL


NORTHERN BOUNDARY WALL

3 SCREENING

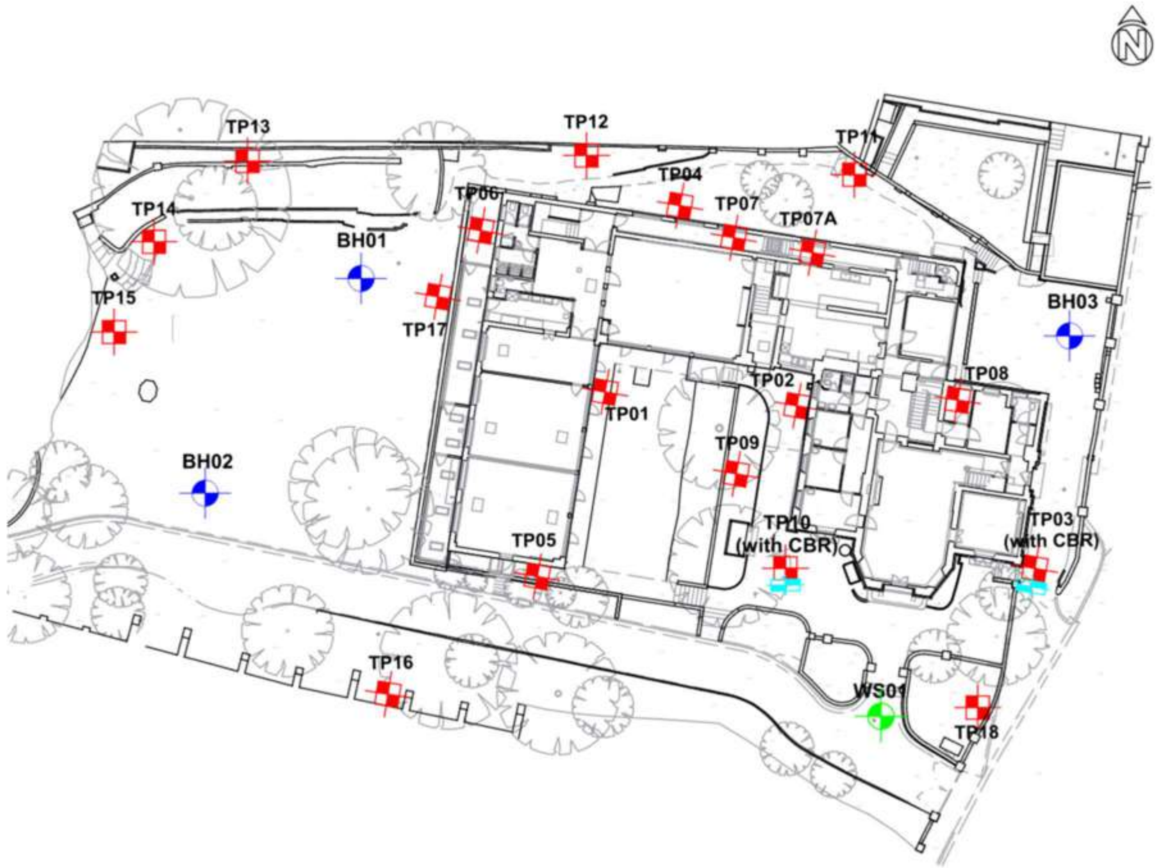
A BIA Screening has been undertaken by A2-SI in accordance with the London Borough of Camden planning policies and guidance. Refer to Appendix E for the full document.

4 SCOPING

The following issues raised in A2-SI's BIA screening process were brought forward for further assessment:

- The site is underlain by Secondary A Aquifers, i.e. the Bagshot Formation and the Claygate Member of the London Clay Formation.
- The formation level of the proposed basement is anticipated to be at 105.1mOD, which is below the short-term design water table of 110.00mOD specific for that area of the site.
- The proposed basement will change the effective proportion of hard surfaced/paved areas.
- Trees maybe felled during the development works. The works may take place in a tree protection zone.
- A single carriageway road (Frognal) is present directly to the east of the site.
- The proposed basement excavation will increase the differential depth of foundations relative to neighbouring properties.

An assessment of these issues has been undertaken in the BIA prepared by A2-SI, which discusses the potential impacts, mitigating factors and further actions proposed for each. Refer to Appendix E for the full document.



SITE INVESTIGATION PLAN

5 SITE INVESTIGATION

A site investigation was carried out by A2-SI in June 2023 to provide site-specific information to support the design of the proposed development. The investigative works comprised:

- 3no. cable percussion boreholes to depths 15-25m
- 1no. window sampling borehole to depth 5m
- 16no. hand-dug trial pits with in-situ strength testing
- 2no. CBR tests
- 1no. dynamic probing to confirm the geometry of the existing retaining wall (TP17)
- Falling head tests to provide an indication of soakage rates
- Installation of 4no. standpipes for groundwater monitoring
- Laboratory testing of soil properties and contamination

Refer to the Interpretive Report prepared by A2-SI in Appendix D for full findings.

GROUND CONDITIONS

The ground conditions discovered on site are summarised in the table below:

DESCRIPTION OF GROUND	START (M BGL)	END (M BGL)
Made Ground	0.00 - 0.30	0.50 - 1.20
Bagshot Formation	0.50 - 1.20	3.80 - 9.20
London Clay Formation – Claygate Member	3.80 - 9.20	> 20.60

GROUNDWATER

The groundwater monitoring readings taken in June and July 2023 encountered groundwater between +106.74 and +109.99m AOD across the site, which is considered to be perched water within the Bagshot Formation.

In the western portion of the site it is recommended that a short-term design water level of 110m AOD is adopted, which is approximately 5m above the formation level of the proposed basement. In the eastern portion of the site it is recommended that a short-term design water level of 107m AOD is adopted, which is approximately 3m below the formation level of the proposed Garage Houses.

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W

6 CONSTRUCTION METHODOLOGY/ENGINEERING STATEMENTS

6.1 OUTLINE GEOTECHNICAL DESIGN PARAMETERS

The following outline, reasonably conservative geotechnical parameters have been determined based on the site investigation data collected. A full table of parameters included in the Interpretive Report in Appendix D.

STRATUM	γ_b (kN/m^3)	Φ'_{CV} (°)	c' (kPa)	c_u (kPa)
Made Ground	18	22	0	-
Bagshot Formation	19	24	0	90
London Clay Formation – Claygate Member (cohesive)	20	24	0	100
London Clay Formation – Claygate Member (granular)	20	35	0	-

6.2 OUTLINE TEMPORARY AND PERMANENT WORKS PROPOSALS

To develop the structural proposals and for the purpose of informing the ground movement assessment, a basement construction sequence has been developed by Structure Workshop. The sequence presents an assumed methodology to minimise disruption to adjoining properties and safeguard the existing retained structures on the site. Refer to the sketch in Appendix B for the proposed sequence of works, and to Section 7 of the BIA in Appendix E for further description.

Safe working routes, hoarding, and temporary protection to sensitive elements will be set up at the start of the construction phase. In advance of any excavation works site wide movement monitoring will be set up. This will include ongoing regular monitoring of the main house, boundary walls, and the flank wall of the nearest neighbouring property. A full movement monitoring proposal together with appropriate trigger values and frequency of readings will be developed in the forthcoming design stages. Movement monitoring results will be checked by the Contractor, Engineer and CA at regular intervals to ensure that there are no unexpected movements. Should any trigger values be exceeded, site work will be immediately stopped to establish the cause of any movement.

The existing retaining walls on the site to be retained will require temporary stabilisation. At this stage we envisage that they will either be tied back with soil anchors, or internally propped with temporary lateral propping. The final solution will depend on the Contractor's proposals and Party Wall negotiations. We have had initial conversations with soil anchoring contractors to provide an initial sizing on the structural drawings.

To form the garage houses at the north of the site some underpinning is proposed with internal temporary lateral propping. This is envisaged to be undertaken in two vertical lifts to reduce the depth of excavations. Where existing retaining walls are to be taken down, some temporary sheet piling is proposed. When all existing walls and ground has been effectively stabilised excavations down to ground level can begin. The entire site can then be piled in one go from a similar ground level.

The extension basement is proposed as top-down construction, with the basement roof slab cast before bulk excavation is carried out. This is to lock the ground floor in place, reducing the likelihood of ground movements, but also to help reduce noise and dust on site.

Due to the water levels discovered the basement will have a secant piled perimeter wall and an internal concrete lining wall with a water-resisting additive. The secant wall is chosen to help control ground water during construction, such that it should be possible to dewater the excavation without significant inflows.

Once formation level is reached the ground slab will be cast, followed by the internal basement vertical structure. Permanent lateral propping to retaining forces is provided by the top and bottom basement slabs. Similarly in the Garage Houses, reinforced concrete retaining walls will provide permanent stabilisation to the adjacent retained brick walls. The walls will be propped by the ground floor and roof slab, which are also proposed in reinforced concrete.

6.3 GROUND MOVEMENT AND DAMAGE IMPACT ASSESSMENT

An assessment of ground movement due to construction of the proposed basement has been undertaken by A2-SI based on the current structural design, excavation depth and footprint, and proposed sequence of work. They have concluded that the potential damage/impact of the proposed works can be limited to *Category 1 – Very Slight*, in accordance with the Burland Scale. Refer to Appendix E for the Ground Movement Assessment report prepared by A2-SI.

6.4 CONTROL OF CONSTRUCTION WORKS

Following the appointment of a Principal Contractor in subsequent project stages, a Construction Method Statement will be developed to determine the best strategy for safely carrying out the works.

In advance of any excavation works site wide movement monitoring will be set up. This will include ongoing regular monitoring of the Main house, boundary walls, and the flank wall of the nearest neighbouring property. A full movement monitoring proposal together with appropriate trigger values, frequency of readings will be developed in the forthcoming design stages. Movement monitoring results will be checked by the Contractor, Engineer and CA at regular intervals to ensure that there are no unexpected movements. Should any trigger values be exceeded, site work will be immediately stopped to establish the cause of any movement.

All piling works will be undertaken in accordance with the structural specification. The proposed sequence allows all piling across the development to be undertaken in one period to minimise disruption to neighbours.

The top-down construction sequence also helps control dust and vibrations during the basement construction. Top-down construction will also help minimise ground movements caused by basement excavation.

Underpinning of existing walls around the Garage Houses will be undertaken in sequence in accordance with the structural specification with limited excavation depths.

During construction temporary rainwater diversions will be in place across the site, and a method for dewatering any perched groundwater inflows will be provided within the basement construction.

7 BASEMENT IMPACT ASSESSMENT

Refer to Section 8 of the BIA report prepared by A2-SI in Appendix B for the full BIA statement in accordance with LB Camden guidelines.

It is proposed that the new structures will be founded on piles bearing onto the Claygate Member of the London Clay Formation, which is considered to be a suitable founding stratum.

A sequence of construction has been developed to demonstrate a safe construction methodology that maintains stability to all surrounding structures and land. During the works a structural monitoring strategy will be in place to control movements and impacts to existing structures adjacent. Sensitive brick structures will be protected and temporarily propped as a precaution where required.

The ground movement assessment prepared by A2-SI, included in Appendix E, has indicated that ground movements caused by the proposed development are within acceptable limits. The risk to adjacent properties is calculated to be limited to Category 1 ‘very slight’ on the Burland Scale.

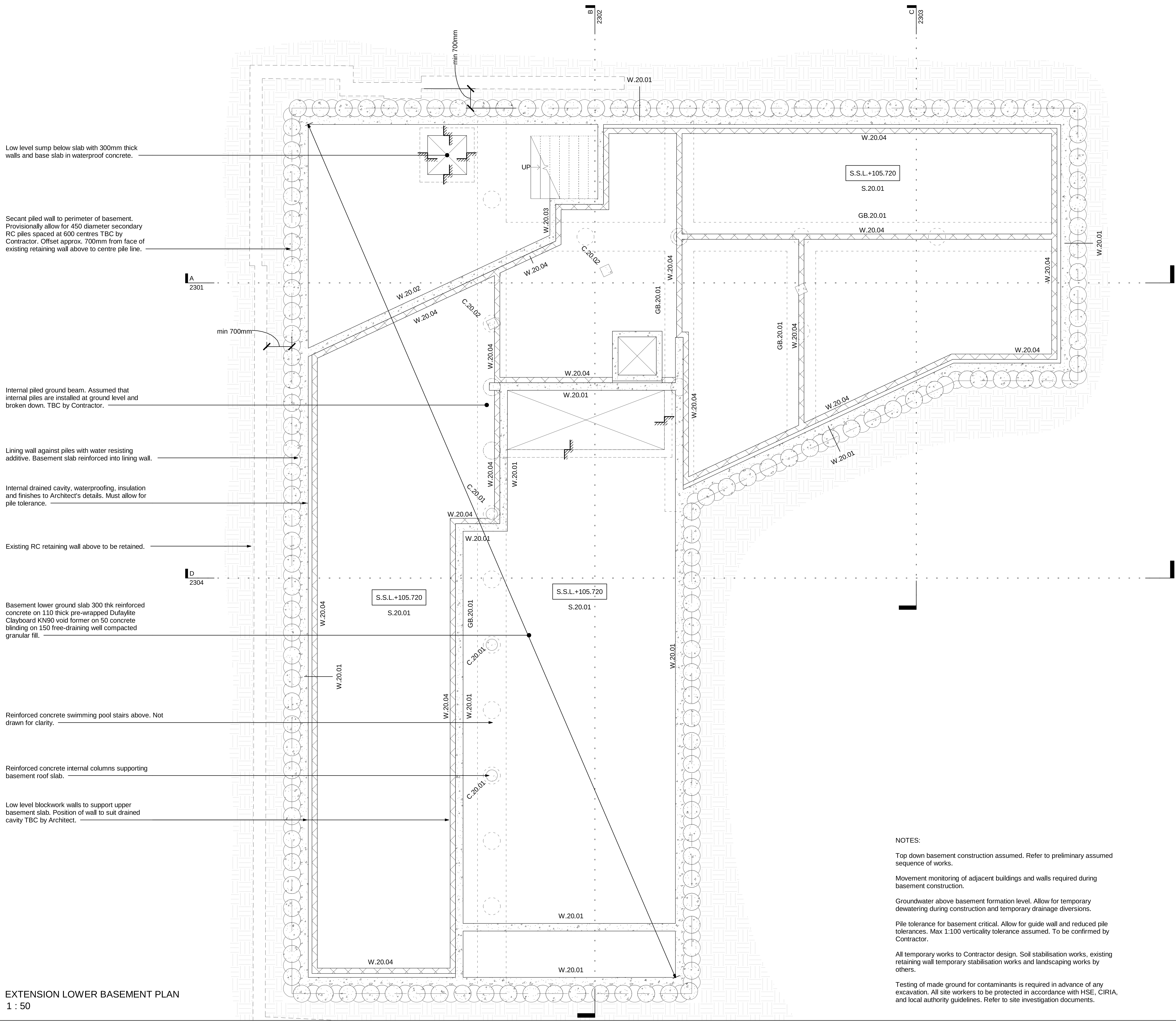
The BIA has concluded that risks to the development and adjacent receptors are low and will be mitigated as part of the design development and construction methodology. Any potential damage can be mitigated by appointment of a suitable experienced Contractor, following an appropriate construction methodology, and putting in place suitable and control measures.

The BIA has identified a potential hydrogeological impact as the excavation will be within the Bagshot Formation and partially within the Claygate Member of the London Clay Formation which are both classed as Secondary A Aquifers. As the geological conditions are largely cohesive with low permeabilities, and the proposed basement is set back from the site extents, overall impacts on the wider hydrogeological environment are considered to be low. A secant piled perimeter is proposed for the basement construction to provide a water cut-off as well as earth-retaining structure.

The BIA has concluded that there is very low risk of surface water flooding. The proposed drainage strategy will reflect the existing system however with attenuation on site for controlled discharge to the public sewer. A drainage strategy and flood risk assessment has been prepared by Civilistix. Refer to their report for further information.

APPENDIX A

STRUCTURAL DRAWINGS



EXTENSION LOWER BASEMENT PLAN
1 : 50

NOTES:

This drawing is to be read in conjunction with all other Architect's and Engineer's drawings, details and specifications.

Any discrepancies in the arrangement and details discovered on site, or otherwise, are to be reported to the Architect or Engineer immediately.

All dimensions in mm. Do not scale from this drawing. Setting out to Architect's details. Drawings to be printed in colour.

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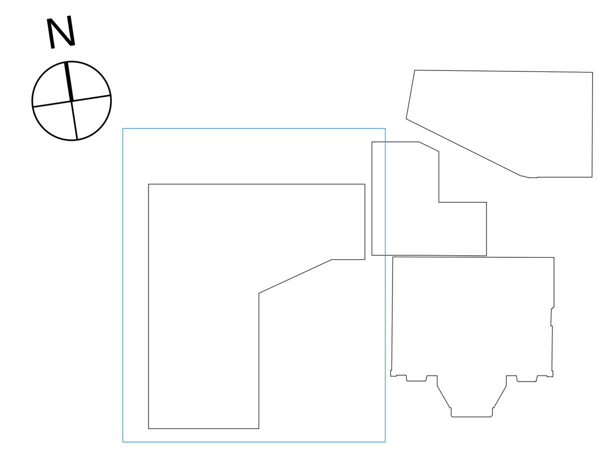

EXTENSION - BEAM SCHEDULE BSMT

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
GB.20.01	450d x 750w	RC 28/35 ground beam

EXTENSION - COLUMN SCHEDULE BSMT

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
C.20.01	300 Dia circular	RC 28/35
C.20.02	250 x 250	RC 28/35

EXTENSION - WALL SCHEDULE BSMT

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
W.20.01	200 Thick	RC 28/35 Water resisting
W.20.02	200 Thick	RC 28/35
W.20.03	150 Thick	RC 28/35
W.20.04	140 Thick	Blockwork

EXTENSION - SLAB SCHEDULE BSMT

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
S.20.01	300 Thick	RC 28/35 ground slab

NOTES:

Top down basement construction assumed. Refer to preliminary assumed sequence of works.

Movement monitoring of adjacent buildings and walls required during basement construction.

Groundwater above basement formation level. Allow for temporary dewatering during construction and temporary drainage diversions.

Pile tolerance for basement critical. Allow for guide wall and reduced pile tolerances. Max 1:100 verticality tolerance assumed. To be confirmed by Contractor.

All temporary works to Contractor design. Soil stabilisation works, existing retaining wall temporary stabilisation works and landscaping works by others.

Testing of made ground for contaminants is required in advance of any excavation. All site workers to be protected in accordance with HSE, CIRIA, and local authority guidelines. Refer to site investigation documents.

REV	DESCRIPTION	DATE
P1	Issued for Information	31.10.23

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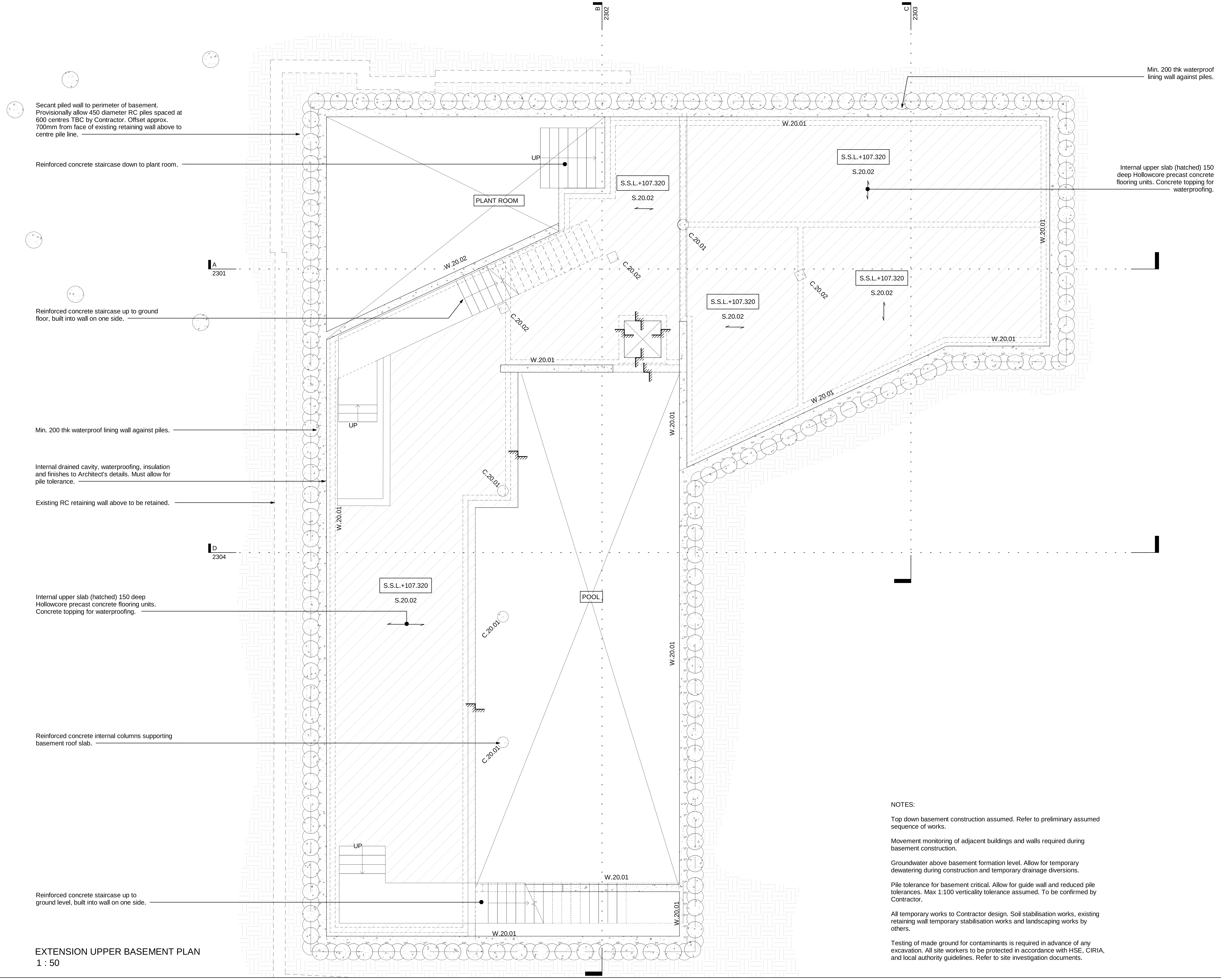
PROJECT
99 FROGNAL

DRAWING TITLE
EXTENSION LOWER BASEMENT PLAN

DRAWING NUMBER	DRAWN	APPROVED	SCALE AT A1
PRELIMINARY	DB	AH	1:50

DRAWING NUMBER	REV.
23020.2201	P1



EXTENSION UPPER BASEMENT PLAN
1 : 50

NOTES:

Top down basement construction assumed. Refer to preliminary assumed sequence of works.

Movement monitoring of adjacent buildings and walls required during basement construction.

Groundwater above basement formation level. Allow for temporary dewatering during construction and temporary drainage diversions.

Pile tolerance for basement critical. Allow for guide wall and reduced pile tolerances. Max 1:100 verticality tolerance assumed. To be confirmed by Contractor.

All temporary works to Contractor design. Soil stabilisation works, existing retaining wall temporary stabilisation works and landscaping works by others.

Testing of made ground for contaminants is required in advance of any excavation. All site workers to be protected in accordance with HSE, CIRIA, and local authority guidelines. Refer to site investigation documents.

NOTES:

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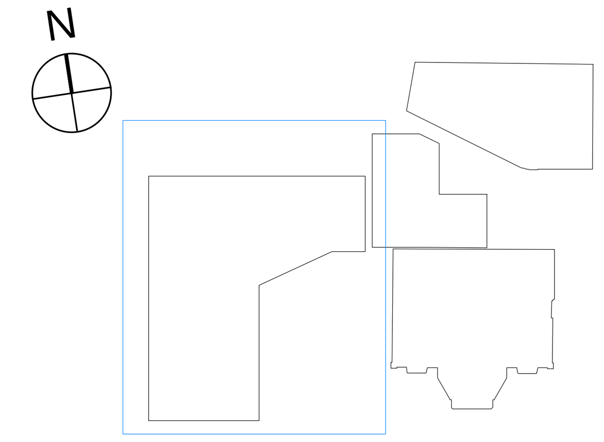

EXTENSION - BEAM SCHEDULE BSMT

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
GB.20.01	450d x 750w	RC 28/35 ground beam

EXTENSION - COLUMN SCHEDULE BSMT

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
C.20.01	300 Dia circular	RC 28/35
C.20.02	250 x 250	RC 28/35

EXTENSION - WALL SCHEDULE BSMT

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
W.20.01	200 Thick	RC 28/35 Water resisting
W.20.02	200 Thick	RC 28/35
W.20.03	150 Thick	RC 28/35
W.20.04	140 Thick	Blockwork

EXTENSION - SLAB SCHEDULE UPPER BSMT

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
S.20.02	150 Thick	Precast concrete floor

REV	DESCRIPTION	DATE
P1	Issued for Information	31.10.23

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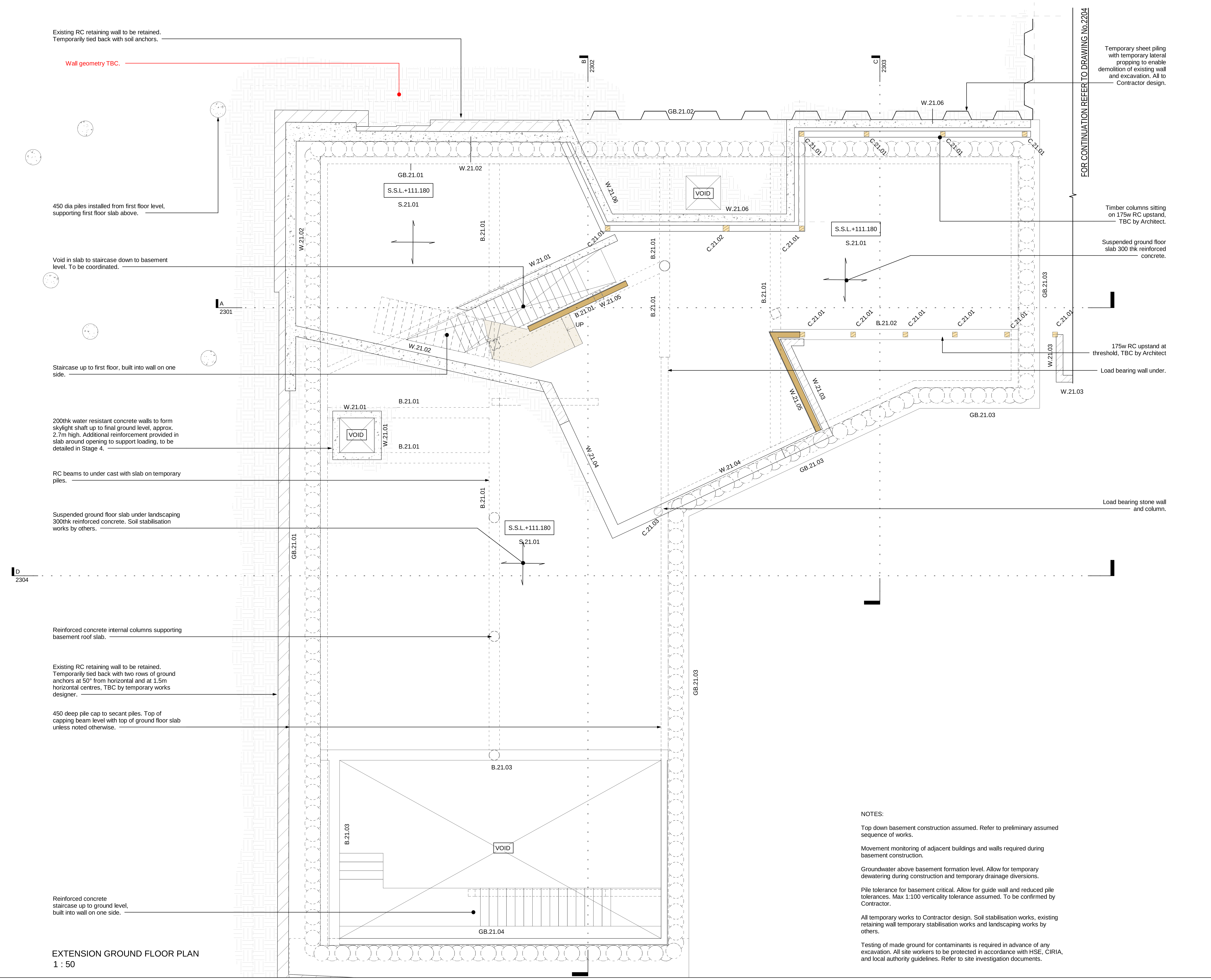
PROJECT
99 FROGNAL

DRAWING TITLE
EXTENSION UPPER BASEMENT PLAN

DRAWING NUMBER	DRAWN	APPROVED	SCALE AT A1
PRELIMINARY	DB	AH	1:50

DRAWING NUMBER	REV.
23020.2202	P1



EXTENSION GROUND FLOOR PLAN
1 : 50

NOTES:

Top down basement construction assumed. Refer to preliminary assumed sequence of works.

Movement monitoring of adjacent buildings and walls required during basement construction.

Groundwater above basement formation level. Allow for temporary dewatering during construction and temporary drainage diversions.

Pile tolerance for basement critical. Allow for guide wall and reduced pile tolerances. Max 1:100 verticality tolerance assumed. To be confirmed by Contractor.

All temporary works to Contractor design. Soil stabilisation works, existing retaining wall temporary stabilisation works and landscaping works by others.

Testing of made ground for contaminants is required in advance of any excavation. All site workers to be protected in accordance with HSE, CIRIA, and local authority guidelines. Refer to site investigation documents.

NOTES:

This drawing is to be read in conjunction with all other Architect's and Engineer's drawings, details and specifications.

Any discrepancies in the arrangement and details discovered on site, or otherwise, are to be reported to the Architect or Engineer immediately.

All dimensions in mm. Do not scale from this drawing. Setting out to Architect's details. Drawings to be printed in colour.

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N

EXTENSION - BEAM SCHEDULE GF

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
B.21.01	625d x 300w	RC 28/35
B.21.02	825d x 300w	RC 28/35
B.21.03	1125d x 300w	RC 28/35
GB.21.01	450d x ~1125w	RC 28/35 ground beam cast existing RC retaining wall
GB.21.02	450d x 1100w	RC 28/35 ground beam
GB.21.03	450d x 800w	RC 28/35 ground beam
GB.21.04	600d x 1125w	RC 28/35 ground beam

EXTENSION - SLAB SCHEDULE GF

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
S.21.01	300 Thick	RC 28/35 slab

EXTENSION - WALL SCHEDULE GF

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
W.21.01	200 Thick	RC 28/35
W.21.02	300 Thick	RC 28/35
W.21.03	200 Thick	Load bearing stone
W.21.04	300 Thick	Load bearing stone
W.21.05	150 x 50 C 24 Studs at 400crs	15mm Ply to outside face
W.21.06	225 Thick	RC 28/35

EXTENSION - COLUMN SCHEDULE GF

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
C.21.01	140 x 140	GL32h Glulam
C.21.02	180 x 180	GL32h Glulam
C.21.03	250 Dia circular	Stone

REV	DESCRIPTION	DATE
P1	Issued for Information	31.10.23

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DRAWING TITLE
EXTENSION GROUND FLOOR PLAN 1

DRAWING NUMBER	DRAWN	APPROVED	SCALE AT A1
PRELIMINARY	DB	AH	1:50

DRAWING NUMBER	REV.
23020.2203	P1

NOTES:

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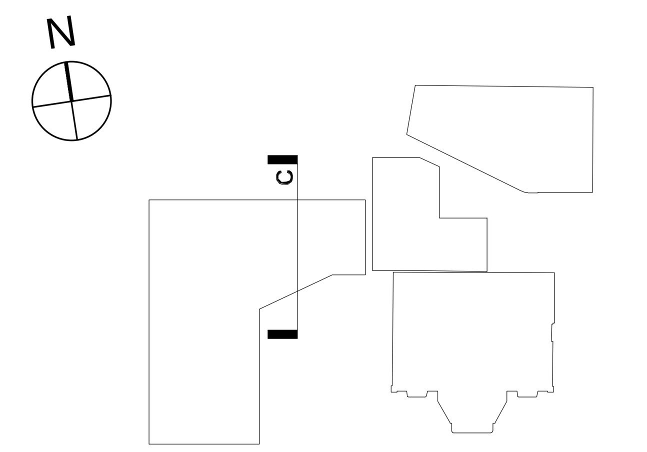
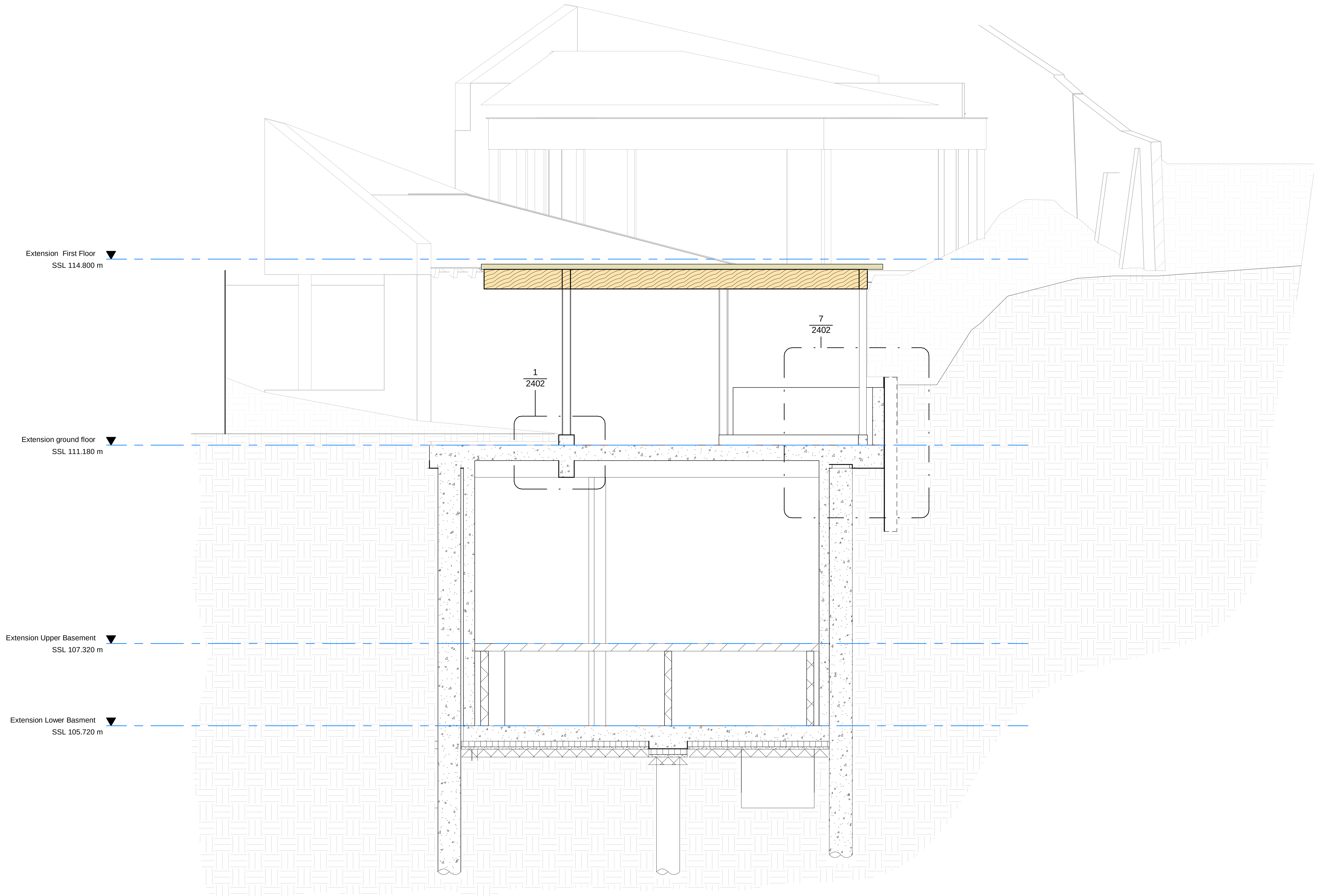
All dimensions in mm. Do not scale from this drawing. Setting out to Architect's details. Drawings to be printed in colour.

0 1 2 5





SECTION C-C
1 : 50

REV	DESCRIPTION	DATE
P1	Issued for Information	31.10.23

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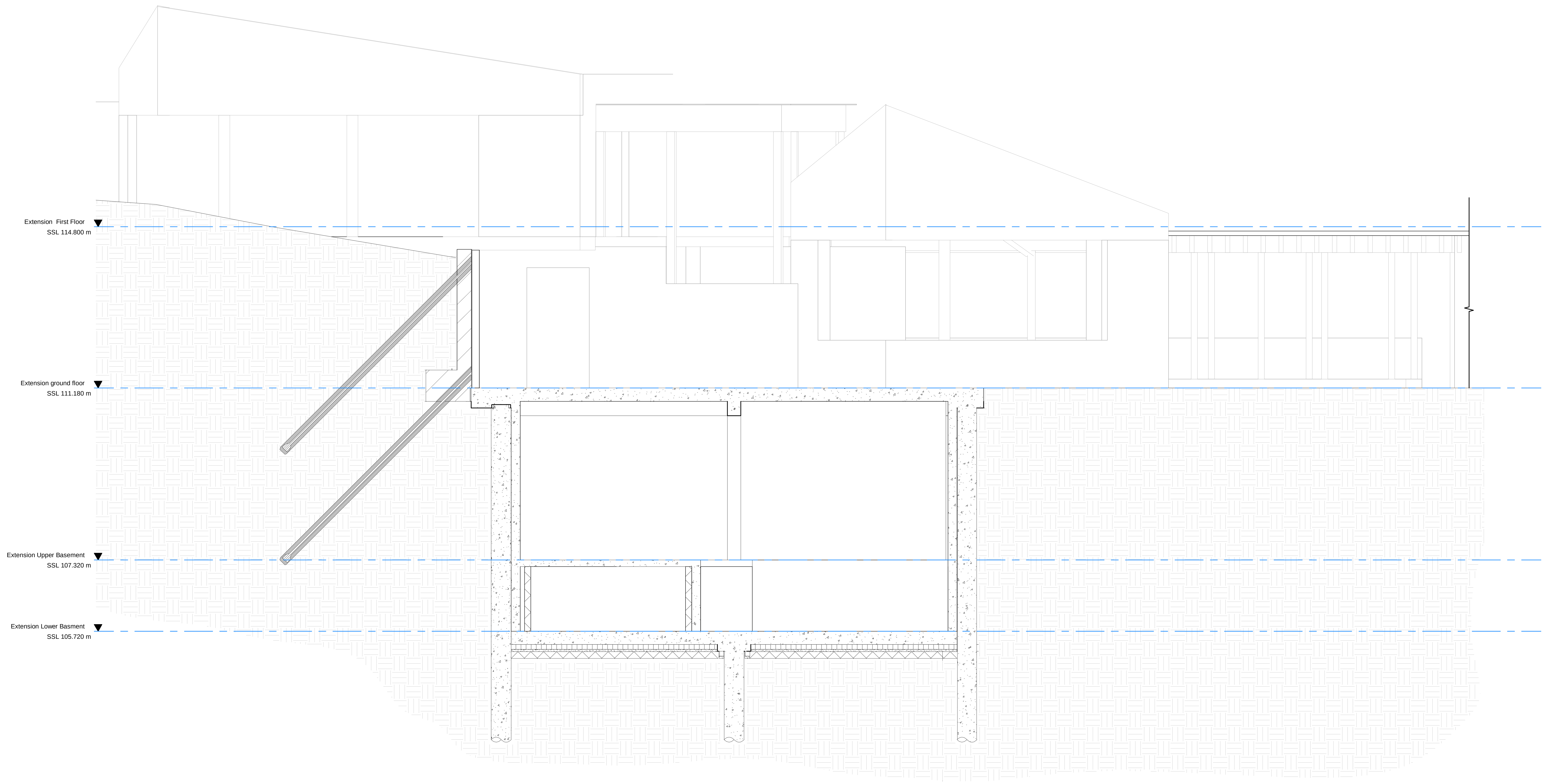
DRAWING TITLE
EXTENSION CROSS SECTION C

DRAWING NUMBER	DRAWN	APPROVED	SCALE AT A1
PRELIMINARY	DB	AH	1:50

DRAWING NUMBER	REV.
23020.2303	P1



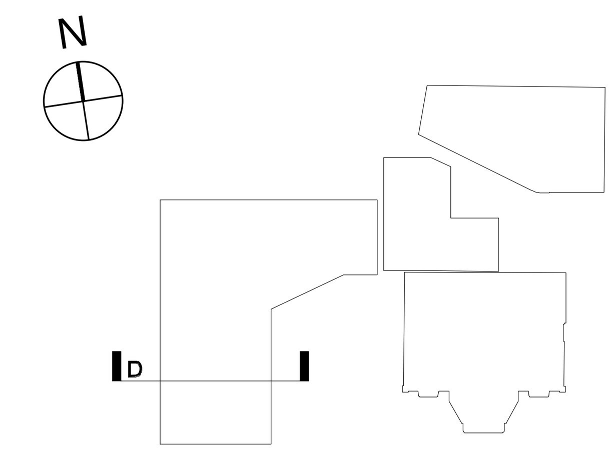
SECTION D-D
1 : 50

NOTES:

This drawing is to be read in conjunction with all other Architect's and Engineer's drawings, details and specifications.

Any discrepancies in the arrangement and details discovered on site, or otherwise, are to be reported to the Architect or Engineer immediately.

All dimensions in mm. Do not scale from this drawing. Setting out to Architect's details. Drawings to be printed in colour.



REV	DESCRIPTION	DATE
P1	Issued for Information	31.10.23

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DRAWING TITLE
EXTENSION CROSS SECTION D

DRAWING NUMBER	DRAWN	APPROVED	SCALE AT A1
PRELIMINARY	DB	AH	1:50

DRAWING NUMBER	REV.
23020.2304	P1

NOTES:

This drawing is to be read in conjunction with all other Architect's and Engineer's drawings, details and specifications.

