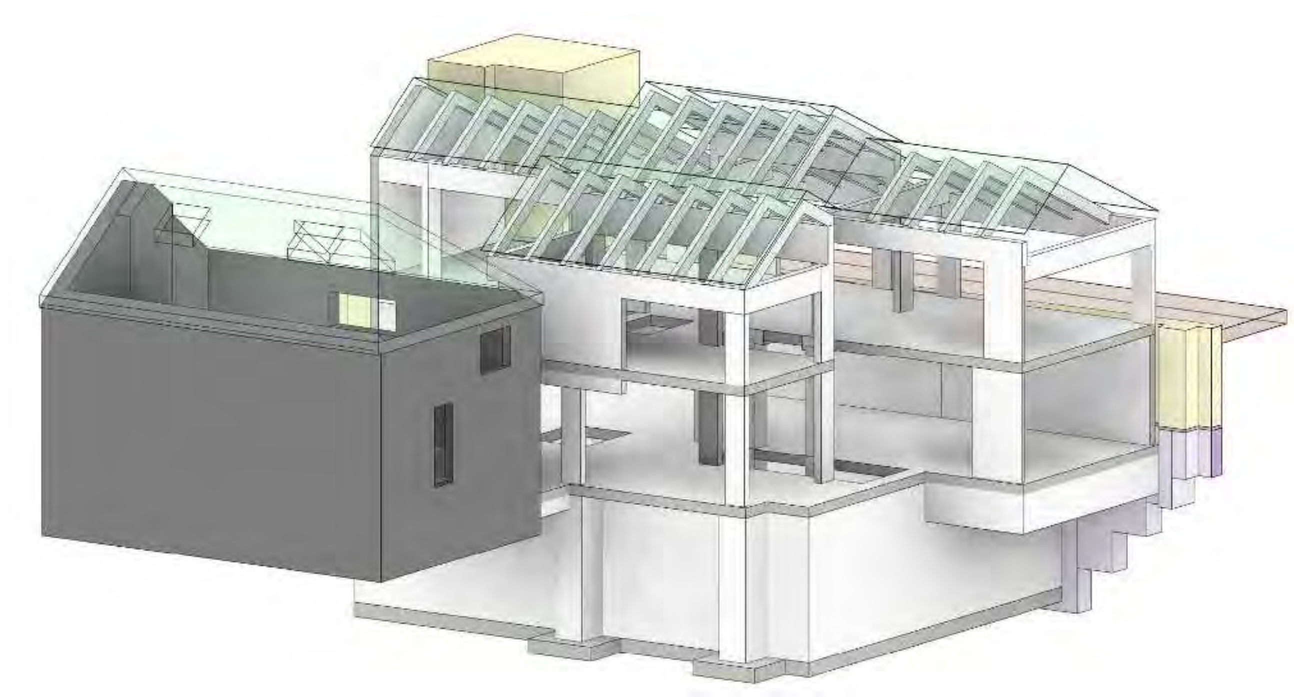
1 Steele's Studios, Haverstock Hill, London NW3 4RN
Structural Engineers Report



Issue 2

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Contents

1 Introduction

1.1 Client Brief

Eckersley O'Callaghan have been asked to provide a Structural Engineers Report (SER) and design information to consider the construction aspects of the proposed development at 1 Steele's Studios, Haverstock Hill, London, NW3 4RN. The proposed residential dwelling comprises one new-build house in place of the existing buildings at the urban site, adjacent to a retained annexe building to the rear corner of the site. The proposed house comprises a 2-storey high reinforced concrete frame with a partial basement.

In support of the pre-application this SER has been compiled in association with a Basement Impact Assessment (BIA) to include physical site investigations, factual geotechnical report and ground movement assessment to meet the requirements of the London Borough of Camden's planning policy criteria for new basement developments.

This report has been prepared in line with the planning policies of LBC Supplementary Planning Documents. The report provides details of the permanent and temporary works and construction techniques, including details of the potential impact of the subterranean development on the existing and neighbouring structures, based on the specific site characteristics, geology and hydrogeology. The ground investigations were carried out in January 2018 and the geotechnical interpretive report and ground movement assessment reports were completed and submitted under a separate cover by Soil Technics Ltd.

1.2 Camden Basement Development Policy

As stated in Camden Development Policy A5 "The Council will only permit basement development where it is demonstrated to its satisfaction that the proposal would not cause harm to:

— neighbouring properties;
— the structural, ground, or water conditions of the area;
— the character and amenity of the area;
— the architectural character of the building; and
— the significance of heritage assets. "

The discussions within this report are based on the consideration of the following LBC policy documents:

— Camden Local Plan 2017
— Camden Planning Guidance for Basements adopted March 2018
— Basement Impact Assessments: Defining the scope of Engineering input (Guidance note 1v0)

1.3 Supporting Documents & Camden Requirements Matrix

In support of this structural report the following supplementary documents have been commissioned and submitted separately:

— Basement Impact Assessment (BIA) by Soil Technics Ltd (R-STQ4296-BIA)
— Ground Investigation Report (GIR) by Soil Technics Ltd (R-STQ4296-G01)

The following table denotes the BIA and SER requirements and where they have been responded to within the submitted material:

Itemised requisites from Camden Scoping Document – "Defining the Scope of Engineering Input" *A Structural Engineering Report should contain…*	**Where this is provided within this report or other supplementary reports**
a. An appraisal of the arrangement of the site and host structure (where present) including any previous alterations, obvious defects, its relationship (or that of the site if vacant) with adjoining buildings and their condition.	The new building is to replace the existing and therefore the appraisal of previous alterations is unnecessary. Details of existing site and boundary conditions are discussed in Section 2.0 of this report.
b. Relevant drawings to show the relationships to the basement of the ground conditions and groundwater, existing trees and infrastructure and how they are addressed in design.	Borehole logs, ground conditions and groundwater level and indicated within sectional views and supplementary reports by Soil Technics Ltd
c. Outline scheme sketches and layouts indicating basic proposals, general layout and preliminary sizing of primary structural elements.	Outline Scheme sketches are included in Appendix C and and within the body of the text of this report.
d. Sketch layouts of structural solution in plan and section for critical elements of the building.	Structural layouts are included in Appendix C and and within the body of the text of this report.
e. Foundation types and size estimates, including verification of an adequate bearing stratum and measures to deal with hydrostatic and/or heave pressures where relevant.	Foundation Sketches are included in Appendix C and and within the body of the text of this report.
f. Requirements for retaining walls, including drawings of underpinning, piling etc. and supporting outline calculations with assumptions clearly stated.	Sketches and Calcs included in Appendix C
g. Assessment of expected ground movements (short and long term) using analytical or empirical means, and how these will affect adjoining or adjacent properties. The design shall limit damage to all buildings to a maximum of Burland Category 1 as set out in CIRIA SP200 Tables 3.1 & 3.2.	Included within BIA by Soil Technics – all burland assessments have been proven to fall within categories 0 and 1 and therefore meet the CPG policies.
h. Details of sequences of construction and temporary propping to demonstrate how movements and building damage will be restricted to those predicted.	Included in Section 3 and 4 of this report and also within Soil Technics BIA Report
i. An outline monitoring strategy to ensure movements are limited to those predicted.	Included in Section 5 of this report
j. Proposals to deal with groundwater during construction and in the permanent condition (where relevant).	Groundwater mitigation strategies are not relevant to this development as the basement is seated within a cohesive non-productive layer of clay which does not comprise groundwater.
k. External drainage layouts showing primary routes and proposals for Sustainable Urban Drainage Systems (SUDS).	Included in Section 3 of this report
l. Details of risk from surface water, sewer and groundwater flooding and how this is addressed in the design (where basement is in flood risk/Critical Drainage area).	Included within the BIA by Soil Technics Ltd
m. Utilities plans and confirmation of consultation with relevant asset owners (where required).	Included within the BIA by Soil Technics Ltd

In order to ensure that a BIA can be demonstrated to comply with the Camden Planning Guidance (CPG), it is recommended that the Structural Engineer's report (SER) is presented as part of a planning application. It may be a standalone document, or may form part of the BIA report.	This document is to be read in conjunction with the BIA and GIR reports provided separately by Soil Technics Ltd.
The SER should demonstrate that the engineering design has been advanced to concept design stage (RIBA Stage 2) as a minimum.	The enclosed information has been developed in line with the RIBA Stage 2 plan of work 2013 to enable preparation of Concept Design, including outline proposals for structural design, outline specifications and preliminary Cost Information along with relevant Project Strategies.
Relevant drawings should be provided to show how the designers have addressed ground conditions and groundwater, existing trees and infrastructure, drainage, flooding, vertical and horizontal loading, structural engineering general arrangement and details, requirements for underpinning, piling and/or other below ground works.	Section drawings are included both within the text of this report and within Appendix C. Supplementary design information and advice has also been sought from the BIA reports.
It should be noted that the services and deliverables are site specific.	The submitted reports have been based on site specific geotechnical information.
Reference should be made to Camden's planning guidance to understand the full requirements of the BIA process.	The full set of LBC requirements have been reviewed in the development of this planning report submittal.

2 Existing Conditions

2.1 Site Access & Existing Buildings

There is one main vehicular entrance to the site from Haverstock Hill to the northeast which will be required during the proposed works. The existing site contains several small buildings linked across site footprint in traditional load bearing masonry and timber floor joists and rafters. These buildings appear to have been first developed around the time of WWII as they are first recorded on the Ordnance Survey in 1953-54.

2.2 Neighbouring Buildings

The adjoining and surrounding buildings forming the remaining 'Steele's Studios' address appear to have been developed prior to our site and are similarly of traditional load bearing masonry and timber roofs and floors over one and two storeys in height.