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All dimensions in mm. Do not scale from this drawing. Setting out to Architect's details. Drawings to be printed in colour.

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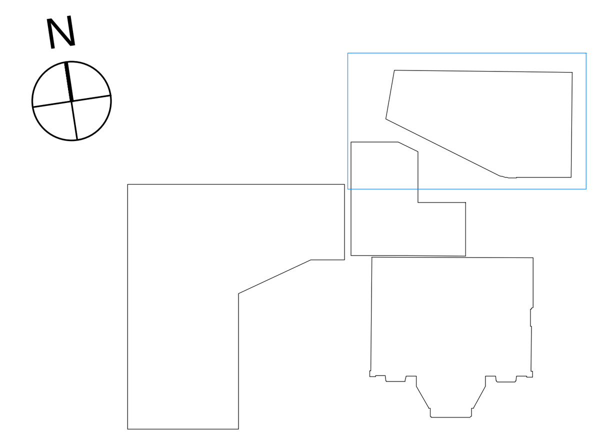


Perimeter piles to be set in approx. 700 mm from existing walls to centre of pile. TBC by land contractor.

Existing masonry retaining wall above. Profile and depth of existing wall below ground is unknown. Wall to be retained and underpinned with mass concrete in underpinning sequence assumed in 2 no vertical lifts. Temporary lateral propping required to Contractor's details.

RC columns supporting roof slab.

450 dia piles to support ground beams.

Internal RC shear walls supporting roof slab and providing lateral stability.

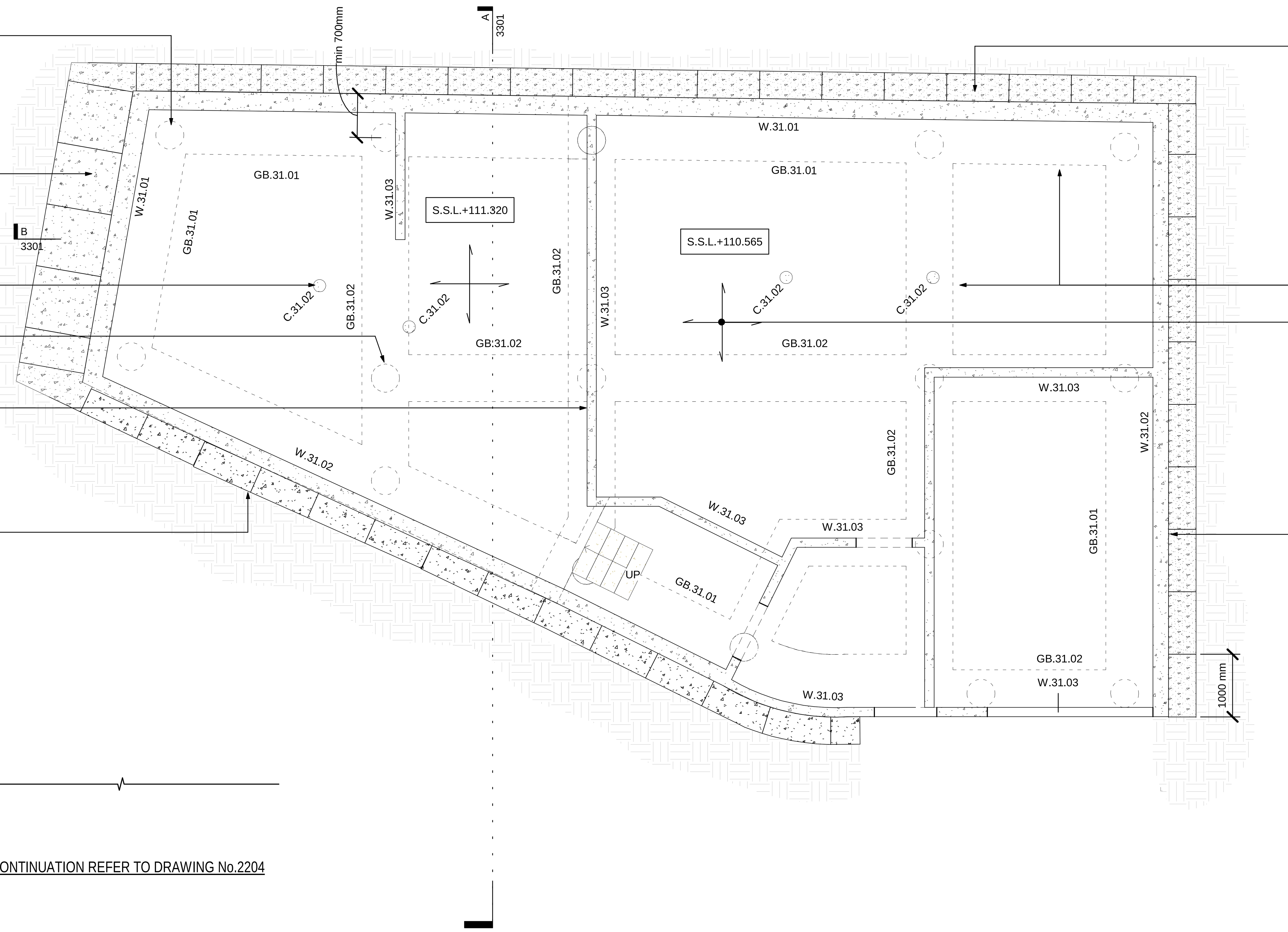
Main house extension built up to garage houses on south west corner. Refer to extension drawings series.

Existing masonry retaining walls above. Profile and depth of existing wall below ground is unknown. Wall to be retained and underpinned with mass concrete in underpinning sequence. Assumed in 2no. vertical lifts. Temporary lateral propping required to Contractor's details.

RC ground beams, 1000 wide where cast against existing wall, 750 wide otherwise.

Ground slab 225 thk reinforced concrete on 110 thick pre-wrapped Dufaylite Clayboard KN30 void former on 50 concrete blinding and 150 granular fill.

Internal insulation and waterproofing to architect's details.



FOR CONTINUATION REFER TO DRAWING No.2204

GARAGE HOUSE - BEAM SCHEDULE GF

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
GB.31.01	450d x 1000w	RC 28/35 ground beam
GB.31.02	450d x 750w	RC 28/35 ground beam

GARAGE HOUSE - COLUMN SCHEDULE GF

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
C.31.02	200 Dia circular	RC 28/35

GARAGE HOUSE - WALL SCHEDULE GF

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
W.31.01	300 Thick	RC 28/35 Water resisting
W.31.02	250 Thick	<varies>
W.31.03	150 Thick	RC 28/35

REV	DESCRIPTION	DATE
P1	Issued for Information	31.10.23

NOTES:

Refer to preliminary assumed sequence of works.

Movement monitoring of adjacent buildings and walls required during basement construction.

Allow for temporary dewatering during construction and temporary drainage diversions.

Pile design is CDP. Setting out to be confirmed by Contractor.

All temporary works to Contractor design. Soil stabilisation works, existing retaining wall temporary stabilisation works and landscaping works by others.

Testing of made ground for contaminants is required in advance of any excavation. All site workers to be protected in accordance with HSE, CIRIA, and local authority guidelines. Refer to site investigation documents.

GARAGE HOUSE GROUND FLOOR PLAN
1 : 50

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DRAWING TITLE
GARAGE HOUSE GROUND FLOOR PLAN

DRAWING NUMBER	DRAWN	APPROVED	SCALE AT A1
PRELIMINARY	DB	AH	1:50

DRAWING NUMBER	REV.
23020.3201	P1

NOTES:

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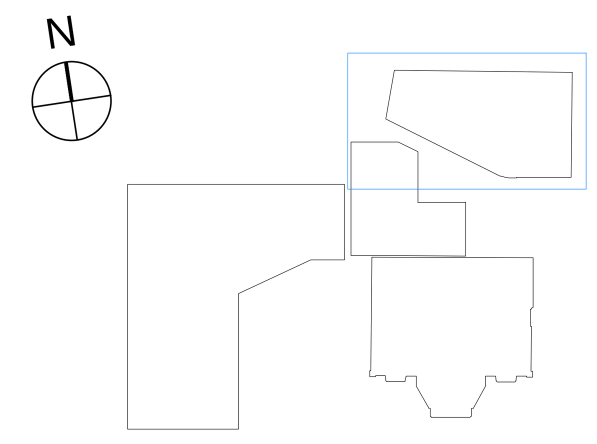

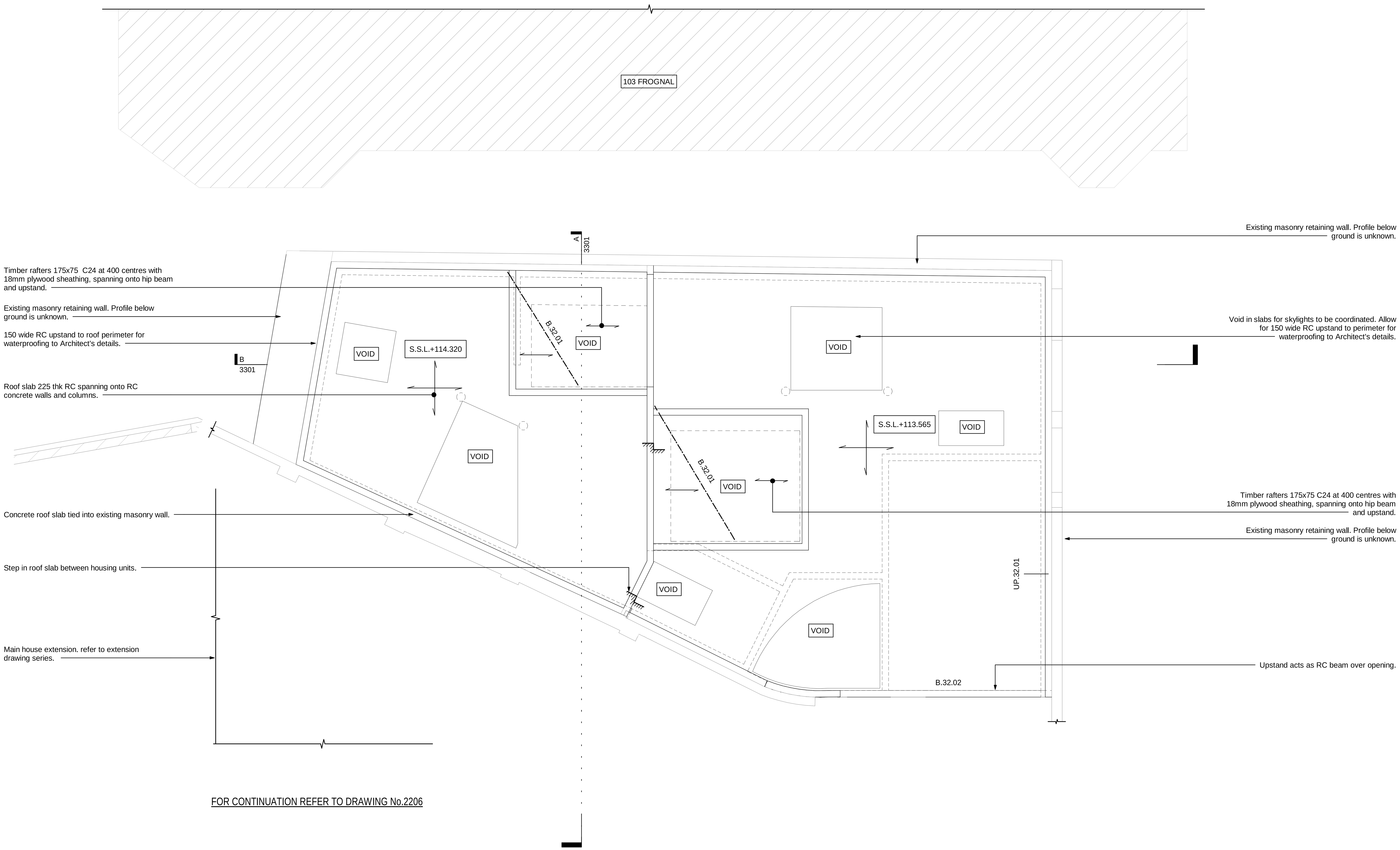

FOR CONTINUATION REFER TO DRAWING No.2206

GARAGE HOUSE - BEAM SCHEDULE 1F

REF.	MEMBER SIZE	MATERIAL/GRADE/NOTES
B.32.01	300d x 100w	GL28h Glulam
B.32.02	350d x 150w	RC 28/35

REV	DESCRIPTION	DATE
P1	Issued for Information	31.10.23

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DRAWING TITLE
GARAGE HOUSE ROOF PLAN

DRAWING NUMBER	DRAWN	APPROVED	SCALE AT A1
PRELIMINARY	DB	AH	1:50

DRAWING NUMBER	REV.
23020.3202	P1

GARAGE HOUSE ROOF PLAN
1 : 50

NOTES:

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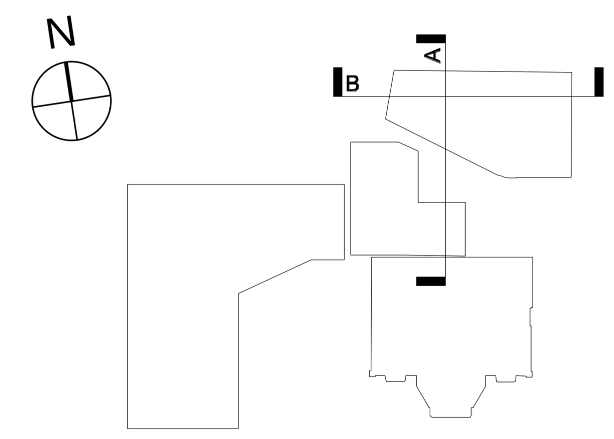
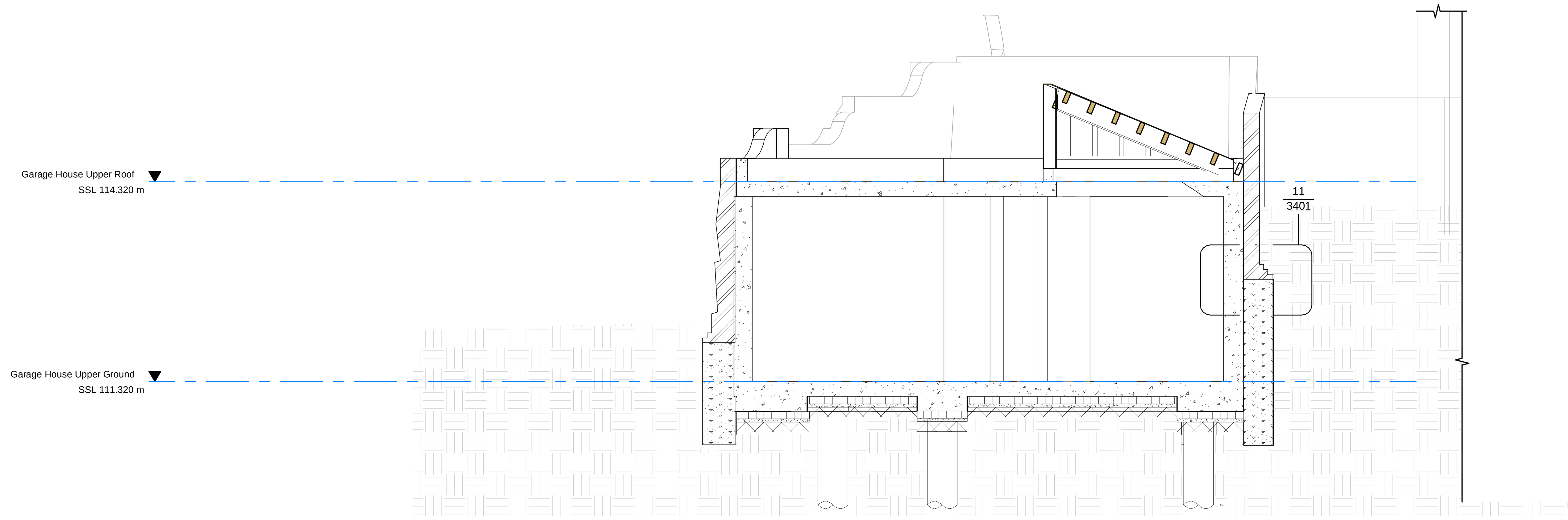
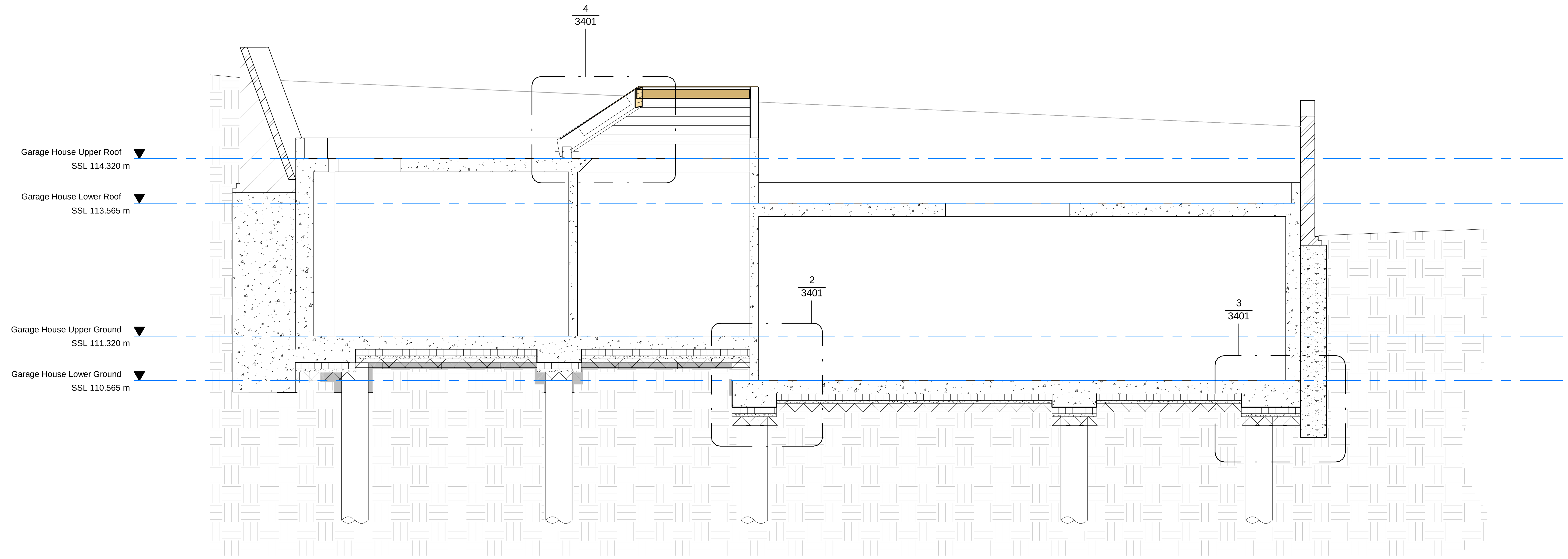
All dimensions in mm. Do not scale from this drawing. Setting out to Architect's details. Drawings to be printed in colour.

0 1 2 5





SECTION A-A
1 : 50



SECTION B-B
1 : 50

REV	DESCRIPTION	DATE
P1	Issued for Information	31.10.23

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PROJECT
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DRAWING TITLE
GARAGE HOUSE CROSS SECTIONS A & B

DRAWING NUMBER	DRAWN	APPROVED	SCALE AT A1
PRELIMINARY	DB	AH	1:50

DRAWING NUMBER	REV.
23020.3301	P1

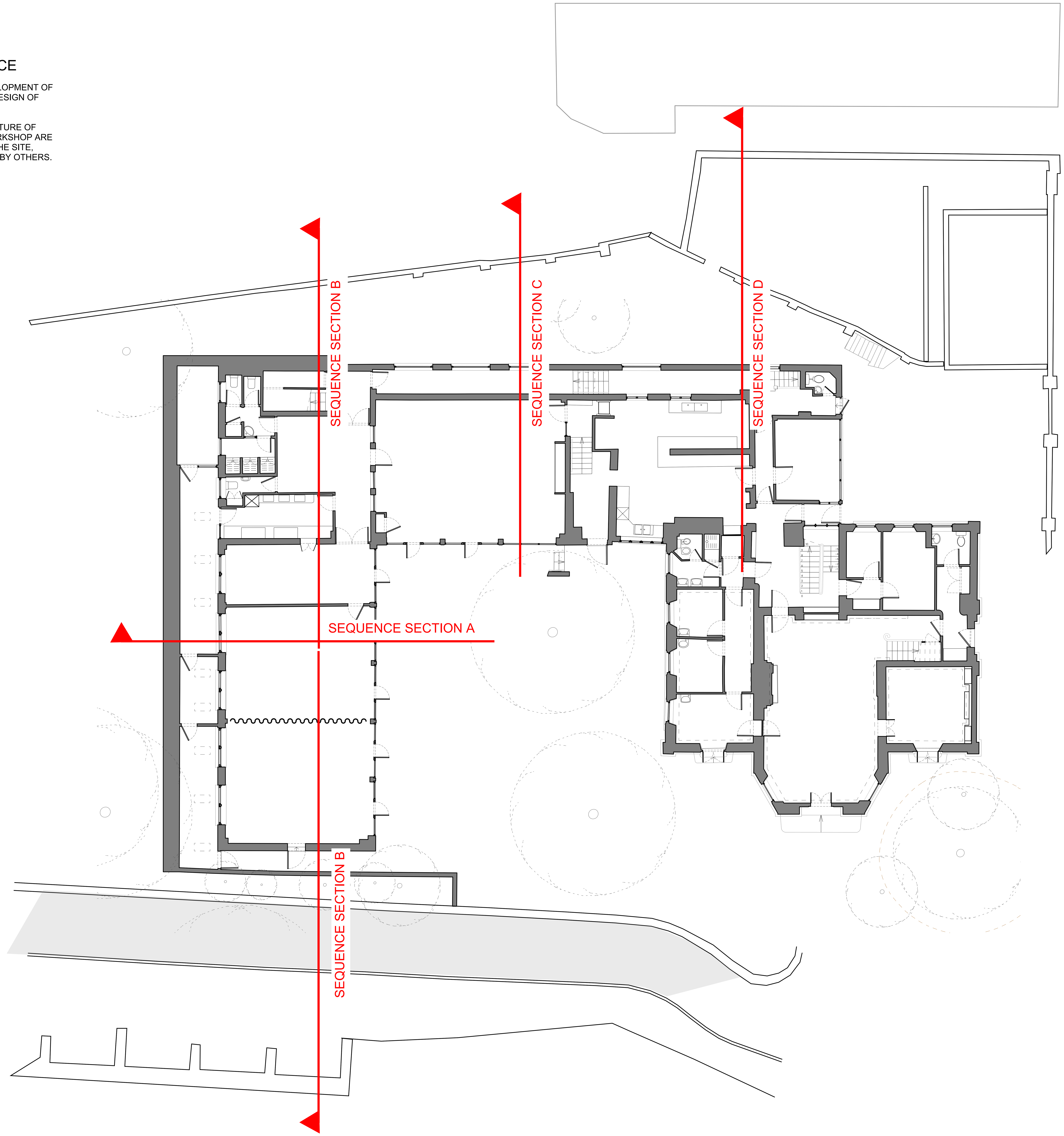
APPENDIX B

BASEMENT CONSTRUCTION SEQUENCE

BASEMENT CONSTRUCTION SEQUENCE

THIS ASSUMED SEQUENCE IS PRELIMINARY TO ENABLE DEVELOPMENT OF THE STRUCTURAL DETAILS. THE FINAL SEQUENCE AND THE DESIGN OF ALL TEMPORY WORKS IS TO THE CONTRACTOR'S DETAILS.

THIS ASSUMED SEQUENCE RELATES TO THE PRIMARY STRUCTURE OF THE BUILDING ONLY, THE DESIGN OF WHICH STRUCTURE WORKSHOP ARE RESPONSIBLE FOR. THE DESIGN OF LANDSCAPING ACROSS THE SITE, BELOW GROUND DRAINAGE AND OTHER BURIED SERVICES IS BY OTHERS.



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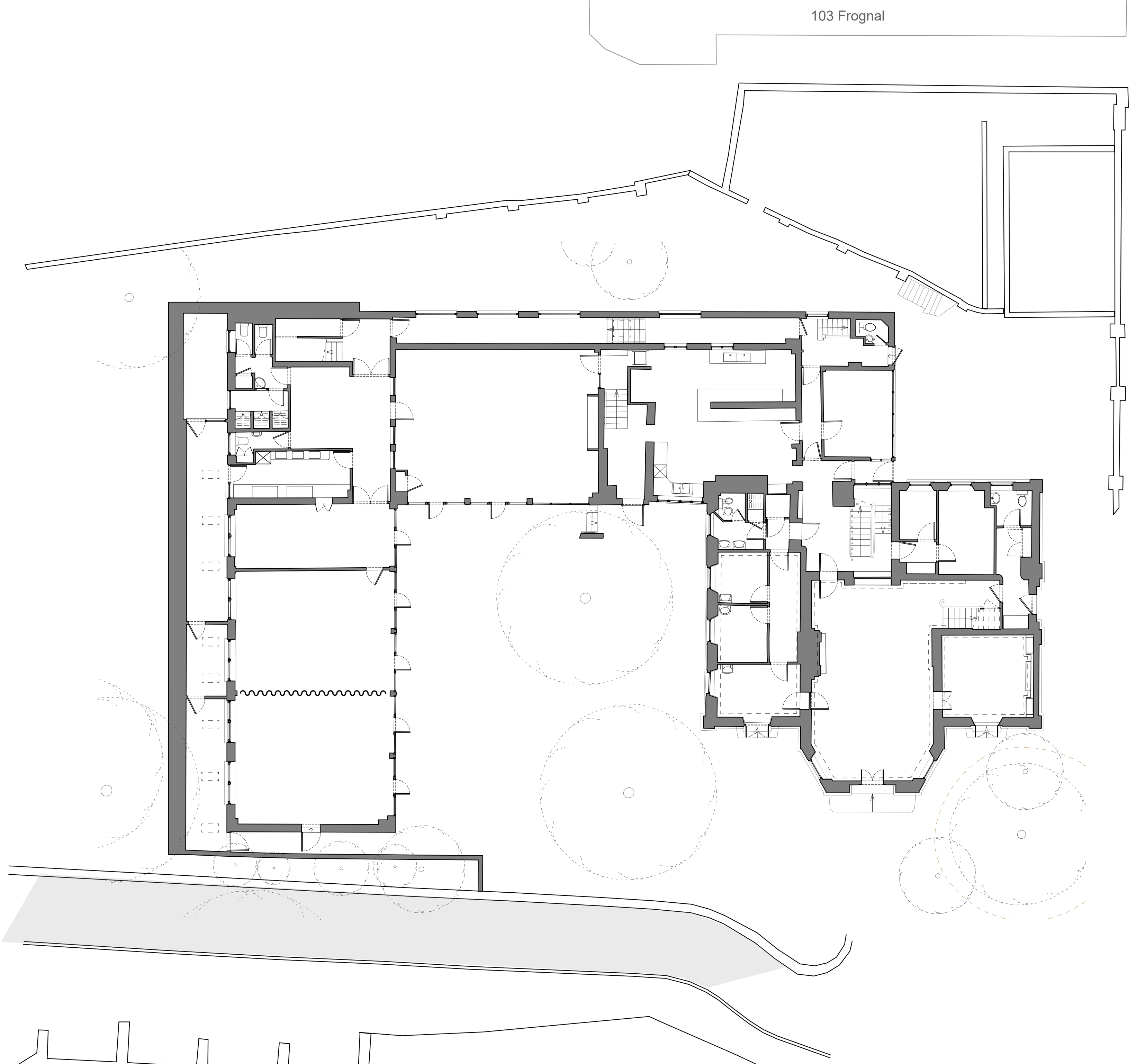
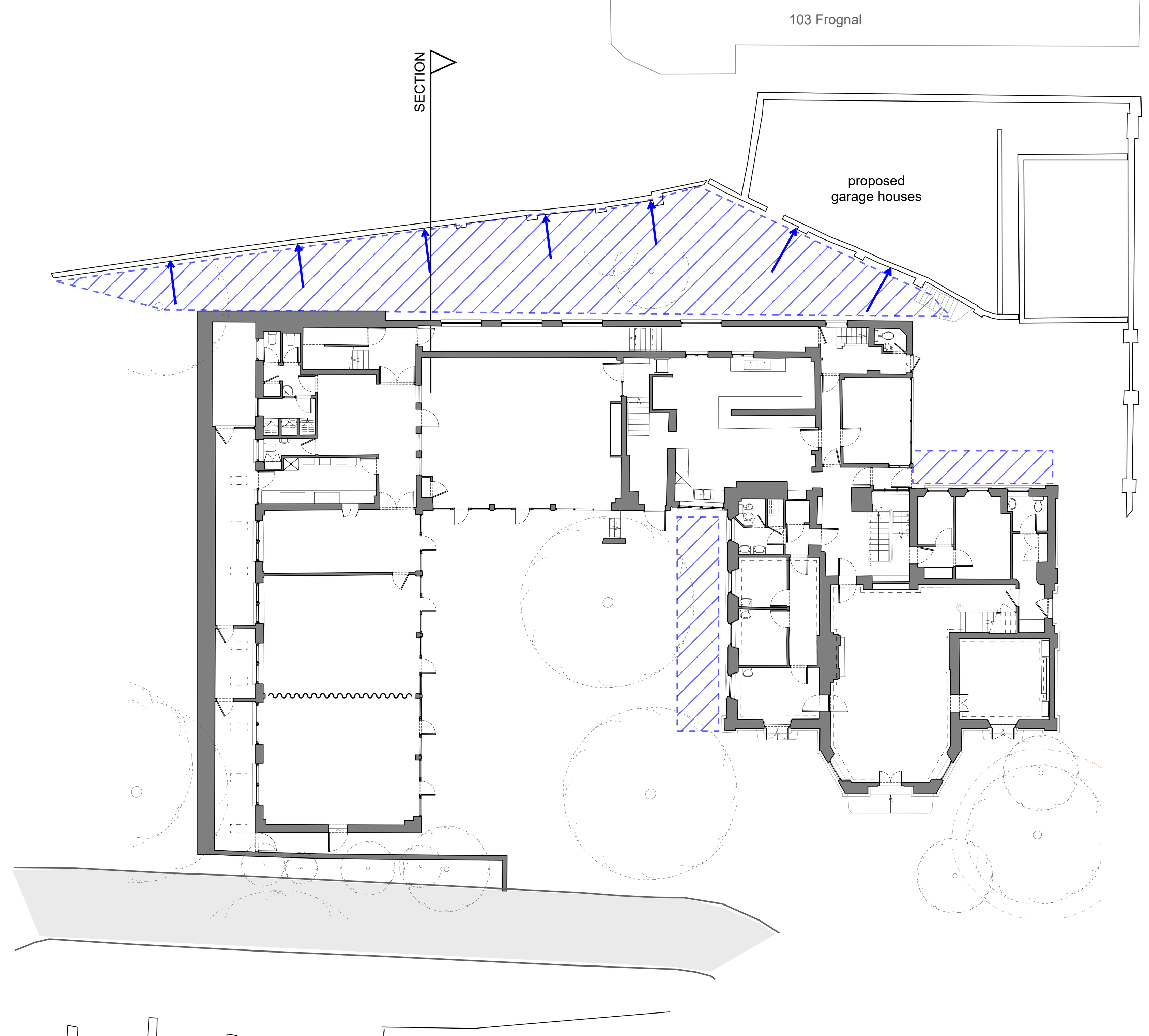
TITLE
BASEMENT CONSTUCTION SEQUENCE

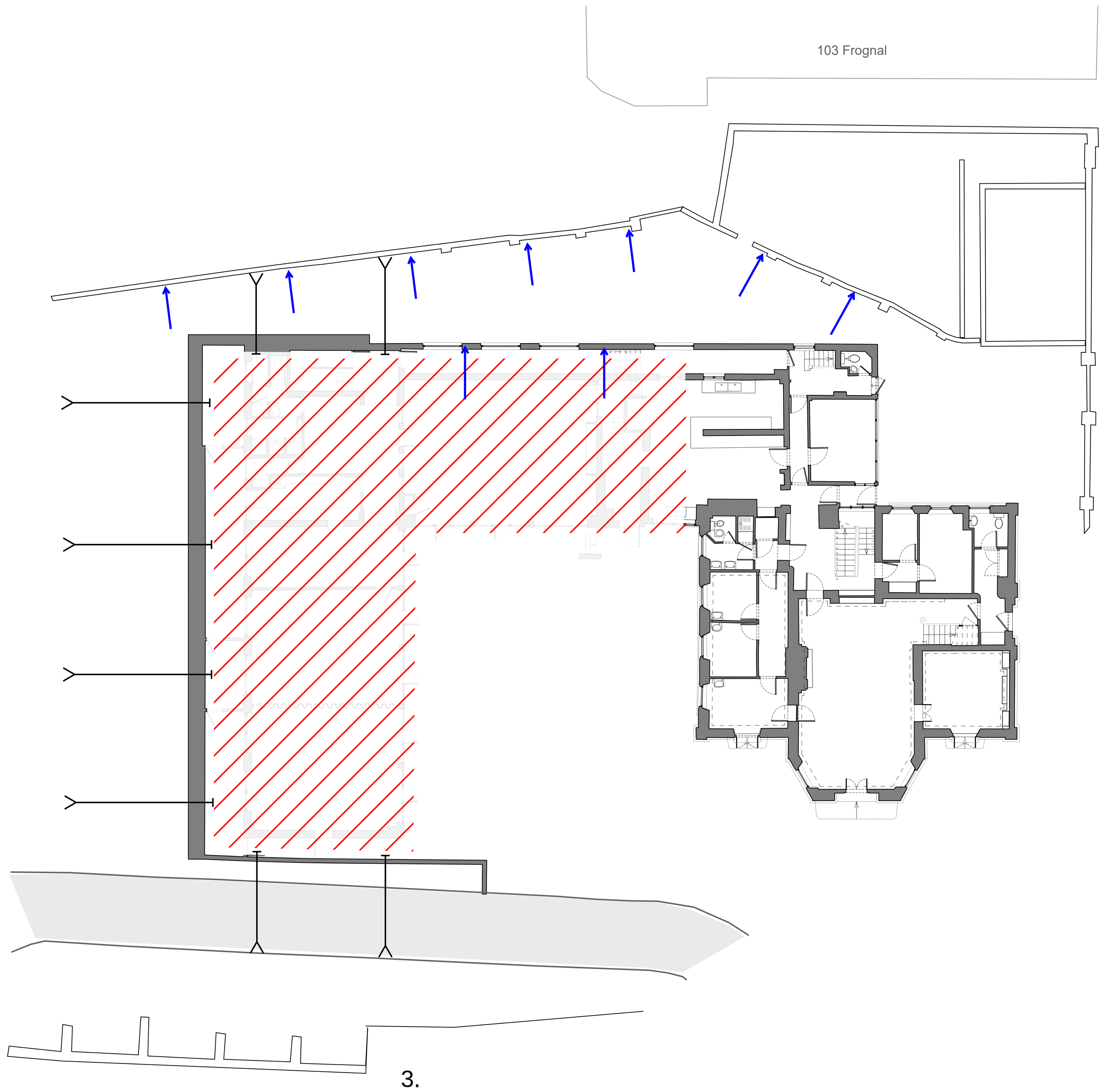
DATE	ENGINEER
NOV 23	AH
PROJECT NUMBER	SKETCH NUMBER
23020	SK27 P4



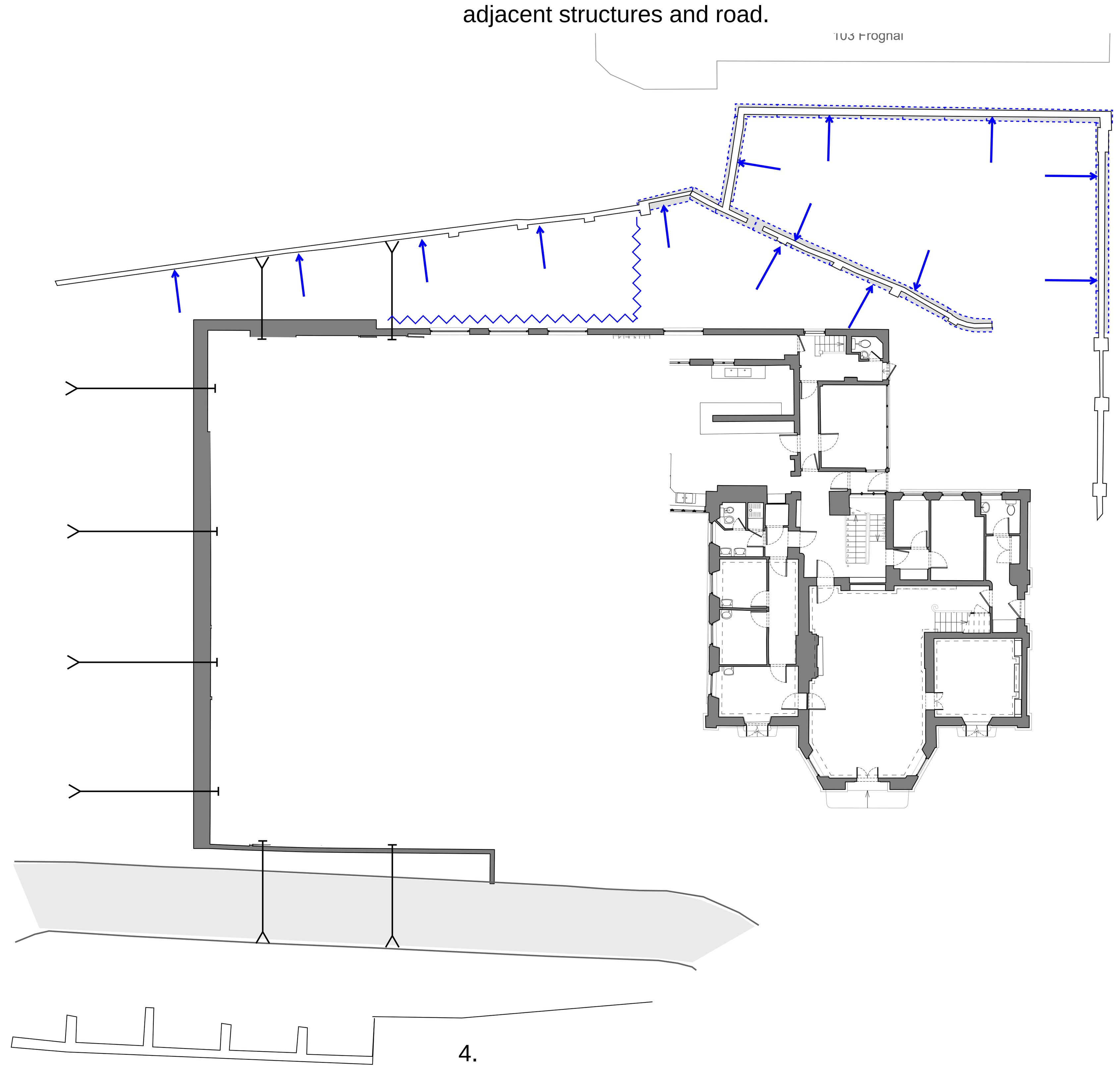
1.
- Set up movement monitoring to existing walls to be retained, including main house, north and south boundary walls, the adjacent property 103 Frognal to the north, and the east wall on Frognal



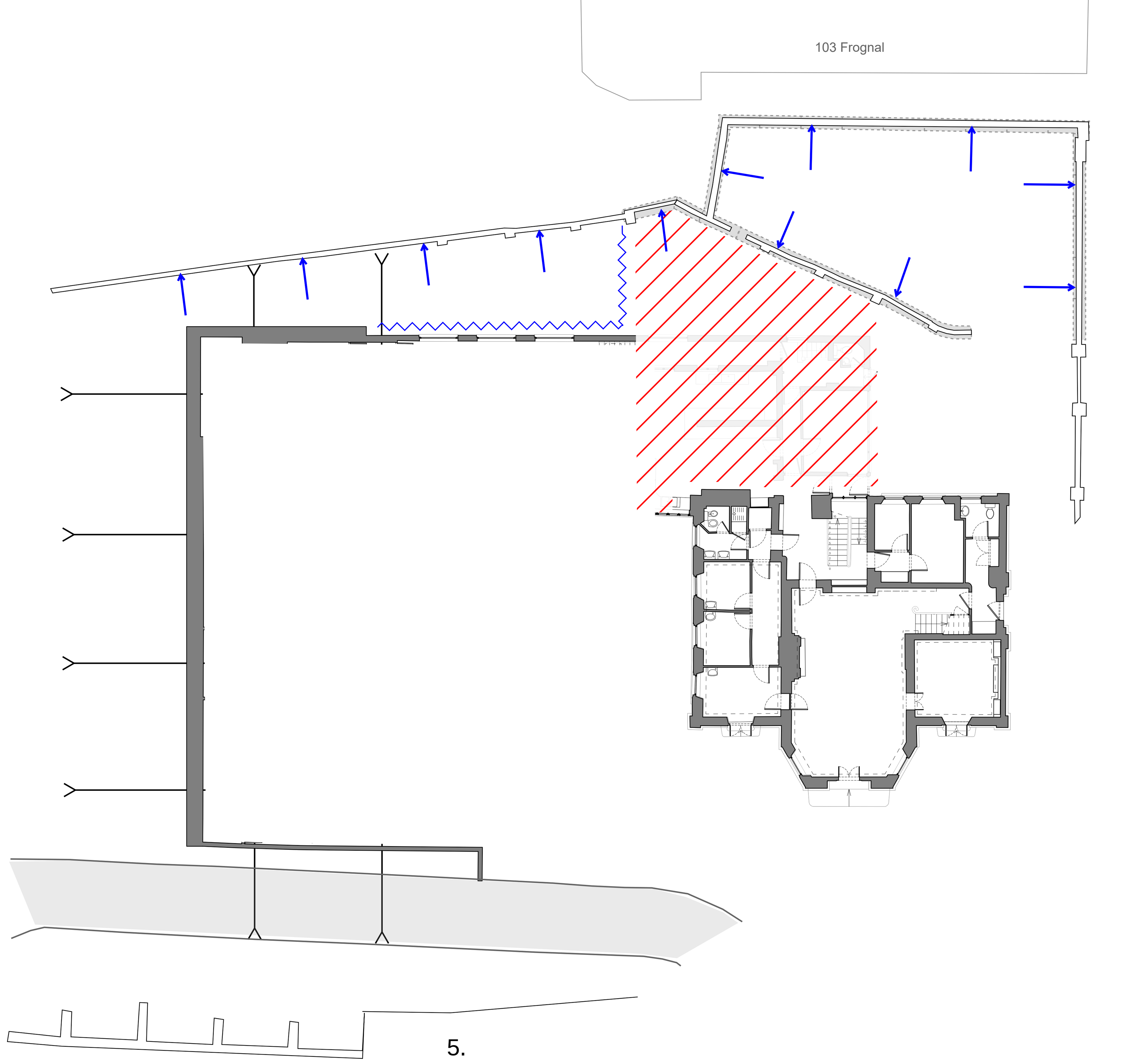
2.
- Create working route along northern boundary to provide sufficient working space for small plant.
- Provide protection/stabilisation to boundary walls and to north & west main house walls.
- Anchoring and remediation works to the northern boundary wall as required for stabilisation of the existing structure – details subject to party wall agreement.
- Lower ground behind existing retaining walls as required to reduce lateral loads while maintaining stability to adjacent structures and road.



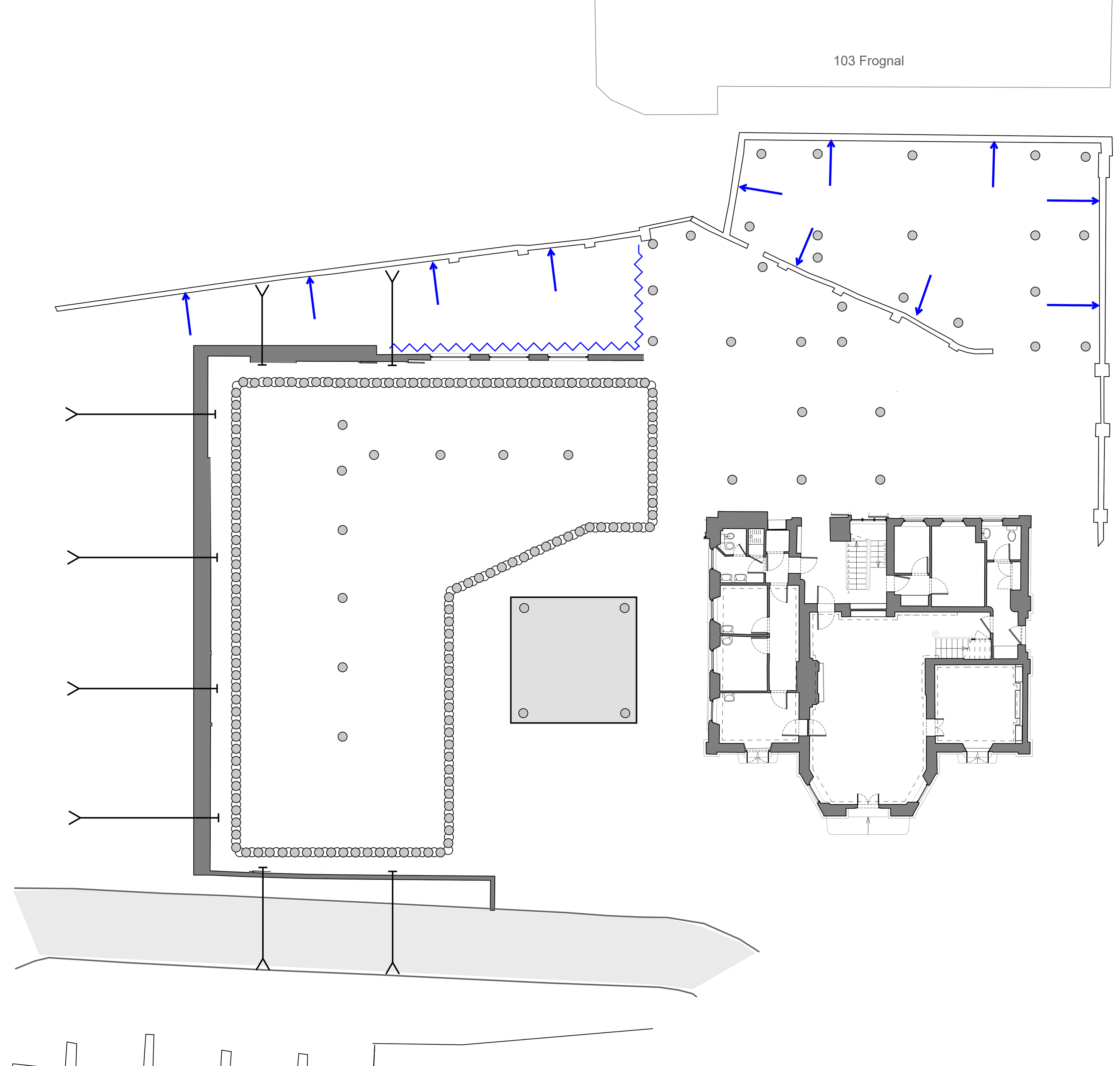
3.
- Demolish west wing of existing extension building and partially demolish north wing to extents of proposed basement.
- Install soil anchors and temporary support to existing retaining walls as required. Undertake demolition and anchoring in sections to ensure stability is maintained.
- Add propping to existing north retaining wall of the existing extension to be demolished later.
- Retain north-west corner of existing extension that provides support to existing garage walls.



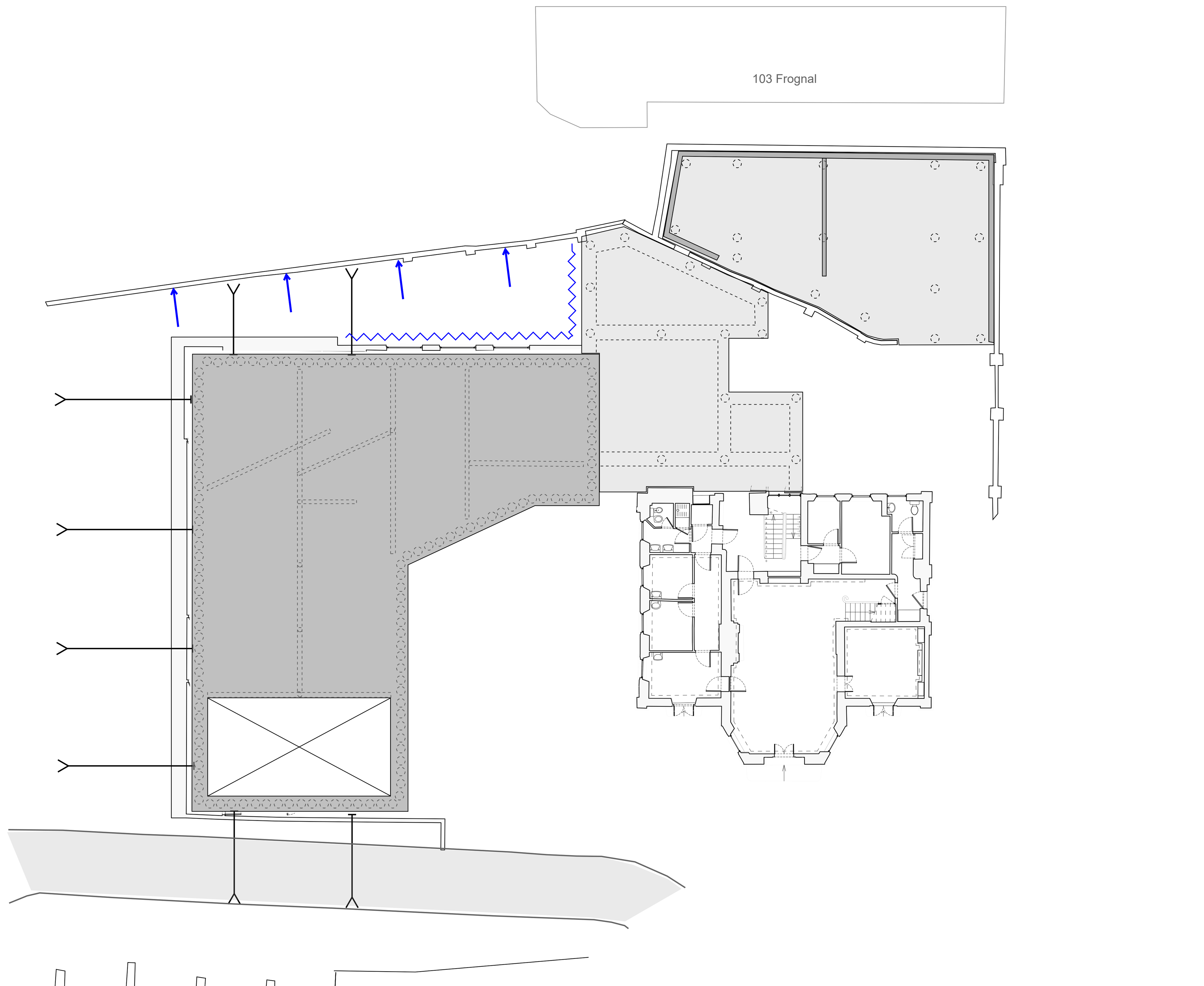
4.
See separate Garage House Construction Sequence sketch.
- Underpin existing walls around garage houses from raised level.
- Install temporary propping and excavate down to formation level in sequence.
- Install temporary sheet piling between extension and north boundary wall.



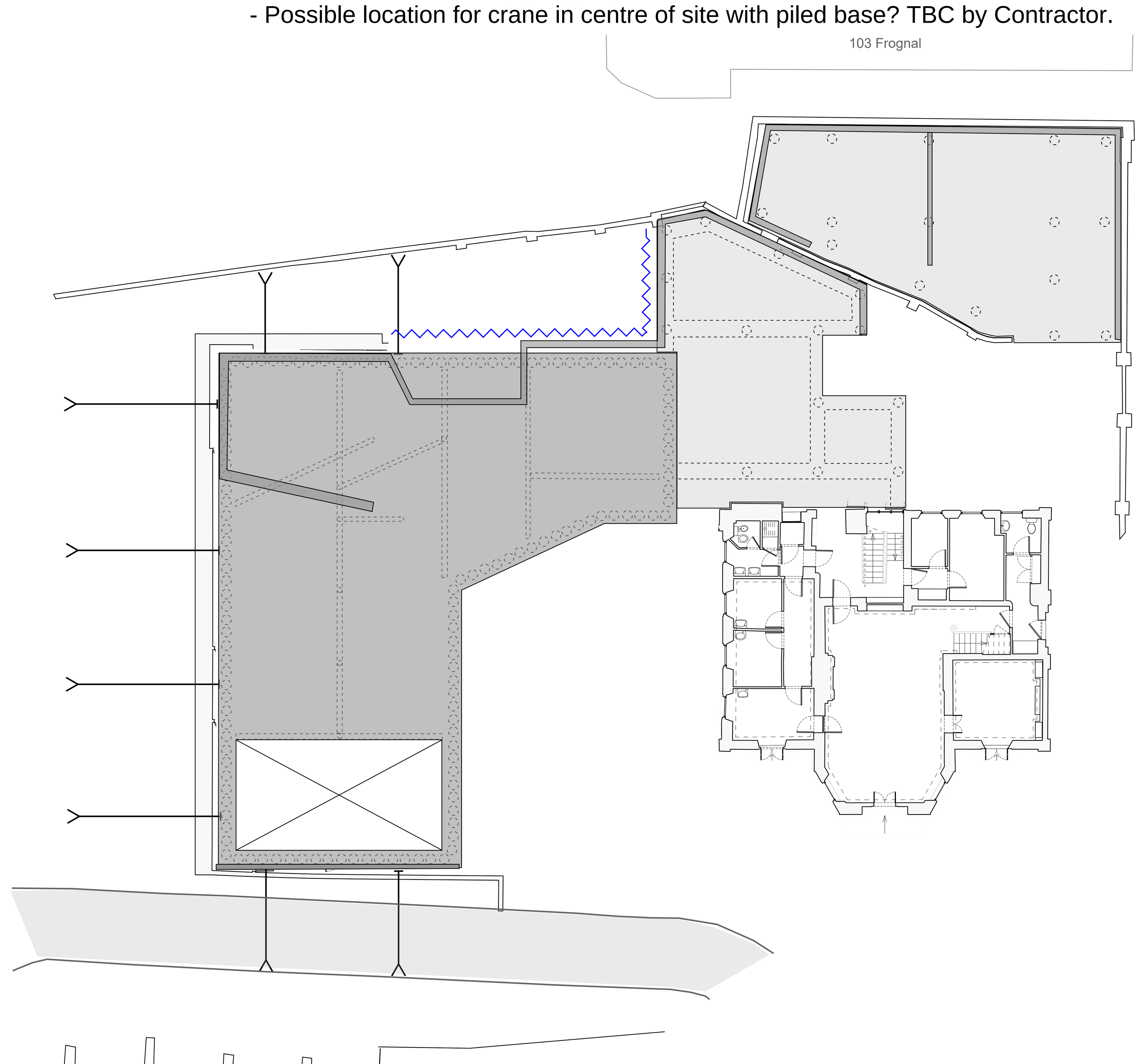
5.
- Demolish remainder of existing extension and excavate ground between existing extension and garage houses down to proposed formation level.



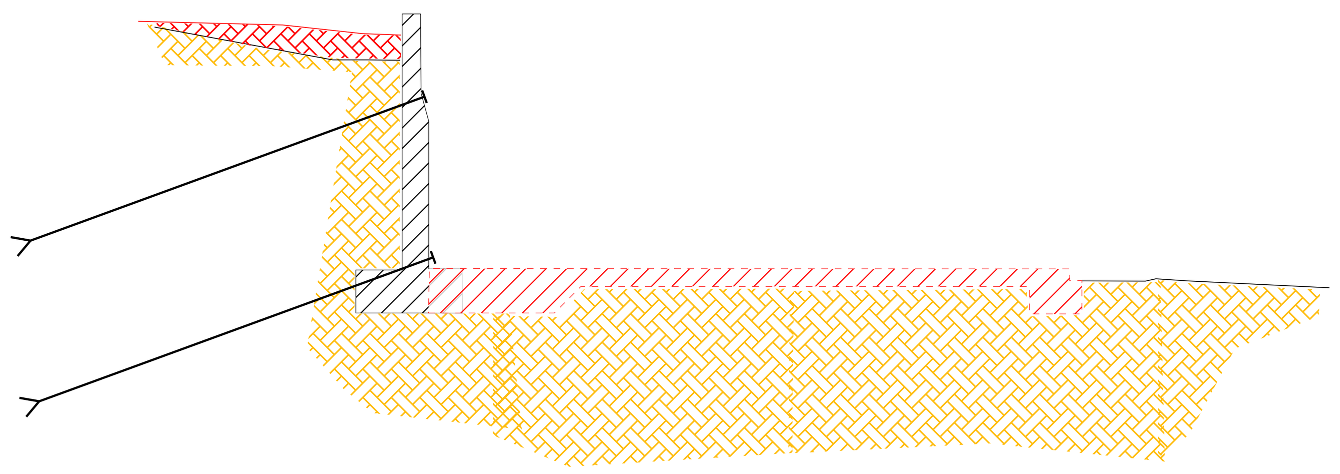
6.
- Install secant piled perimeter wall to basement and other piled foundations for the proposed extension from existing extension ground floor level. Piled foundations at garage houses can be installed at the same time.
- Work around temporary propping.
- Possible location for crane in centre of site with piled base? TBC by Contractor.



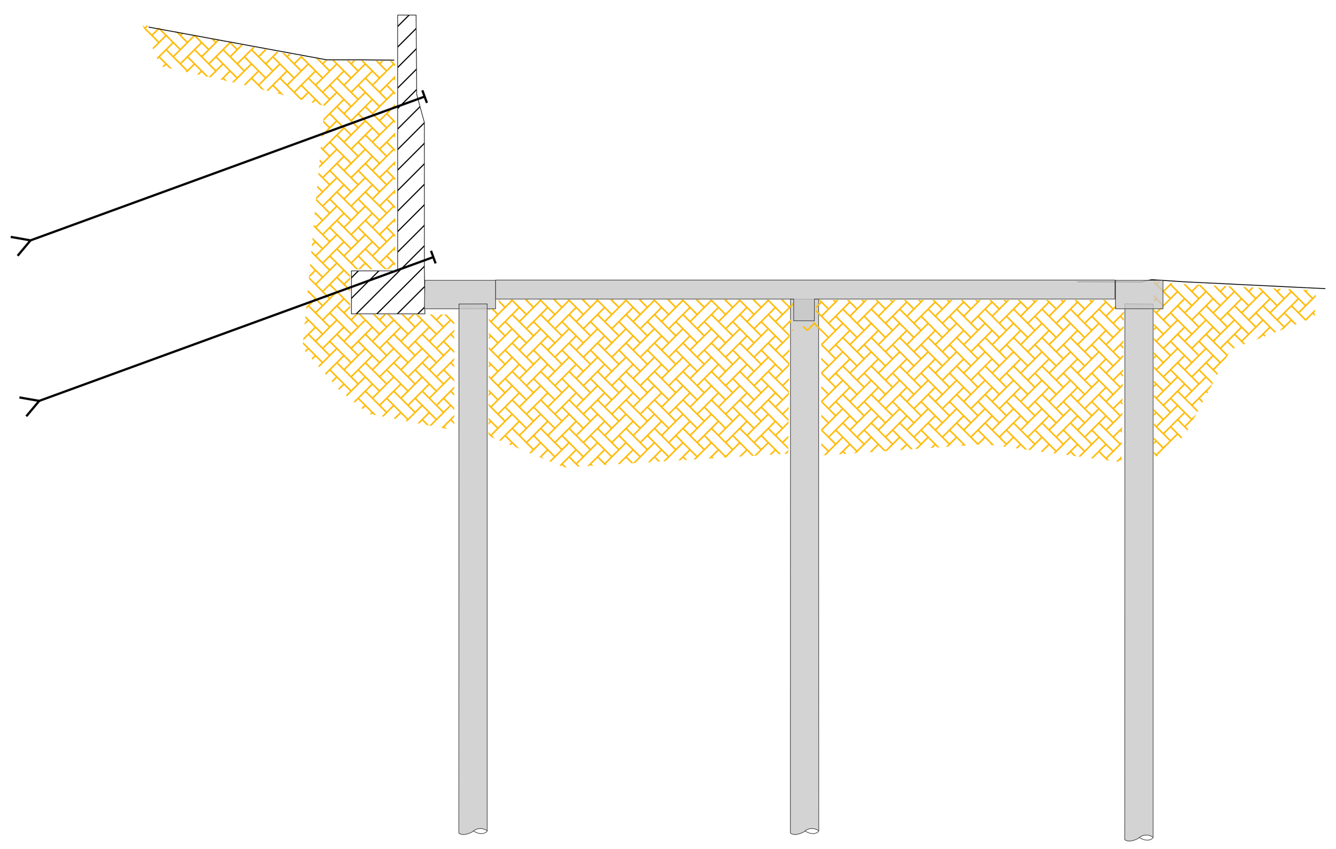
7.
- Cast perimeter capping beam, basement roof slab and downstand beams on ground on temporary internal piles. Ground floor slab for east side of proposed extension can be cast simultaneously.
- Top down basement construction. Once roof slab cast, bulk excavation of basement can begin through large opening at south end of basement slab.
Refer to basement construction sequence sections. Progress basement construction in parallel with work above ground as Contractor sees fit.



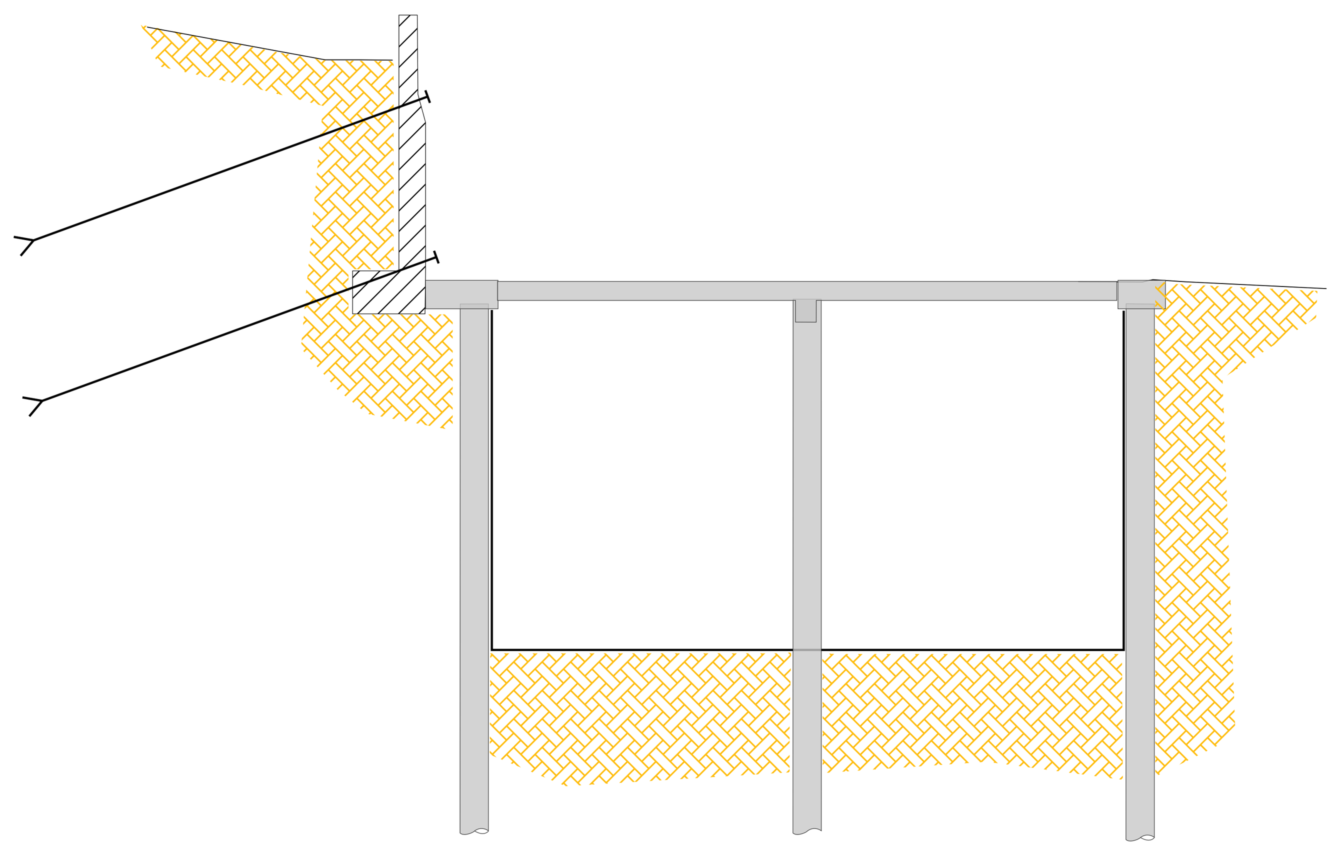
8.
- Construct permanent retaining walls at ground floor on north side of new extension and one south wall against road.
- Remove sheet piling
- Backfill and install earth and landscaping works across site.
- Construction of superstructure above ground.



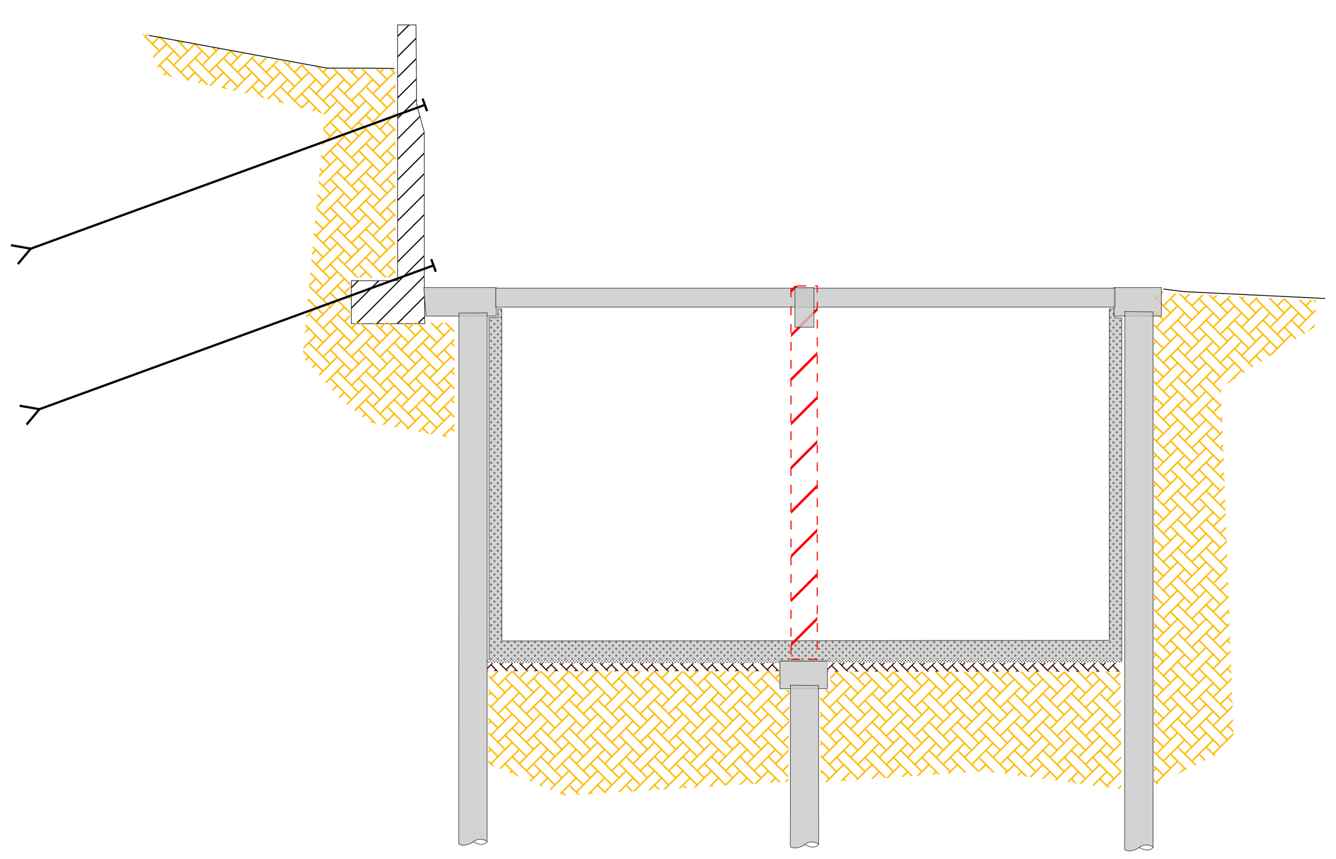
3.
- Lower earth behind wall to final level.
- Re-support existing retaining wall with soil anchors to take full lateral load
- Demolish existing extension. Undertake demolition and anchoring in sections to ensure stability is maintained.
- Cut base of existing retaining wall flush with wall with diamond tipped saw.
- Break out existing ground slab



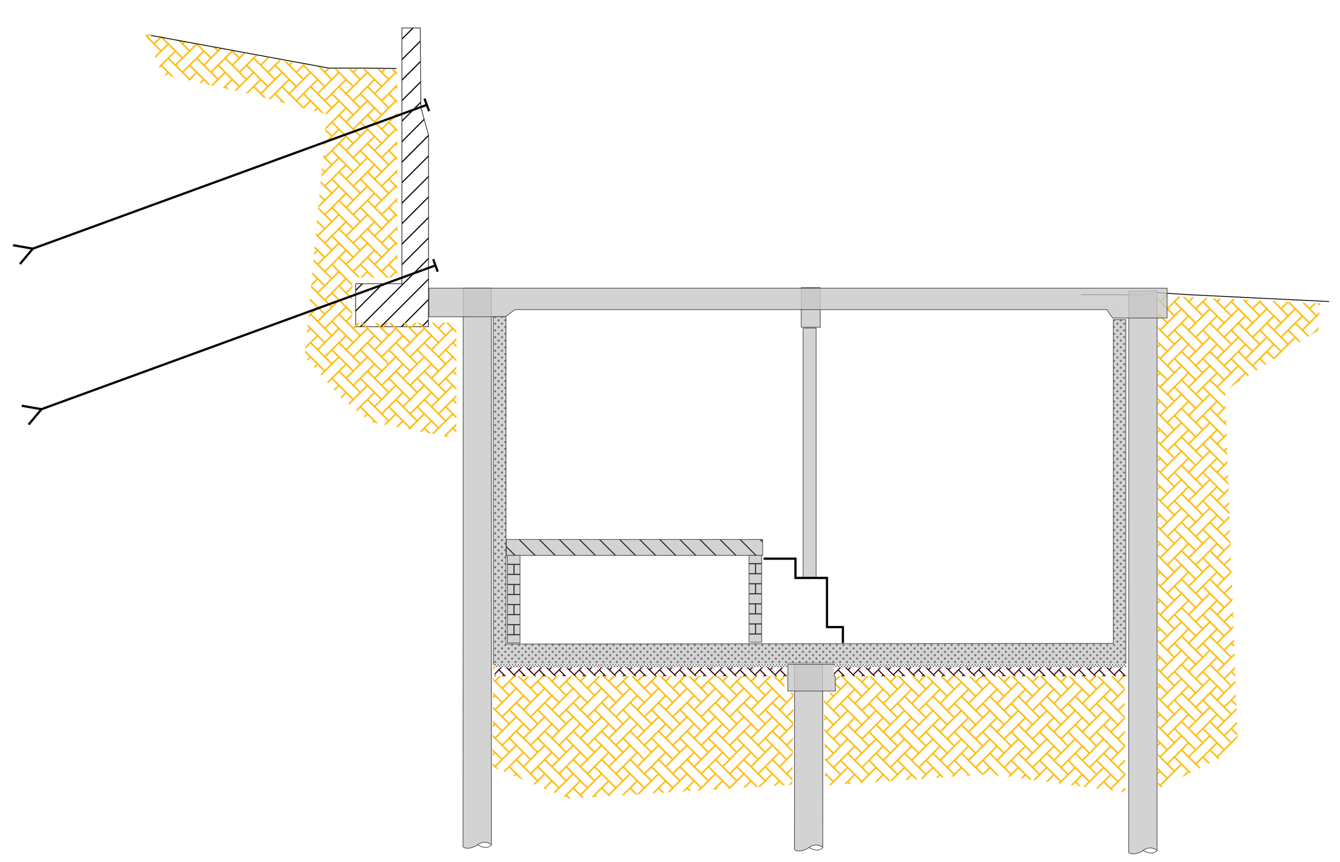
6 / 7A.
- Install piles from ground level.
- Cast perimeter capping beam, basement roof slab and downstand beams on perimeter piles and temporary internal piles.
- Slab to be cast on blinding and sheeting. Pipes to be installed to allow future pouring of basement lining wall.



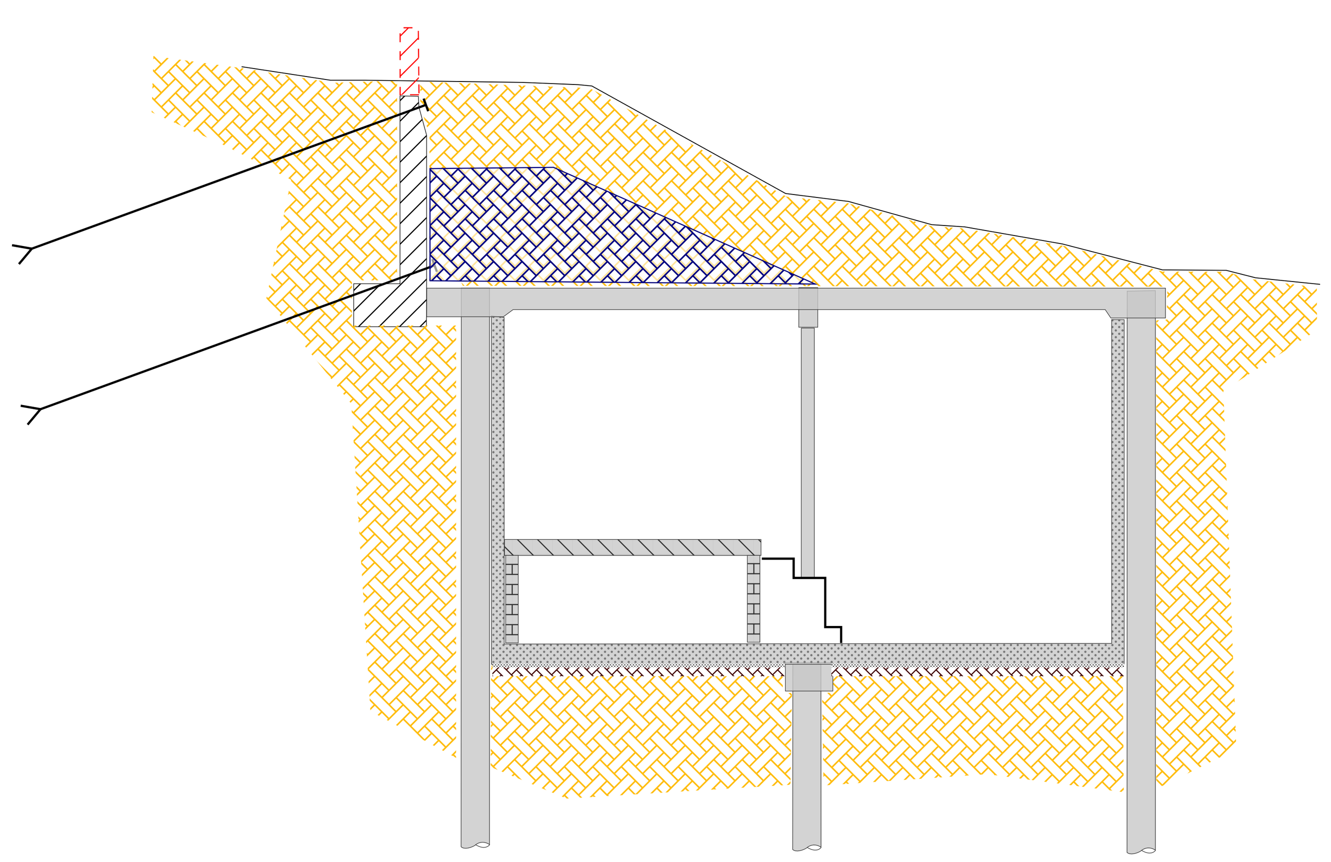
7B.
- Using slab opening at south end for access and spoil removal, excavate to formation level around internal temporary piles.
- Internal piles support basement roof slab in temporary case.



7C.
- Cast basement ground beams at low level, low level sumps, basement slab, and lining walls in waterproof concrete.
- Build permanent internal columns and shear walls.
- Demolish temporary internal piles once roof slab fully supported on permanent vertical structure.

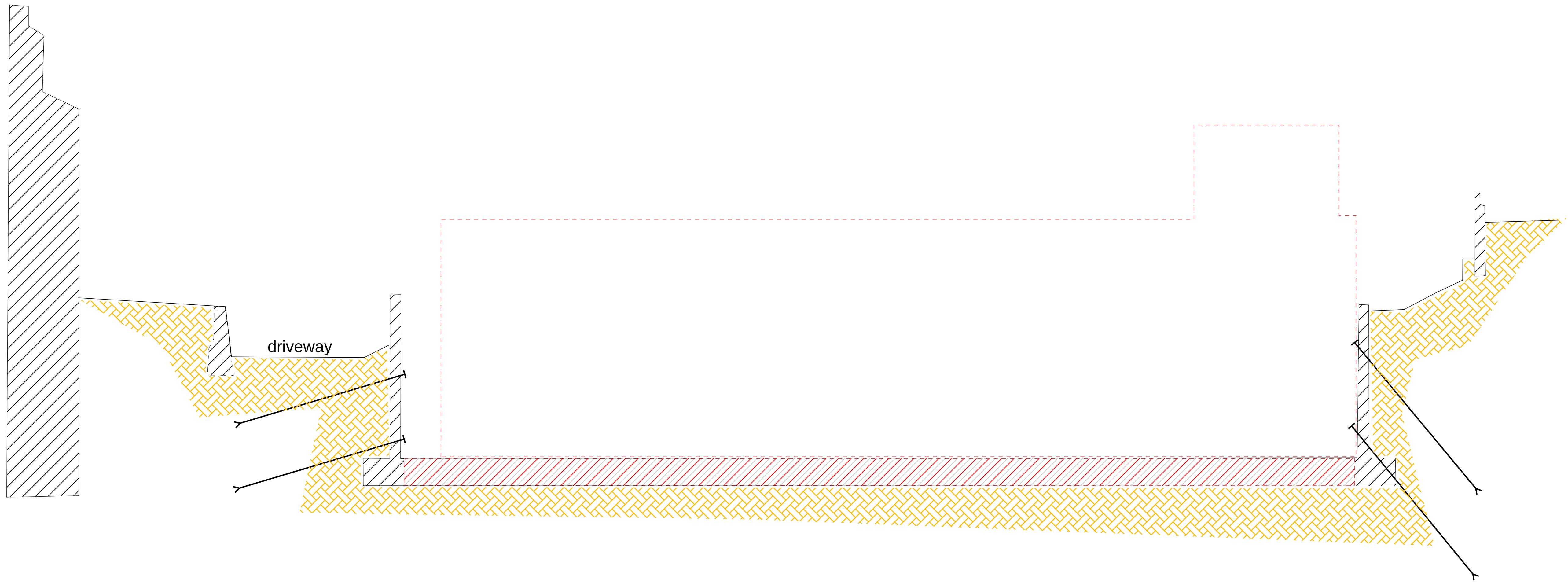


7D.
- Build internal block walls and lift in upper beam and block floor.
- Internal waterproof pool structure to be installed. Design by others.

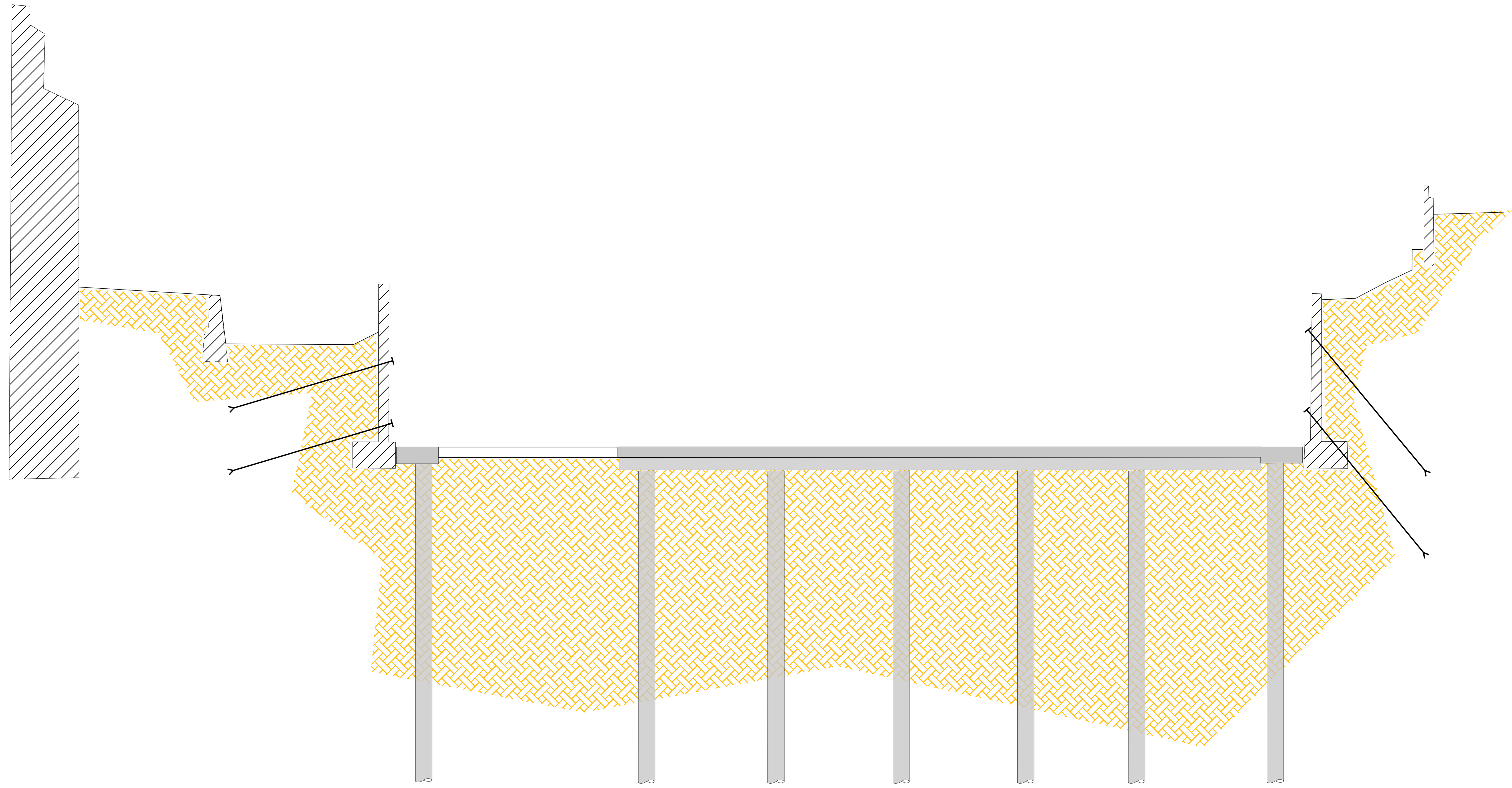


8.
- Backfill over basement roof with light-weight construction and top soil, and landscape as per proposed design. Permanent soil stabilisation works by others.
- Demolish top of existing retaining walls where required.