Figure 2 Existing Site Plan

2.3 Existing Conditions

Borehole logs available in Soil Technics Report indicate the following subsoil strata generally as follows:

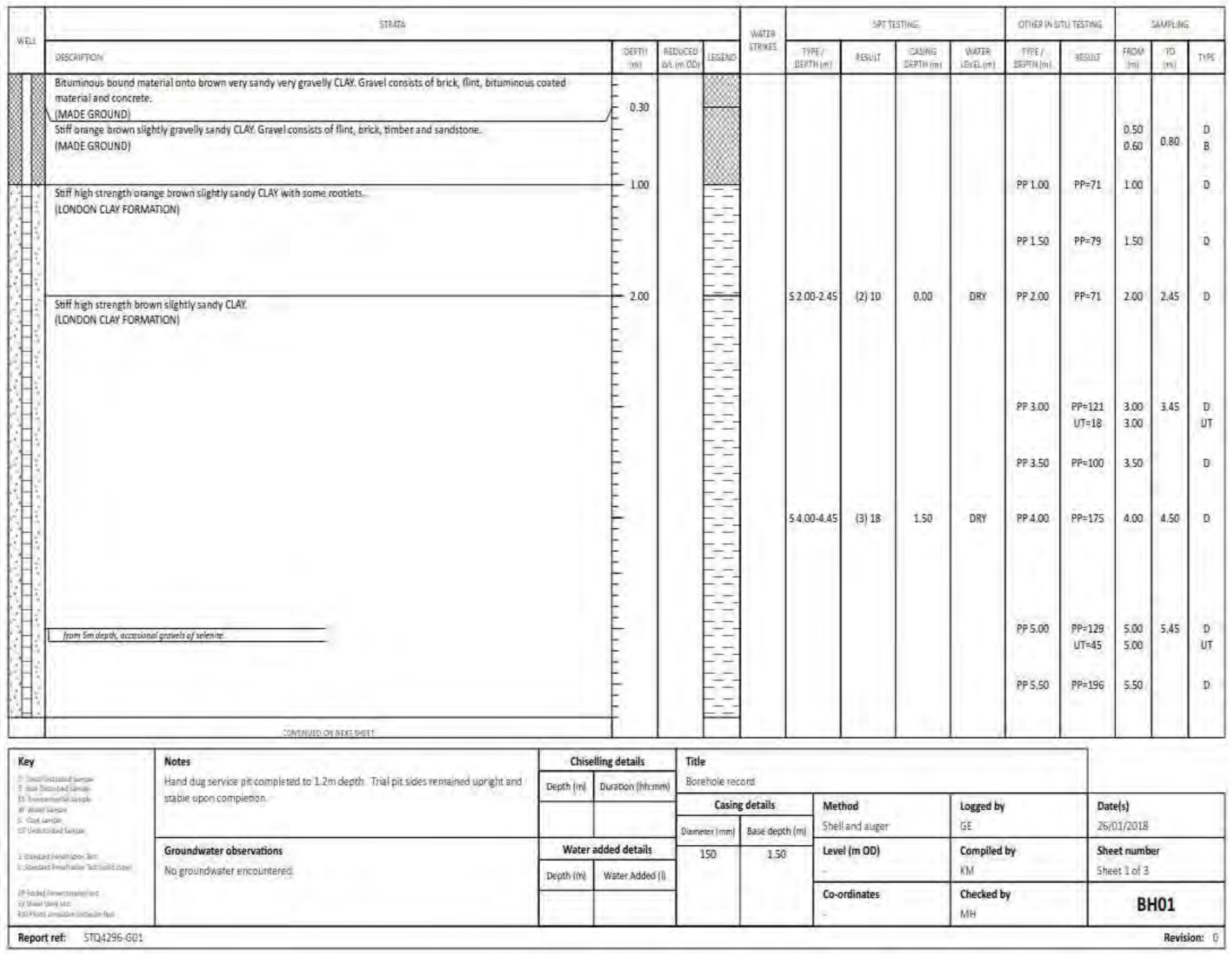
0.0 - 1m of Made Ground,

1m - 2m Stiff high strength orange brown slightly sandy CLAY,

2m - and beyond Stiff high strength brown slightly sandy CLAY (London Clay Formation)

Standpipes were installed within all boreholes identifying Groundwater has been measured at depths of between 0.82m and 7.40m. However, based on recharge testing, this water is not considered representative of a continuous water table at the site.

Three trial pits were completed and are logged within both BIA and GIR reports.



soiltechnics
environmental and geotechnical consultants

Description (Strata)	Depth (m)	Reduced lvl (m OD)	Water strikes	SPT type / depth (m)	SPT result	Casing depth (m)	Water level (m)	Other in situ type / depth (m)	Result	Sampling from (m)	To (m)	Type
Bituminous bound material onto brown very sandy very gravelly CLAY. Gravel consists of brick, flint, bituminous coated material and concrete. (MADE GROUND)	0.30											
Stiff orange brown slightly gravelly sandy CLAY. Gravel consists of flint, brick, timber and sandstone. (MADE GROUND)										0.50	0.80	D
										0.60		B
Stiff high strength orange brown slightly sandy CLAY with some rootlets. (LONDON CLAY FORMATION)	1.00							PP 1.00	PP=71	1.00		D
								PP 1.50	PP=79	1.50		D
Stiff high strength brown slightly sandy CLAY. (LONDON CLAY FORMATION)	2.00			S 2.00-2.45	(2) 10	0.00	DRY	PP 2.00	PP=71	2.00	2.45	D
								PP 3.00	PP=121	3.00	3.45	D
									UT=18	3.00		UT
								PP 3.50	PP=100	3.50		D
				S 4.00-4.45	(3) 18	1.50	DRY	PP 4.00	PP=175	4.00	4.50	D
from 5m depth, occasional gravels of selenite.								PP 5.00	PP=129	5.00	5.45	D
									UT=45	5.00		UT
								PP 5.50	PP=196	5.50		D

CONTINUED ON NEXT SHEET

Notes: Hand dug service pit completed to 1.2m depth. Trial pit sides remained upright and stable upon completion.

Groundwater observations: No groundwater encountered.

Chiselling details: Depth (m) | Duration (hh:mm)

Water added details: Depth (m) | Water Added (l)

Title: Borehole record

Casing details: Diameter (mm) 150 | Base depth (m) 1.50

Method: Shell and auger | **Logged by:** GE | **Date(s):** 26/01/2018

Level (m OD): - | **Compiled by:** KM | **Sheet number:** Sheet 1 of 3

Co-ordinates: - | **Checked by:** MH | **BH01**

Report ref: STQ4296-G01 **Revision:** 0

Figure 3 Site Specific Borehole Records Extracted from Soil Technics Report – BH01 Sheet 1

2.4 Existing Below Ground Drainage and Public Sewers

Drainage records for the surrounding streets have been obtained from Thames Water records department and are shown adjacent. These indicate that there exists a parallel public sewer running s across the yard of Stanbury Court to the north of our site towards Haverstock Hill and our site drainage separately discharges to the southeast along Steeles Mews North.

A site wide cctv drainage survey was carried out in 2018 to establish the existing condition and the invert levels to the existing combined below ground drainage system. Much of the existing basement drainage will be reconfigured due to the proposed new facilities on the site incorporating sustainable urban drainage systems and separating the existing combined system in line with Thameswater SUDs requirements.

2.5 Existing Hydrogeology & Hydrology

Hydrology and hydrogeology is covered separately in the reports provided by Soil Technics (BIA and GIR).