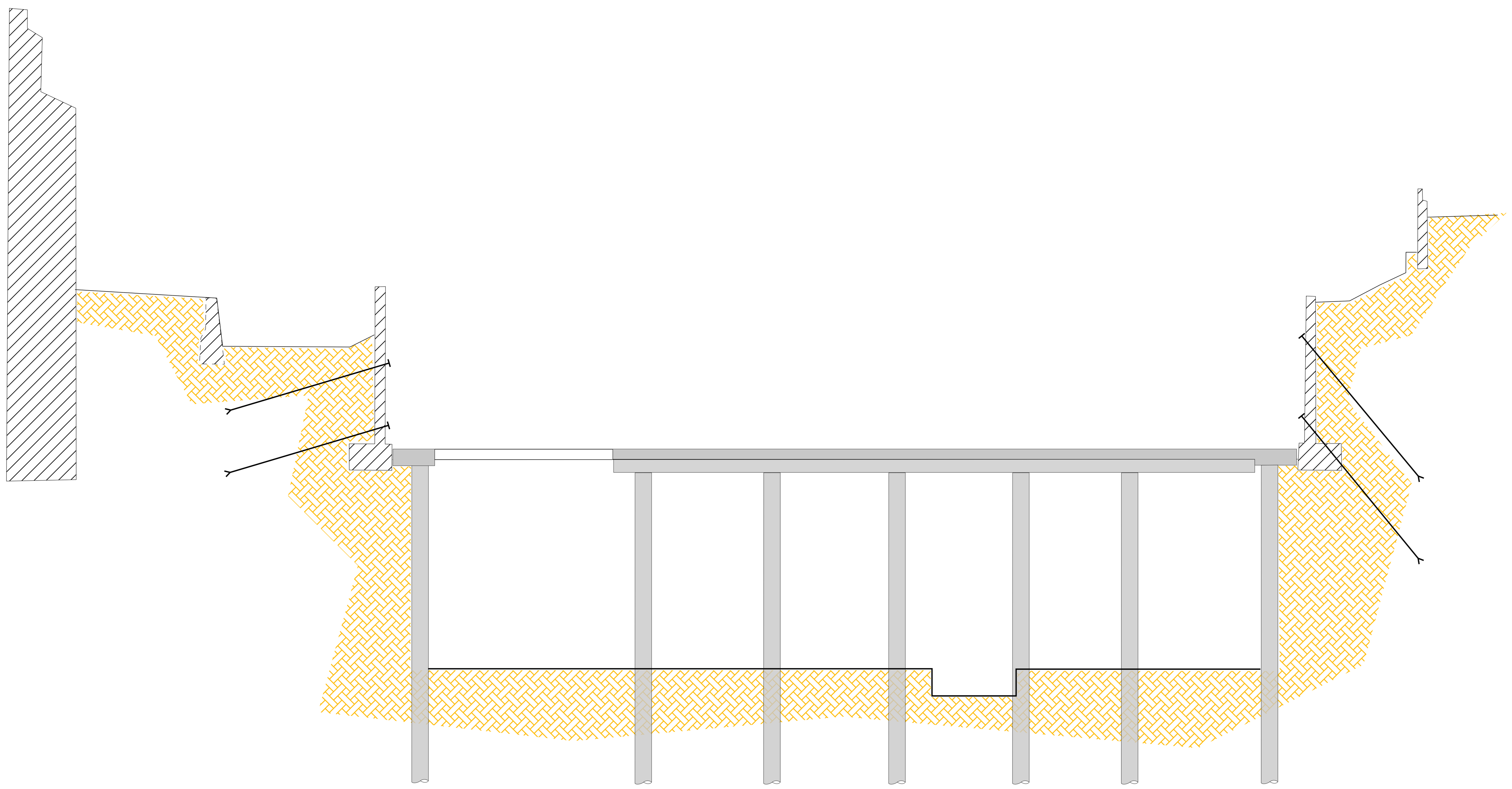
BASEMENT SEQUENCE A



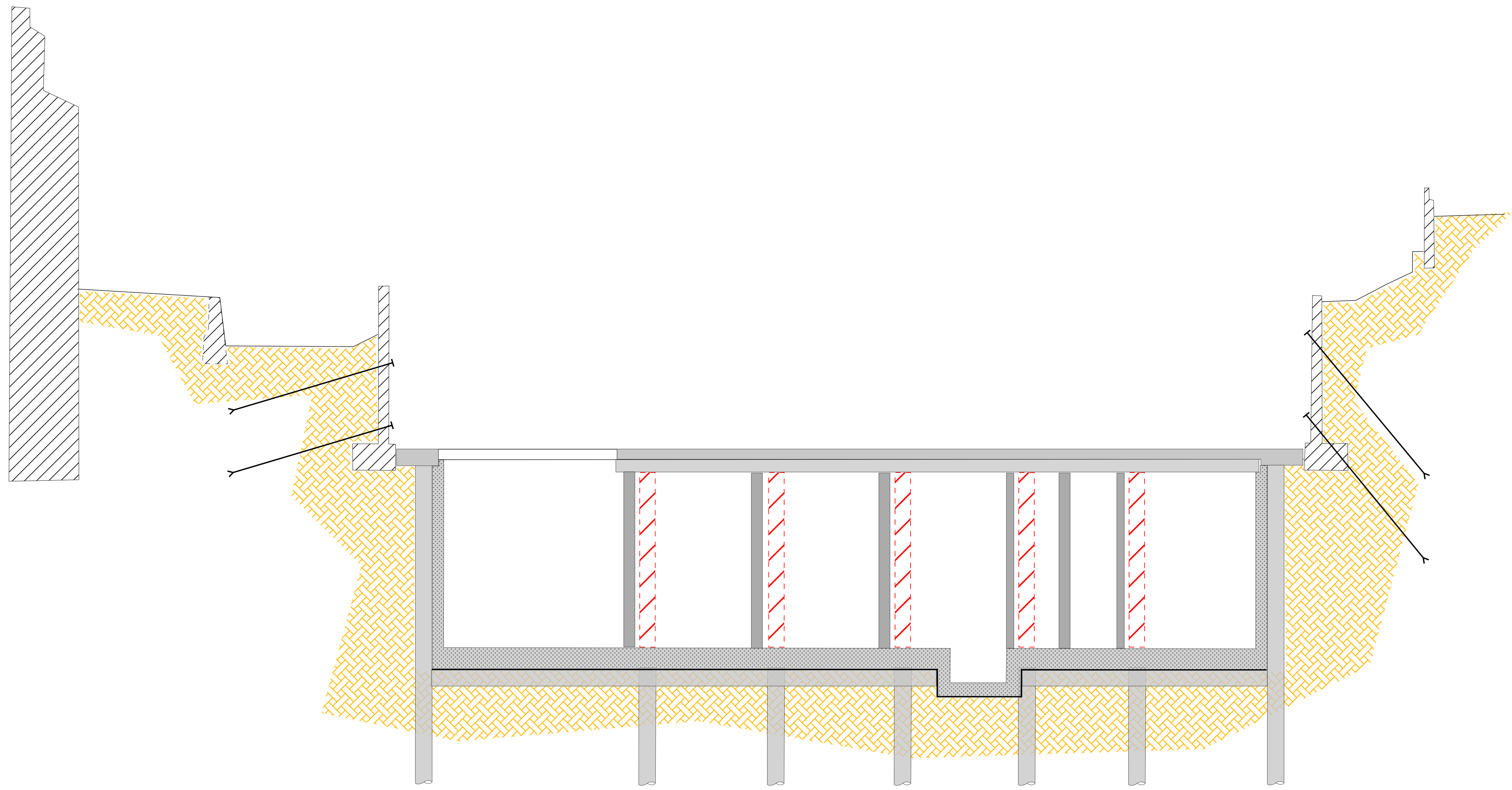
3.
- Re-support existing retaining wall with soil anchors to take full lateral load
- Demolish existing extension. Undertake demolition and anchoring in sections to ensure stability is maintained.
- Cut base of existing retaining wall flush with wall with diamond tipped saw.
- Break out existing ground slab



6 / 7A.
- Install piles from ground level.
- Cast perimeter capping beam, basement roof slab and downstand beams on perimeter piles and temporary internal piles.
- Slab to be cast on blinding and sheeting. Pipes to be installed to allow future pouring of basement lining wall.

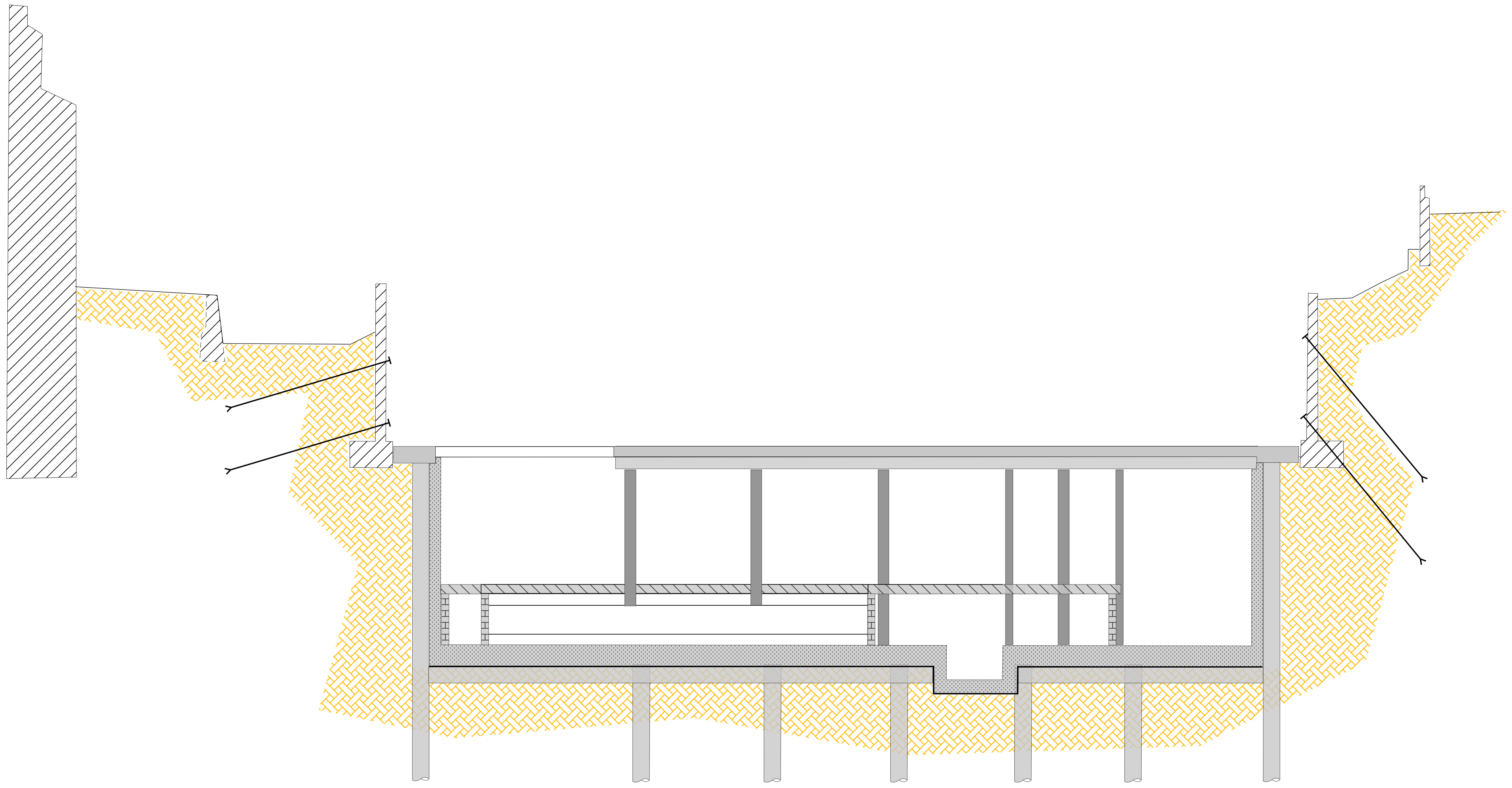


7B.
- Using slab opening at south end for access and spoil removal, excavate to formation level around internal temporary piles.
- Internal piles support basement roof slab in temporary case.

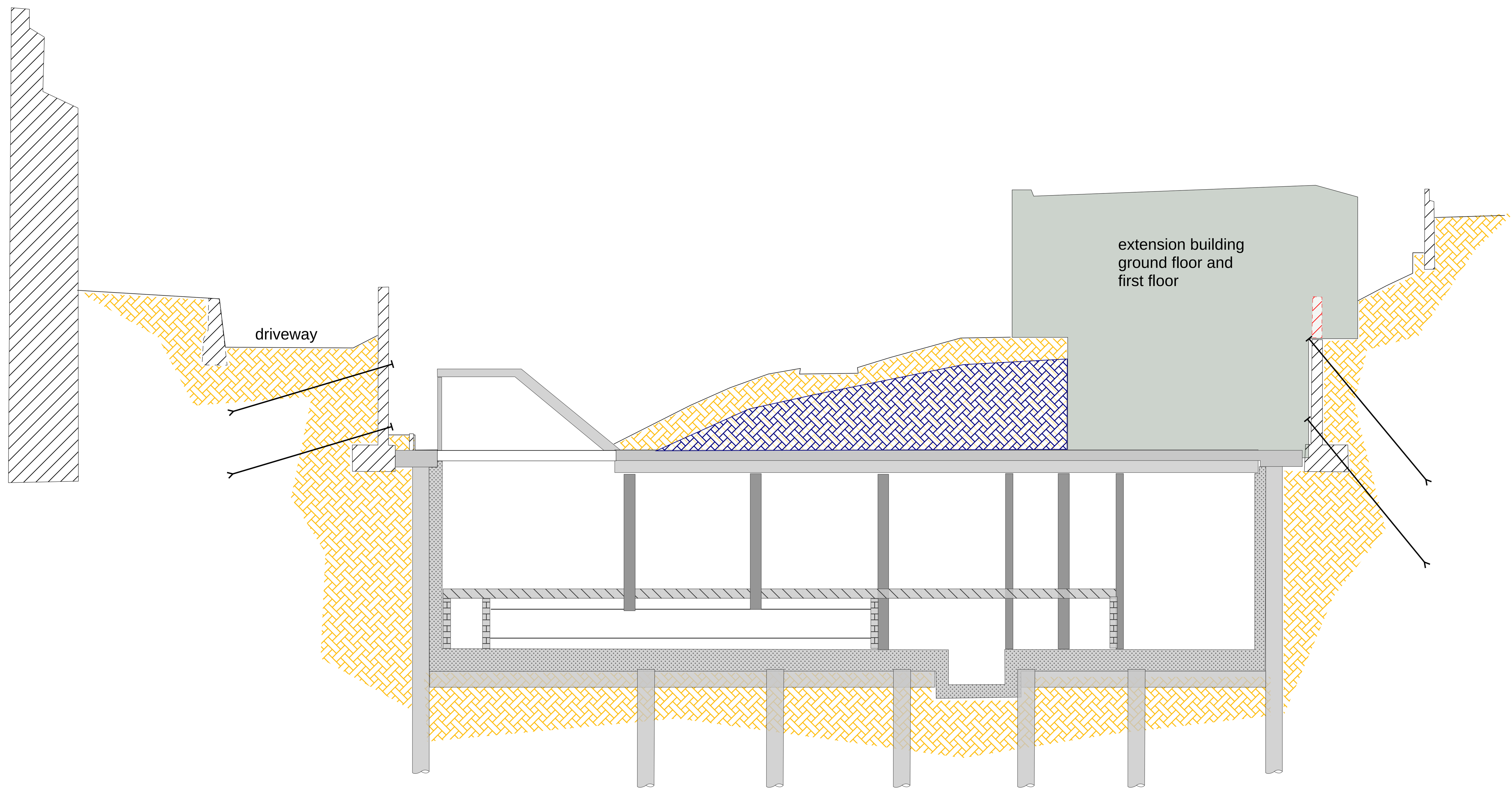


7C.
- Cast basement ground beams at low level, low level sumps, basement slab, and lining walls in waterproof concrete.
- Build permanent internal columns and shear walls.
- Demolish temporary internal piles once roof slab fully supported on permanent vertical structure.

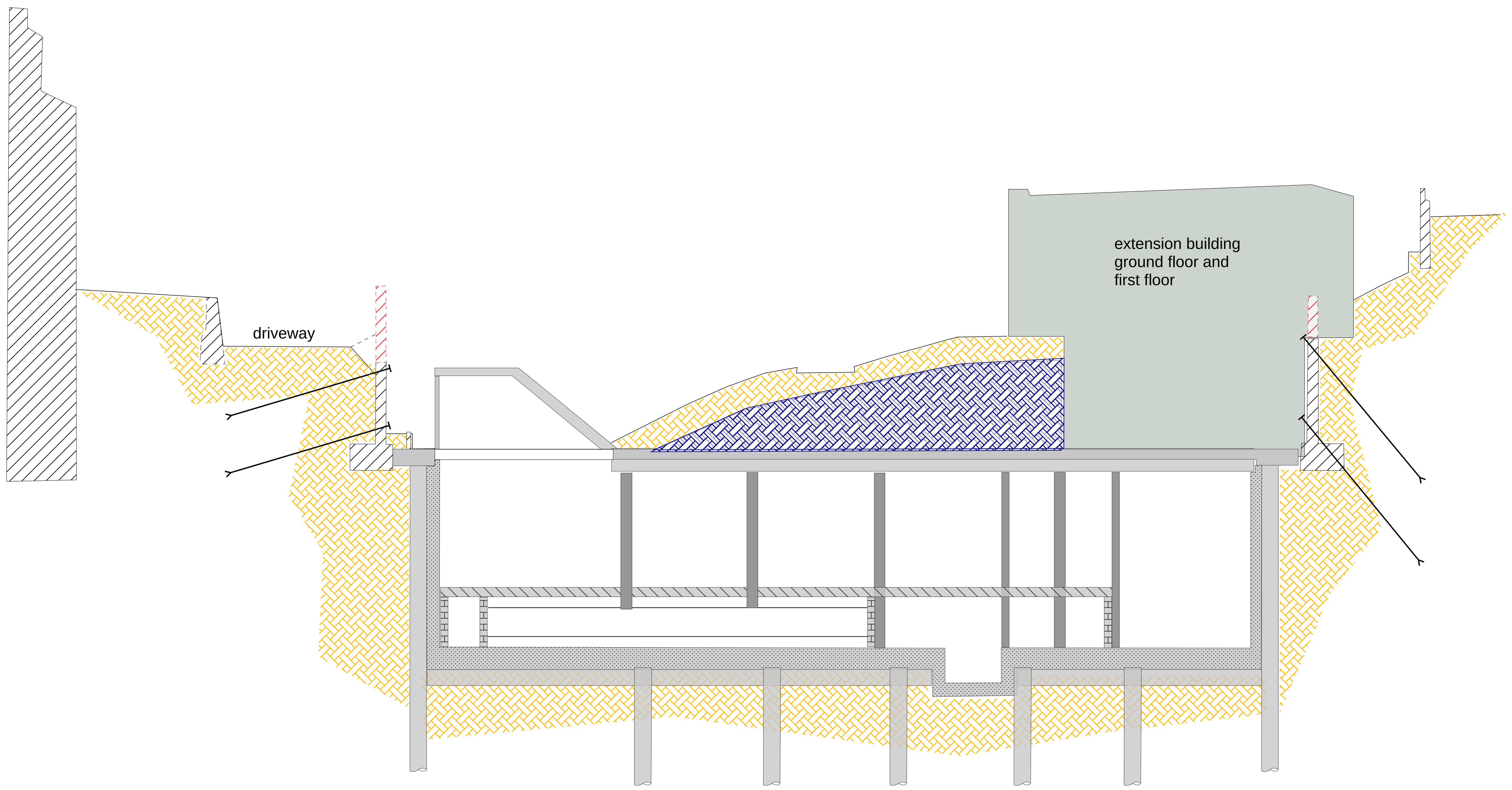
BASEMENT SEQUENCE B



7D.
- Build internal block walls and lift in upper beam and block floor.
- Internal waterproof pool structure to be installed. Design by others.

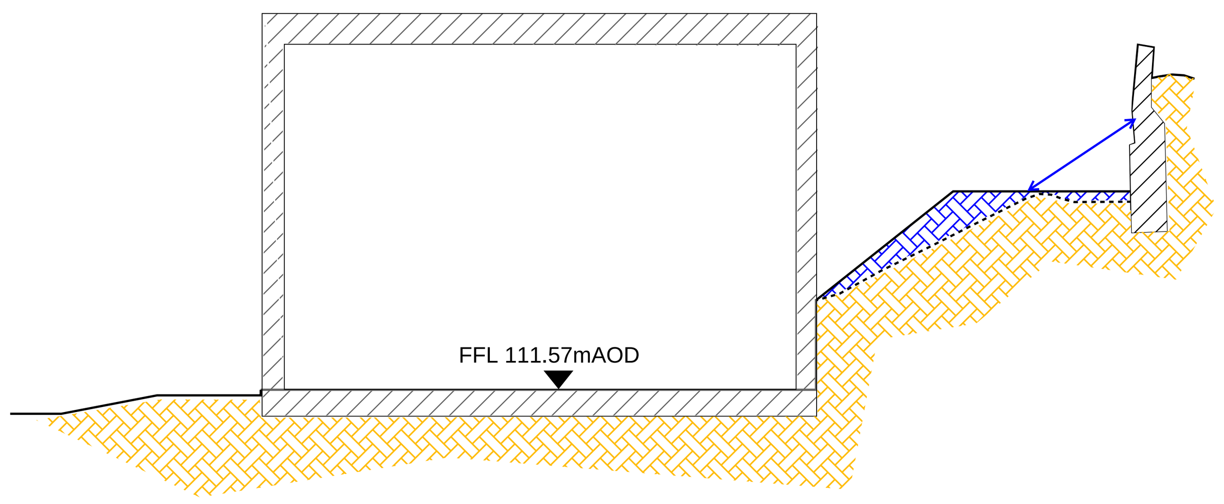


8A.
- Construct permanent retaining walls at ground floor level.
- Backfill over basement roof with light-weight construction and top soil, and landscape as per proposed design. Permanent soil stabilisation works by others.
- Construct superstructure above ground.
- Construct low-level retaining wall in front of existing RC retaining wall along driveway as part of landscaping works.

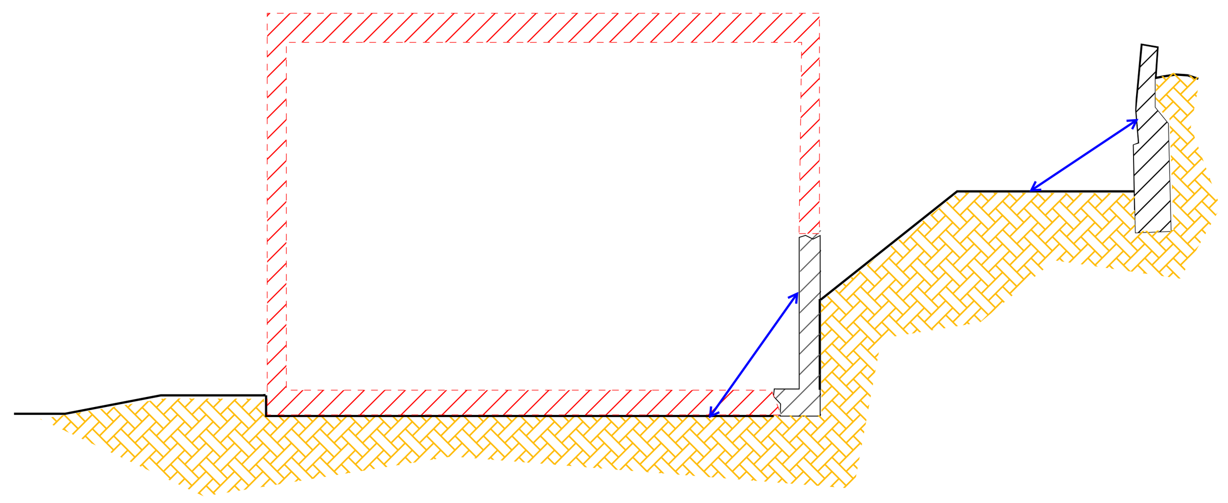


8B.
- Re-profile ground as per proposed landscaping. Assumed that slope stabilisation is required adjacent to driveway, to be designed by others.
- Demolish top of existing RC retaining wall where it protrudes above final ground level.

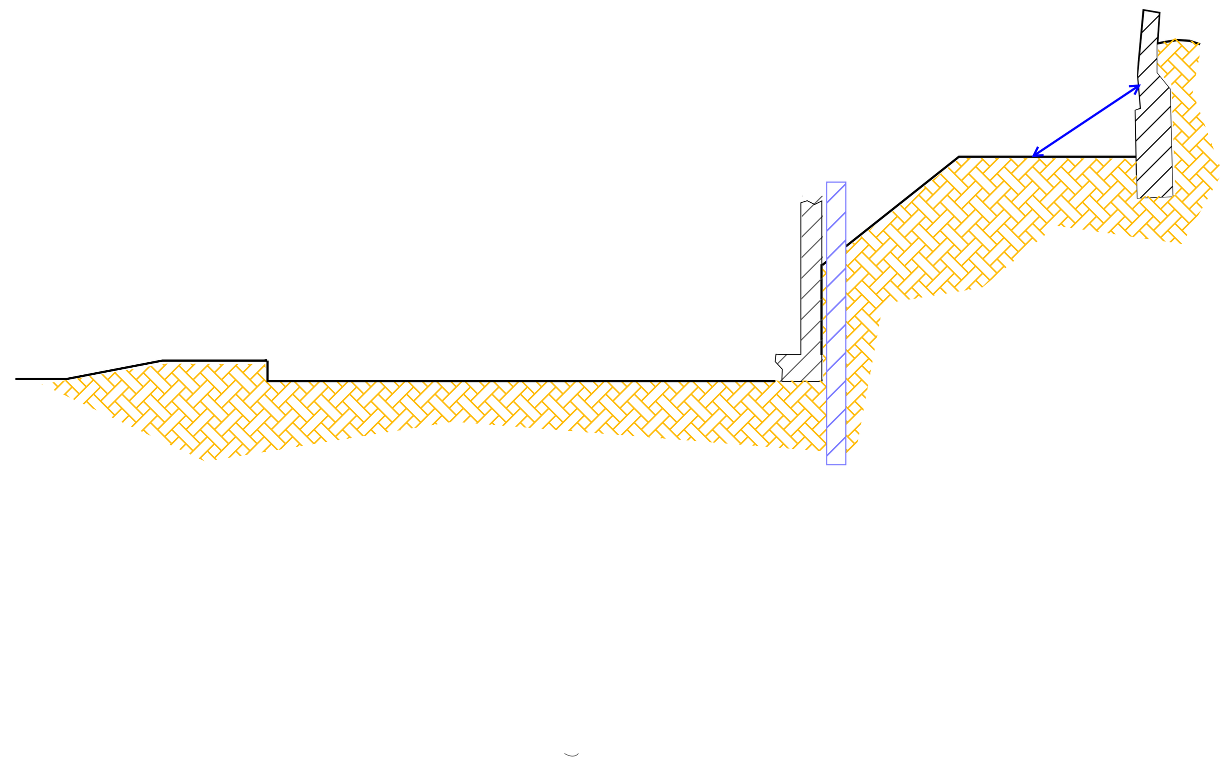
BASEMENT SEQUENCE B



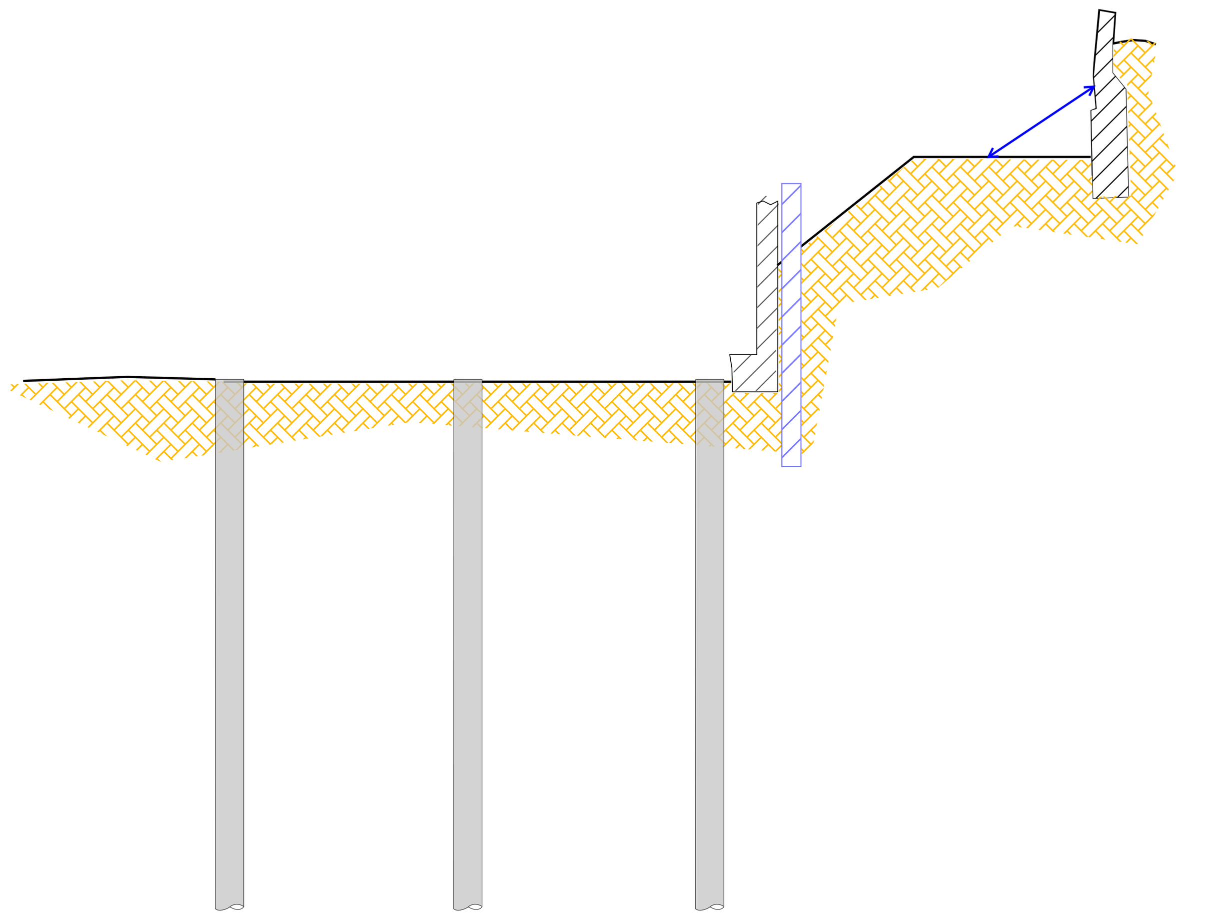
2.
- Create working route along northern boundary to provide sufficient working space for small plant.
- Install soil anchoring or internal propping to north boundary wall.



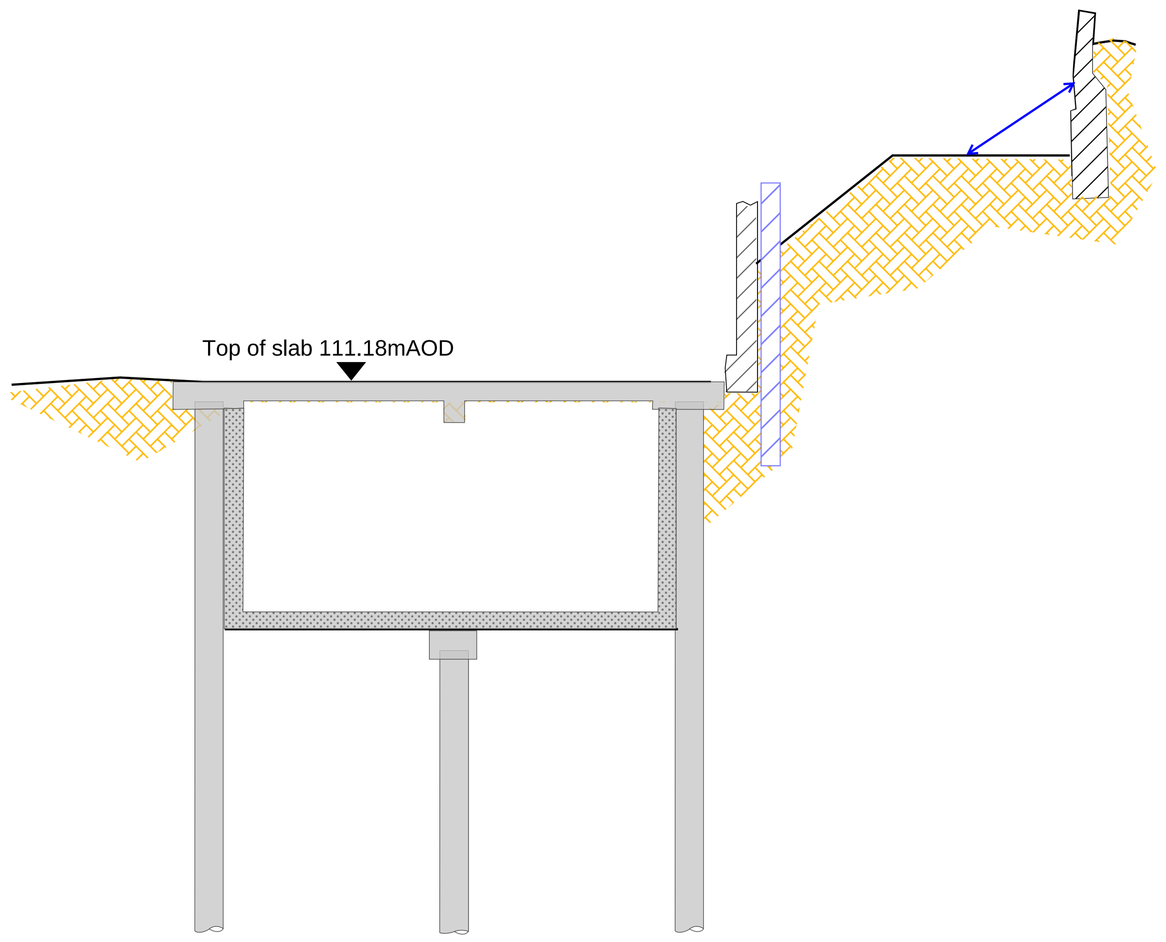
3.
- Demolish existing extension building.
- Add temporary propping to existing north retaining wall of extension, where sheet piling will be installed at a later stage.



4.
- Install sheet piling behind existing retaining wall.

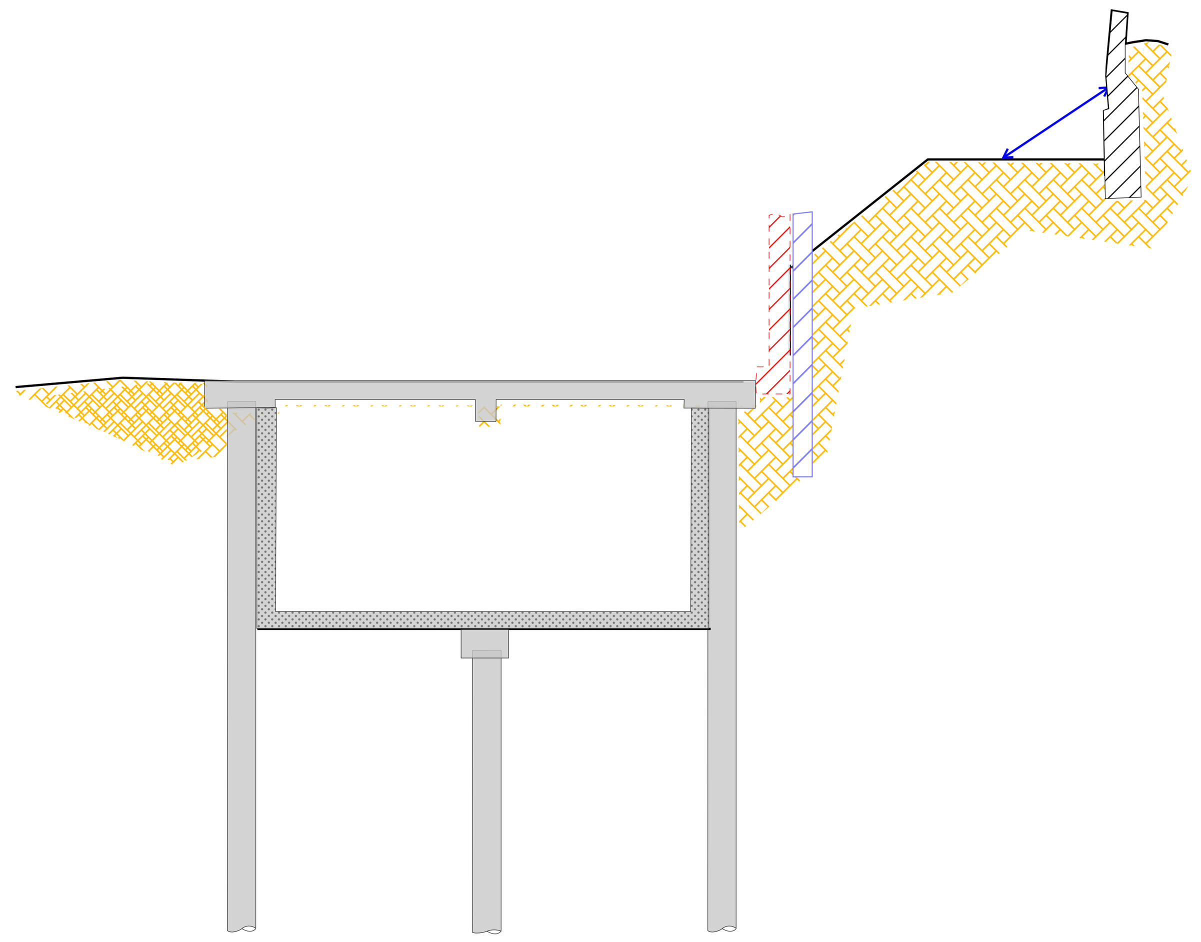


6.
- Install secant piled perimeter wall to basement and other piled foundations for basement from existing extension ground floor level.

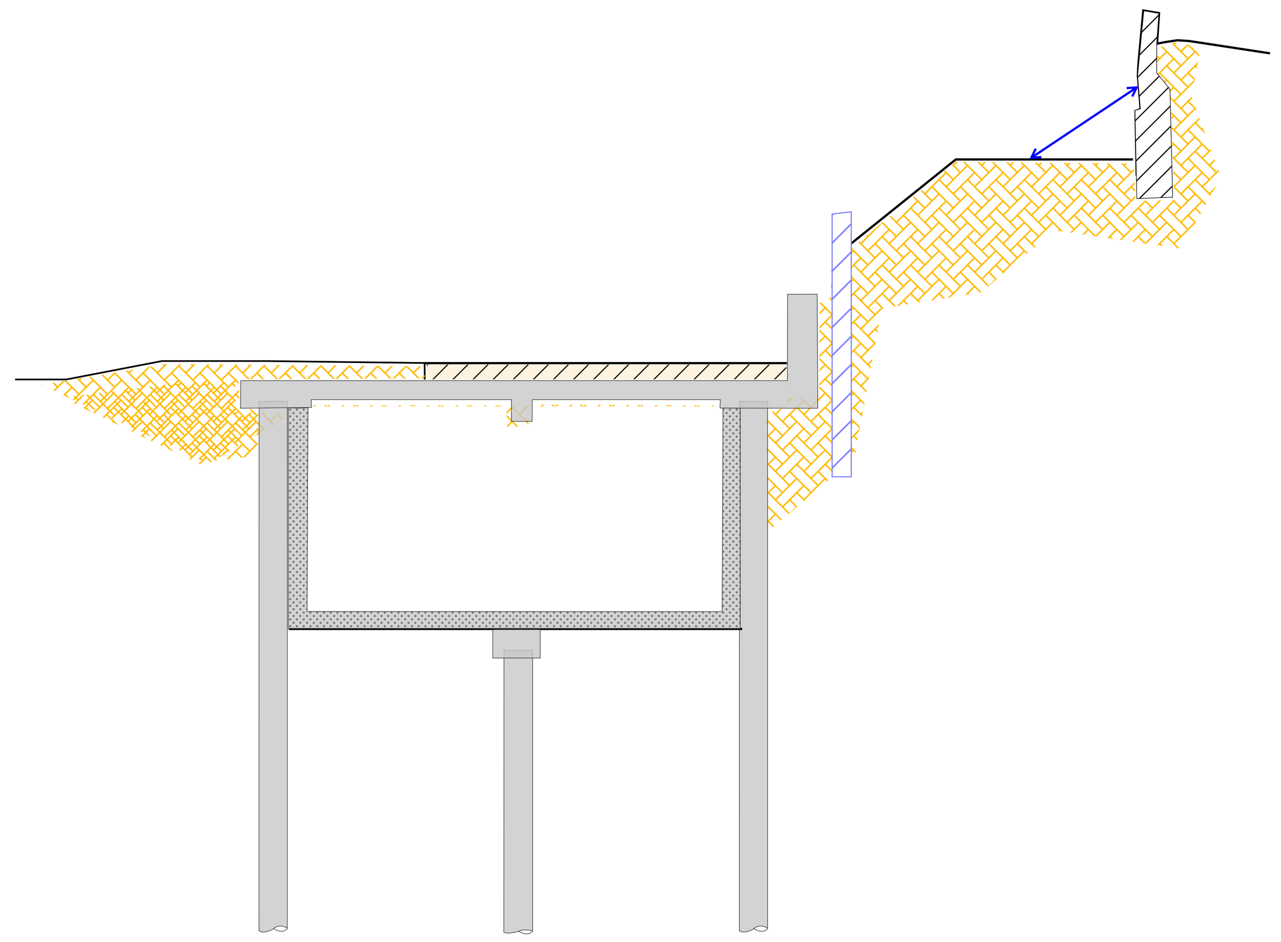


7A.
- Cast perimeter capping beam, basement roof slab and downstand beams on perimeter piles and temporary internal piles.
- Work around temporary propping, re-supporting lateral propping to retaining wall on ground floor slab.
- Top down construction of basement, excavating from south end around temporary piles.