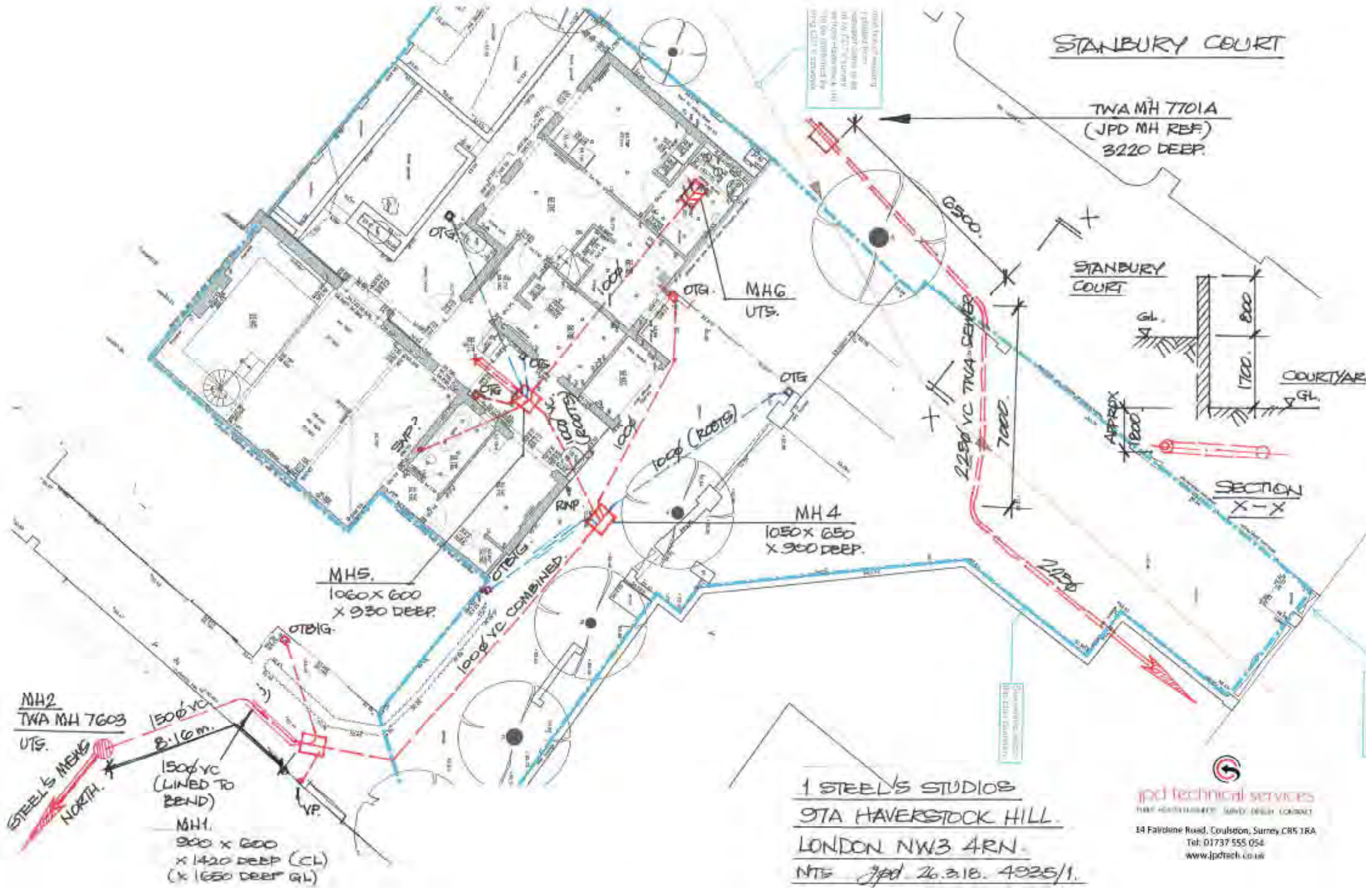


Figure 4 CCTV survey Information from JPD Technical Ltd

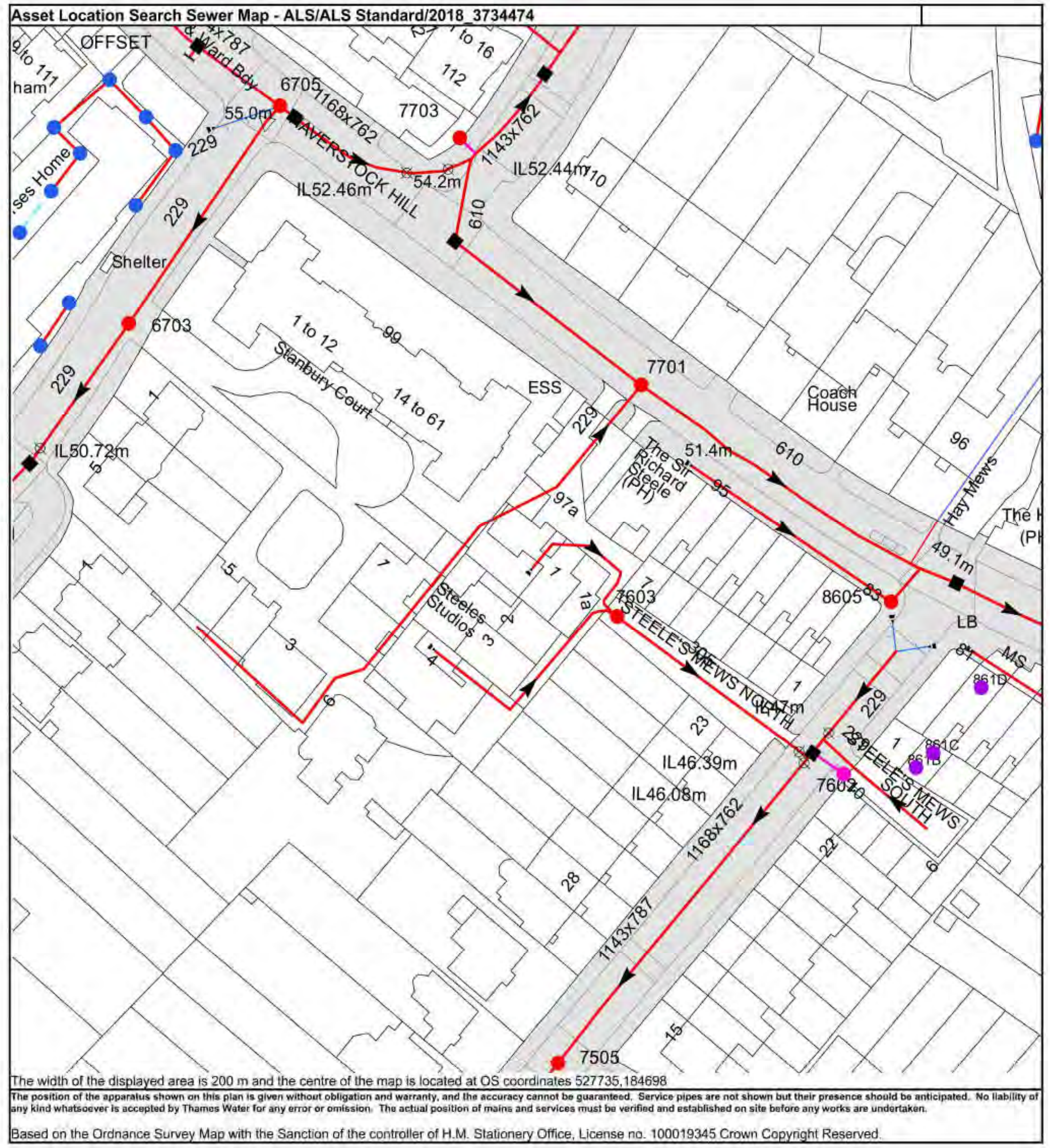


Figure 5 Existing Public Sewer Record Extract - Thames Water 2018

3 Overall Structural Proposals

3.1 Proposed Development

The structural proposals are described in detail on the drawings in Appendix C. These should be read in conjunction with the Architect's drawings and those of other consultants. The following sections summarise structural proposals and describe the approach to the existing neighbouring structures. The new building will comprise an in-situ concrete frame forming the basement box, the upper floors as well as the double pitched roof with a series of reinforced concrete cranked beams.

The existing annexe building will be retained entirely (shown in darker grey in the below isometric view), and some crack stitch repair work is required to stabilise the existing gable end walls. The surrounding boundary/party walls will be underpinned where necessary to allow excavations to progress.

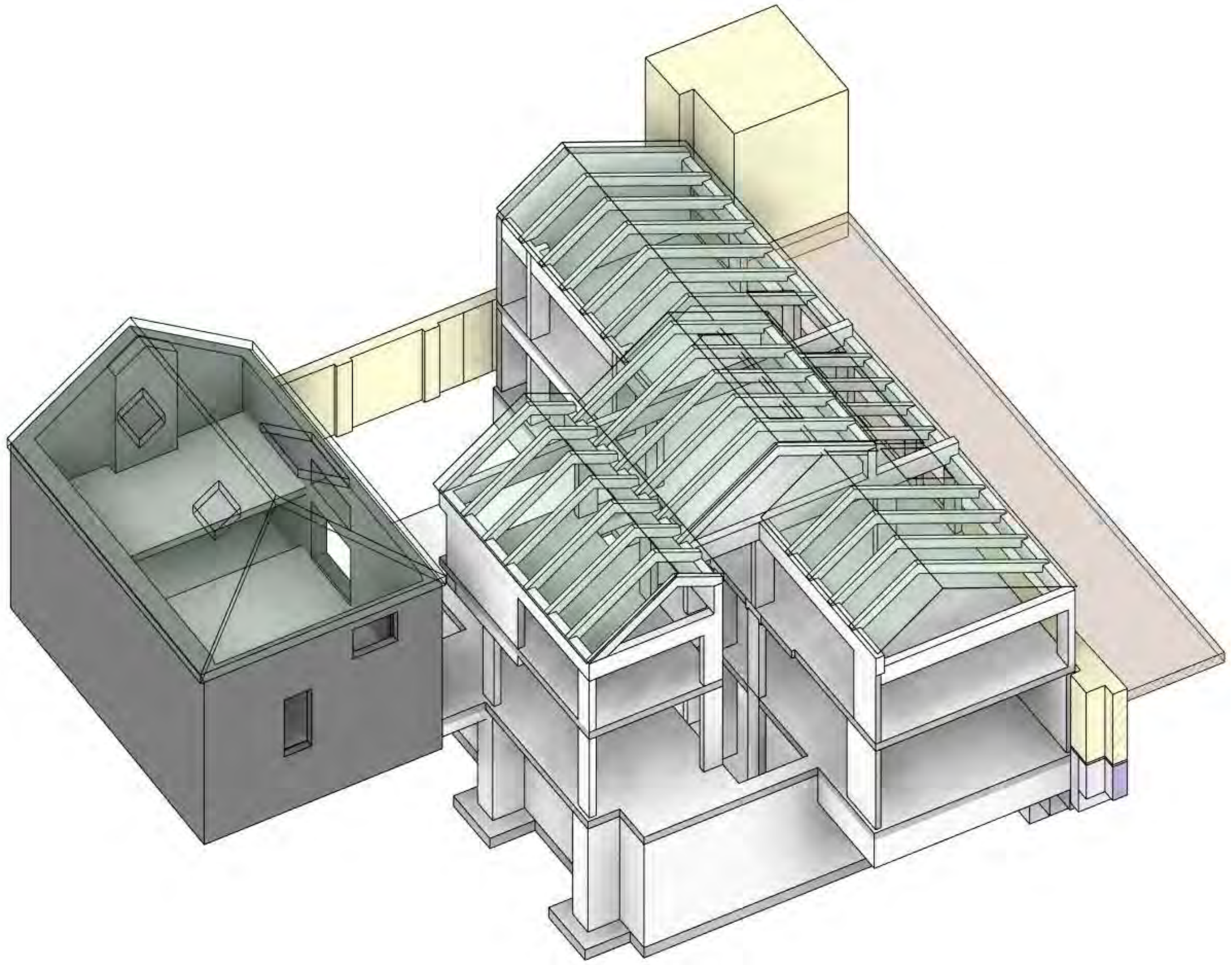


Figure 6 Isometric View Showing Proposed Structural Framing and Groundworks Basement Box Construction