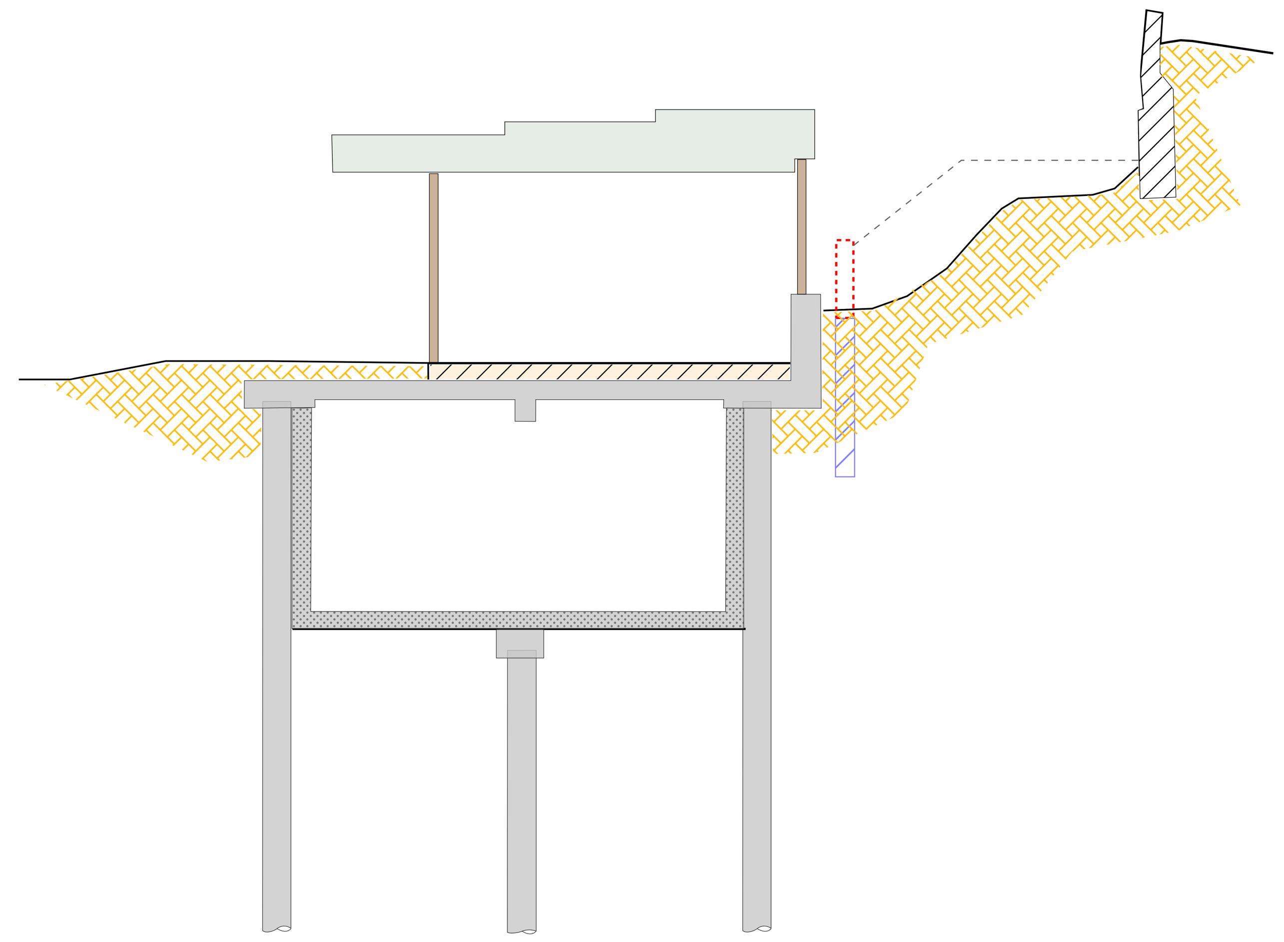
Refer to basement construction sequence A.



7B.
- Demolish existing concrete retaining wall working around temporary propping to sheet piled wall.

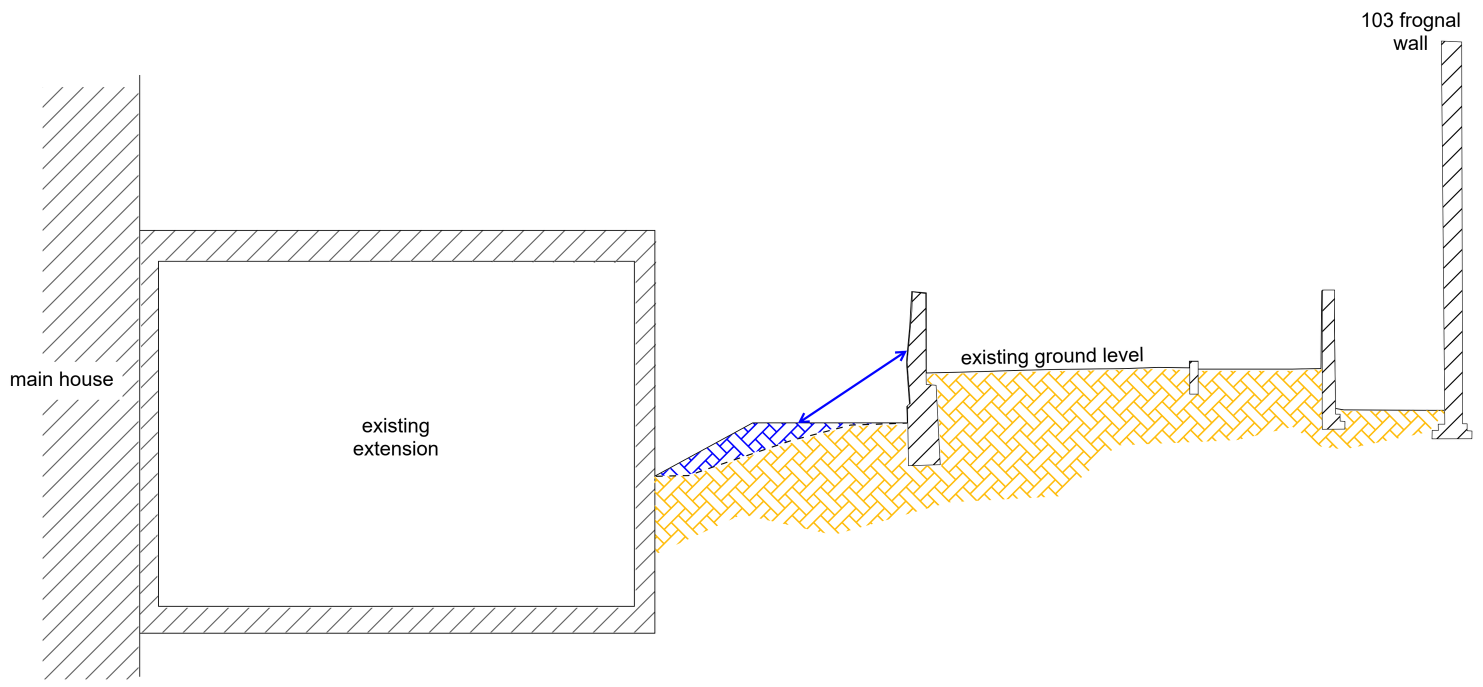


8A.
- Construct permanent retaining walls and drainage at ground floor level.

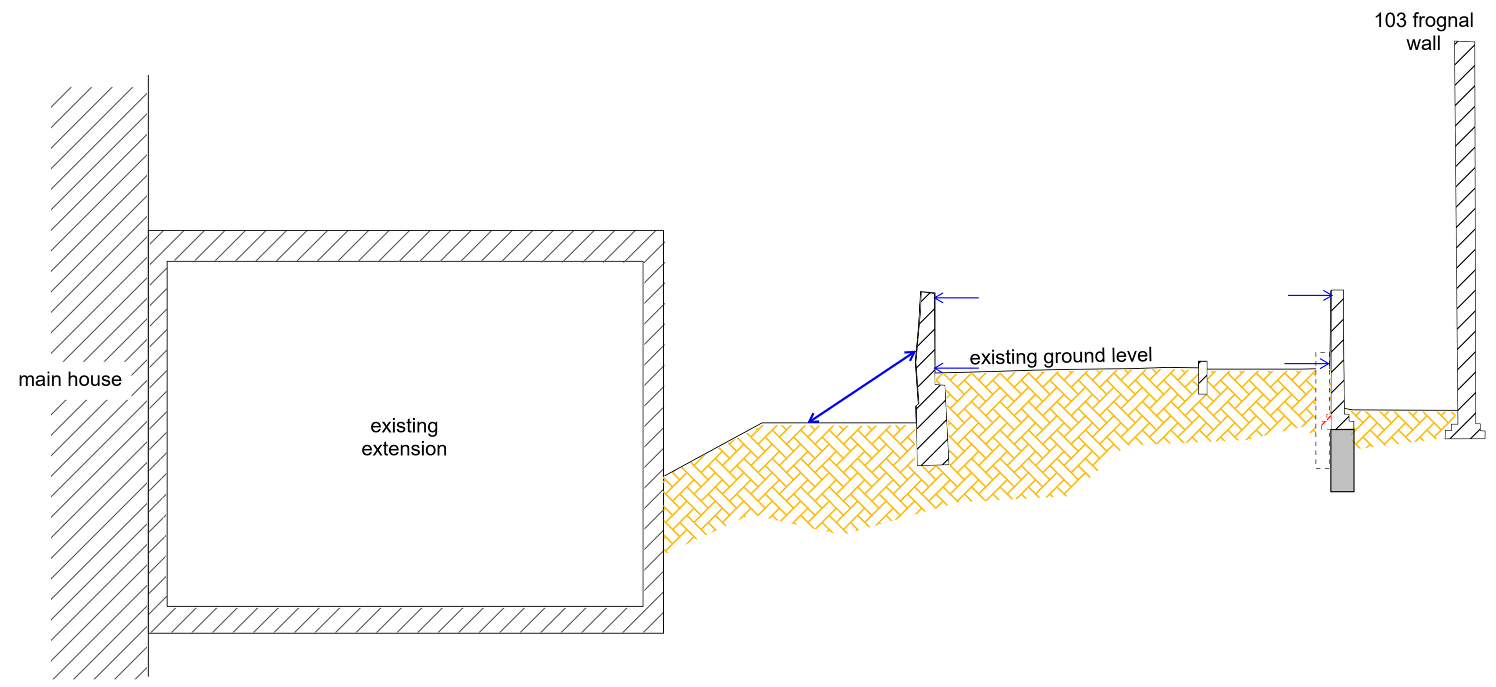


8B.
- Construction of superstructure above ground.
- Backfill and install earth and permanent soil stabilisation and landscaping works.
- Remove or cut down top of sheet piling.

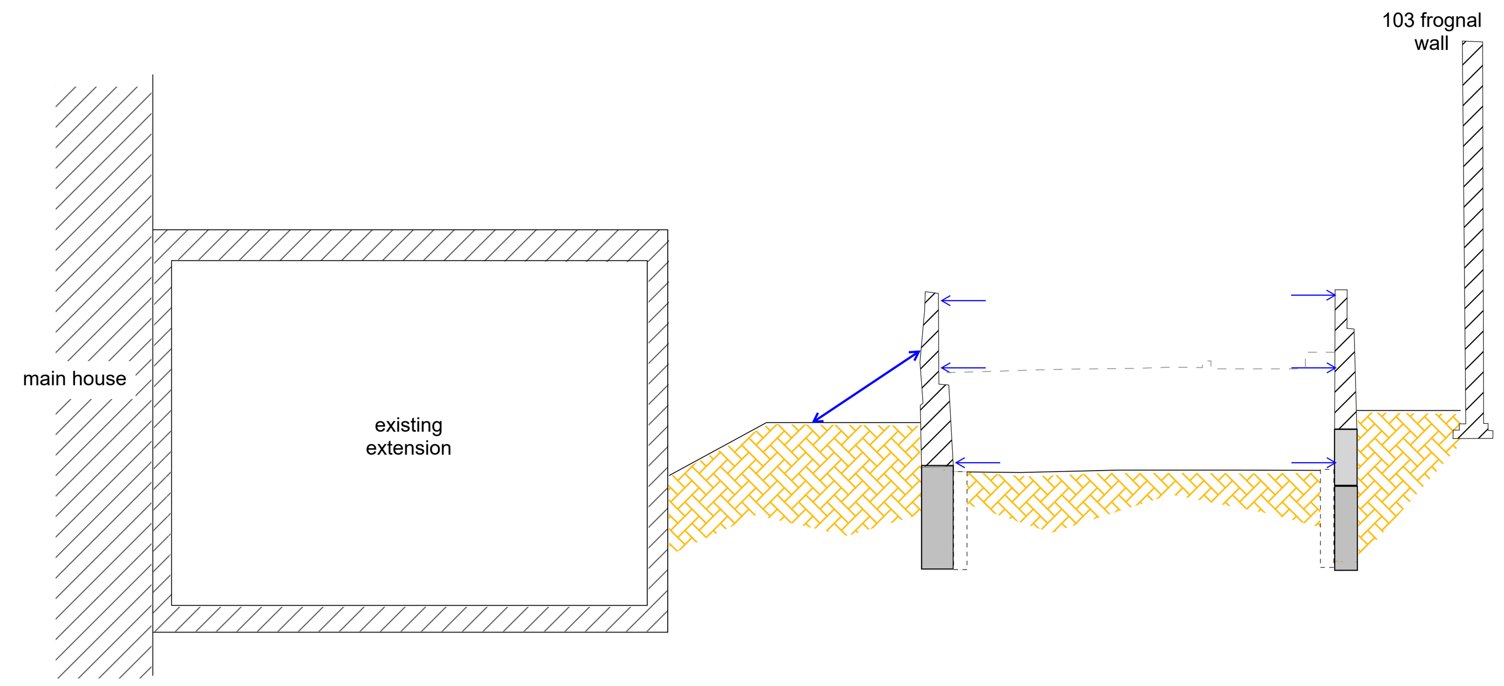
BASEMENT SEQUENCE C



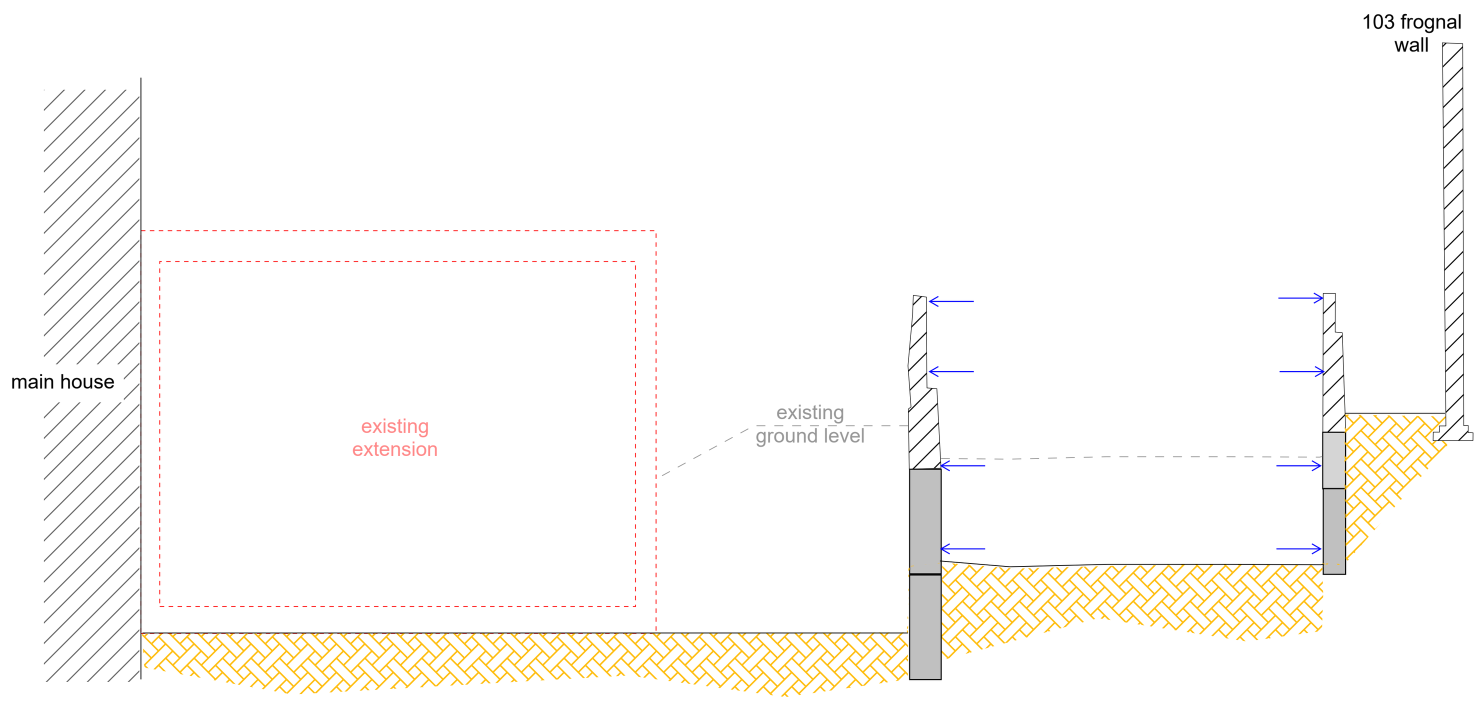
2.
- Install temporary propping to existing garden wall.
- Undertake levelling works as required to provide suitable base for propping.



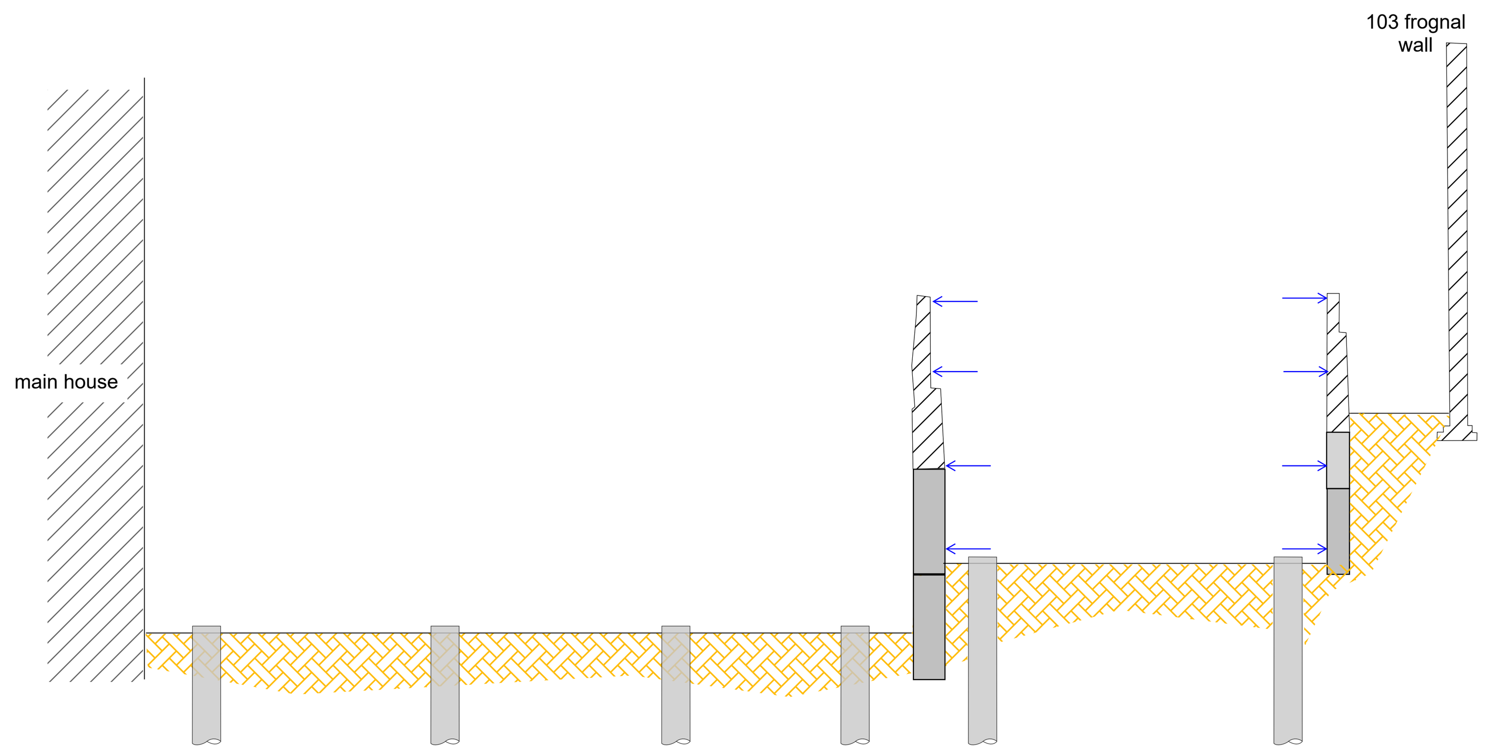
4A.
- Install first lift of underpinning in sequence to west, north and east existing walls to approximately half-way down to proposed new formation level.
- Install temporary lateral propping at high level.



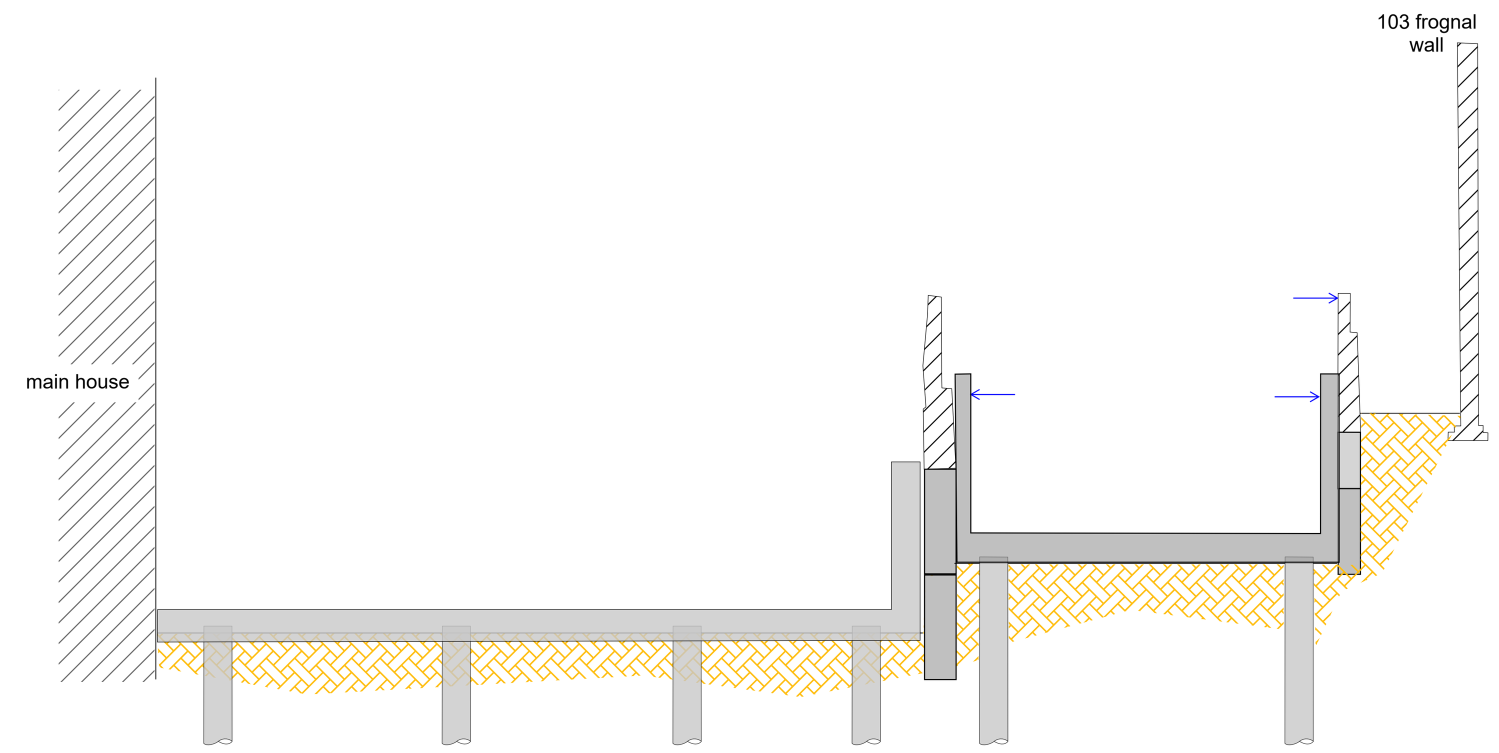
4B.
- Excavate ground down to approximately mid-height excavation level.
- Install additional temporary lateral propping as required just above excavation level to stabilise walls and first lift of underpinning.
- Install second lift of underpinning in sequence to all perimeter walls to below formation level. (on southern garage wall depth of underpinning will need to be to formation level of proposed extension to main house)



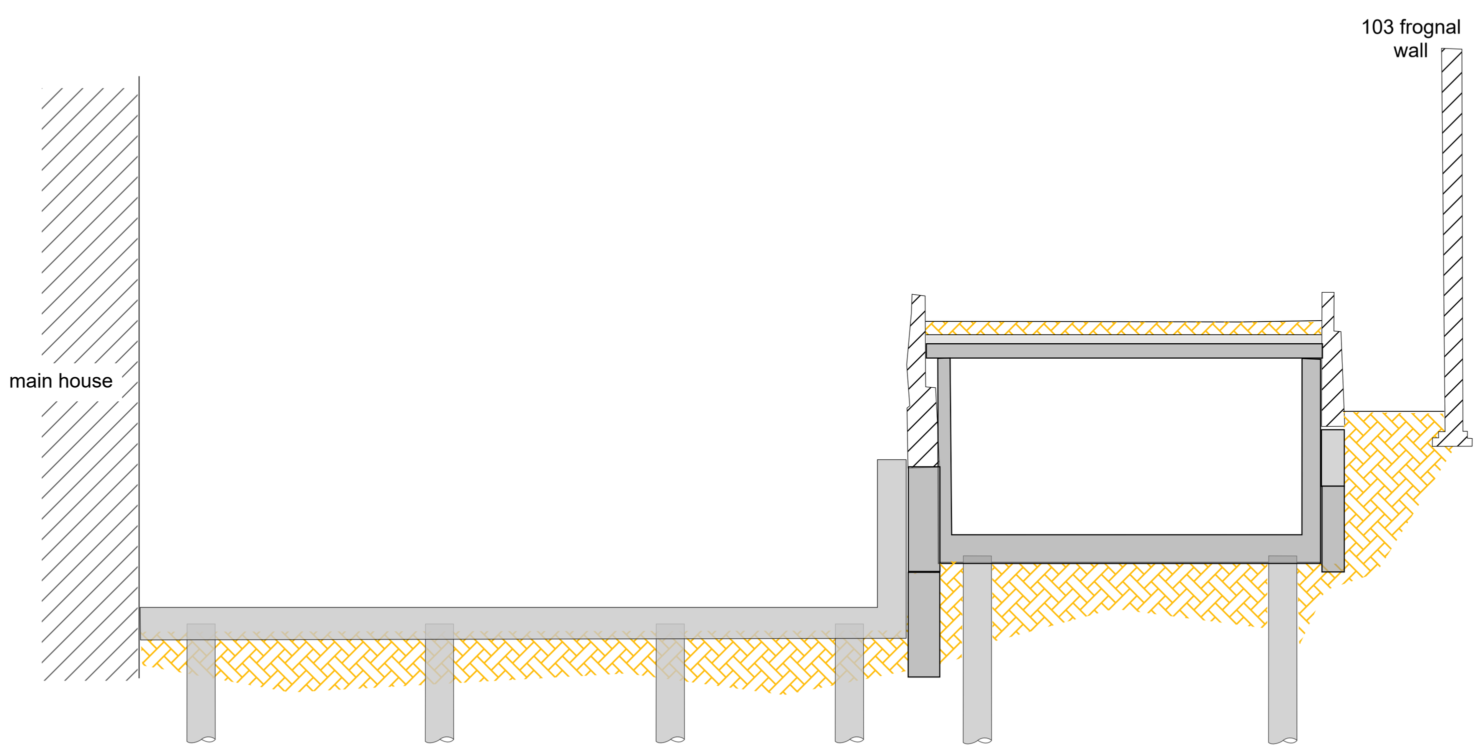
5A.
- Demolish existing extension building and excavate ground level in between down to proposed formation level.



6.
- Excavate down to garage house formation level
- Install piles for garage houses and extension building working around temporary propping.



7.
- Cast ground slab and load-bearing walls, working around temporary propping.
- Relocate propping onto new RC walls as they gain strength gain strength.
- New RC walls provide permanent stabilisation to existing brick walls.



8.
- Install roof slab to garage houses. Roof slab provides permanent prop to top of new RC walls.
- Remove temporary props.
- Construct superstructure of extension building

GARAGE HOUSES SEQUENCE D

APPENDIX C

PRELIMINARY STRUCTURAL CALCULATIONS FOR BASEMENT

STRUCTURE
WORKSHOP

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99 FROGNAL

PRELIMINARY STRUCTURAL CALCULATIONS FOR BASEMENT

PROJECT NO	23020
PREPARED BY	ALIYA HOSSAIN MENG
REVIEWED BY	DANIEL DOWEK MA MENG CENG MISTRUCTE

REVISION	DATE	COMMENTS
P1	02/11/2023	Issued for information

STRUCTURE
WORKSHOP

CONTENTS

SUMMARY

This calculation package covers the preliminary sizing of key basement structural elements that form part of the new development at 99 Frognal. Detailed calculations shall be carried out to complete the design and for Building Control approval. The project includes full demolition of the existing extension building and construction of a new extension with a basement. The proposals also include the construction of two additional housing units located just north of the main house in the location of the existing garage building. The site is located in Hampstead in the London Borough of Camden.

Structure Workshop have developed a preliminary assumed sequence of works for the basement construction.

A site specific ground investigation and ground movement analysis have been undertaken by A2 Site Investigation. Allowable design values for the geological strata on site provided by A2 have been used for the design of retaining walls and foundations. For details of the site investigation findings and the results of the ground movement analysis, please refer to the Basement Impact Assessment and associated Appendices.

The foundations for the basement in the proposed extension comprise secant piled walls around the perimeter, with a reinforced concrete piled ground beam and slab at the base. The basement excavation is approximately 6.5m below existing ground level, and the groundwater level in this location is high. therefore the piles are designed to withstand hydrostatic pressures as well as lateral forces from the retained earth and surcharge above ground. This pack contains the preliminary analysis and design undertaken for the extension basement foundations, slabs and beams.

The Garage Houses are to be constructed immediately adjacent to existing party walls, and is in close proximity to the large 3-storey grade II listed neighbouring building. The existing brick walls will be underpinned and temporarily supported during excavation works, and the new structure will be designed to provide permanent support for lateral loads from retainined earth. Refer to the Basement Construction Structural Report for further details.

These calculations should be read in conjunction with the following structural engineering drawings:

23020.2201	Extension Lower Basement Plan
23020.2202	Extension Upper Basement Plan
23020.2203	Extension Ground Floor Plan 1
23020.2301	Extension Section A
23020.2302	Extension Section B
23020.2303	Extension Section C
23020.2304	Extension Section D
23020.2401	Extension Details Sheet 1
23020.2402	Extension Details Sheet 2
23020.3201	Garage Houses Ground Floor Plan
23020.3202	Garage Houses First Floor Plan
23020.3301	Garage Houses Section A
23020.3401	Garage Houses Details Sheet 1

DESIGN ROOF LOADS

ROOF 1 — *Extension - Buried Basement*

									Dead Gk	Live Qk	Total Σ	Units
Soil	1.500 m	*Average depth for design of foundation loads*						18.0 kN/m^3	27.00			
		2.00 m depth assumed for design of slab S.21.01										
RC Slab	0.300 m							24.0 kN/m^3	7.20			
RC Roof beams	0.05							24.0 kN/m^3	1.20			
Rigid Insulation	0.300 m							1.0 kN/m^3	0.30			
Vapour Control									0.01			
Plasterboard + skim	0.015 mm							9.0 kN/m^3	0.14			
Live										5.00		
								TOTAL	35.85	5.00		kN/m^2

ROOF 2 — *Extension - Green roof*

									Gk	Qk	Σ	
Soil	0.600 m							18.0 kN/m^3	10.80			
OSB3 sheathing	0.018 m							7.0 kN/m^3	0.13			
Rigid Insulation	0.300 m							1.0 kN/m^3	0.30			
Vapour Control									0.01			
OSB3 sheathing	0.018 m							7.0 kN/m^3	0.13			
Glulam Timber Rafters	0.420 m	x	0.115	m	at	0.60	m crs.	6.5 kN/m^3	0.52			
Live	Snow									3.00		
								TOTAL	11.89	3.00		kN/m^2

ROOF 3 — *Extension - Stone feature roof*

									Gk	Qk	Σ	
Finishes	0.050							25.0 kN/m^3	1.25			
OSB3 sheathing	0.018 m							7.0 kN/m^3	0.13			
Rigid Insulation	0.300 m							1.0 kN/m^3	0.30			
Vapour Control									0.01			
OSB3 sheathing	0.018 m							7.0 kN/m^3	0.13			
Timber Rafters	0.225 m	x	0.09	m	at	0.60	m crs.	5.0 kN/m^3	0.17			
Timber Battens	0.025 m	x	0.04	m	at	0.40	m crs.	5.0 kN/m^3	0.01			
Plasterboard + skim	0.015 mm							9.0 kN/m^3	0.14			
Live	Snow									3.00		
								TOTAL	2.13	3.00		kN/m^2

ROOF 4 — *Garage Houses - Flat slab*

									Gk	Qk	Σ	
Soil	0.500 m							18.0 kN/m^3	9.00			
RC Slab	0.225 m							24.0 kN/m^3	5.40			
Rigid Insulation	0.300 m							1.0 kN/m^3	0.30			
Vapour Control									0.01			
Plasterboard + skim	0.015 mm							9.0 kN/m^3	0.14			
Live										3.00		
								TOTAL	14.85	3.00		kN/m^2

ROOF 5 — *Garage Houses - Timber frame 'pop-outs'*

									Gk	Qk	Σ	
Finishes	0.050							25.0 kN/m^3	1.25			
OSB3 sheathing	0.018 m							7.0 kN/m^3	0.13			
Rigid Insulation	0.300 m							1.0 kN/m^3	0.30			
Vapour Control									0.01			
OSB3 sheathing	0.018 m							7.0 kN/m^3	0.13			
Timber Rafters	0.175 m	x	0.075	m	at	0.40	m crs.	5.0 kN/m^3	0.16			
Plasterboard + skim	0.015 mm							9.0 kN/m^3	0.14			
Live										1.50		
								TOTAL	2.11	1.50		kN/m^2

DESIGN FLOOR LOADS

			Dead	Live	Total	Units
FLOOR 1	*Extension - Basement ground slab*		Gk	Qk	Σ	
Finishes	0.030 m	20.0 kN/m³	0.60			
Screed	0.080 m	22.0 kN/m³	1.76			
Rigid Insulation	0.150 m	1.0 kN/m³	0.15			
RC Slab	0.300 m	24.0 kN/m³	7.20			
Live				5.00		
		TOTAL	9.71	5.00		kN/m²

			Gk	Qk	Σ	
FLOOR 2	*Extension - Ground Floor above basement*					
Finishes	0.030 m	20.0 kN/m³	0.60			
Screed	0.080 m	22.0 kN/m³	1.76			
Rigid Insulation	0.150 m	1.0 kN/m³	0.15			
RC Slab	0.300 m	24.0 kN/m³	7.20			
Plasterboard + skim	0.015 mm	9.0 kN/m³	0.14			
Live				1.50		
		TOTAL	9.85	1.50		kN/m²

			Gk	Qk	Σ	
FLOOR 3	*Extension - First Floor RC slab*					
Finishes	0.030 m	20.0 kN/m³	0.60			
Screed	0.080 m	22.0 kN/m³	1.76			
Rigid Insulation	0.150 m	1.0 kN/m³	0.15			
RC Slab	0.225 m	24.0 kN/m³	5.40			
Plasterboard + skim	0.015 mm	9.0 kN/m³	0.14			
Live				1.50		
		TOTAL	8.05	1.50		kN/m²

			Gk	Qk	Σ	
FLOOR 4	*Extension - Ground Floor RC slab*					
Finishes	0.030 m	20.0 kN/m³	0.60			
Screed	0.080 m	22.0 kN/m³	1.76			
Rigid Insulation	0.150 m	1.0 kN/m³	0.15			
RC Slab	0.300 m	24.0 kN/m³	7.20			
Live				1.50		
		TOTAL	9.71	1.50		kN/m²

			Gk	Qk	Σ	
FLOOR 5	*Garage Houses - Ground Floor RC slab*					
Finishes	0.030 m	20.0 kN/m³	0.60			
Screed	0.080 m	22.0 kN/m³	1.76			
Rigid Insulation	0.150 m	1.0 kN/m³	0.15			
RC Slab	0.225 m	24.0 kN/m³	5.40			
Live				1.50		
		TOTAL	7.91	1.50		kN/m²

			Gk	Qk	Σ	
FLOOR 6	*Extension - timber suspended first floor (House 2)*					
Finishes	0.020 m	7.0 kN/m³	0.14			
Floorboards	0.022 m	5.0 kN/m³	0.11			
Timber Joists	0.200 m x 0.05 m at 0.40 m crs.	5.0 kN/m³	0.13			
Noggins			0.05			
Services			0.05			
Plasterboard + skim	0.015 mm	9.0 kN/m³	0.14			
Live				1.50		
		TOTAL	0.61	1.50		kN/m²

DESIGN FOUNDATION LOADS

									Dead	Live	Total	Units
FOUNDATIONS 1	*Extension - Basement perimeter secant piles*								Gk	Qk	Σ	
Secant piles	0.450	m dia.		6	m deep			24.0 kN/m^3	64.8			
Capping beam	0.750	m wide	x	0.45	m deep			24.0 kN/m^3	8.10			
								TOTAL	72.9	0.00		kN/m
FOUNDATIONS 2	*Extension - Basement piles under central columns*								Gk	Qk	Σ	
Piles	0.450	m dia.	x	1	m deep	2	m spacing	24.0 kN/m^3	1.91			
Capping beam	0.750	m wide	x	0.45	m deep			24.0 kN/m^3	8.10			
								TOTAL	10.01	0.00		kN/m
FOUNDATIONS 3	*Extension - Piles under First Floor RC ground slab*								Gk	Qk	Σ	
Piles	0.450	m dia.	x	1	m deep	4	nr.	24.0 kN/m^3	1.05			
Capping beam	0.750	m wide	x	0.45	m deep			24.0 kN/m^3	8.10			
								TOTAL	9.15	0.00		kN/m
FOUNDATIONS 4	*Extension - Piles under Ground Floor RC ground slab*								Gk	Qk	Σ	
Piles	0.450	m dia.	x	1	m deep	14	nr.	24.0 kN/m^3	0.94			
Capping beam	0.750	m wide	x	0.45	m deep			24.0 kN/m^3	8.10			
								TOTAL	9.04	0.00		kN/m
FOUNDATIONS 5	*Garage Houses - Underpinning existing walls*								Gk	Qk	Σ	
Mass concrete	0.550	m wide	x	2.5	m deep			24.0 kN/m^3	33.00			
Dry pack	0.550	m wide	x	0.1	m deep			22.0 kN/m^3	1.21			
								TOTAL	34.21	0.00		kN/m
FOUNDATIONS 6	*Garage Houses - Perimeter piles*								Gk	Qk	Σ	
Piles	0.450	m dia.	x	1	m deep	12	nr.	24.0 kN/m^3	1.01			
Capping beam	1.000	m wide	x	0.45	m deep	46	m long	24.0 kN/m^3	10.80			
								TOTAL	11.81	0.00		kN/m
FOUNDATIONS 7	*Garage Houses - Internal piles*								Gk	Qk	Σ	
Piles	0.450	m dia.	x	1	m deep	4	nr.	24.0 kN/m^3	0.45			
Capping beam	0.750	m wide	x	0.45	m deep	34	m long	24.0 kN/m^3	8.10			
								TOTAL	8.55	0.00		kN/m

[ ] note weight of pile below formation level not included in calculation

DESIGN WALL LOADS

										Dead	Live	Total	Units
WALL TYPE 1	*Extension - Basement Wall*									Gk	Qk	Σ	
Secant piles	See FOUNDATIONS 1												
Water resistant concret	0.200 m							24.0	kN/m^3	4.80			
Insulation										0.10			
Blockwork wall	0.140 m							20.0	kN/m^3	2.80			
OSB3 sheathing	0.009 m							7.0	kN/m^3	0.06			
Battens	0.025 m	x	0.05	m	at	1.20	m crs.	5.0	kN/m^3	0.01			
Plasterboard + skim	0.015 m							9.0	kN/m^3	0.14			
									TOTAL	7.90	0.00		kN/m^2

WALL TYPE 2	*Extension - Loadbearing Stone Wall (Ground Floor)*									Gk	Qk	Σ	
Stone outer wall	0.200 m							25.0	kN/m^3	5.00			
Insulation										0.10			
Timber studs	0.140 m	x	0.05	m	at	0.60	m crs.	5.0	kN/m^3	0.06			
Plywood sheathing	0.018 m							6.0	kN/m^3	0.11			
Plasterboard + skim	0.015 m							9.0	kN/m^3	0.14			
									TOTAL	5.40	0.00		kN/m^2