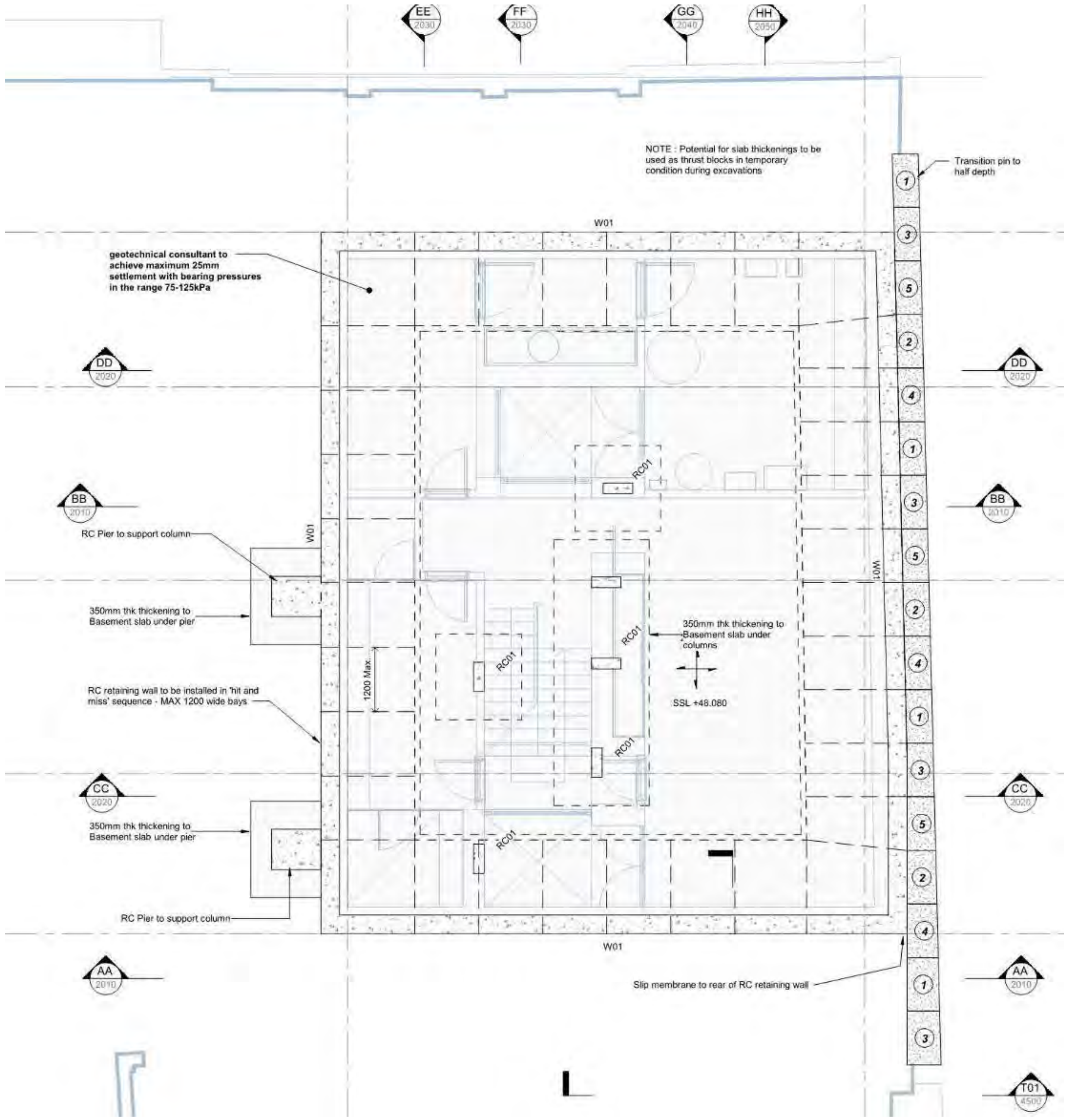


Figure 7 Plan of basement structure

3.2 Basement Construction & Waterproofing

Perimeter boundary and party walls will be underpinned where necessary. Internally to the underpins a reinforced concrete liner wall will be cast inboard with a slip joint placed against the rear face of the wall stem. The liner wall will contain a waterproofing additive which will provide one permanent layer of defence against water ingress into the basement. A secondary waterproofing system will be provided in the form of either a drained cavity system or an external tanking system applied to the external line of the liner wall prior to pouring concrete.

The basement slab is designed as suspended, spanning between slab thickenings, in order to accommodate the heave from the unloading of the underlying London Clay. A void-former will be positioned underneath the suspended slab to allow for the heave movement associated with the relief of overburden pressures and the vertical gravity load acting around the perimeter walls will act in resistance to the uplift pressures associated with overburden relief.

3.3 Foundations

Boreholes have confirmed the geology at the site as London clay from a shallow to significant depth. The proposed building will be founded for the most part at a depth of approximately 4m below ground level. The load path is taken down to a greater depth than the current condition and therefore will be less susceptible to movements associated with volume change. Soil Technics have confirmed allowable bearing pressures 175kN/m below retaining walls and between 90-140 kN/m for shallow spread foundations of varying widths.

3.4 Retaining Walls

Horizontal earth pressures are resisted by the retaining walls spanning between basement and ground floor slab level. Horizontal reactions are resisted by diaphragm action in the floor slabs transferred into the opposing walls of the basement.

3.5 Lateral Stability

Stability of the new building is provided by diaphragm action in the floor slabs transferring horizontal loads into the concrete shear walls which extend down to the basement level walls and foundations and in-turn into the underlying soil.

The new building is formed against the perimeter retaining walls and in close proximity to adjoining buildings and will therefore require a slip joint to avoid imparting any drawdown effects to the surround structures.

3.6 Superstructure

The in-situ concrete construction of the upper levels continues the material approach of the building. It provides efficient thin floors with inherent soundproofing for the residential dwelling. Both ground and first floor slabs are designed as 250mm thick reinforced concrete flat slabs spanning approximately 5 meters, supported by external RC walls or internal columns. In addition, a series of transfer beams have been introduced to support the floor and columns over column-free areas such as the long-glazed bay to the South West corner of the building over which a transfer beams spans approximately 8m.

The façade comprises brick infill panels tied back to a metal stud or blockwork inner leaf to be determined at the next stage. The duo-pitch roof comprises a series of exposed reinforced concrete cranked beams at typically 2m centres, spanning between primary beams framed around the perimeter. The infill panels of the roof have not been detailed yet but are currently assumed to be precast plank with a structural topping poured on top to ensure diaphragm action and tying of the roof with the primary support elements.

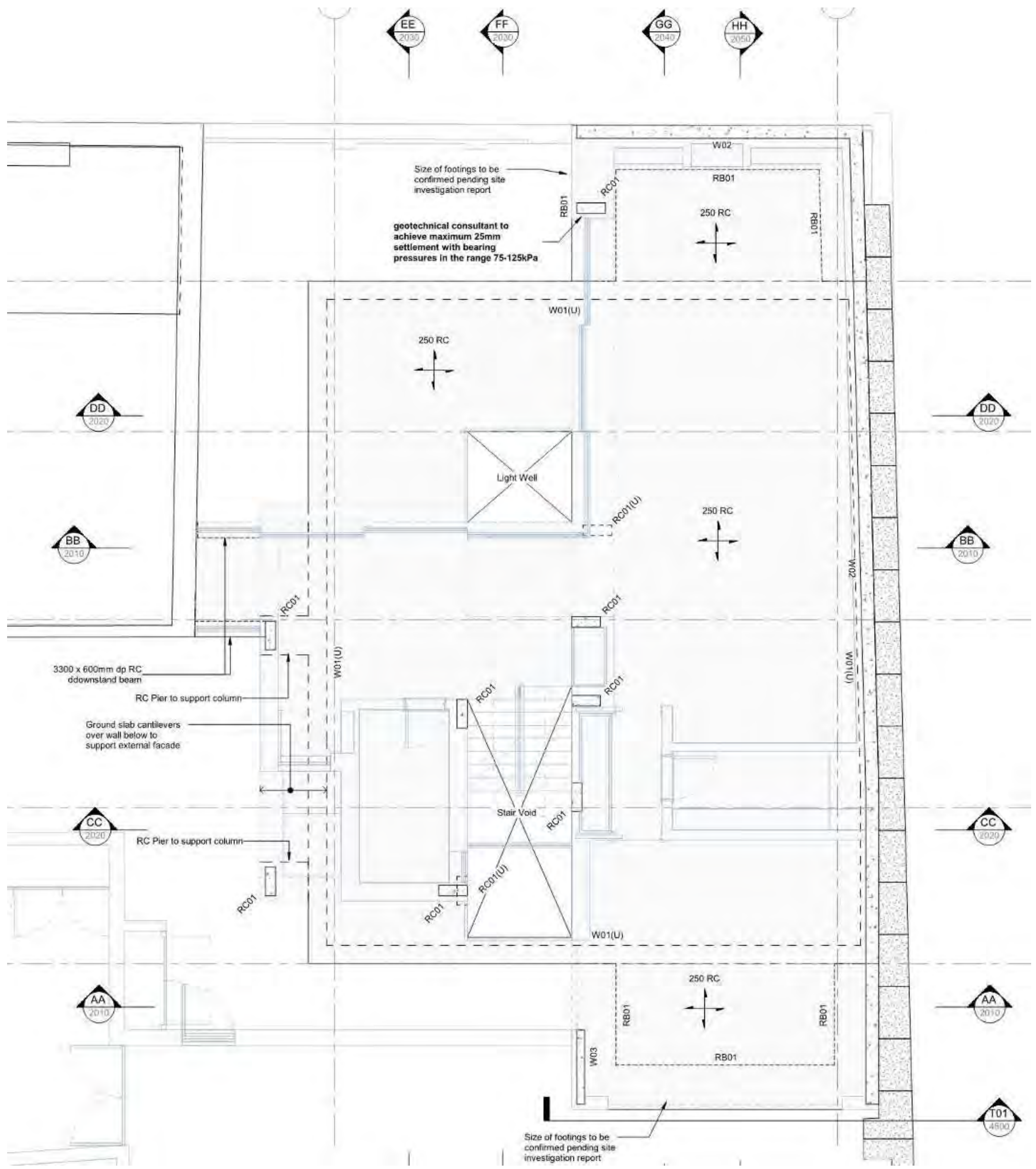


Figure 8 Plan of ground floor structure

3.7 Works to Party Walls

The existing perimeter and site boundary walls are to be retained and will need to be underpinned to enable the basement excavations to progress across the site. A concrete liner wall will be cast inboard of the underpinned walls with a waterproof additive. The existing corbelled footings projecting into the excavation will be carefully removed using non-percussive techniques to mitigate vibration through the shared foundations. The underpin base width will match that of the existing footing and will hence retain the existing bearing pressures with no net increase.

3.8 Suggested Temporary Works

The main excavation works for the basement can be completed either in one of two ways, either i) the 'top-down' manner or ii) with an 'open excavation'. At this stage it is not necessary to establish the final choice of construction as both options will provide an equally suitable proposal for resisting earth and surcharge pressures. Once a contractor is appointed the final temporary works solution will be agreed and circulated for approval under the party wall act.

— If completed using a 'top-down' manner the ground floor slab would be cast first and a localised opening within it would be retained to excavate earth through. This would therefore negate the requirement for a set of flying shores across the excavation.

— Alternatively, the 'open excavation' option would provide ease of access for removal of soil however this method would require either diagonal props into the excavation to resist earth pressures (as shown adjacent), or horizontal shores across the full span width of the excavation. The adjacent plan indicates a likely propping strategy for an open excavation with restrains provided at close centres (~3m max).