WALL TYPE 3	*Extension - RC Retaining Wall (Ground Floor)*									Gk	Qk	Σ	
Concrete	0.275 m							24.0	kN/m^3	6.60			
Insulation										0.10			
Timber studs	0.140 m	x	0.05	m	at	0.60	m crs.	5.0	kN/m^3	0.06			
Blockwork wall	0.140 m							20.0	kN/m^3	2.80			
Plywood sheathing	0.018 m							6.0	kN/m^3	0.11			
Plasterboard + skim	0.015 m							9.0	kN/m^3	0.14			
									TOTAL	9.80	0.00		kN/m^2

WALL TYPE 4	*Extension - Timber Stud External*									Gk	Qk	Σ	
Cladding	0.020 m							25.0	kN/m^3	0.50			
OSB3 sheathing	0.018 m							7.0	kN/m^3	0.13			
Timber studs	0.140 m	x	0.05	m	at	0.60	m crs.	5.0	kN/m^3	0.06			
Insulation										0.10			
Plasterboard + skim	0.015 m							9.0	kN/m^3	0.14			
									TOTAL	0.92	0.00		kN/m^2

WALL TYPE 5	*Extension - Glazing*									Gk	Qk	Σ	
Glass	0.016 m							25	kN/m^3	0.40			
Framing										0.30			
									TOTAL	0.70	0.00		kN/m^2

DESIGN WALL LOADS (cont'd)

												Dead	Live	Total	Units
WALL TYPE 6	*Garage Houses - 300 wall*											Gk	Qk	Σ	
Reinforced concrete	0.300	m							24.0	kN/m^3		7.20			
Insulation												0.10			
OSB3 sheathing	0.009	m							7.0	kN/m^3		0.06			
Battens	0.025	m	x	0.05	m	at	1.20	m crs.	5.0	kN/m^3		0.01			
Plasterboard + skim	0.015	m							9.0	kN/m^3		0.14			
											TOTAL	7.50	0.00		kN/m

WALL TYPE 7	*Garage Houses - 250 wall*											Gk	Qk	Σ	
Reinforced concrete	0.250	m							24.0	kN/m^3		6.00			
Insulation												0.10			
OSB3 sheathing	0.009	m							7.0	kN/m^3		0.06			
Battens	0.025	m	x	0.05	m	at	1.20	m crs.	5.0	kN/m^3		0.01			
Plasterboard + skim	0.015	m							9.0	kN/m^3		0.14			
											TOTAL	6.30	0.00		kN/m

WALL TYPE 8	*Garage Houses - 150 wall*											Gk	Qk	Σ	
Reinforced concrete	0.150	m							24.0	kN/m^3		3.60			
Insulation												0.10			
OSB3 sheathing	0.009	m							7.0	kN/m^3		0.06			
Battens	0.025	m	x	0.05	m	at	1.20	m crs.	5.0	kN/m^3		0.01			
Plasterboard + skim	0.015	m							9.0	kN/m^3		0.14			
											TOTAL	3.90	0.00		kN/m

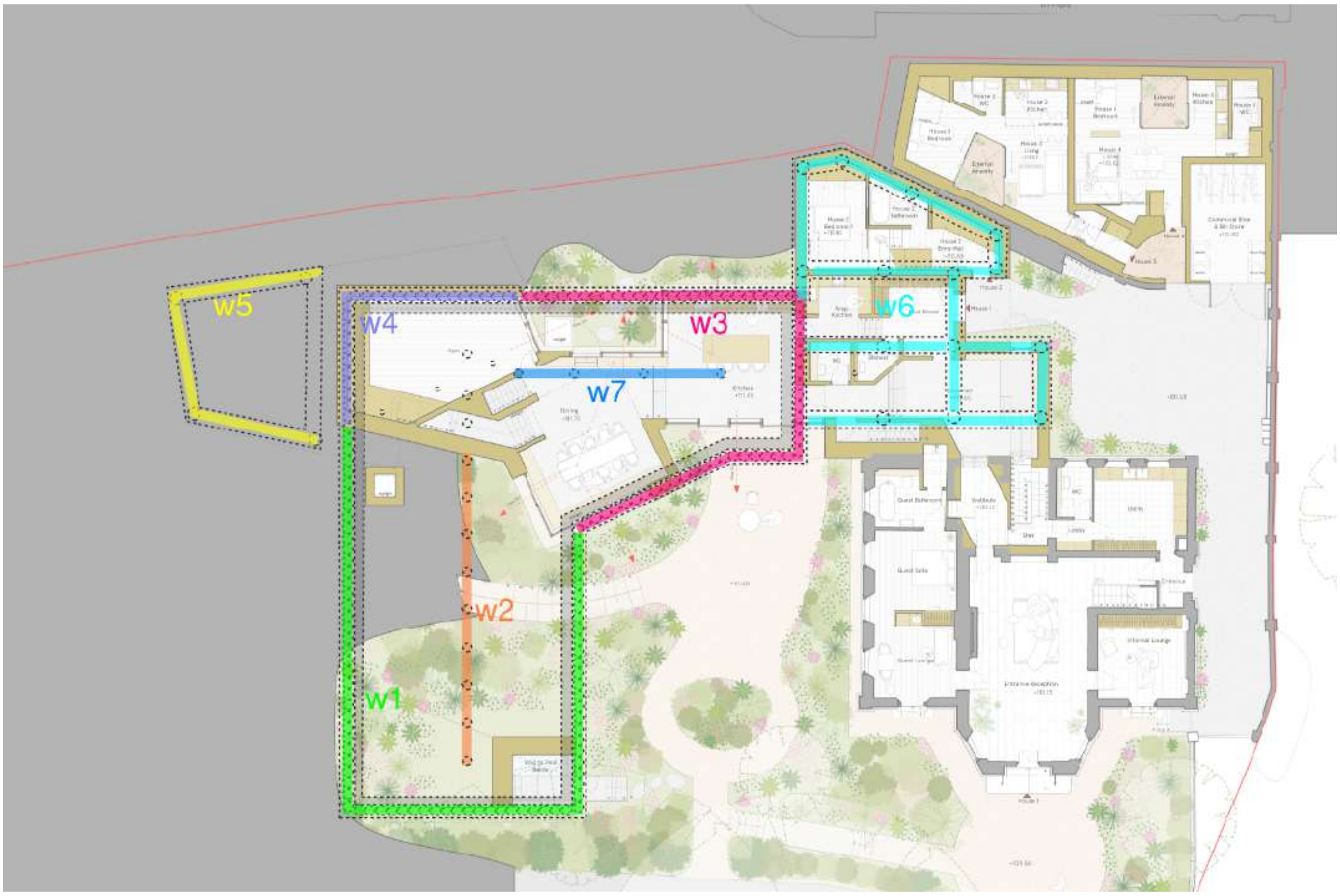
WALL TYPE 9	*Garage Houses - Brick Masonry*											Gk	Qk	Σ	
Brickwork	0.215	m							20.0	kN/m^3		4.30			
Insulation												0.10			
Blockwork	0.100	m							15.0	kN/m^3		1.50			
Plasterboard + skim	0.015	m							9.0	kN/m^3		0.14			
											TOTAL	6.04	0.00		kN/m^2

ASSUMED LOADS FOR NEIGHBOURING PROPERTY

				Dead	Live	Total	Units
WALL TYPE 10	*103 Frognal - Loadbearing brick wall*			Gk	Qk	Σ	
Brickwork	0.330 m	20.0 kN/m^3		6.60			
Insulation				0.10			
Blockwork	0.100 m	15.0 kN/m^3		1.50			
Internal finishes				0.20			
			TOTAL	8.40	0.00		kN/m^2
FLOOR 6	*103 Frognal - GF / 1F / 2F Timber floors*			Gk	Qk	Σ	
Finishes	0.020 m	7.0 kN/m^3		0.50			
Floorboards	0.020 m	5.0 kN/m^3		0.10			
Timber Joists				0.20			
Services				0.05			
Internal finishes	0.015 mm	9.0 kN/m^3		0.20			
Live					1.50		
			TOTAL	1.05	1.50		kN/m^2
ROOF 6	*103 Frognal - Zinc and Timber Roof*			Gk	Qk	Σ	
Finishes				0.5			
Timber Rafters				0.20			
Internal finishes				0.20			
Live	Snow				0.60		
			TOTAL	0.90	0.60		kN/m^2
FOUNDATIONS 5	*103 Frognal - Strip footings*			Gk	Qk	Σ	
Mass concrete	0.600 m wide x 0.7 m deep	24.0 kN/m^3		10.08			
			TOTAL	10.08	0.00		kN/m

STRUCTURE WORKSHOP	PROJECT	99 Frognal	PROJECT NO	23020	DATE	25/10/2023
	TITLE	Foundation Load Distribution	SHEET NO	8	ENG	AH

The total loads from the new development have been calculated based on layouts provided by the Architect. These loads are presented as distributed loads (UDLs) along the foundation lines, which have been split up as shown in the diagram below.



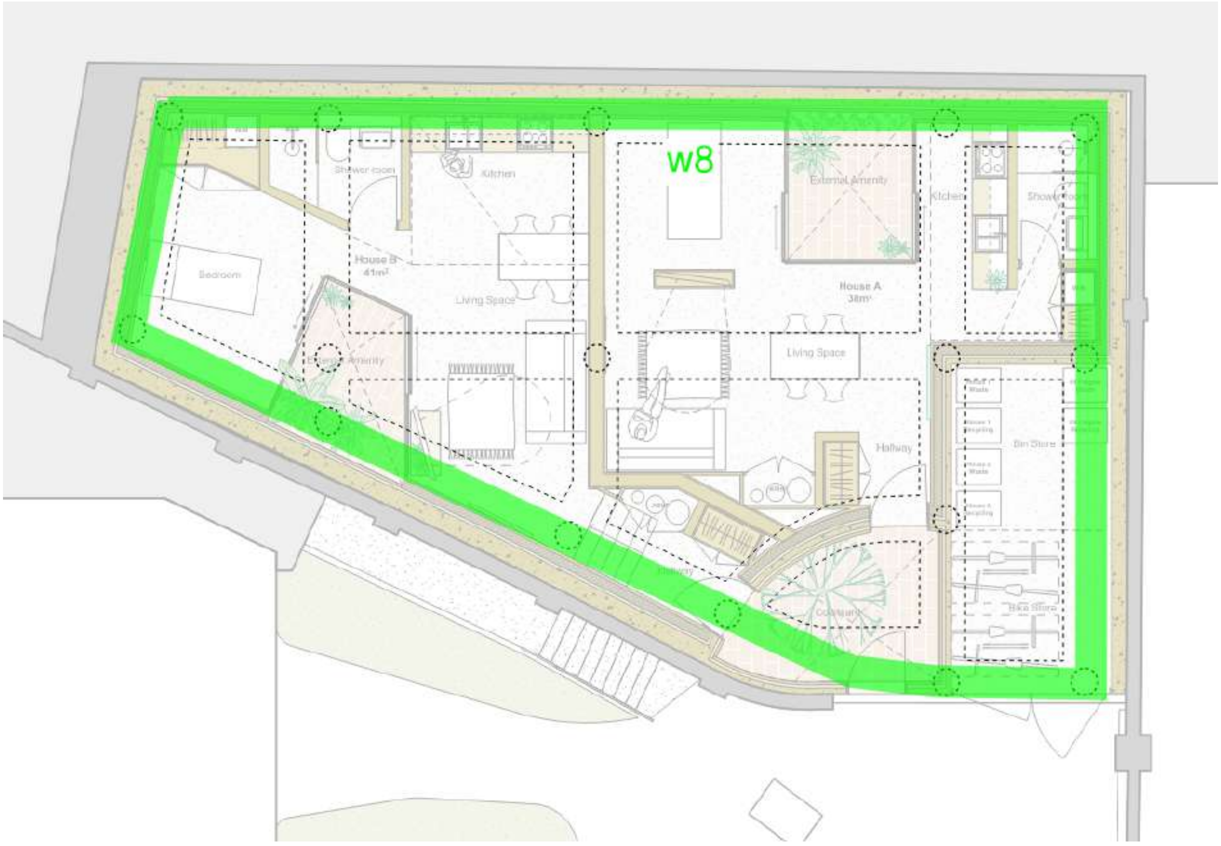
Line load total lengths

L_{w1}	40	m
L_{w2}	14	m
L_{w3}	30.9	m
L_{w4}	14	m
L_{w5}	17.9	m
L_{w6}	56.8	m
L_{w7}	9.5	m

Line loads (unfactored)

	Dead	Live	Total	
	Gk	Qk	Σ	
w1	201	19	220	kN/m
w2	238	50	288	kN/m
w3	214	29	243	kN/m
w4	316	44	360	kN/m
w5	37	13	50	kN/m
w6	73	10	83	kN/m
w7	108	31	139	kN/m

The total load from the proposed garage houses have been calculated based on the latest layouts received from the architect at the time of writing. This is presented as a distributed load (UDLs) along the perimeter foundation line, as indicated in the diagram below.



Line load total length

L_{w8} 46 m

		Dead	Live	Total	
Line loads (unfactored)		Gk	Qk	Σ	
	w8	129	12	141	kN/m

STRUCTURE WORKSHOP	PROJECT	99 Frognal	PROJECT NO	23020	DATE	25/10/2023
	TITLE	Foundation Load Takedown	SHEET NO	10	ENG	AH

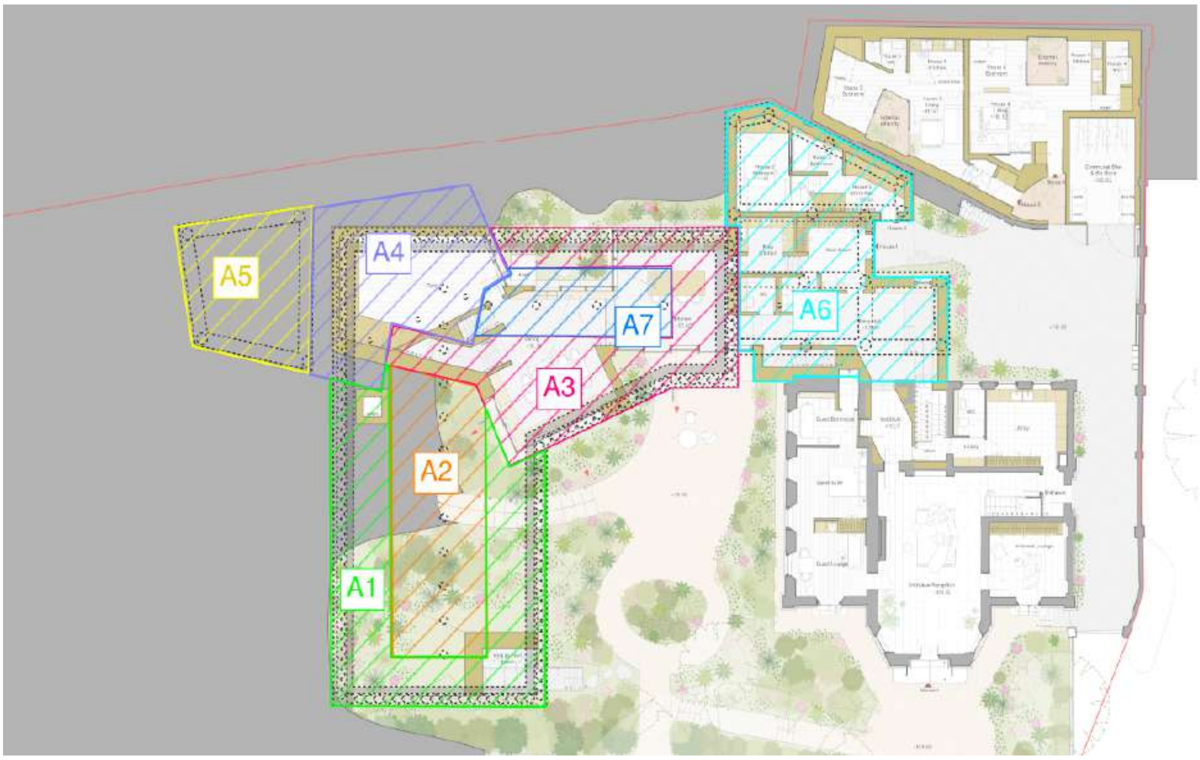
EXTENSION

LOAD AREA BREAKDOWN

Basement - buried	Total area acting on secant piles	**A1**	**103**	**m^2**
	Slab area		77	m^2
Basement - buried	Area acting on central piles	**A2**	**70**	**m^2**
Basement - NE	Area under GF acting on secant piles	**A3**	**103.0**	**m^2**
	Area under GF acting on central piles	**A7**	**34.0**	**m^2**
	Basement slab area		137	m^2
	GF slab area		110	m^2
	Stone feature roof area		41.4	m^2
	Green roof area		72.7	m^2
Basement - NW	Area under GF + 1F	**A4**	**74.8**	**m^2**
	Basement slab area		35	m^2
	GF Slab area		46	m^2
	1F Slab area		74.8	m^2
	Stone feature roof area		36.7	m^2
	Green roof area		46.5	m^2
First Floor - West	Area acting on ground beams	**A5**	**49.8**	**m^2**
Ground Floor - East	Area acting on ground beams	**A6**	**122**	**m^2**

WALL HEIGHTS

WALL TYPE 1	Basement	5.1	m
WALL TYPE 2	Stone Loadbearing	3.4	m
WALL TYPE 3	RC retaining	3.0	m



STRUCTURE WORKSHOP	PROJECT	99 Frognal	PROJECT NO	23020	DATE	25/10/2023
	TITLE	Foundation Load Takedown	SHEET NO	11	ENG	AH

			Dead	Live	Total	
LINE LOAD w1			Gk	Qk	Σ	
FLOOR 1 x Area / L_{w1}	Basement		18.7	9.6		kN/m
ROOF 1 x Area / L_{w1}	Basement roof (buried)		69.0	9.6		kN/m
FOUNDATIONS 1	Secant piles		72.9			kN/m
WALL TYPE 1 x wall height	Basement		40.3			kN/m
		TOTAL	200.9	19.3	220.1	kN/m
LINE LOAD w2			Gk	Qk	Σ	
FLOOR 1 x Area / L_{w2}	Basement		48.6	25.0		kN/m
ROOF 1 x Area / L_{w2}	Basement roof (buried)		179.2	25.0		kN/m
FOUNDATIONS 2	Central piled ground beam		10.0			kN/m
		TOTAL	237.8	50.0	287.8	kN/m
LINE LOAD w3 A3 / (A3+A7) 0.75	*Loads split between w3 and w7*		Gk	Qk	Σ	
FLOOR 1 x Area / L_{w3}	Basement*		32.4	16.7		kN/m
FLOOR 2 x Area / L_{w3}	Ground Floor*		26.3	4.0		kN/m
FOUNDATIONS 1	Secant piles		72.9			kN/m
WALL TYPE 1 x wall height	Basement		40.3			kN/m
WALL TYPE 2 x wall height X wall length / L_{w3}	Loadbearing stone		9.5			kN/m
WALL TYPE 3 x wall height X wall length / L_{w3}	RC retaining*		9.7			
ROOF 2 x Area / L_{w3}	Green roof*		21.0	5.3		kN/m
ROOF 3 x Area / L_{w3}	Stone feature roof*		2.1	3.0		kN/m
		TOTAL	214.3	29.0	243.3	kN/m
LINE LOAD w4			Gk	Qk	Σ	
FLOOR 1 x Area / L_{w4}	Basement		24.3	12.5		kN/m
FLOOR 2 x Area / L_{w4}	Ground Floor		32.3	5.4		kN/m
FLOOR 3 x Area / L_{w4}	First Floor		43.0	8.0		kN/m
FOUNDATIONS 1	Secant piles		72.9			kN/m
WALL TYPE 1 x wall height	Basement		40.3			kN/m
WALL TYPE 2 x wall height X wall length / L_{w4}	First Floor stone loadbearing		11.7			kN/m
WALL TYPE 3 x wall height X wall length / L_{w4}	Ground Floor RC external		43.3			kN/m
WALL TYPE 4 x wall height X wall length / L_{w4}	First Floor timber external		3.3			kN/m
ROOF 2 x Area / L_{w4}	Green roof		39.5	10.0		kN/m
ROOF 3 x Area / L_{w4}	Stone feature roof		5.6	7.9		kN/m
		TOTAL	316.1	43.8	359.8	kN/m
LINE LOAD w5			Gk	Qk	Σ	
FLOOR 3 x Area / L_{w5}	First Floor ground slab		22.38	4.17		kN/m
ROOF 3 x Area / L_{w5}	Stone feature roof		5.92	8.35		kN/m
FOUNDATIONS 3	Piles and ground beams		9.15			kN/m
WALL TYPE 2 x wall height X wall length / L_{w5}	Stone loadbearing		20.9			
		TOTAL	37.4	12.5	50.0	kN/m
LINE LOAD w6 *(assuming green roof loads instead of first floor loads conservatively)*			Gk	Qk	Σ	
FLOOR 4 x Area / L_{w6}	Ground Floor ground slab		20.86	3.22		kN/m
ROOF 2 x Area / L_{w6}	Green roof		25.53	6.44		kN/m
FOUNDATIONS 4	Piles and ground beams		9.04			kN/m
WALL TYPE 2 x wall height X wall length / L_{w6}	Stone loadbearing		17.46			kN/m
		TOTAL	72.9	9.7	82.5	kN/m

LINE LOAD w7	*A7 / (A3+A7) 0.25		Gk	Qk	Σ	
FLOOR 1 x Area / L_{w7}		Basement	34.75	17.89		kN/m
FLOOR 2 x Area / L_{w7}		Ground Floor	28.3	4.3		kN/m
FOUNDATIONS 2		Central piled ground beam	10.0	0.00		kN/m
WALL TYPE 3 x wall height x wall length / L_{w7}		RC retaining*	10.4	0.00		
ROOF 2 x Area / L_{w7}		Green roof*	22.6	5.7		kN/m
ROOF 3 x Area / L_{w7}		Stone feature roof*	2.30	3.24		kN/m
		TOTAL	108.3	31.1	139.4	kN/m

GARAGE HOUSES

LOAD AREA BREAKDOWN

	Area
Total Roof slab area:	104 m^2
"Pop-outs" area:	25 m^2
Total Ground slab area:	140 m^2

Total length of external walls:	Length	Height	Area
WALL TYPE 6	16.5 m	2.7 m	44.55 m^2
WALL TYPE 7	14.3 m	2.7 m	38.61 m^2
WALL TYPE 8	18 m	2.7 m	48.6 m^2
WALL TYPE 9	4.5 m	2.7 m	12.15 m^2

Assume total load applied around perimeter ground beams: L_{w7} 46 m

		Dead	Live	Total	
LINE LOAD w8		Gk	Qk	Σ	
ROOF	RC slab and timber frame 'pop-outs'	34.71	7.60	42	kN/m
WALLS	RC external walls	18.28	0.00	18	kN/m
FLOOR	Ground Floor RC slab	24.07	4.57	29	kN/m
FOUNDATIONS	Piles and ground beams	52.27	0.00	52	kN/m
	TOTAL	129	12	141	kN/m

BUOYANCY CHECK

BS EN 1997-1

GEOMETRY

Existing Ground Level		GL	111.4	mAOD
Assumed Ground Water Level	Assume at ground level in worst case	GWL	111.4	mAOD
Basement Formation Level			105.4	mAOD
Depth below water level		h	6.0	m

PROPERTIES

Water Unit Weight	γ_w	9.81	kN/m3

UPLIFT

Uplift Pressure	$p = \gamma_w \times h$	p	58.9	kN/m2
Partial Factor (permanent Unfavourable)		$\gamma_{G;dst}$	1.1	
Partial Factor (permanent Favourable)		$\gamma_{G;stb}$	0.9	

DOWNWARD ACTION

Proposed soil load on roof and all live loads are omitted as these are favourable actions

w1'	154.7	kN/m	L_{w1}	40	m	w1' x L_{w1}	6187	kN
w2'	102.8	kN/m	L_{w2}	14	m	w2' x L_{w2}	1439	kN
w3'	195.2	kN/m	L_{w3}	30.9	m	w3' x L_{w3}	6030	kN
w4'	279.8	kN/m	L_{w4}	14	m	w4' x L_{w4}	3917	kN
w7'	110.2	kN/m	L_{w5}	15	m	w7' x L_{w7}	1654	kN

Total weight (unfactored)	$\Sigma (w_i L_{wi})$	W	17573	kN
Total weight (factored)	$Gk = \gamma_{G;stb} \times W$	Gk_{TOT}	15816	kN

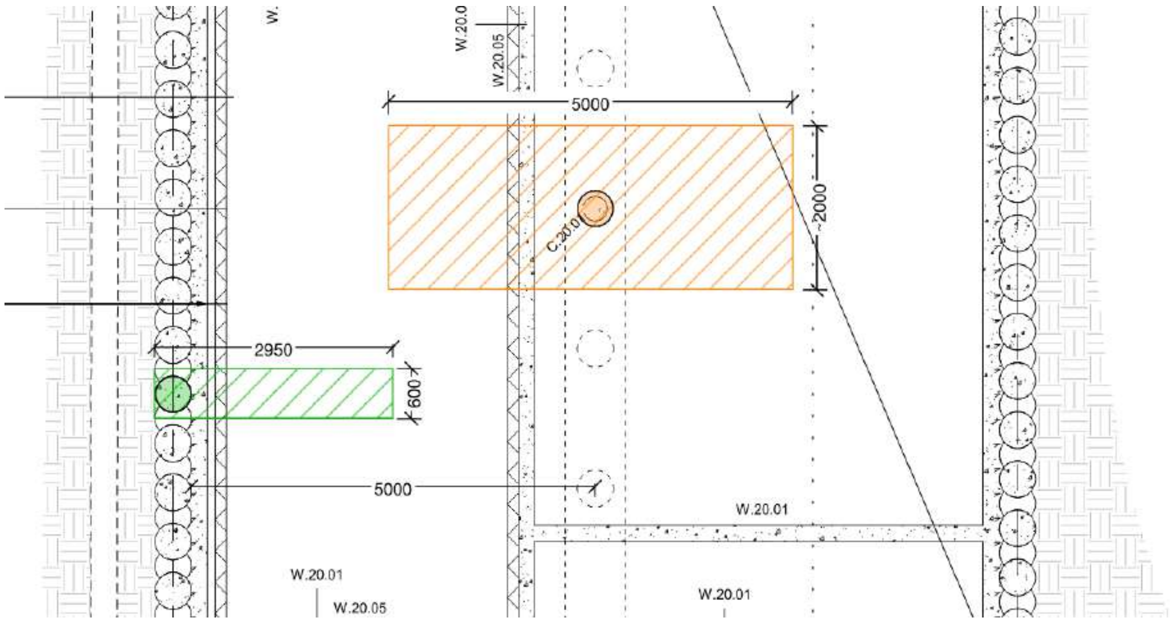
GLOBAL CHECK

WHOLE BASEMENT

Total Area	A1 + A2 + A3 + A4 + A7	A	385	m^2
Upwards Force	$A \times \gamma_w h$	↑	22649	kN
Downwards Force	Gk_{TOT}	↓	15816	kN

Basement is buoyant

Tension reinforcement required below slab to anchor down.



PERIMETER PILES

Area acting on single pile	Male (reinforced) piles only, 600 spacings	A	1.8	m2
Buoyancy Force	P = $\gamma_{G;dst}$ x p x A	P	115	kN
Dead load acting on single pile	Gk = $\gamma_{G;stb}$ x w1' x 600mm (pile spacing)	Gk	84	kN
Tension force in pile	T = P - Gk	T	31	kN

450dia. pile approx. 10m deep

INTERNAL PILES

Area acting on single pile		A	10	m2
Buoyancy Force	P = $\gamma_{G;dst}$ x p x A	P	647	kN
Dead load acting on single pile	Gk = $\gamma_{G;stb}$ x w2' x ~2m spacing	Gk	185	kN
Tension force in pile		T	462	kN

450dia. pile approx. 15m deep

Table 6.1 Equivalent safe working loads (kN) in axial compression (C) and tension (T) for bored piles for Zone 1

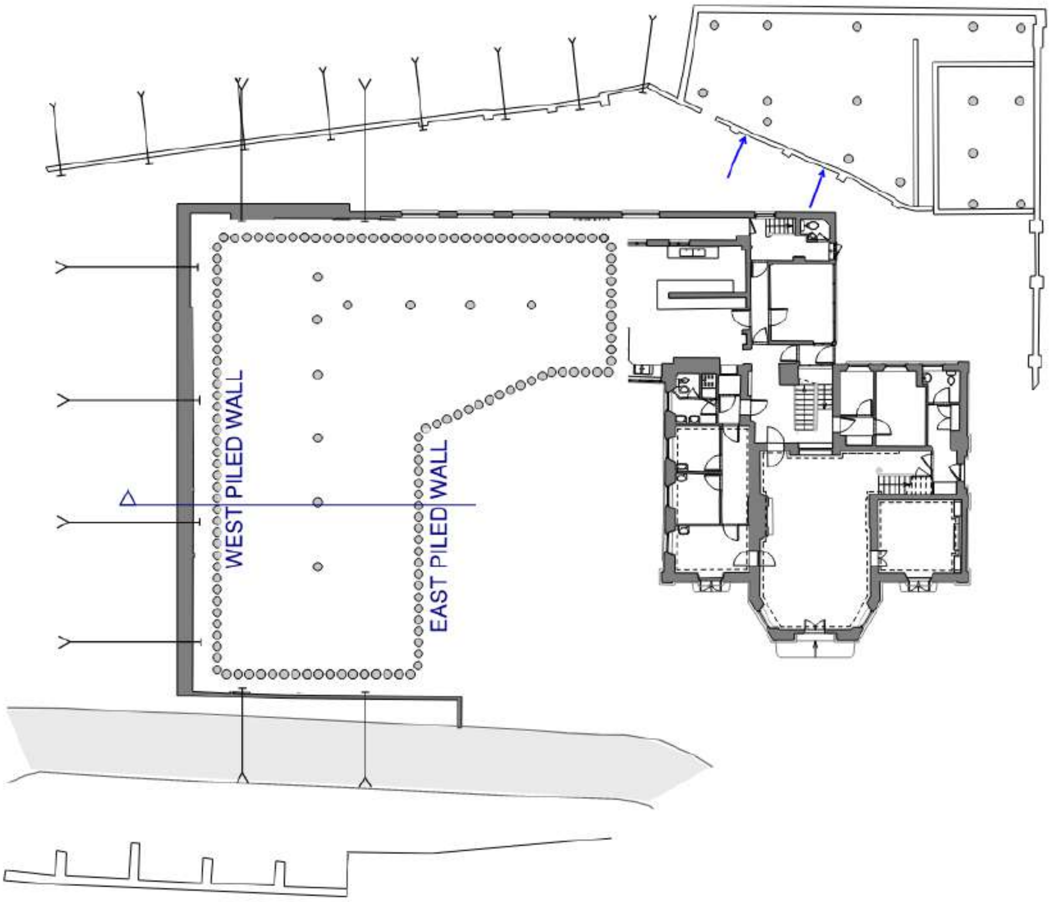
Pile Diameter (mm)		300		450		600	
Pile Type		C	T	C	T	C	T
Pile Length (m)	10.0	440	205	790	310	1055	415
	12.5	535	280	940	420	1420	560
	15.0	635	360	1090	540	1640	720
	17.5	750	450	1260	675	1870	900

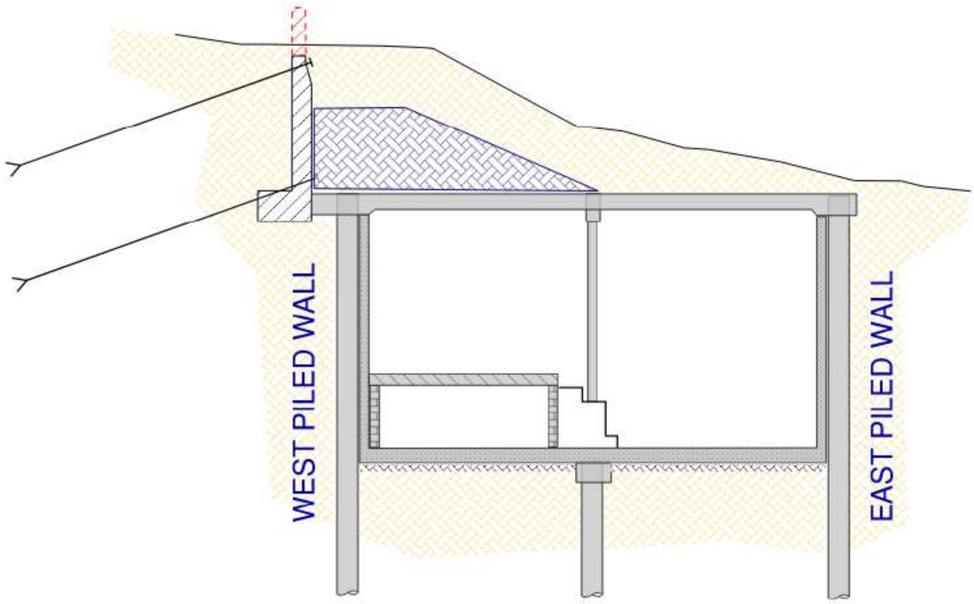
1. Pile capacities calculated using EC7 NA Design Approach 1 Combination 2 partial factors.
2. Length taken from the top of the pile (109.0mOD) at basement formation level.
3. Diameters are tool diameters.
4. Permanent/variable load split taken as 70%/30%.
5. Lateral pile loading has not been considered in the provided capacities.
6. Long-term water table adopted.
7. GEO evaluation only. STR verification to be completed in accordance with BS EN 1992.

A2 Site Investigation. Interpretive report

BASEMENT RETAINING WALLS

The walls of the basement are proposed to be 450dia. Reinforced piles at 600mm spacings are designed to take the loads from surcharge, soil and hydrostatic pressures. The following sheets present the preliminary calculations undertakn to jusitify this concept design. The final design will be to piling Contractor's details.





WEST PILED WALL - PROPPED RETAINING WALL

GEOMETRY

Proposed Ground Level			114.8	mAOD
Design Ground Water level			113.8	mAOD
Basement formation level			105.5	mAOD
Top of pile level			111.2	mAOD
Wall Height		h	5.68	m
Retained height		z	9.25	m
Ground water level	(metres below surface)	z_w	1.00	m
Ground water height	$= z - z_w$	h_w	8.25	m
Saturated Unit Weight	Bagshot Formation. GEA Interpretive Report	γ_{sat}	19	kN/m3
Water Unit Weight		γ_w	9.81	kN/m3
Submerged Unit Weight	$\gamma_{sub} = \gamma_{sat} - \gamma_w$	γ_{sub}	9.19	kN/m3
Shear Angle	GEA Interpretive Report	φ	24	deg
K coefficient active pressure	Ka = (1 - sin φ) / (1 + sin φ)	K_a	0.422	
K coefficient at-rest pressure	Ko = (1 - sin φ)	K_o	0.593	
	conservstively use Ko for preliminary design			

DESIGN LOADS

SURCHARGE

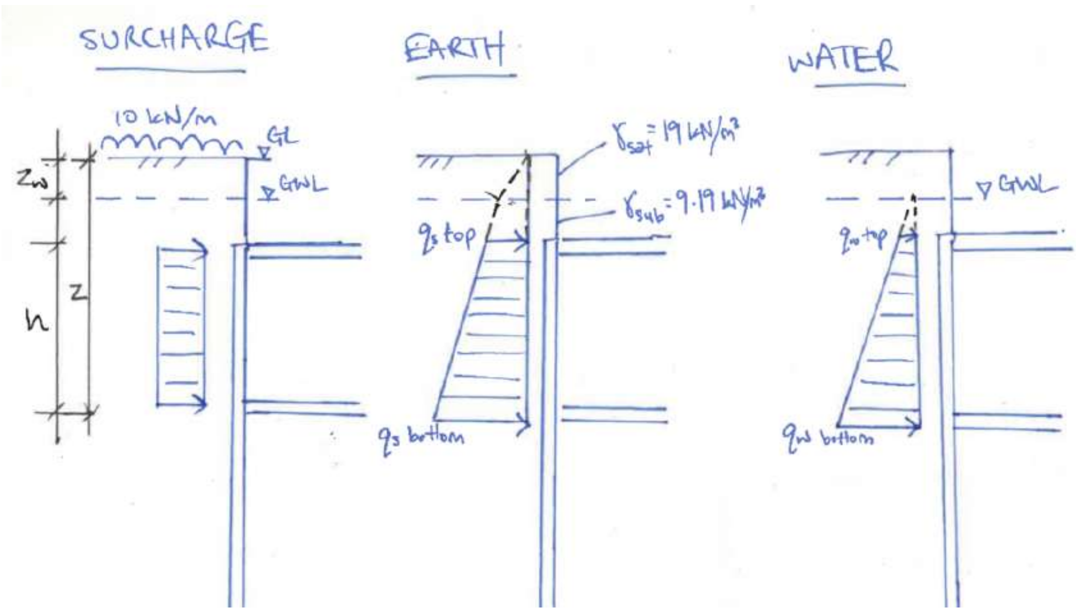
Surcharge	= 10 kN/m^2	w	10.0	kN/m^2
Pressure	= w x K	q	5.93	kN/m^2

EARTH PRESSURE

Pressure at base of wall	$= \gamma_{sub} \times K \times h_w + \gamma_{sat} \times K \times z_w$	q_s (bottom)	56.25	kN/m^2
Pressure at top of wall	$= \gamma_{sub} \times K \times (h_w - h) + \gamma_{sat} \times K \times z_w$	q_s (top)	25.28	kN/m^2

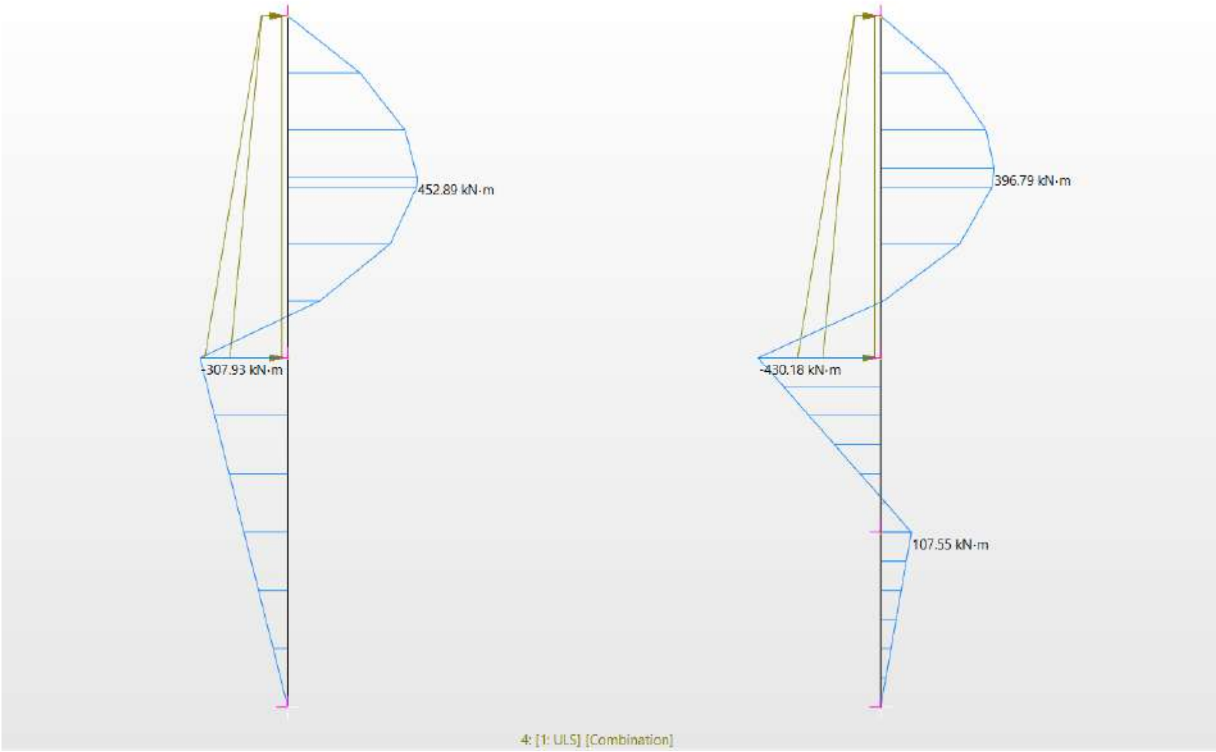
WATER PRESSURE

Pressure at base of wall	= γw x hw	qw bot	80.93	kN/m^2
Pressure at top of wall	= γw x (z-h)	qw top	25.21	kN/m^2



WEST PILED WALL - PROPPED RETAINING WALL

STRAND ANALYSIS



The left model shown in the snip above assumes pinned supports at the basement roof and lower ground slab level, and pinned at the base at an embedment depth of 5.8m (assumed).

The second model was prepared as a sensitivity check. It assumes that there is additional support to the embedded pile, modelled as an additional pin midway up. This reduces the max. moment in the pile above ground (down to 397kNm) but incrases the max. moment at the ground slab level (up to 430kNm). This is an improvement on the first model therefore a maximum moment of 452.6kNm has been assumed for preliminary design.

This assessment does not account for the benefitting actions of any shear walls or the upper basement slab, composite action of the lining wall or the effect of soil structure interaction (SSI).

<u>DESIGN MOMENTS FROM STRAND ANALYSIS</u>

Surcharge		M_q	18.3	kNm/m
Soil pressure		M_s	123.3	kNm/m
Water pressure		M_w	160.3	kNm/m
TOTAL MOMENT	$M_t = M_s + M_e + M_w$	M_t	301.93	kNm/m
Ultimate design moment	x 1,5 partial safety factor	Mt ult	452.89	kNm/m
Design Moment per pile (ULS)	*600mm spacing*	Mt ult	**271.7**	**kNm**

WEST PILED WALL - PROPPED RETAINING WALL

GEOMETRY

Pile diameter		h	450	mm
Pile spacing		s piles	600	mm
Nominal cover to bars		cnom	50	mm
Long. Bar dia.		φ	32	mm
Link dia		φv	8	mm
Number of longitudinal bars		N	6	
Spacing	*assume min. spacing* 100 mm	s bars	158	mm
				OK
Concrete Strength	*Concrete strength class C28/35*	fck	28	N/mm^2
Steel Strength		fyk	500	N/mm^2

RC COLUMN CHECK

Compressive force per pile		N	**180.1**	kN
N / h^2 fck			0.03	
M / h^3 fck	Take moment from Strand analysis		0.11	
d			302	
d/h			0.67	
ρ fyk / fck	*From pocket book charts (p.138)*		0.45	
ρ			0.0252	
Area of required reinforcement	$\rho = 4 A_s / \pi h^2$	As req	**4,008**	mm^2
				OK
Minimum reinf.	0.4% Ac *(p. 141)*	A_s min	636	mm^2
Maximum reinf.	4% Ac *(p. 141)*	A_s max	6,362	mm^2
Area of provided reinforcement		As prov	**4,825**	mm^2
				PASS

ACCEPT 6 no. 32 dia. reinforcement bars in 450 dia. concrete pile

EAST PILED WALL - PROPPED RETAINING WALL

GEOMETRY

Proposed Ground Level			111.9	mAOD
Design Ground Water level			110.9	mAOD
Basement formation level			105.5	mAOD
Top of pile level			111.2	mAOD
Wall Height		h	5.68	m
Retained height		z	6.40	m
Ground water level	(metres below surface)	z_w	1.00	m
Ground water height	$= z - z_w$	h_w	5.40	m
Saturated Unit Weight	Bagshot Formation. GEA Interpretive Report	γ_{sat}	19	kN/m3
Water Unit Weight		γ_w	9.81	kN/m3
Submerged Unit Weight	$\gamma_{sub} = \gamma_{sat} - \gamma_w$	γ_{sub}	9.19	kN/m3
Shear Angle	GEA Interpretive Report	φ	24	deg
K coefficient active pressure	Ka = (1 - sin φ) / (1 + sin φ)	K_a	0.422	
K coefficient at-rest pressure	Ko = (1 - sin φ)	K_o	0.593	
	conservatively use Ko for preliminary design			

DESIGN LOADS

SURCHARGE

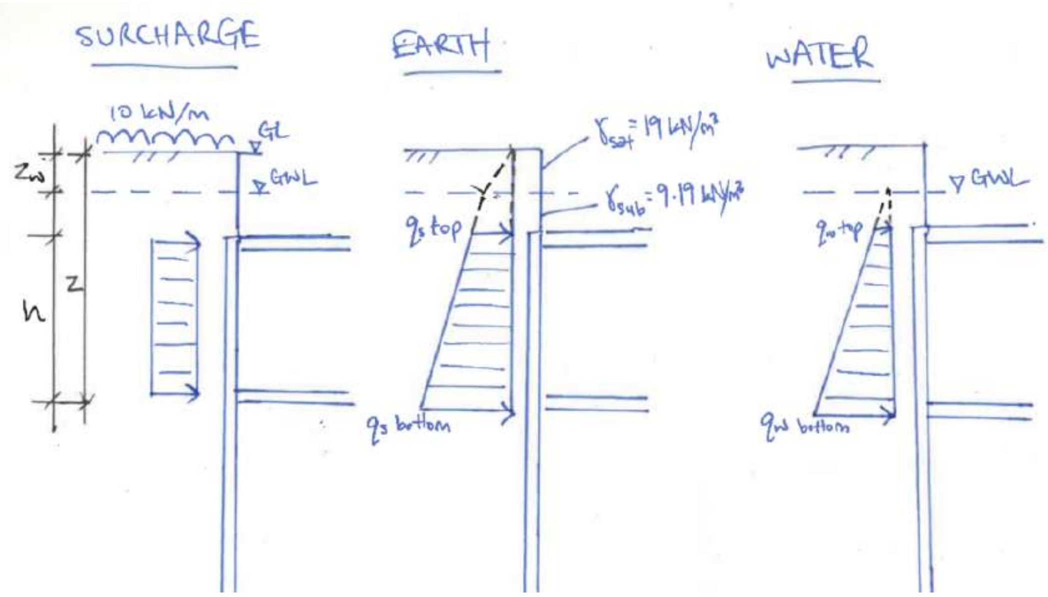
Surcharge	= 10 kN/m^2	w	10.0	kN/m^2
Pressure	= w x K	q	5.93	kN/m^2

EARTH PRESSURE

Pressure at base of wall	$= \gamma_{sub} \times K \times h_w + \gamma_{sat} \times K \times z_w$	q_s (bottom)	40.71	kN/m^2
Pressure at top of wall	$= \gamma_{sub} \times K \times (h_w - h) + \gamma_{sat} \times K \times z_w$	q_s (top)	9.75	kN/m^2

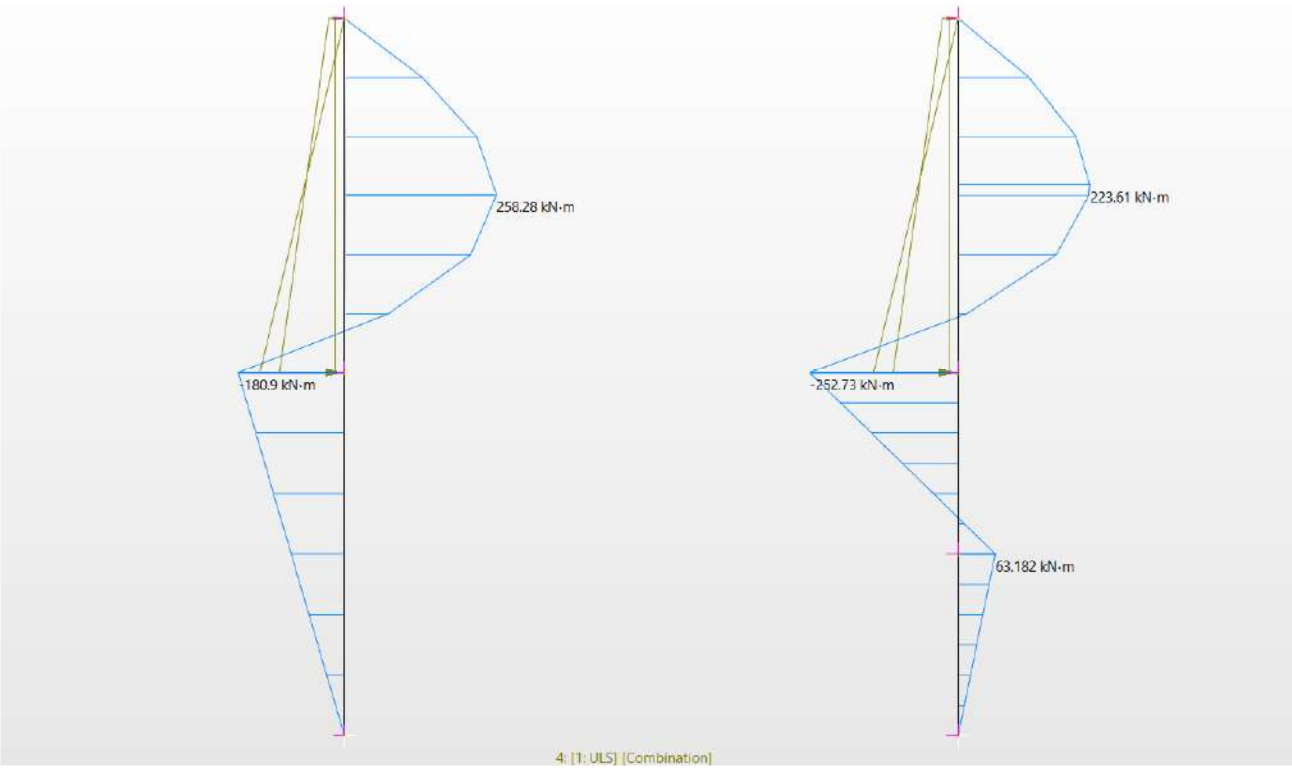
WATER PRESSURE

Pressure at base of wall	= γw x hw	qw bot	52.97	kN/m^2
Pressure at top of wall	= γw x (z-h)	qw top	0.00	kN/m^2



EAST PILED WALL - PROPPED RETAINING WALL

STRAND ANALYSIS



The left model shown in the snip above assumes pinned supports at the basement roof and lower ground slab level, and pinned at the base at an embedment depth of 5.8m (assumed).

The second model was prepared as a sensitivity check. It assumes that there is additional support to the embedded pile, modelled as an additional pin midway up. This reduces the max. moment in the pile above ground (down to 223.6kNm) but incrases the max. moment at the ground slab level (up to 252.7Nm). This is an improvement on the first model therefore a maximum moment of 258.2kNm has been assumed for preliminary design.

This assessment does not account for the benefitting actions of any shear walls or the upper basement slab, composite action of the lining wall or the effect of soil structure interaction (SSI).

<u>DESIGN MOMENTS FROM STRAND ANALYSIS</u>

Surcharge		M_q	18.2	kNm/m
Soil pressure		M_s	75.5	kNm/m
Water pressure		M_w	78.6	kNm/m
TOTAL MOMENT	$M_t = M_s + M_e + M_w$	M_t	172.19	kNm/m
Ultimate design moment	x 1,5 partial safety factor	Mt ult	258.28	kNm/m
Design Moment per pile (ULS)	*600mm spacing*	Mt ult	**155.0**	**kNm**

EAST PILED WALL - PROPPED RETAINING WALL

GEOMETRY

Pile diameter		h	450	mm
Pile spacing		s piles	600	mm
Nominal cover to bars		cnom	50	mm
Long. Bar dia.		φ	20	mm
Link dia		φv	8	mm
Number of longitudinal bars		N	6	
Spacing	*assume min. spacing* 100 mm	s bars	164	mm
				OK
Concrete Strength	*Concrete strength class C28/35*	fck	28	N/mm^2
Steel Strength		fyk	500	N/mm^2

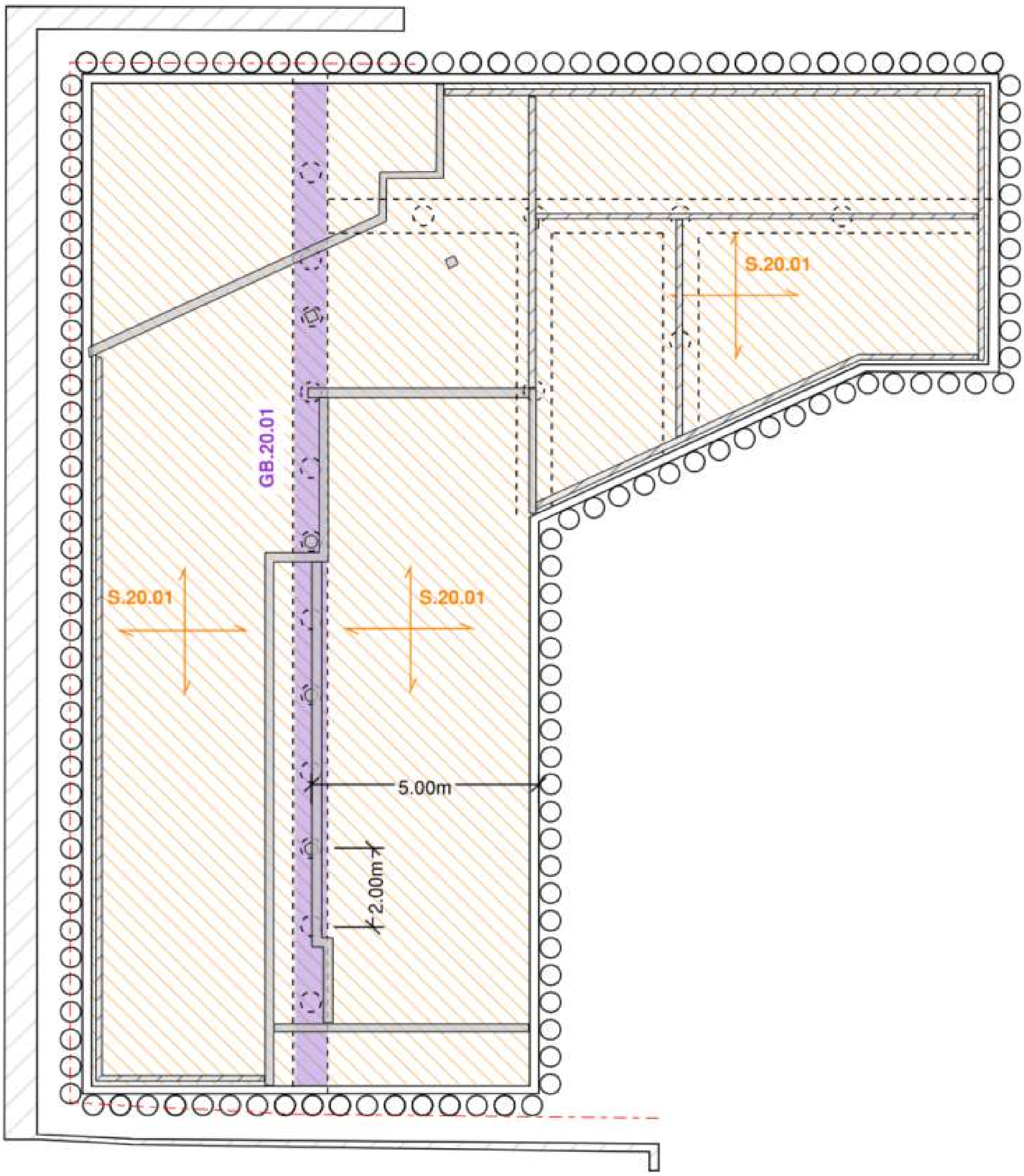
RC COLUMN CHECK

Compressive force per pile		N	**180.1**	**kN**
$N / h^2 fck$			0.03	
$M / h^3 fck$	Take moment from Strand analysis		0.06	
d			314	
d/h			0.70	
ρ fyk / fck	*From pocket book charts (p.138)*		0.20	
ρ			0.0112	
Area of required reinforcement	$\rho = 4 As / \pi h^2$	As req	**1,781**	mm^2
				OK
Minimum reinf.	0.4% Ac *(p. 141)*	A_s min	636	mm^2
Maximum reinf.	4% Ac *(p. 141)*	A_s max	6,362	mm^2
Area of provided reinforcement		As prov	**1,885**	mm2
				PASS

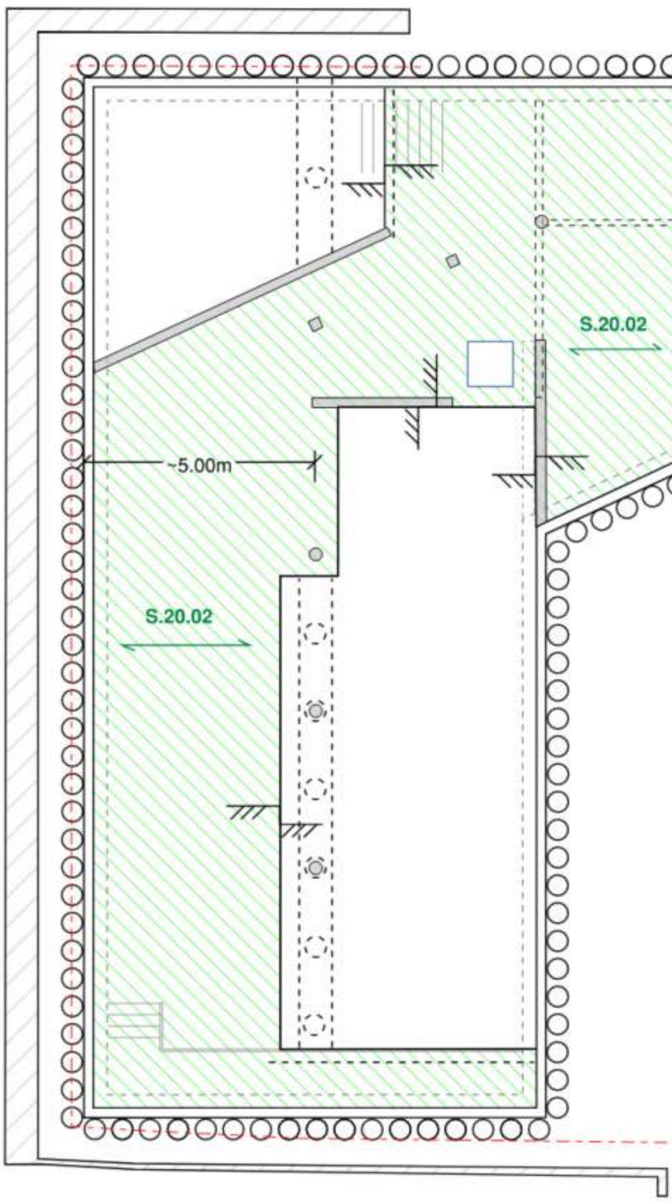
ACCEPT 6 no. 20 dia. reinforcement bars in 450 dia. concrete pile

STRUCTURE WORKSHOP	PROJECT	99 Frognal	PROJECT NO	23020	DATE 06/10/2023
	TITLE	Basement Layout	SHEET NO	22	ENG AH

BASEMENT STRUCTURAL LAYOUT



LOWER BASEMENT



UPPER BASEMENT

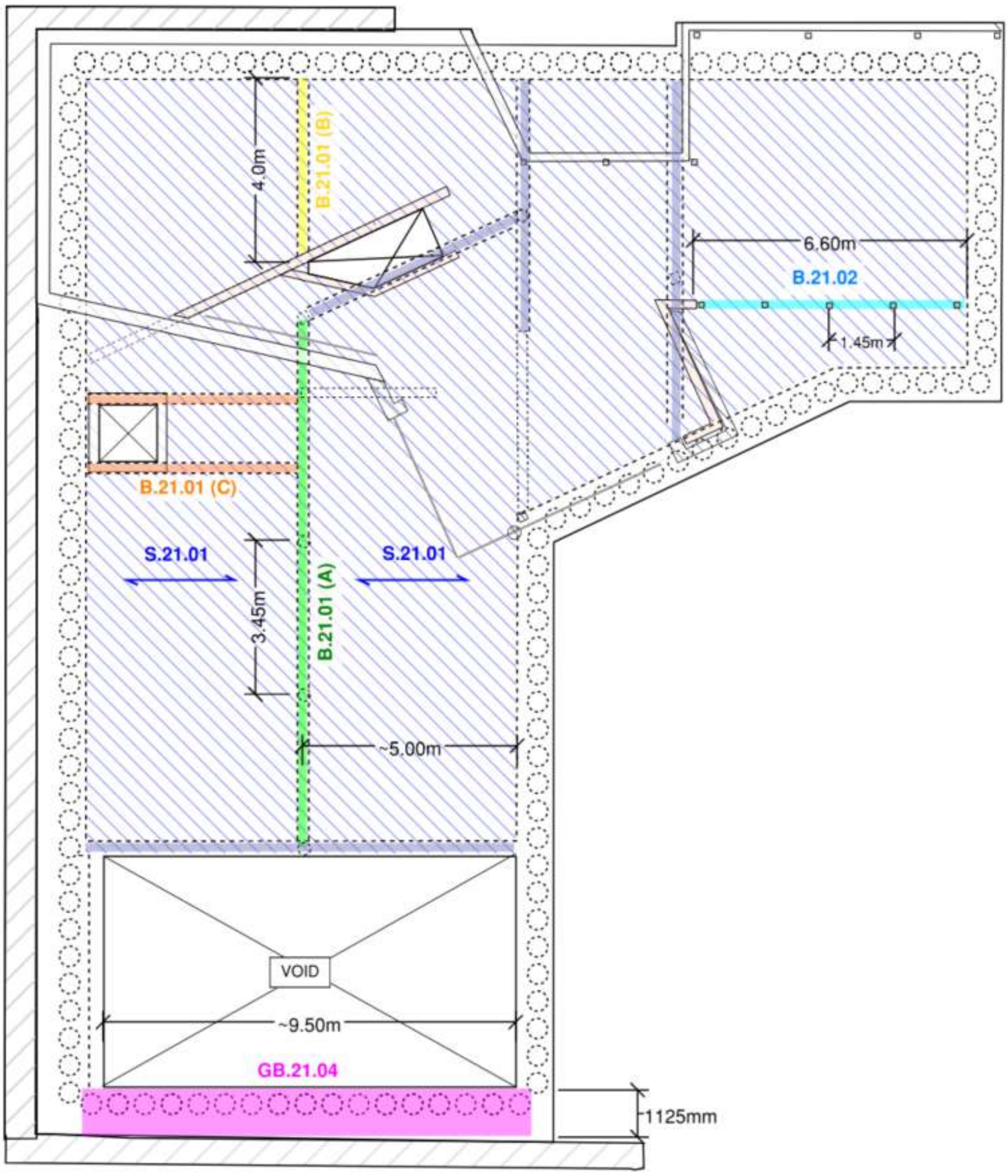
To simplify the construction process it is proposed that internal upper slab S.20.02 is formed of precast concrete panels spanning blockwork walls. The depth has been sized with reference to the FP McCann Hollowcore datasheets, see the Table below. Due to the potential for heavy plant being moved across the floor, an imposed load of 5kN/m2 has been assumed conservatively. The maxium span of these panels would be 5.0m. As such, a **150mm deep panel** is sufficient.

HOLLOWCORE LOAD/SPAN TABLE

Spans indicated opposite allow for characteristic service load (live load kN/m²) + unit self WT + 1.5kN/m² for floor finishes.

Unit Depth (mm)	Self Weight (kN/m²)	Fire Rating (hrs)	Characteristic Service Load kN/m²									
			0.75	1.5	2.0	2.5	3.0	4.0	5.0	7.5	10	15.0
150	2.36	*1	7.50	7.50	7.50	7.50	7.50	7.10	6.60	5.80	5.20	4.50
150H	3.02	*1	7.50	7.50	7.50	7.50	7.40	6.90	6.40	5.60	5.10	4.40
200	2.98	*1	10.00	9.90	9.70	9.20	9.00	8.40	7.90	7.00	6.30	5.40
250	3.62	*1	12.50	11.70	11.30	10.90	10.50	9.80	9.30	8.20	7.50	6.40
260	3.47	*1	13.00	12.50	12.00	11.50	11.00	10.50	10.00	8.50	8.00	7.00
300	3.99	2	14.60	14.30	14.10	13.60	13.30	12.50	11.90	10.70	9.70	7.90
350	4.41	2	16.00	15.00	14.90	14.70	14.50	14.20	13.20	12.00	10.80	9.50
400	4.77	2	17.00	17.00	17.00	16.30	15.70	15.10	14.40	13.10	12.10	10.50
450	5.36	2	17.00	17.00	17.00	17.00	16.50	16.20	15.20	14.00	13.00	11.30
500	5.92	2	18.00	18.00	18.00	18.00	18.00	17.20	16.50	15.00	13.90	12.00

PROJECT	99 Frognal	PROJECT NO	23020	DATE	06/10/2023
TITLE	Basement Layout	SHEET NO	24	ENG	AH



GROUND FLOOR / BASEMENT ROOF

RC SLAB S.20.01

SLAB GEOMETRY

Design span		L	5	m
Slab thickness		h	300	mm
Bottom layer cover		c_b	50	mm
Top layer cover		c_t	50	mm

MATERIAL PROPERTIES

Concrete Strength	C28/35	f_{ck}	28	N/mm^2
Steel strength	High yield reinforcement	f_{yk}	500	N/mm^2

DESIGN FORCES

Design load	Assume worst case = uplift - selfweight of slab	w	57.5	kN/m /m
Major Sagging Moment		$M_{s,Ed,major}$	101	kNm
Minor Sagging Moment		$M_{s,Ed,minor}$	0	kNm
Major Hogging Moment		$M_{h,Ed,major}$	180	kNm
Minor Hogging Moment		$M_{h,Ed,minor}$	0	kNm

BOTTOM REINFORCEMENT - MAJOR DIRECTION

Reinforcement provided	diameter, $Ø_{b1}$ 16 spacing 150	$A_{s,prov}$	1340	mm^2
Effective depth	$= h - c_b - Ø_{b1} / 2$	d	242	mm
K Factor	$= M / d^2 f_{ck}$ < 0.168 :. No compression reinforcement req'd	K	0.061	
Lever arm	$= 0.5 d [1 + \sqrt{(1 - 3.53K)}]$, $z < 0.95 d$	z	228	mm
Reinforcement required	$= \max [M / 0.87 f_{yk} z ; 0.0013 b d]$, $< 0.04 b h$	$A_{s,req'd}$	1015	mm^2

$A_{s,prov}$ > $A_{s,req'd}$:. OK

BOTTOM REINFORCEMENT - MINOR DIRECTION

Reinforcement provided	diameter, $Ø_{b2}$ 12 spacing 200	$A_{s,prov}$	565	mm^2
Effective depth	$= h - c_b - Ø_{b1} - Ø_{b2} / 2$	d	228	mm
K Factor	$= M / d^2 f_{ck}$ < 0.168 :. No compression reinforcement req'd	K	0.000	
Lever arm	$= 0.5 d [1 + \sqrt{(1 - 3.53K)}]$, $z < 0.95 d$	z	217	mm
Reinforcement required	$= \max [M / 0.87 f_{yk} z ; 0.0013 b d]$, $< 0.04 b h$	$A_{s,req'd}$	296	mm^2

$A_{s,prov}$ > $A_{s,req'd}$:. OK

TOP REINFORCEMENT - MAJOR DIRECTION

Reinforcement provided	diameter, $Ø_{t1}$ 16 spacing 100	$A_{s,prov}$	2011	mm^2
Effective depth	$= h - ct - Øt_1 / 2$	d	242	mm
K Factor	$= M / d^2 f_{ck}$ < 0.168 :. No compression reinforcement req'd	K	0.110	
Lever arm	$= 0.5 d [1 + \sqrt{(1 - 3.53K)}]$, $z < 0.95 d$	z	216	mm
Reinforcement required	$= \max [M / 0.87 f_{yk} z ; 0.0013 b d]$, $< 0.04 b h$	$A_{s,req'd}$	1916	mm^2

$A_{s,prov}$ > $A_{s,req'd}$:. OK

TOP REINFORCEMENT - MINOR DIRECTION

Reinforcement provided	diameter, $Ø_{b2}$ 12 spacing 200	$A_{s,prov}$	565	mm^2
Effective depth	$= h - c_t - Ø_{t1} - Ø_{t2} / 2$	d	228	mm
K Factor	$= M / d^2 f_{ck}$ < 0.168 :. No compression reinforcement req'd	K	0.000	
Lever arm	$= 0.5 d [1 + \sqrt{(1 - 3.53K)}]$, $z < 0.95 d$	z	217	mm
Reinforcement required	$= \max [M / 0.87 f_{yk} z ; 0.0013 b d]$, $< 0.04 b h$	$A_{s,req'd}$	296	mm^2

$A_{s,prov}$ > $A_{s,req'd}$:. OK

750 wide x 450 dp Reinforced Concrete Ground Beam (BS EN 1992-1-1:2004)

BEAM GEOMETRY

Beam span	Design span	L	2.0	m
Beam depth		d	450	mm
Beam width		b	750	mm
Cover	Assume 50mm cover	c	50	mm

MATERIAL PROPERTIES

Concrete Strength	C28/35	f_{ck}	28	N/mm²
Steel strength	High yield reinforcement	f_{yk}	500	N/mm²
Concrete Tensile Strength		f_{ctm}	2.80	N/mm²

DESIGN FORCES

Design Moment	$wl^2/8$	FLOOR 1. Assume 5m width of ground slab acting on beam	M_{Ed}	52	kNm
Design Shear	wl/2		V_{Ed}	103	kN

TENSION REINFORCEMENT

Reinforcement provide	Use 3no. H16 bars	$A_{s,prov}$	603	mm²
Effective depth	= h - c - Ølinks - Øbar / 2	d	376	mm
K Factor	= M / b d² fck	K	0.017	-
	δ = 0.85 K < 0.168 :. No compression reinforcement req'd			
Lever arm	= 0.5 d [1 + √ (1 - 3.53K)], z < 0.95 d	z	357	mm
Min. reinforcement	= max [(0.26 fctm b d) / fyk ; 0.0013 b d]	$A_{s,min}$	411	mm²
Reinforcement require	= max [M / 0.87 fyk z ; $A_{s,min}$] , < 0.04 b h	$A_{s,req}$	411	mm²

$A_{s,prov}$ > As,req :. OK

SHEAR REINFORCEMENT

Design shear stress	= V_{Ed} / 0.9 d b	v_{Ed}	0.406	N/mm²
Strut capacity	cotθ = 2.5	$v_{Rd,max\,c}$	3.430	N/mm²
	cotθ = 1.0	$v_{Rd,max\,c}$	4.970	N/mm²
	v_{Ed} < nax cotθ=2.5 :. cotθ = 2.5			
Strut angle	minimum strut angle (cotθ=2.5)	θ	21.80	°
Max link spacing	= 0.75 d	s_{max}	282	mm
Shear links required	= v_{Ed} b / (0.87 f_{yk} cotθ)	A_{sw} / s	0.28	mm
Shear links required	= v_{Ed} b s_{max} / (0.87 f_{yk} cotθ)	A_{sw}	79	mm
Shear links provided	Use 2no H16 link legs	$A_{sw,prov}$	402	mm²
Spacing required	= min($A_{sw,prov}$/(A_{sw}/s) , s_{max})	s	250	mm

$A_{sw,prov}$ > A_{sw} :. OK

s < s_{max} :. OK

DEFLECTION

Required reinforcemen	= As / b d	ρ	0.002	-
Reference ratio	= √ f_{ck} / 1000	ρ_0	0.005	-
System factor	Simply supported beam	K	1.0	-
Factor 2	n/a	F2	1.0	-
Factor 3	= $A_{s,prov}$ / $A_{s,req}$, ≤ 1.5	F3	1.47	-
Span/depth ratio limit	= F2 F3 K [11 + 1.5 √(fck) ρ0/ρ + 3.2 √(fck) (ρ0/ρ -1)^1.5]	L/d_{lim}	73.5	-

5.3 < 73.5 :. OK

RC SLAB S.21.01

SLAB GEOMETRY

Design span	L	5	m
Slab thickness	h	300	mm
Bottom layer cover	c_b	50	mm
Top layer cover	c_t	50	mm

MATERIAL PROPERTIES

Concrete Strength	C28/35	f_{ck}	28	N/mm^2
Steel strength	High yield reinforcement	f_{yk}	500	N/mm^2

DESIGN FORCES

Design load	Buried basement (ROOF 1) load, w = 1.35Gk + 1.5Qk	w	68.0	kN/m
Major Sagging Moment		$M_{s,Ed,major}$	119	kNm
Minor Sagging Moment		$M_{s,Ed,minor}$	0	kNm
Major Hogging Moment		$M_{h,Ed,major}$	213	kNm
Minor Hogging Moment		$M_{h,Ed,minor}$	0	kNm

BOTTOM REINFORCEMENT - MAJOR DIRECTION

Reinforcement provided	diameter, $Ø_{b1}$ 16 spacing 150	$A_{s,prov}$	1340	mm^2
Effective depth	$= h - c_b - Ø_{b1} / 2$	d	242	mm
K Factor	$= M / d^2 f_{ck}$ < 0.168 :. No compression reinforcement req'd	K	0.073	
Lever arm	$= 0.5\ d\ [1 + \sqrt{(1 - 3.53K)}],\ z < 0.95\ d$	z	225	mm
Reinforcement required	$= \max [\ M / 0.87\ f_{yk}\ z\ ;\ 0.0013\ b\ d\ ],\ < 0.04\ b\ h$	$A_{s,req'd}$	1215	mm^2
		$A_{s,prov}$ >	$A_{s,req'd}$	:. OK

BOTTOM REINFORCEMENT - MINOR DIRECTION

Reinforcement provided	diameter, $Ø_{b2}$ 10 spacing 200	$A_{s,prov}$	393	mm^2
Effective depth	$= h - c_b - Ø_{b1} - Ø_{b2} / 2$	d	229	mm
K Factor	$= M / d^2 f_{ck}$ < 0.168 :. No compression reinforcement req'd	K	0.000	
Lever arm	$= 0.5\ d\ [1 + \sqrt{(1 - 3.53K)}],\ z < 0.95\ d$	z	218	mm
Reinforcement required	$= \max [\ M / 0.87\ f_{yk}\ z\ ;\ 0.0013\ b\ d\ ],\ < 0.04\ b\ h$	$A_{s,req'd}$	298	mm^2
		$A_{s,prov}$ >	$A_{s,req'd}$	:. OK

TOP REINFORCEMENT - MAJOR DIRECTION

Reinforcement provided	diameter, $Ø_{t1}$ 16 spacing 100	$A_{s,prov}$	2011	mm^2
Effective depth	$= h - ct - Øt_1 / 2$	d	242	mm
K Factor	$= M / d^2 f_{ck}$ < 0.168 :. No compression reinforcement req'd	K	0.130	
Lever arm	$= 0.5\ d\ [1 + \sqrt{(1 - 3.53K)}],\ z < 0.95\ d$	z	210	mm
Reinforcement required	$= \max [\ M / 0.87\ f_{yk}\ z\ ;\ 0.0013\ b\ d\ ],\ < 0.04\ b\ h$	$A_{s,req'd}$	2326	mm^2
		$A_{s,prov}$ <	$A_{s,req'd}$	FAIL

TOP REINFORCEMENT - MINOR DIRECTION

Reinforcement provided	diameter, $Ø_{b2}$ 10 spacing 200	$A_{s,prov}$	393	mm^2
Effective depth	$= h - c_t - Ø_{t1} - Ø_{t2} / 2$	d	229	mm
K Factor	$= M / d^2 f_{ck}$ < 0.168 :. No compression reinforcement req'd	K	0.000	
Lever arm	$= 0.5\ d\ [1 + \sqrt{(1 - 3.53K)}],\ z < 0.95\ d$	z	218	mm
Reinforcement required	$= \max [\ M / 0.87\ f_{yk}\ z\ ;\ 0.0013\ b\ d\ ],\ < 0.04\ b\ h$	$A_{s,req'd}$	298	mm^2
		$A_{s,prov}$ >	$A_{s,req'd}$	:. OK

600 wide x 1125 dp Reinforced Concrete Beam

(BS EN 1992-1-1:2004)

BEAM GEOMETRY

Beam span	Design span	L	9.5	m
Beam depth	depth in direction of applied forces	d	1125	mm
Beam width		b	600	mm
Cover	Assume 50mm cover	c	50	mm

MATERIAL PROPERTIES

Concrete Strength	C28/35	f_{ck}	28	N/mm²
Steel strength	High yield reinforcement	f_{yk}	500	N/mm²
Concrete Tensile Strength		f_{ctm}	2.80	N/mm²

DESIGN FORCES

Design Moment	$wl^2/8$	w = 201 kN/m	M_{Ed}	2268	kNm
Design Shear	wl/2		V_{Ed}	955	kN

TENSION REINFORCEMENT

Reinforcement provide	Use 16no. H25 bars *(2 layers of 8no. bars)*	$A_{s,prov}$	7854	mm²
Effective depth	= h - c - Ølinks - Øbar - horiz. pitch / 2	d	993	mm
K Factor	= M / b d² fck	K	0.137	-
	δ = 0.85 K < 0.168 :. No compression reinforcement req'd			
Lever arm	= 0.5 d [1 + √ (1 - 3.53K)], z < 0.95 d	z	853	mm
Min. reinforcement	= max [(0.26 fctm b d) / fyk ; 0.0013 b d]	$A_{s,min}$	867	mm²
Reinforcement requirec	= max [M / 0.87 fyk z ; $A_{s,min}$] , < 0.04 b h	$A_{s,req}$	6112	mm²

$A_{s,prov}$ > As,req :. OK

SHEAR REINFORCEMENT

Design shear stress	= V_{Ed} / 0.9 d b	v_{Ed}	1.781	N/mm²
Strut capacity	cotθ = 2.5	$v_{Rd,max\ c}$	3.430	N/mm²
	cotθ = 1.0	$v_{Rd,max\ c}$	4.970	N/mm²
	v_{Ed} < nax cotθ=2.5 :. cotθ = 2.5			
Strut angle	minimum strut angle (cotθ=2.5)	θ	21.80	°
Max link spacing	= 0.75 d	s_{max}	744	mm
Shear links required	= v_{Ed} b / (0.87 f_{yk} cotθ)	A_{sw} / s	0.98	mm
Shear links required	= v_{Ed} b s_{max} / (0.87 f_{yk} cotθ)	A_{sw}	732	mm
Shear links provided	Use 3no H20 link legs	$A_{sw,prov}$	942	mm²
Spacing required	= min($A_{sw,prov}$/(A_{sw}/s) , s_{max})	s	700	mm

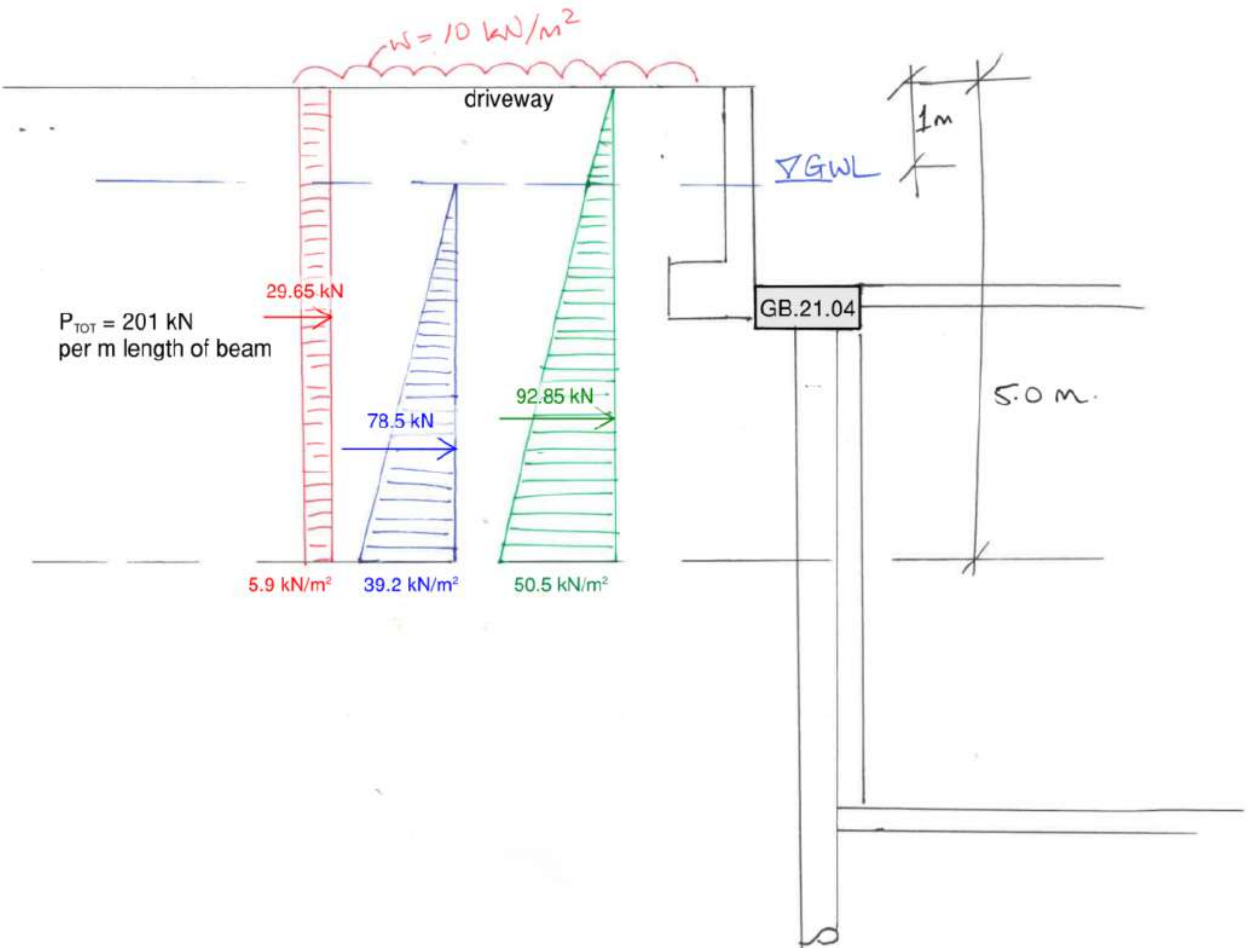
$A_{sw,prov}$ > A_{sw} :. OK

s < s_{max} :. OK

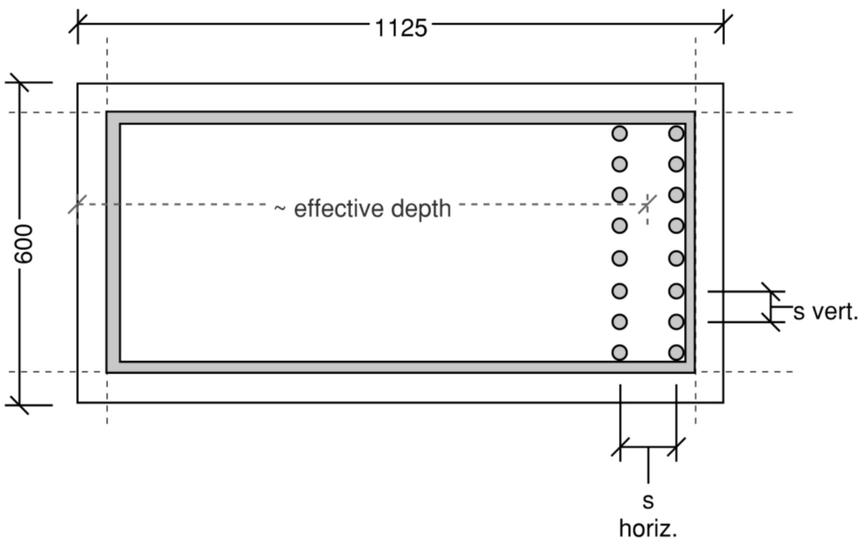
DEFLECTION

Required reinforcemen	= As / b d	ρ	0.005	-
Reference ratio	= √ f_{ck} / 1000	$ρ_0$	0.005	-
System factor	Simply supported beam	K	1.0	-
Factor 2	n/a	F2	1.0	-
Factor 3	= $A_{s,prov}$ / $A_{s,req}$, ≤ 1.5	F3	1.28	-
Span/depth ratio limit	= F2 F3 K [11 + 1.5 √(fck) ρ0/ρ]	L/d_{lim}	24.0	-