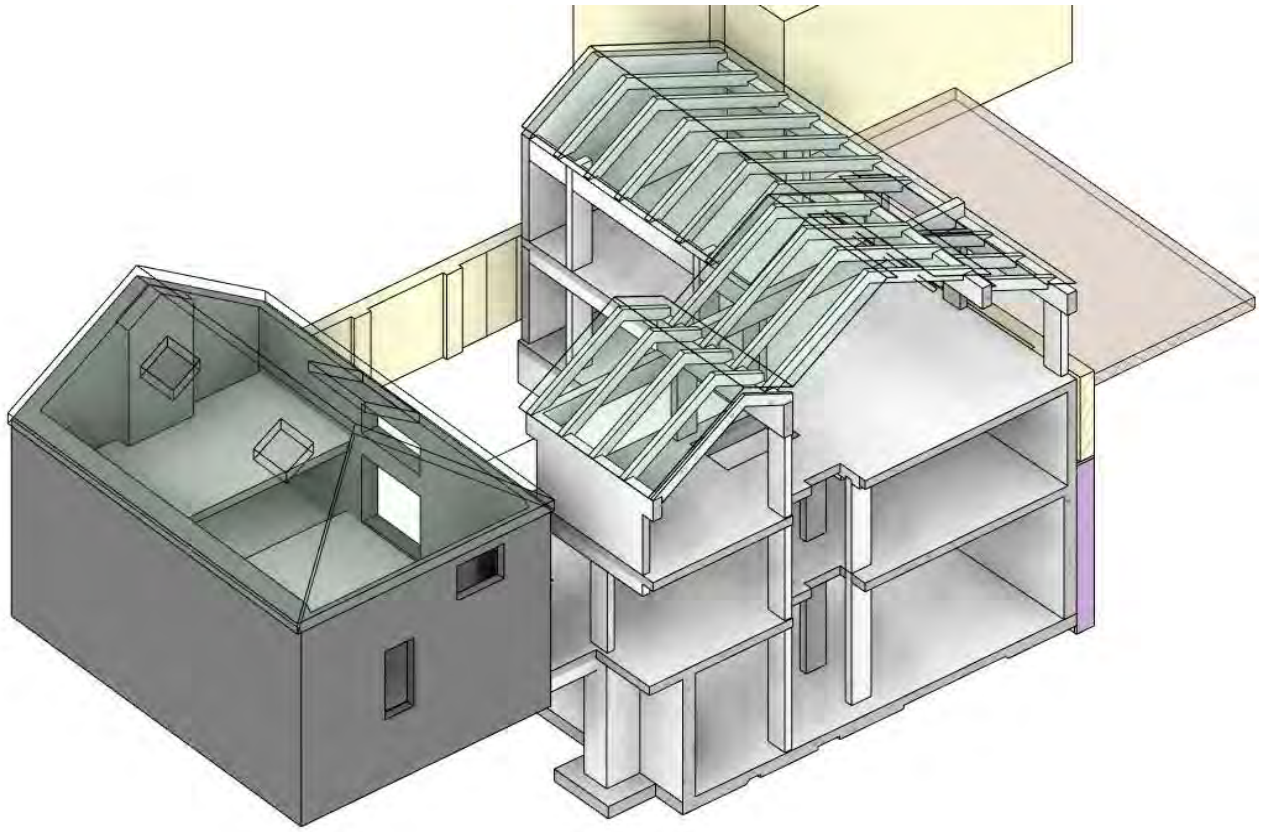


Figure 9 Isometric View of basement in transverse section

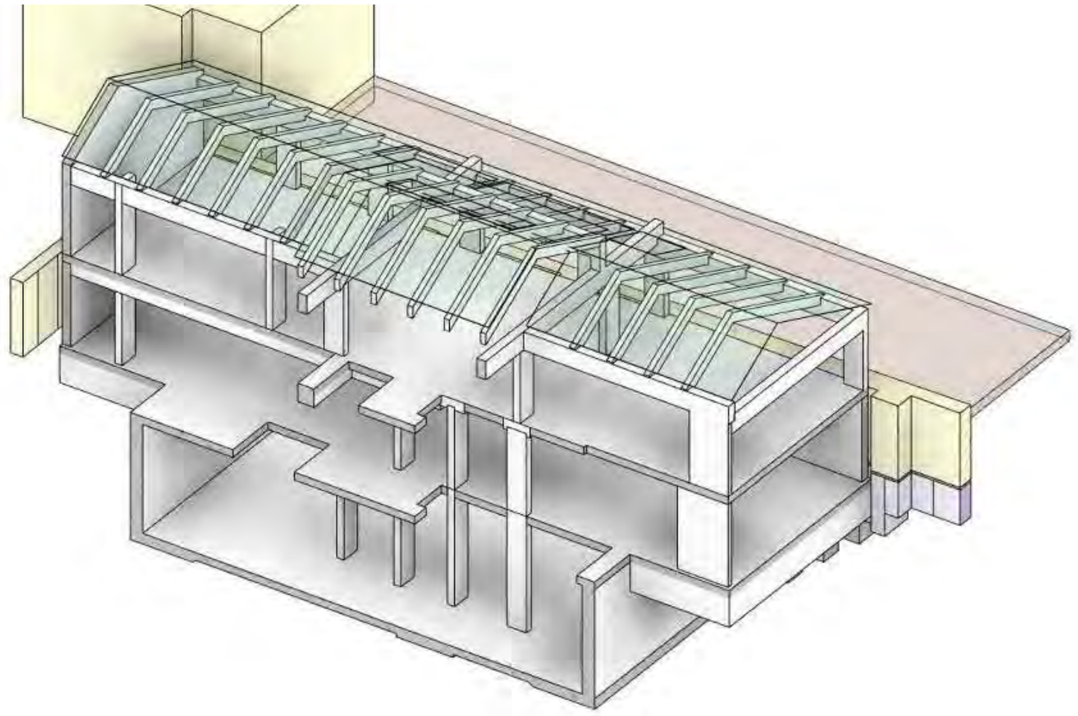


Figure 10 Isometric View of basement longitudinal section

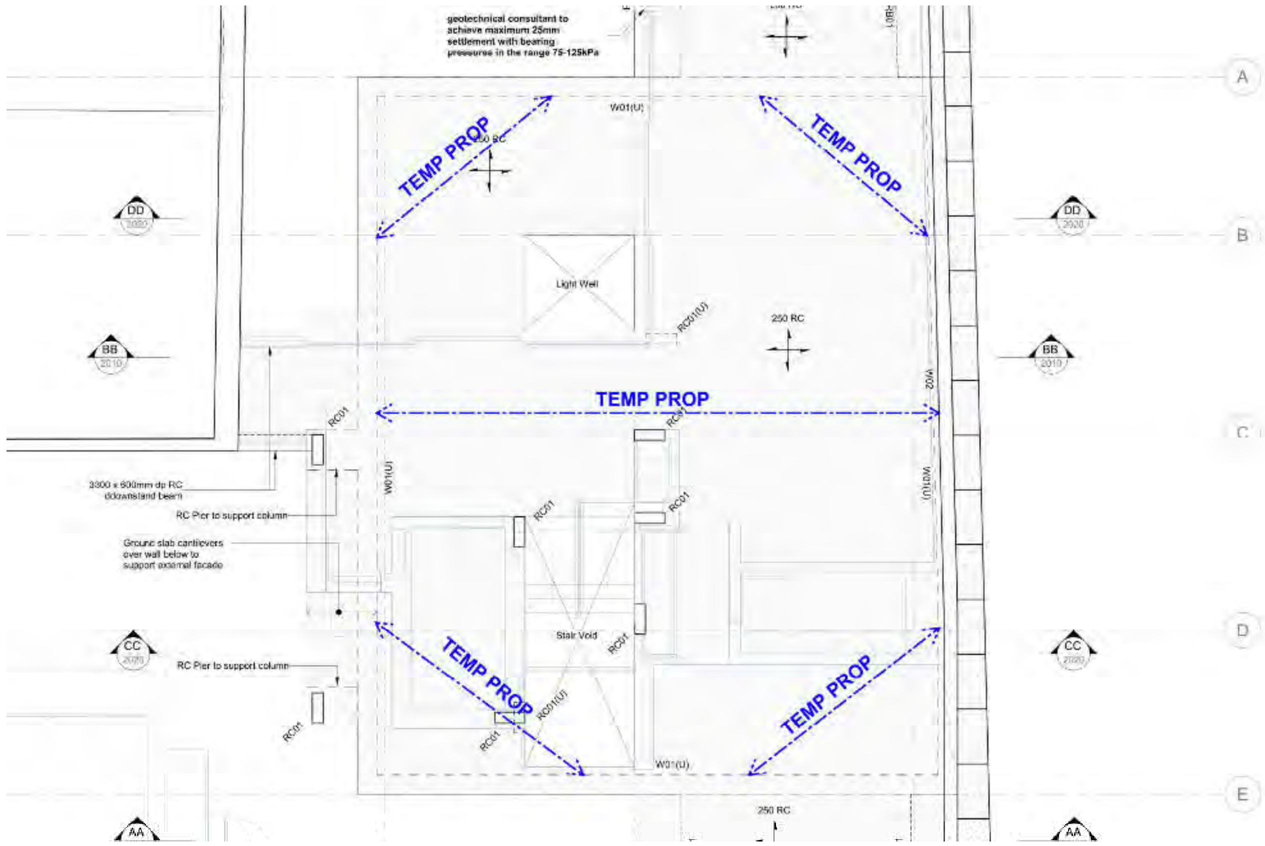


Figure 11 Plan at Ground floor indicating possible flying shores at close centres to restrain surrounding earth until slab is poured

3.9 Typical Underpinning Sequence

All excavations will require temporary support to the sides of the excavations. Any localised excavations e.g. for the installation of sumps or underpins will require temporary trench shores to be in place. Underpin excavations are to be backfilled after each underpin is installed.

All excavations for underpins and RC retaining walls are to be constructed in an agreed sequence, be a maximum of 1.0m wide. The sequence is to be such that no two adjacent pins are cast within 48 hours of one another.

Typically underpins are cast in a 1 3 5 2 4 1 3 sequence to avoid the casting of adjacent bays in succession. This reduces the risk of delayed curing and settlement.

Underpins are to extend to the underside of the proposed basement excavation level. Proprietary side shutter would be used to provide protection to operatives and retain stability to the ground.

The rear face of underpinning to be aligned with rear face of the re-supported wall. The front face of underpin is to align with internal face of the supported wall. Pins to be cast approximately 75mm below base of existing foundations to allow for adequate zone of dry-packing.

Dry-pack is to be installed tight between top of pins and underside of existing walls at least 24hours after casting. Excavations are to be back filled to the existing ground level.