9.6 < 24.0 :. OK



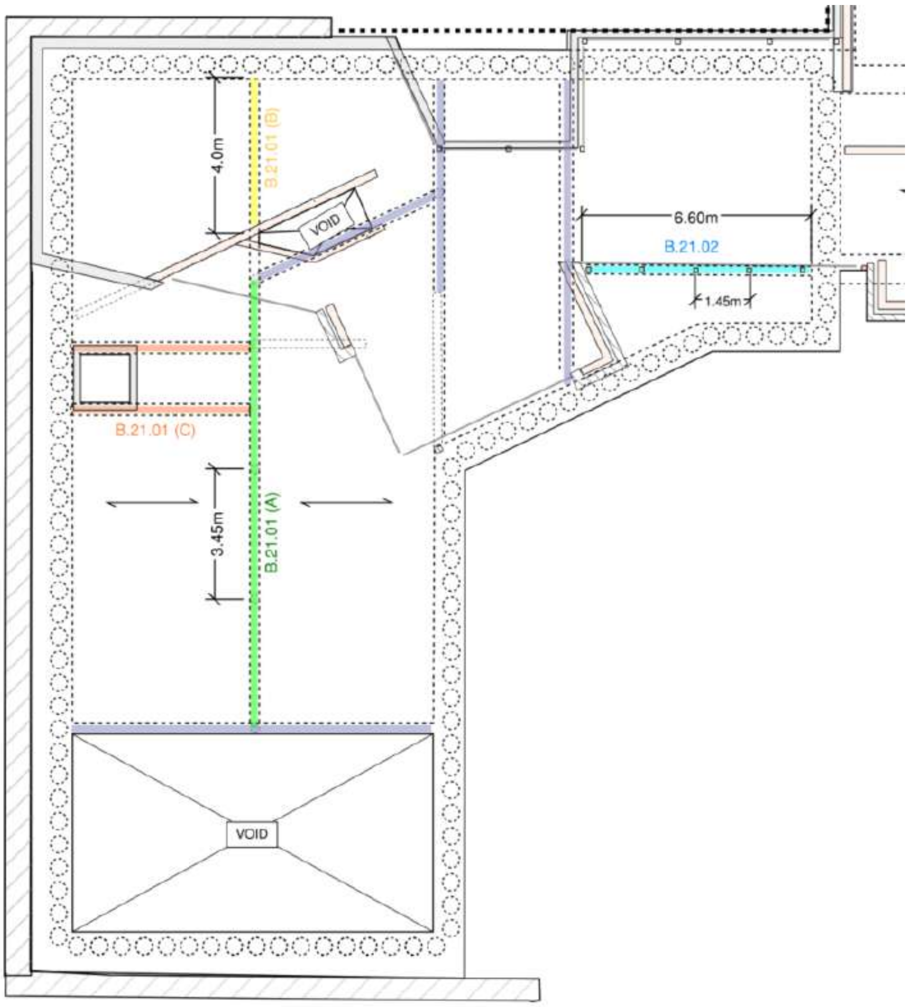
DESIGN FORCES Surcharge + Water + Soil

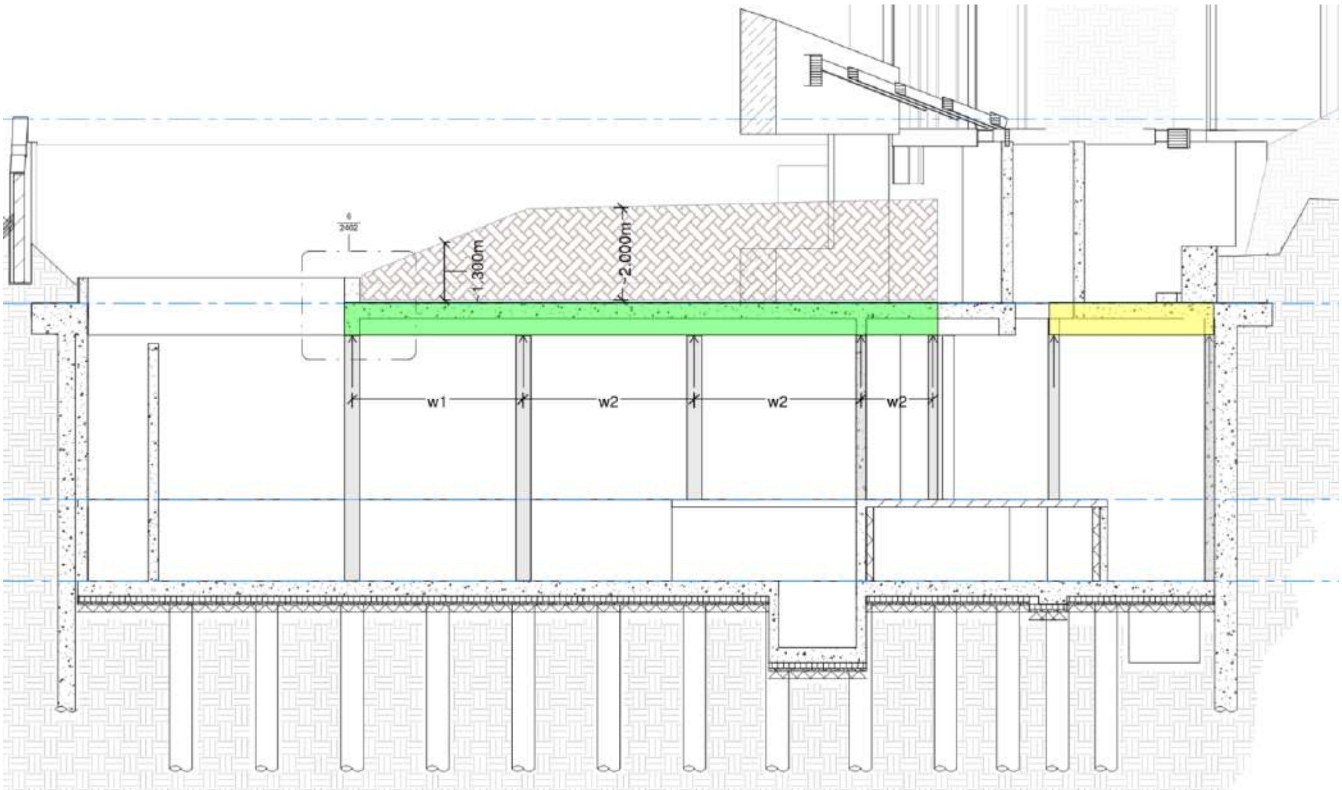


CROSS SECTION OF CAPPING BEAM GB.21.04

Vertical pitch	= (b - 2*c - 2*Ølinks - Øbar) / (no. bars - 1)	s vert	62	mm
Horizontal pitch	Allowable pitch given bar size, from rebar detailing tables	s horiz	75	mm

BASEMENT ROOF BEAM LAYOUT





BEAM DESIGN LOADS

					Dead	Live	Total	Units
BEAM B.21.01 (A)	*Basement roof under landscaping*				Gk	Qk	Σ	
RC Slab	0.300 m			24.0 kN/m³	7.20			
Rigid Insulation	0.300 m			1.0 kN/m³	0.30			
Vapour Control					0.01			
Plasterboard + skim	0.015 mm			9.0 kN/m³	0.14			
Live						5.00		
Soil	Avg. Depth 1	1.300 m		18.0 kN/m³	36.00			
	Avg. Depth 2	2.000 m	Typical load (conservative)	18.0 kN/m³	23.40			
Line Load, w1				TOTAL	43.65	5.00		kN/m²
width of slab acting on beam	5 m				218.2	25.00		kN/m
				ULS	**294.6**	**37.5**	**332.1**	**kN/m**
Line Load, w2				TOTAL	31.05	5.00		kN/m²
width of slab acting on beam	5 m				155.2	25.00		kN/m
				ULS	**209.6**	**37.5**	**247.1**	**kN/m**
BEAM B.21.01 (B)	*Basement roof under Ground Floor*				Gk	Qk	Σ	
Finishes	0.030 m			20.0 kN/m³	0.60			
Screed	0.080 m			22.0 kN/m³	1.76			
Rigid Insulation	0.150 m			1.0 kN/m³	0.15			
RC Slab	0.300 m			24.0 kN/m³	7.20			
Plasterboard + skim	0.015 mm			9.0 kN/m³	0.14			
Live	gym					5.00		
				TOTAL	9.85	5.00		kN/m²
width of slab acting on beam	5 m				49.2	25.00		kN/m
				ULS	**66.45**	**37.5**	**104**	**kN/m**
BEAM B.21.01 (C)	*Basement roof under landscaping and skylight*				Gk	Qk	Σ	
ROOF 1					Gk	Qk	Σ	
Soil	2.500 m		*in location with deepest soil cover*	18.0 kN/m³	45.00			
RC Slab	0.300 m			24.0 kN/m³	7.20			
RC Roof beams	0.05			24.0 kN/m³	1.20			
Rigid Insulation	0.300 m			1.0 kN/m³	0.30			
Vapour Control					0.01			
Plasterboard + skim	0.015 mm			9.0 kN/m³	0.14			
Live						5.00		
				TOTAL	53.85	5.00		kN/m²
SKYLIGHT SHAFT								
Concrete walls	0.200 m thick	x 2.700 m	high	24.0 kN/m³	12.96			kN/m
BEAM B.21.02	*Basement roof under columns*				Gk	Qk	Σ	
POINT LOADS								
Columns	Green roof (ROOF 2)	x 6.525 m²	acting on one column		77.55	19.58		kN
				ULS	**104.7**	**29.36**	**134.1**	**kN**
UDLs								
Ground Floor	FLOOR 4	x 3.00 m	width acting on beam		29.13	4.50		kN/m
				ULS	**39.33**	**6.75**	**46.08**	**kN/m**

300 wide x 625 dp Reinforced Concrete Beam (BS EN 1992-1-1:2004)

BEAM GEOMETRY

Beam span	Design span	L	3.45	m
Beam depth		d	625	mm
Beam width		b	300	mm
Cover	Assume 50mm cover	c	50	mm

MATERIAL PROPERTIES

Concrete Strength	C28/35	f_{ck}	28	N/mm²
Steel strength	High yield reinforcement	f_{yk}	500	N/mm²
Concrete Tensile Strength		f_{ctm}	2.80	N/mm²

DESIGN FORCES

Design Moment	*Max. sagging moment. From Strand7 Analysis*	M_{Ed}	219	kNm
Design Shear	*From Strand7 Analysis*	V_{Ed}	540	kN

TENSION REINFORCEMENT

Reinforcement provide	Use 3no. H25 bars	$A_{s,prov}$	1473	mm²
Effective depth	= h - c - Ølinks - Øbar / 2	d	547	mm
K Factor	= M / b d² fck	K	0.087	-
	δ = 0.85 K < 0.168 :. No compression reinforcement req'd			
Lever arm	= 0.5 d [1 + √ (1 - 3.53K)], z < 0.95 d	z	500	mm
Min. reinforcement	= max [(0.26 fctm b d) / fyk ; 0.0013 b d]	$A_{s,min}$	239	mm²
Reinforcement requirec	= max [M / 0.87 fyk z ; $A_{s,min}$] , < 0.04 b h	$A_{s,req}$	1008	mm²

$A_{s,prov}$ > As,req :. OK

SHEAR REINFORCEMENT

Design shear stress	= V_{Ed} / 0.9 d b	v_{Ed}	3.658	N/mm²
Strut capacity	cotθ = 2.5	$v_{Rd,max\,c}$	3.430	N/mm²
	cotθ = 1.0	$v_{Rd,max\,c}$	4.970	N/mm²
	v_{Ed} < nax cotθ=1.0 :. 1 < cotθ <2.5			
Strut angle	= 0.5 sin-1 (vEd / 0.2 fck (1 - fck/250))	θ	23.68	°
Max link spacing	= 0.75 d	s_{max}	410	mm
Shear links required	= v_{Ed} b / (0.87 f_{yk} cotθ)	A_{sw} / s	1.11	mm
Shear links required	= v_{Ed} b s_{max} / (0.87 f_{yk} cotθ)	A_{sw}	453	mm
Shear links provided	Use 4no H16 link legs	$A_{sw,prov}$	804	mm²
Spacing required	= min($A_{sw,prov}$/(A_{sw}/s) , s_{max})	s	400	mm

$A_{sw,prov}$ > A_{sw} :. OK

s < s_{max} :. OK

DEFLECTION

Required reinforcemen	= As / b d	ρ	0.003	-
Reference ratio	= √ f_{ck} / 1000	ρ_0	0.005	-
System factor	Simply supported beam	K	1.0	-
Factor 2	n/a	F2	1.0	-
Factor 3	= $A_{s,prov}$ / $A_{s,req}$, ≤ 1.5	F3	1.46	-
Span/depth ratio limit	= F2 F3 K [11 + 1.5 √(fck) ρ0/ρ + 3.2 √(fck) (ρ0/ρ -1)^1.5]	L/d_{lim}	54.4	-

6.3 < 54.4 :. OK

300 wide x 625 dp Reinforced Concrete Beam

(BS EN 1992-1-1:2004)

BEAM GEOMETRY

Beam span	Design span	L	3.45	m
Beam depth		d	625	mm
Beam width		b	300	mm
Cover	Assume 50mm cover	c	50	mm

MATERIAL PROPERTIES

Concrete Strength	C28/35	f_{ck}	28	N/mm²
Steel strength	High yield reinforcement	f_{yk}	500	N/mm²
Concrete Tensile Strength		f_{ctm}	2.80	N/mm²

DESIGN FORCES

Design Moment	*Max. hogging moment. From Strand7 Analysis*	M_{Ed}	356	kNm
Design Shear	*From Strand7 Analysis*	V_{Ed}	590	kN

TENSION REINFORCEMENT

Reinforcement provide	Use 6no. H20 bars	$A_{s,prov}$	1885	mm²
Effective depth	= d - c - Ølinks - Øbar - max(25mm ; Øbar)/2 changed for double layer	d	527	mm
K Factor	= M / b d² fck	K	0.153	-
	δ = 0.85 K < 0.168 :. No compression reinforcement req'd			
Lever arm	= 0.5 d [1 + √ (1 - 3.53K)], z < 0.95 d	z	442	mm
Min. reinforcement	= max [(0.26 fctm b d) / fyk ; 0.0013 b d]	$A_{s,min}$	230	mm²
Reinforcement requirec	= max [M / 0.87 fyk z ; $A_{s,min}$] , < 0.04 b h	$A_{s,req}$	1853	mm²

$A_{s,prov}$ > As,req :. OK

SHEAR REINFORCEMENT

Design shear stress	= V_{Ed} / 0.9 d b	v_{Ed}	4.148	N/mm²
Strut capacity	cotθ = 2.5	$v_{Rd,max\,c}$	3.430	N/mm²
	cotθ = 1.0	$v_{Rd,max\,c}$	4.970	N/mm²
	v_{Ed} < nax cotθ=1.0 :. 1 < cotθ <2.5			
Strut angle	= 0.5 sin-1 (vEd / 0.2 fck (1 - fck/250))	θ	28.26	°
Max link spacing	= 0.75 d	s_{max}	395	mm
Shear links required	= v_{Ed} b / (0.87 f_{yk} cotθ)	A_{sw} / s	1.54	mm
Shear links required	= v_{Ed} b s_{max} / (0.87 f_{yk} cotθ)	A_{sw}	607	mm
Shear links provided	Use 4no H16 link legs	$A_{sw,prov}$	804	mm²
Spacing required	= min($A_{sw,prov}$/(A_{sw}/s) , s_{max})	s	350	mm

$A_{sw,prov}$ > A_{sw} :. OK

s < s_{max} :. OK

DEFLECTION

Required reinforcemen	= As / b d	ρ	0.006	-
Reference ratio	= √ f_{ck} / 1000	ρ_0	0.005	-
System factor	Simply supported beam	K	1.0	-
Factor 2	n/a	F2	1.0	-
Factor 3	= $A_{s,prov}$ / $A_{s,req}$, ≤ 1.5	F3	1.02	-
Span/depth ratio limit	= F2 F3 K [11 + 1.5 √(fck) ρ0/ρ]	L/d_{lim}	18.8	-

6.6 < 18.8 :. OK

300 wide x 625 dp Reinforced Concrete Beam

(BS EN 1992-1-1:2004)

BEAM GEOMETRY

Beam span	Design span	L	4.0	m
Beam depth		d	625	mm
Beam width		b	300	mm
Cover	Assume 50mm cover	c	50	mm

MATERIAL PROPERTIES

Concrete Strength	C28/35	f_{ck}	28	N/mm²
Steel strength	High yield reinforcement	f_{yk}	500	N/mm²
Concrete Tensile Strength		f_{ctm}	2.80	N/mm²

DESIGN FORCES

Design Moment	*From Strand7 Analysis*	M_{Ed}	220	kNm
Design Shear	*From Strand7 Analysis*	V_{Ed}	220	kN

TENSION REINFORCEMENT

Reinforcement provide	Use 3no. H25 bars	$A_{s,prov}$	1473	mm²
Effective depth	= h - c - Ølinks - Øbar / 2	d	547	mm
K Factor	= M / b d² fck	K	0.088	-
	δ = 0.85 K < 0.168 :. No compression reinforcement req'd			
Lever arm	= 0.5 d [1 + √ (1 - 3.53K)], z < 0.95 d	z	500	mm
Min. reinforcement	= max [(0.26 fctm b d) / fyk ; 0.0013 b d]	$A_{s,min}$	239	mm²
Reinforcement require	= max [M / 0.87 fyk z ; $A_{s,min}$] , < 0.04 b h	$A_{s,req}$	1011	mm²

$A_{s,prov}$ > As,req :. OK

SHEAR REINFORCEMENT

Design shear stress	= V_{Ed} / 0.9 d b	v_{Ed}	1.491	N/mm²
Strut capacity	cotθ = 2.5	$v_{Rd,max\ c}$	3.430	N/mm²
	cotθ = 1.0	$v_{Rd,max\ c}$	4.970	N/mm²
	v_{Ed} < nax cotθ=2.5 :. cotθ = 2.5			
Strut angle	minimum strut angle (cotθ=2.5)	θ	21.80	°
Max link spacing	= 0.75 d	s_{max}	410	mm
Shear links required	= v_{Ed} b / (0.87 f_{yk} cotθ)	A_{sw} / s	0.41	mm
Shear links required	= v_{Ed} b s_{max} / (0.87 f_{yk} cotθ)	A_{sw}	169	mm
Shear links provided	Use 2no H16 link legs	$A_{sw,prov}$	402	mm²
Spacing required	= min($A_{sw,prov}$/(A_{sw}/s) , s_{max})	s	400	mm

$A_{sw,prov}$ > A_{sw} :. OK

s < s_{max} :. OK

DEFLECTION

Required reinforcemen	= As / b d	ρ	0.003	-
Reference ratio	= √ f_{ck} / 1000	$ρ_0$	0.005	-
System factor	Simply supported beam	K	1.0	-
Factor 2	n/a	F2	1.0	-
Factor 3	= $A_{s,prov}$ / $A_{s,req}$, ≤ 1.5	F3	1.46	-
Span/depth ratio limit	= F2 F3 K [11 + 1.5 √(fck) ρ0/ρ + 3.2 √(fck) (ρ0/ρ -1)^1.5]	L/d_{lim}	53.9	-

7.3 < 53.9 :. OK

STRUCTURE WORKSHOP	PROJECT	99 Frognal	PROJECT NO	23020	DATE	31/07/2023
	TITLE	RC Beam B.21.01 (C)	SHEET NO	35	ENG	AH

300 wide x 625 dp Reinforced Concrete Beam

(BS EN 1992-1-1:2004)

BEAM GEOMETRY

Beam span	Design span	L	5.0	m
Beam depth		d	625	mm
Beam width		b	300	mm
Cover	Assume 50mm cover	c	50	mm

MATERIAL PROPERTIES

Concrete Strength	C28/35	f_{ck}	28	N/mm²
Steel strength	High yield reinforcement	f_{yk}	500	N/mm²
Concrete Tensile Strength		f_{ctm}	2.80	N/mm²

DESIGN FORCES

Design Moment	$wl^2/8$	M_{Ed}	345	kNm
Design Shear	wl/2	V_{Ed}	276	kN

TENSION REINFORCEMENT

Reinforcement provide	Use 6no. H20 bars	$A_{s,prov}$	1885	mm²
Effective depth	= d - c - Ølinks - Øbar - max(25mm ; Øbar)/2 changed for double layer	d	527	mm
K Factor	= M / b d² fck	K	0.148	-
	δ = 0.85 K < 0.168 :. No compression reinforcement req'd			
Lever arm	= 0.5 d [1 + √ (1 - 3.53K)], z < 0.95 d	z	445	mm
Min. reinforcement	= max [(0.26 fctm b d) / fyk ; 0.0013 b d]	$A_{s,min}$	230	mm²
Reinforcement require	= max [M / 0.87 fyk z ; $A_{s,min}$] , < 0.04 b h	$A_{s,req}$	1781	mm²

$A_{s,prov}$ > As,req :. OK

SHEAR REINFORCEMENT

Design shear stress	= V_{Ed} / 0.9 d b	v_{Ed}	1.940	N/mm²
Strut capacity	cotθ = 2.5	$v_{Rd,max\ c}$	3.430	N/mm²
	cotθ = 1.0	$v_{Rd,max\ c}$	4.970	N/mm²
	v_{Ed} < nax cotθ=2.5 :. cotθ = 2.5			
Strut angle	minimum strut angle (cotθ=2.5)	θ	21.80	°
Max link spacing	= 0.75 d	s_{max}	395	mm
Shear links required	= v_{Ed} b / (0.87 f_{yk} cotθ)	A_{sw} / s	0.54	mm
Shear links required	= v_{Ed} b s_{max} / (0.87 f_{yk} cotθ)	A_{sw}	211	mm
Shear links provided	Use 4no H16 link legs	$A_{sw,prov}$	804	mm²
Spacing required	= min($A_{sw,prov}$/(A_{sw}/s) , s_{max})	s	350	mm

$A_{sw,prov}$ > A_{sw} :. OK

s < s_{max} :. OK

DEFLECTION

Required reinforcemen	= As / b d	ρ	0.005	-
Reference ratio	= √ f_{ck} / 1000	$ρ_0$	0.005	-
System factor	Simply supported beam	K	1.0	-
Factor 2	n/a	F2	1.0	-
Factor 3	= $A_{s,prov}$ / $A_{s,req}$, ≤ 1.5	F3	1.06	-
Span/depth ratio limit	= F2 F3 K [11 + 1.5 √(fck) ρ0/ρ]	L/d_{lim}	19.9	-

9.5 < 19.9 :. OK

300 wide x 825 dp Reinforced Concrete Beam (BS EN 1992-1-1:2004)

BEAM GEOMETRY

Beam span	Design span	L	6.6	m
Beam depth		d	825	mm
Beam width		b	300	mm
Cover	Assume 50mm cover	c	50	mm

MATERIAL PROPERTIES

Concrete Strength	C28/35	f_{ck}	28	N/mm²
Steel strength	High yield reinforcement	f_{yk}	500	N/mm²
Concrete Tensile Strength		f_{ctm}	2.80	N/mm²

DESIGN FORCES

Design Moment	ULS	M_{Ed}	692	kNm
Design Shear	ULS	V_{Ed}	433	kN

TENSION REINFORCEMENT

Reinforcement provide	Use 6no. H25 bars	$A_{s,prov}$	2945	mm²
Effective depth	= d - c - Ølinks - Øbar - max(25mm ; Øbar)/2 changed for double layer	d	722	mm
K Factor	= M / b d² fck	K	0.158	-
	δ = 0.85 K < 0.168 :. No compression reinforcement req'd			
Lever arm	= 0.5 d [1 + √ (1 - 3.53K)], z < 0.95 d	z	600	mm
Min. reinforcement	= max [(0.26 fctm b d) / fyk ; 0.0013 b d]	$A_{s,min}$	315	mm²
Reinforcement require	= max [M / 0.87 fyk z ; $A_{s,min}$] , < 0.04 b h	$A_{s,req}$	2648	mm²

$A_{s,prov}$ > As,req :. OK

SHEAR REINFORCEMENT

Design shear stress	= v_{Ed} / 0.9 d b	v_{Ed}	2.224	N/mm²
Strut capacity	cotθ = 2.5	$v_{Rd,max\ c}$	3.430	N/mm²
	cotθ = 1.0	$v_{Rd,max\ c}$	4.970	N/mm²
	v_{Ed} < nax cotθ=2.5 :. cotθ = 2.5			
Strut angle	minimum strut angle (cotθ=2.5)	θ	21.80	°
Max link spacing	= 0.75 d	s_{max}	541	mm
Shear links required	= v_{Ed} b / (0.87 f_{yk} cotθ)	A_{sw} / s	0.61	mm
Shear links required	= v_{Ed} b s_{max} / (0.87 f_{yk} cotθ)	A_{sw}	332	mm
Shear links provided	Use 2no H16 link legs	$A_{sw,prov}$	402	mm²
Spacing required	= min($A_{sw,prov}$/(A_{sw}/s) , s_{max})	s	500	mm

$A_{sw,prov}$ > A_{sw} :. OK

s < s_{max} :. OK

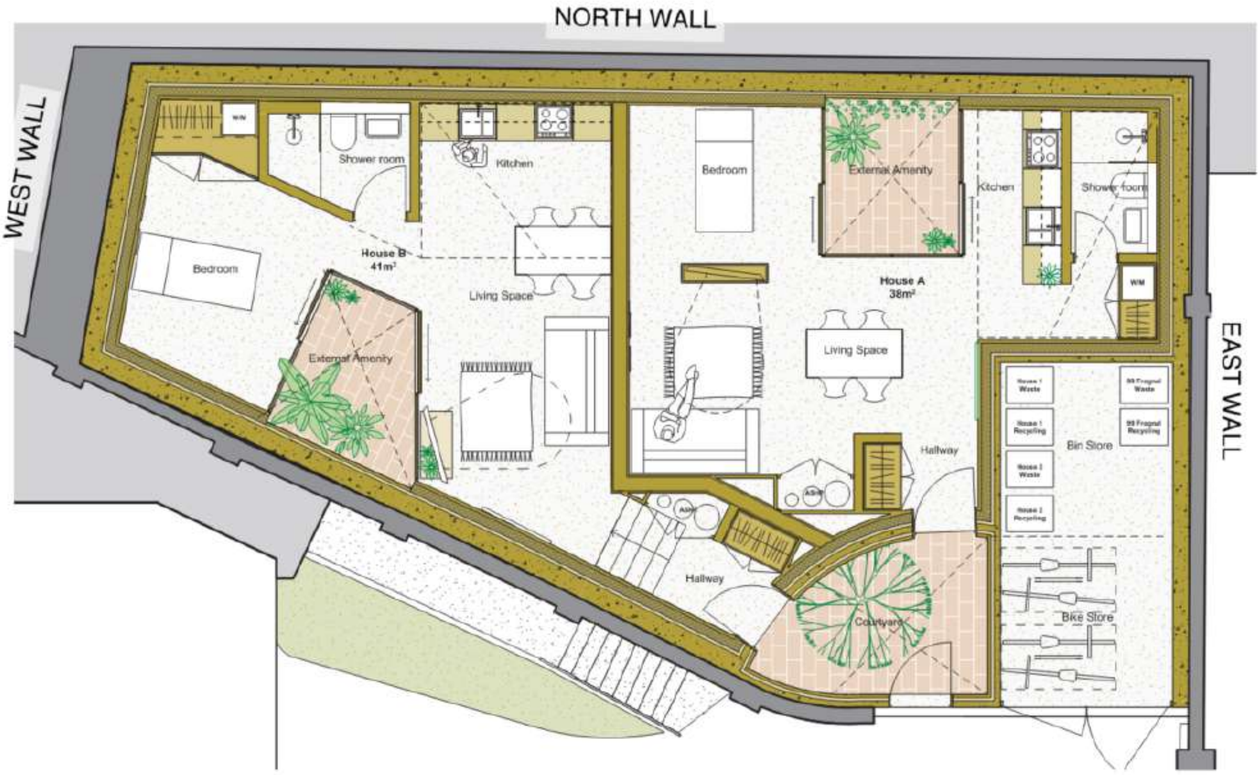
DEFLECTION

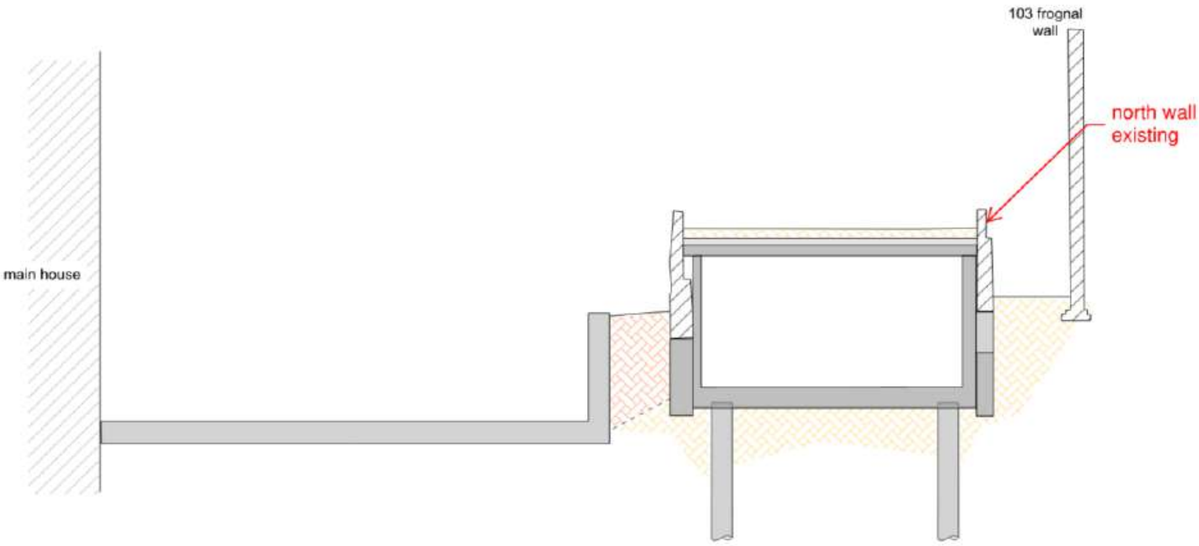
Required reinforcemen	= As / b d	ρ	0.004	-
Reference ratio	= √ f_{ck} / 1000	ρ_0	0.005	-
System factor	Simply supported beam	K	1.0	-
Factor 2	n/a	F2	1.0	-
Factor 3	= $A_{s,prov}$ / $A_{s,req}$, ≤ 1.5	F3	1.11	-
Span/depth ratio limit	= F2 F3 K [11 + 1.5 √(fck) ρ0/ρ + 3.2 √(fck) (ρ0/ρ -1)^1.5]	L/d_{lim}	24.3	-

9.1 < 24.3 :. OK

STRUCTURE WORKSHOP	PROJECT	99 Frognal	PROJECT NO	23020	DATE	12/09/2023
	TITLE	Garage Houses - Retaining Walls	SHEET NO	37	ENG	AH

GARAGE HOUSES





STRUCTURAL DESCRIPTION

Existing brick retaining walls on north, east & west are proposed to be underpinned in two vertical lifts to enable excavation.

New RC retaining wall to be built inside existing wall to provide permant resistance to retaining forces.

Permanent propping to new retaining wall provided at top and bottom of wall by new slabs.

New walls designed to resist surcharge from adjacent soil and structures, and hydrostatic pressures from groundwater at ground level.

Refer to assumed sequence of works. Temporary propping and underpinning to Contractor design

EXISTING CONDITION

NORTH WALL

GEOMETRY

Height of retained earth		h_s	2.5	m
Height of water	Assume water at ground level	h_w	2.5	m
Height of stem		l	3.1	m
Wall thickness		t	300	mm
Main diameter		dia	20	mm
Main bar centres	s < min(3h ; 400) **OK**	s	200	mm
Cover		c_{nom}	50	mm
Width	Calculation per m length of wall	b	1000	mm
Effective depth		d	240	mm
Area of steel per m length of wall	**OK**	As	1,571	mm^2
Minimum reinf.	0.4% Ac *(p. 141)*	A_s min	1,200	mm^2
Maximum reinf.	4% Ac *(p. 141)*	A_s max	12,000	mm^2

MATERIAL PROPERTIES

Soil Unit Weight		γ_{sat}	19	kN/m^3
Friction angle		ϕ'	24	°
Cohesion		c'	0	
Ko coefficient	Ko = (1 - sin φ)	Ko	0.5933	
Water Unit Weight		γ_w	9.81	kN/m^3
Submerged Soil Unit Weight		γ_{sub}	9.19	kN/m^3
RC Concrete Unit Weight		γ_{conc}	25.0	kN/m^3
Concrete Strength	C28/35	fcu	35	N/mm2
Steel Strength		fyk	500	N/mm2

DESIGN LOADS

AXIAL LOADING	Factored ROOF 4 load, assume 3m width acting.	N_{Ed}	**60.1**	**kN/m**

SURCHARGE

Surcharge pressure from neighbouring footing, w2

Area/Element	Width/Height	Dead Load	Live Load		Dead	Live	Total	Units
	m	kN/m^2	kN/m^2		Gk	Qk	Σ	
330 Brick Wall	12.00	8.40	0.00		100.8	0.0		
Footings	1.00	10.08	0.00		10.1	0.0		
Roof	4.50	0.90	0.60		4.1	2.7		
Ground Floor	4.50	1.05	1.50		4.7	6.8		
1st Floor	4.50	1.05	1.50		4.7	6.8		
2nd Floor	4.50	1.05	1.50		4.7	6.8		
				TOTAL	28.3	23.0	51.26	kN/m

SURCHARGE

Neighbour footing pressure	= w x K	q	30.41	kN/m^2
Distance of Neighbours		x	2.3	m
Path Surcharge	= 10 kN/m^2	w	10.0	kN/m^2
Path Pressure	= w x K	q	5.93	kN/m^2
Total surcharge pressure on wall			36.34	kN/m^2
Wall Moment	From strand	M_q	40.44	kNm/m

EARTH PRESSURE

Pressure at base of wall	= γ_{sub} x K_a x h_s	q_s	13.63	kN/m^2
Active Force	= q_s x l /2	P_s	17.04	kN/m
Wall moment	From strand	M_s	7.00	kNm/m

WATER PRESSURE

Pressure at base of wall	= γ_w x h_w	qw	24.53	kN/m^2
Force tri	= q_w x l /2	P_w	30.66	kN/m
Wall moment	From strand	M_w	12.59	kNm/m

ULTIMATE DESIGN MOMENT	M_T (ULS) = 1.5 x (M_w + M_s + M_w)	Mt ult	**90.0**	**kNm/m**

RC WALL CHECK

K	K = M / bd^2fck	K	0.045	
	K < 0.168 :. No compression reinforcement req'd			
z	= 0.5 d [1 + √ (1 - 3.53K)], z < 0.95 d	z	228	mm
Required reinforcement		As req	908	mm2/m
Provided reinforcement		As prov	1,571	mm2/m

PASS

SLENDERNESS

Effective height factor			0.95	
End condition at top			3	
End condition at bottom			2	
Effective height of wall		l_0	2.95	m
Slenderness factor	= 1.53 As fyk / 1000 t fck	ω	0.11	
	= 0.69 √[(1+2 ω)(1000 t fck) / NEd] ≥ 1.0	ξ	10.11	
smaller end moment		M1	-44.8	
larger end moment		M2	90.0	

l_0 / h = 9.817

4.38 (1.7 - M1 / M2) ξ = 97.2950875

l_0 / h < 4.38 (1.7 - M1 / M2) ξ

:. Wall isn't slender

EAST WALL

GEOMETRY

Height of retained earth		h_s	2.0	m
Height of water	Assume water at ground level following rainfall	h_w	2.0	m
Height of stem		l	3.1	m
Wall thickness		t	250	mm
Main diameter		dia	16	mm
Main bar centres	s < min(3h ; 400) **OK**	s	200	mm
Cover		c_{nom}	50	mm
Width	Calculation per m length of wall	b	1000	mm
Effective depth		d	192	mm
Area of steel per m length of wall	**OK**	As	1,005	mm^2
Minimum reinf.	0.4% Ac *(p. 141)*	A_s min	1,000	mm^2
Maximum reinf.	4% Ac *(p. 141)*	A_s max	10,000	mm^2

MATERIAL PROPERTIES

Soil Unit Weight		γ_{sat}	19	kN/m^3
Friction angle		ϕ'	24	°
Cohesion		c'	0	
Ko coefficient	Ko = (1 - sin φ)	Ko	0.593263357	
Water Unit Weight		γ_w	9.81	kN/m^3
Submerged Soil Unit Weight		γ_{sub}	9.19	kN/m^3
RC Concrete Unit Weight		γ_{conc}	25.0	kN/m^3
Concrete Strength	C28/35	fcu	35	N/mm2
Steel Strength		fyk	500	N/mm2

DESIGN LOADS

AXIAL LOADING	Factored line load w7. N_{Ed} = 1.35Gk + 1.5Qk (per m length)	N_{Ed}	**192.8**	**kN/m**

SURCHARGE

Driveway Surcharge	= 10 kN/m^2	w	10.0	kN/m^2
Drawiveway Pressure	= w x K	q	5.93	kN/m^2
Wall Moment	From strand	M_q	5.44	kNm/m

EARTH PRESSURE

Pressure at base of wall	= γ_{sub} x K_a x h_s	q_s	10.90	kN/m^2
Active Force	= q_s x l /2	P_s	10.90	kN/m
Wall moment	From strand	M_s	4.20	kNm/m

WATER PRESSURE

Pressure at base of wall	= γ_w x h_w	qw	19.62	kN/m^2
Force tri	= q_w x l /2	P_w	19.62	kN/m
Wall moment	From strand	M_w	7.57	kNm/m

ULTIMATE DESIGN MOMENT	M_T (ULS) = 1.5 x (M_w + M_s + M_w)	Mt ult	**25.8**	**kNm/m**

RC WALL CHECK

K	$K = M / bd^2 fck$	K	0.020	
	K < 0.168 :. No compression reinforcement req'd			
z	$= 0.5\ d\ [1 + \sqrt{(1 - 3.53K)}],\ z < 0.95\ d$	z	182	mm
Required reinforcement		As req	325	mm2/m
Provided reinforcement		As prov	1,005	mm2/m

PASS

SLENDERNESS

Effective height factor			0.95	
End condition at top			3	
End condition at bottom			2	
Effective height of wall		l_0	2.95	m
Slenderness factor	$= 1.53\ As\ fyk / 1000\ h\ fck$	ω	0.09	
	$= 0.69 \sqrt{[(1+2\omega)(1000\ h\ fck) / NEd]} \geq 1.0$	ξ	5.04	
smaller end moment		M1	-44.8	
larger end moment		M2	25.8	

l_0 / h 11.780

$4.38 (1.7 - M1 / M2)\ \xi =$ 75.83717033

$l_0 / h < 4.38 (1.7 - M1 / M2)\ \xi$

:. Wall isn't slender

WEST WALL

GEOMETRY

Height of retained earth			h_s	4.3	m
Height of water	Assume water at ground level following rainfall		h_w	4.3	m
Height of stem			l	3.1	m
Wall thickness			t	300	mm
Main diameter			dia	20	mm
Main bar centres	s < min(3h ; 400)	**OK**	s	200	mm
Cover			c_{nom}	50	mm
Width	Calculation per m length of wall		b	1000	mm
Effective depth			d	240	mm
Area of steel per m length of wall		**OK**	As	1,571	mm^2
Minimum reinf.	0.4% Ac *(p. 141)*		A_s min	1,200	mm^2
Maximum reinf.	4% Ac *(p. 141)*		A_s max	12,000	mm^2

MATERIAL PROPERTIES

Soil Unit Weight		γ_{sat}	19	kN/m^3
Friction angle		ϕ'	24	°
Cohesion		c'	0	
Ko coefficient	Ko = (1 - sin φ)	Ko	0.593263357	
Water Unit Weight		γ_w	9.81	kN/m^3
Submerged Soil Unit Weight		γ_{sub}	9.19	kN/m^3
RC Concrete Unit Weight		γ_{conc}	25.0	kN/m^3
Concrete Strength	C28/35	fcu	35	N/mm2
Steel Strength		fyk	500	N/mm2

DESIGN LOADS

AXIAL LOADING	Factored line load w7. N_{Ed} = 1.35Gk + 1.5Qk (per m length)	N_{Ed}	**192.8**	**kN/m**

SURCHARGE

Path Surcharge	= 10 kN/m^2	w	10.0	kN/m^2
Path Pressure	= w x K	q	5.93	kN/m^2
Wall Moment	From strand	M_q	7.12	kNm/m

EARTH PRESSURE

Pressure at base of wall	= γ_{sub} x K_a x h_s	q_s	23.44	kN/m^2
Active Force	= q_s x l /2	P_s	50.40	kN/m
Wall moment	From strand	M_s	18.68	kNm/m

WATER PRESSURE

Pressure at base of wall	= γ_w x h_w	qw	42.18	kN/m^2
Force tri	= q_w x l /2	P_w	90.69	kN/m
Wall moment	From strand	M_w	38.57	kNm/m
ULTIMATE DESIGN MOMENT	M_T (ULS) = 1.5 x (M_w + M_s + M_w)	Mt ult	**96.6**	**kNm/m**

RC WALL CHECK

K	$K = M / bd^2 f_{ck}$	K	0.048	
	K < 0.168 :. No compression reinforcement req'd			
z	$= 0.5\,d\,[1 + \sqrt{(1 - 3.53K)}]$, $z < 0.95\,d$	z	228	mm
Required reinforcement		As req	974	mm2/m
Provided reinforcement		As prov	1,571	mm2/m

PASS

SLENDERNESS

Thickness and axial loading same as North Wall :. not slender

APPENDIX D

INTERPRETIVE REPORT BY A2 SITE INVESTIGATION

APPENDIX E

BASEMENT IMPACT ASSESSMENT BY A2 SITE INVESTIGATION