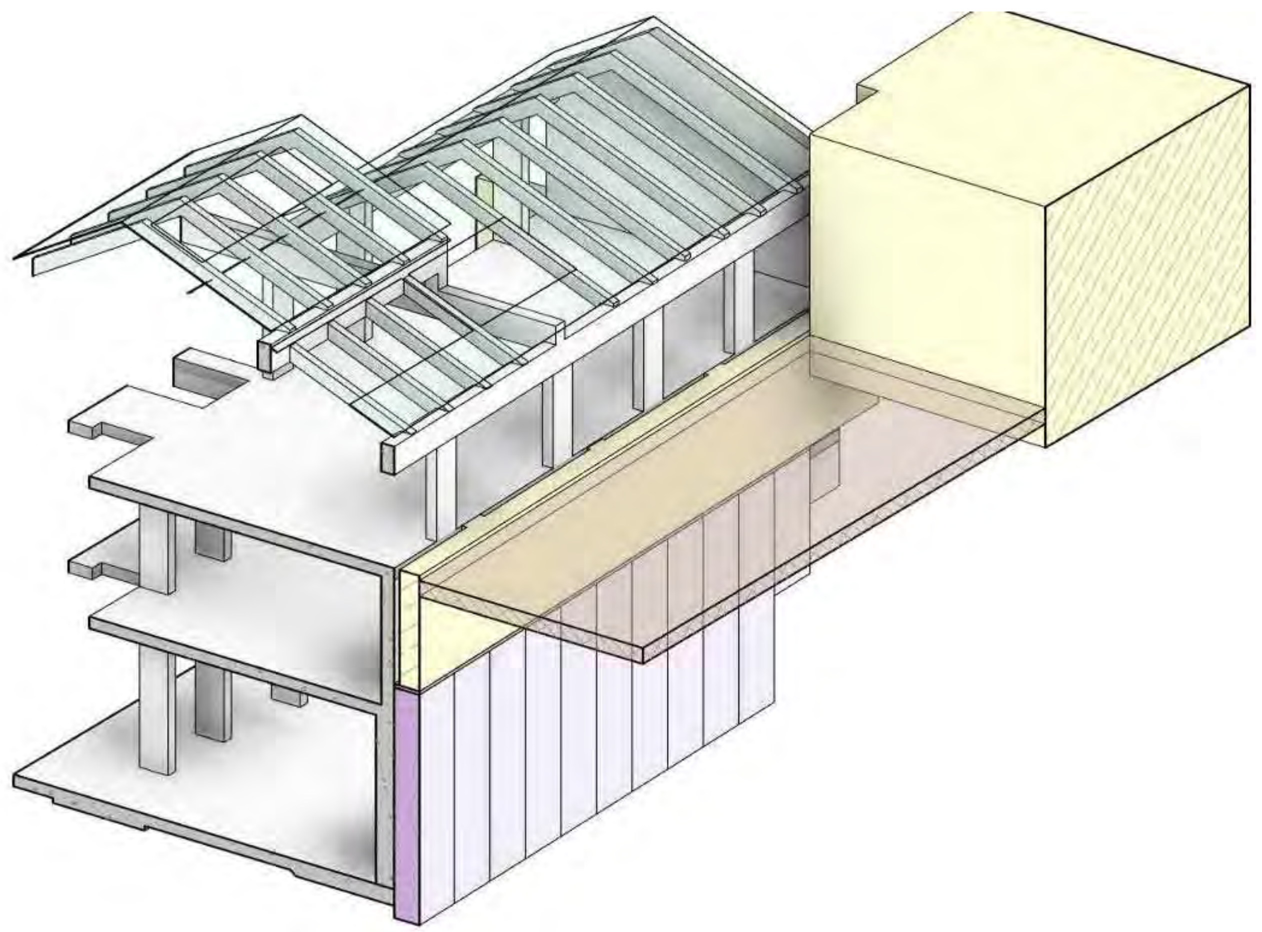


Figure 12 Transverse section showing underpins (purple) to boundary wall and internal concrete liner wall box construction

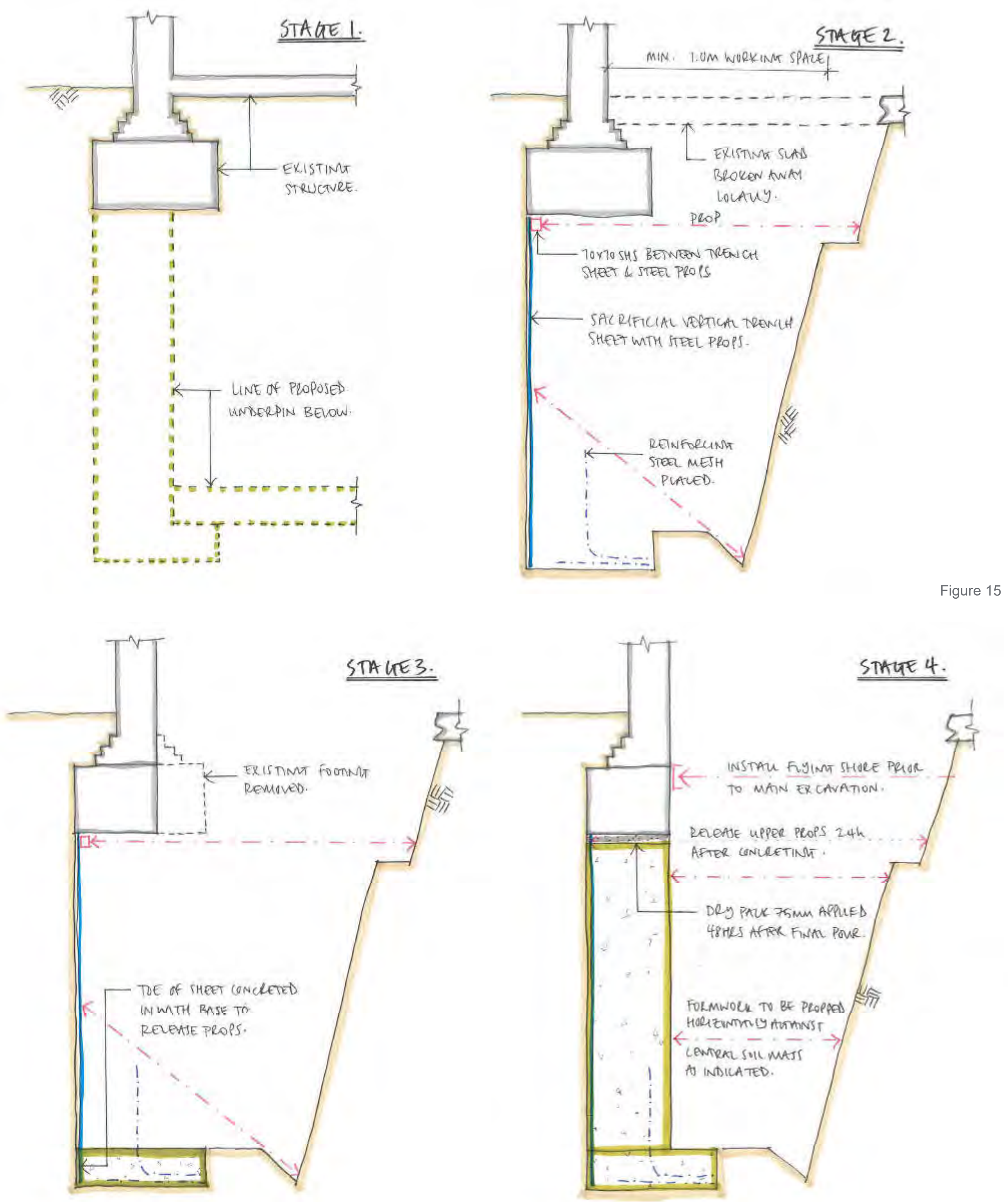


Figure 15

Figure 13 Typical Underpinning Sequence Stages 1 to 4

3.10 Proposed Below Ground Drainage

The proposed drainage will be split into foul and surface water until the last possible location before being discharged into the public sewer and leaving the site. The adjacent sketches illustrate the basement and ground level drainage strategies for dealing with storm and foul water. A stormwater attenuation tank will be provided externally below the hard/soft landscaping to allow for the reduction in surface water run-off at a rate to be agreed with Thameswater.

The ground is predominantly impermeable clay and therefore not suitable for infiltration. The attenuation tank will be fitted with a flow restrictor (hydrobrake) to slow the discharge to an acceptable rate.

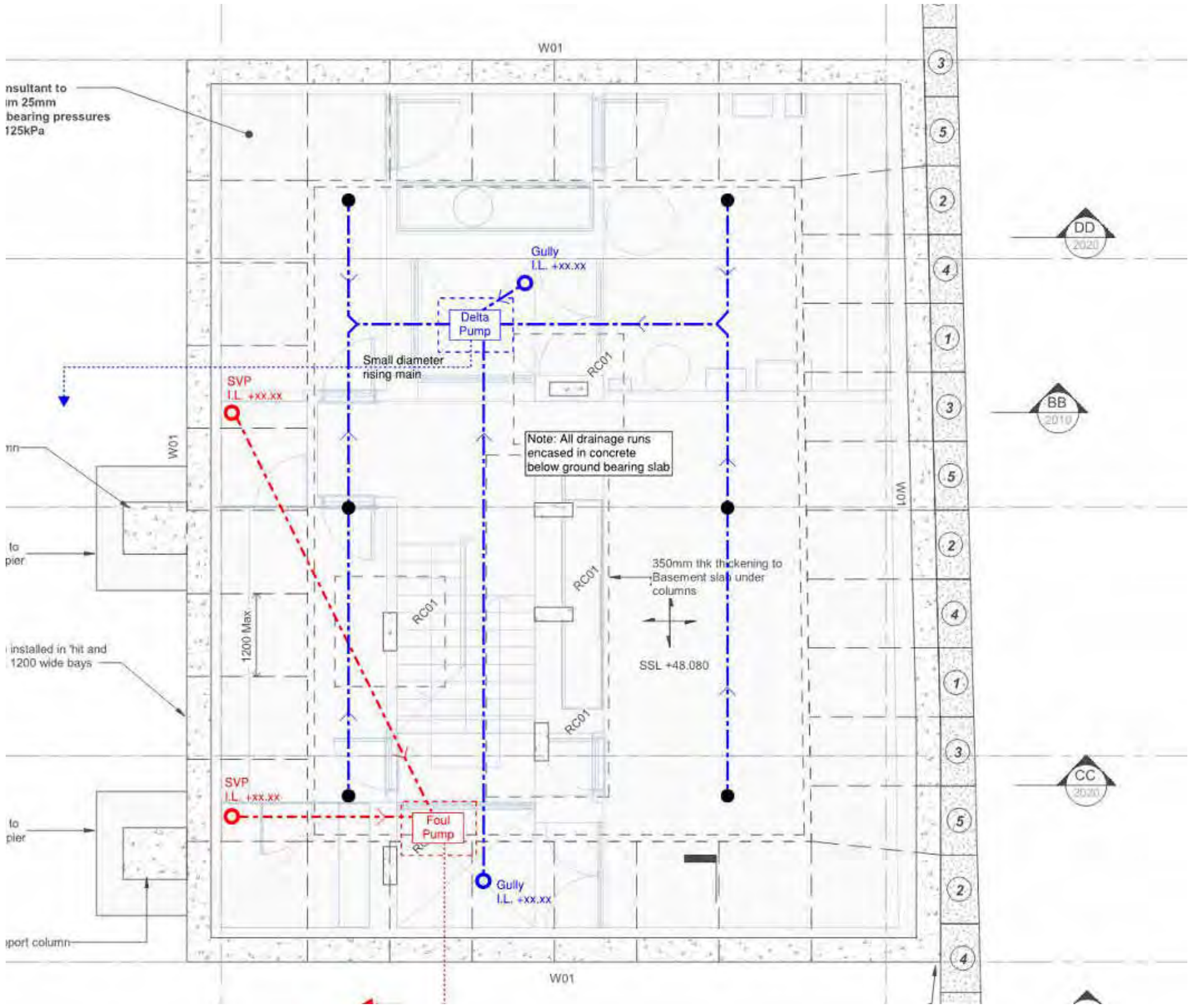


Figure 14 Basement level drainage layout

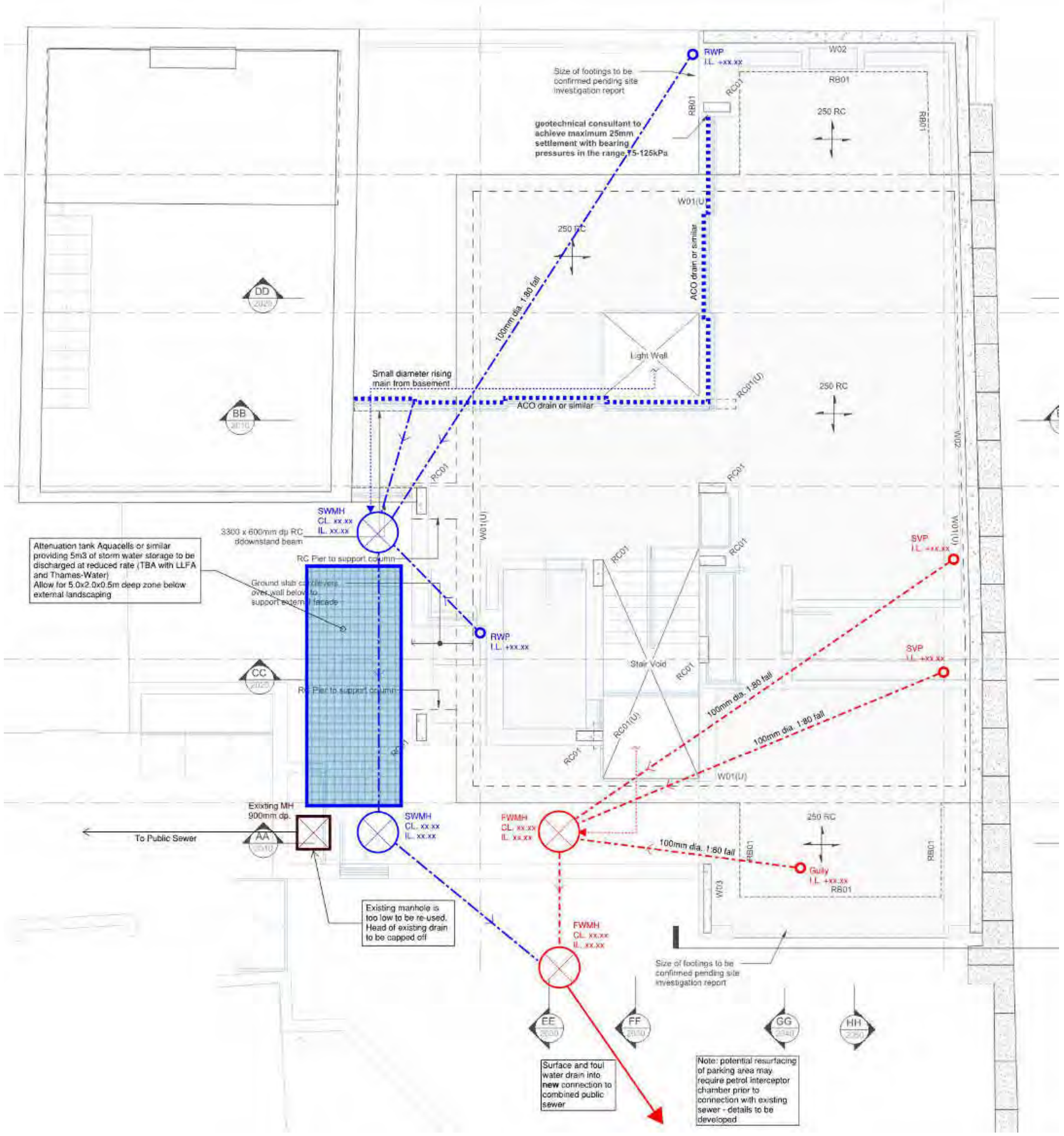


Figure 15 Ground level drainage layout

4 Suggested Basement Construction Sequence

Selecting the appropriate contractor for the works will be very important. They will be required to demonstrate a track record of suitable experience in construction works of this nature. The following proposed construction sequence is subject to modification by the selected contractor.

4.1 Basement Construction & Temporary Works

The retaining wall construction to the perimeter of the new basement box requires propping in the temporary condition.

— Horizontal propping of the head of the concrete stem retaining walls.
— Horizontal support of earth during excavation works not shown in the permanent works drawings e.g. localised excavations, the stability of ramps and areas of battered back soil etc.

4.2 Site Set-up and Initial Temporary works

— Carry out site topographic survey and set up benchmarks as required.
— Terminate and divert existing services.
— A hoarding will be constructed to site boundaries as necessary.
— Set up site office and welfare facilities.
— Access to the proposed new basement will be available from Haverstock Hill only and so it is assumed that all deliveries and removals will be made from here.
— The site entrance will be manned by a banksman during operational hours to ensure construction deliveries do not pose potential risk to pedestrians and site operatives.
— Carry out soft strip of existing building on completion of R&D asbestos survey.
— Full details of movement monitoring proposals to be provided at tender/construction stage (RIBA stage 4/5 equivalent), shown indicatively on plan.
— Install monitoring targets to retained structures, adjoining buildings and boundary walls as necessary.
— Carry out baseline readings over period of two weeks to generate control readings.
— Carefully separate existing wall structures to be demolished from boundary walls being retained.
— Demolition of shared walls – those shared with adjoining buildings - to be carried out as far as possible using non-percussive methods.
— Commence demolition of existing buildings within the site whilst protecting adjoining structures from debris and impact etc.
— Commence careful demolition works in reverse order of construction.

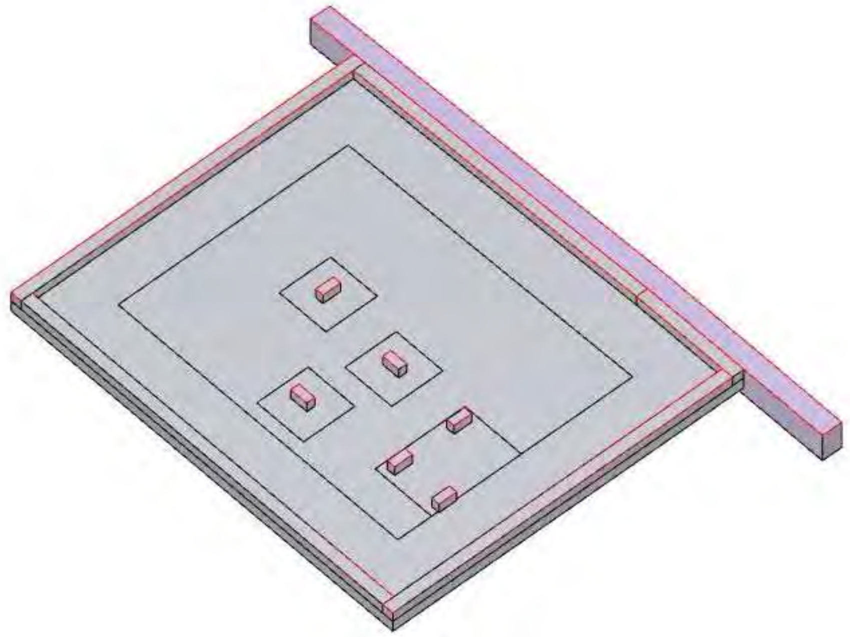


Figure 16 Basement level retaining wall boot construction and wall stem kicker shown adjacent to underpinned boundary wall

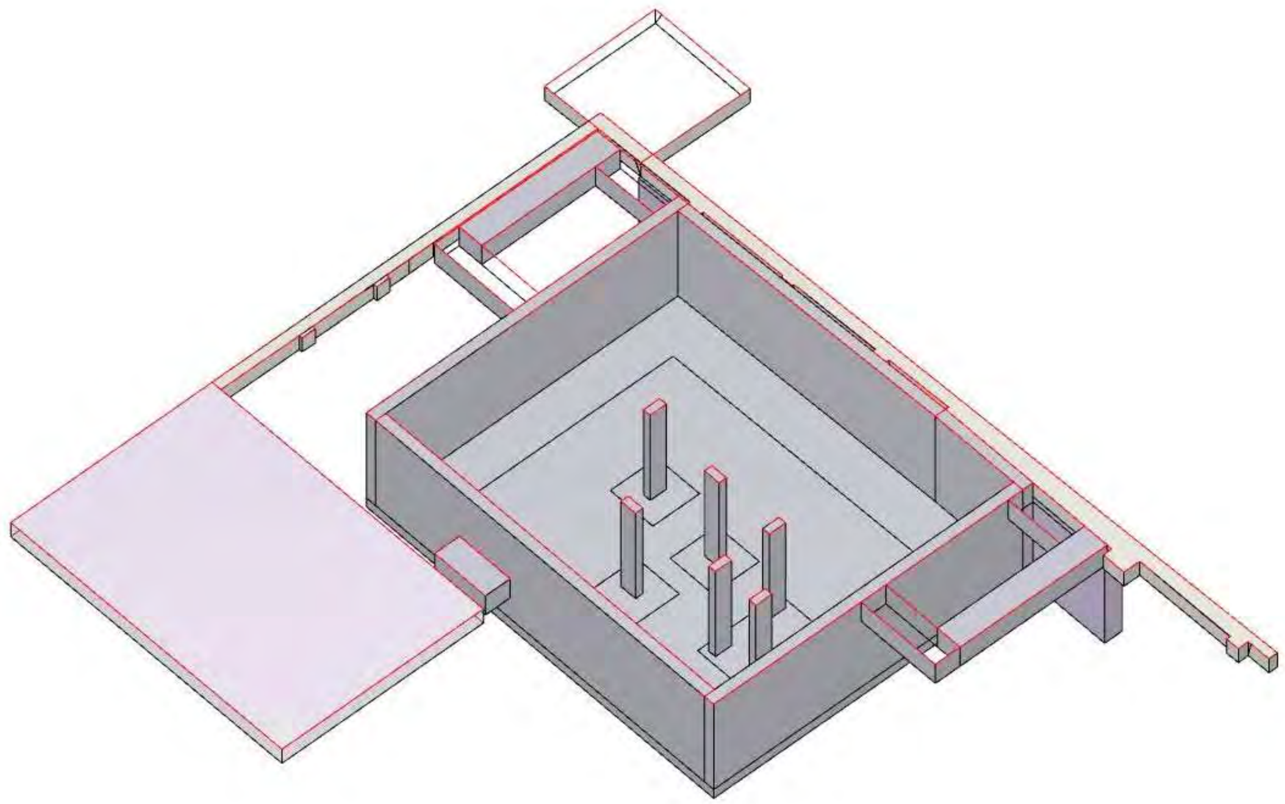


Figure 17 Isometric section showing internal column grid and retaining wall stems

4.3 Excavation of Basement

- Retaining walls to be propped at head to minimise potential for deflection.
- Layout and arrangement of flying or diagonal shores required to be developed with specialist groundworks contractor.
- Details to be developed within Basement Construction Plan on appointment of Main Contractor.
- Excavate to formation level
- Intermittent shoring may be required at mid-height to retaining wall.
- It may be necessary to provide some limited de-watering during the excavations to remove perched water within the made ground and head deposited layers. This will be confined to the plan area within the site excavation and hence de-watering will not affect the content of the surrounding soils.
- Install blinding layer on completion of excavation.
- Install required below ground drainage runs, manholes and sumps for cavity drain, storm and foul water systems.
- Install void-former & lay reinforcement for basement slab including shear dowels to perimeter of basement.
- Basement slab concrete to include waterproofing additive.

4.4 Superstructure Construction Phase

- Install basement level columns and waterproof liner walls.
- Pour ground floor level slab.
- Continue superstructure works up to roof level – assumed ~4 week cycle per level of superstructure installation to be developed with appointed contractor.
- Shores can be removed upon adequate strength gain of suspended floor slabs (now providing horizontal prop to head of retaining walls).
- Boundary wall movement monitoring to be carried out on a weekly basis throughout basement dig and construction sequence.
- The basement box construction has now been completed and the typical floor to floor superstructure works will follow in sequence.
- The structural works are now complete and the work can concentrate on making the building weather tight, upon which the finishing trades can commence.

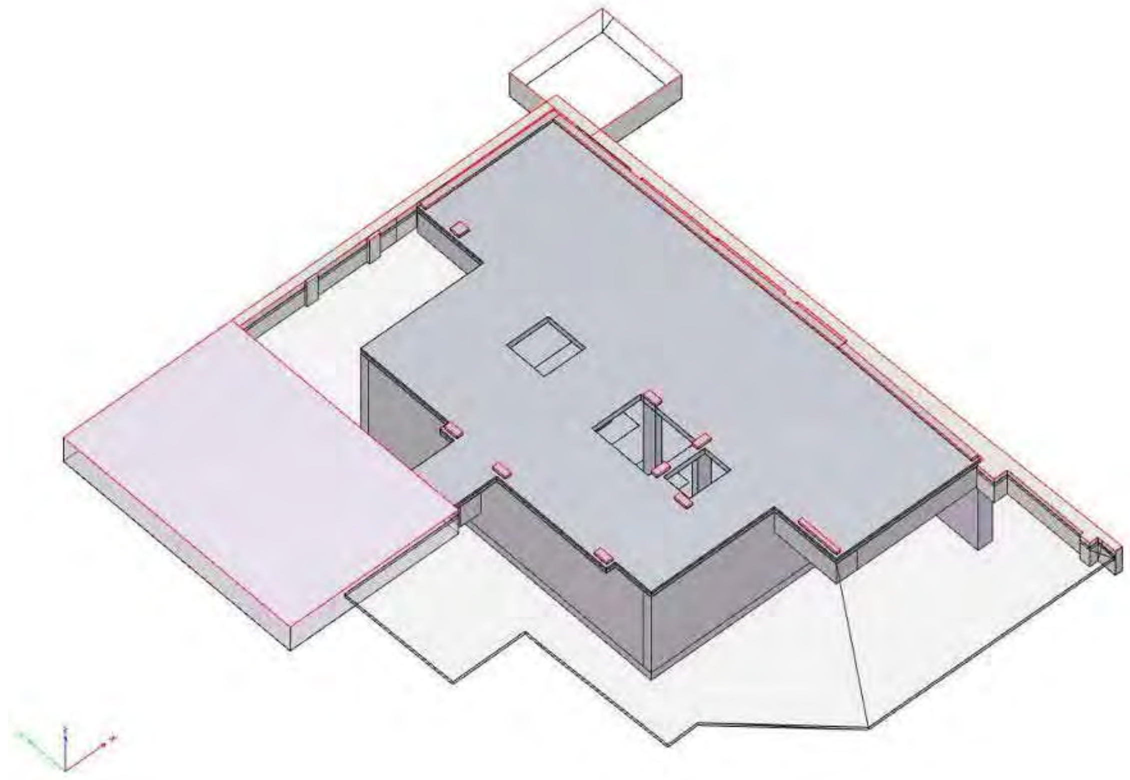


Figure 18 Isometric view of capping slab 'lid' over basement construction

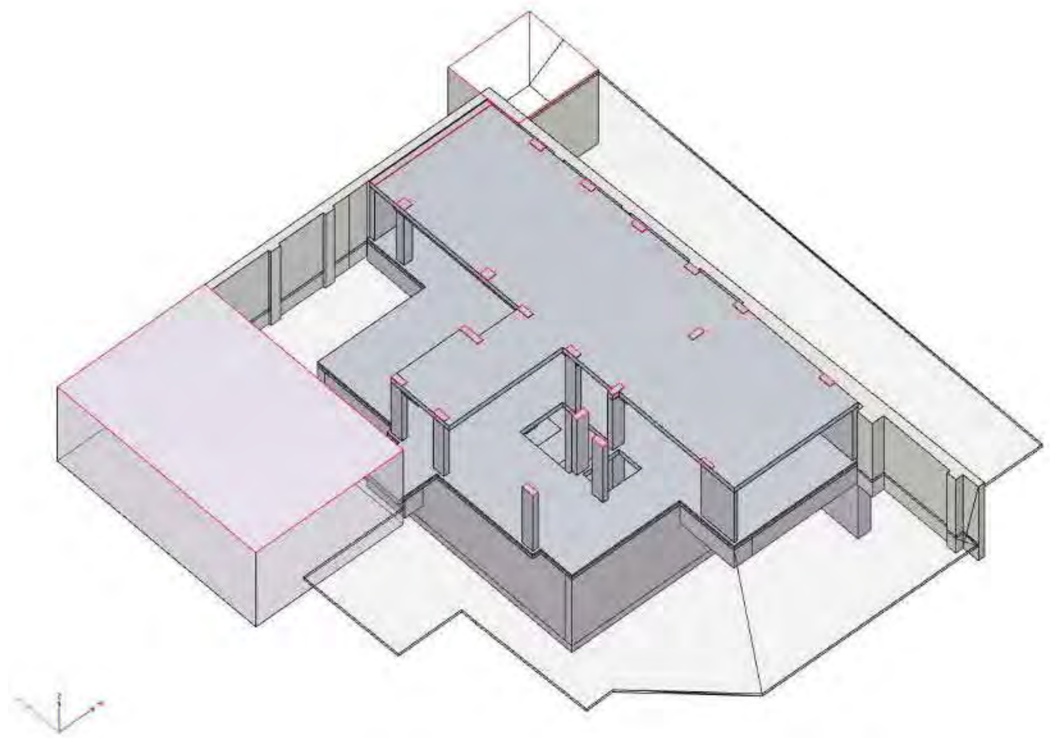


Figure 19 Isometric view of first floor slab continuing the superstructure

5 Impacts on Surrounding Structures

5.1 Safeguarding the Stability of Existing Buildings & Environment

Stability of the existing buildings and local environment adjacent to the building site will be maintained throughout the build process and for the building design life by the careful planning, implementation and coordination of the temporary and permanent structural works.

The horizontal stability of the ground and adjacent structures in the temporary condition will be provided by temporary works Propping the excavation walls at the level of the propose ground floor level. In the permanent condition the horizontal and vertical stability of the building will be provided by floor diaphragms tying into the external retaining walls matching the at rest pressures contained in the existing condition. The temporary works framing will not be removed until all of the permanent works are completely installed, and the concrete has cured sufficiently.

To prevent lateral movement and provide lateral stability of the ground throughout excavation, new underpins underneath the existing boundary walls will be propped horizontally at the head. The props restraining the head of the wall will comprise the temporary waler beams located just below ground level. These are to remain in place until the permanent new basement structure is completed. The props will ensure that the surrounding ground beyond the excavation is continuously supported during construction.

As described above, the stability and structural integrity of the surrounding earth and the neighbouring properties will be maintained throughout construction without any structurally detrimental effect to existing condition.

5.2 Ground Movement Assessment & Predicted Building Movements

In accordance with the requirements of CPG4, consideration has been given to the likely damage to the adjacent buildings according to the 'Burland Scale'.

In order to predict and mitigate the likely damage category Soil Technics Ltd have carried out a site specific ground movement assessment. They have considered the likely movement due to installation of the underpinning together with ground movement due to excavation in front of the walls/underpins. Their report has concluded that the predicted damage to the existing buildings would generally be 'Negligible' (Category 0), with some limited areas of 'Very Slight' (Category 1) along sections of the existing and neighbouring buildings. The CIRIA C580 damage category assessment has predicted the maximum crack width associated with the works would be less than 1mm wide. On this basis the level of damage predicted is considered to be within acceptable limits.

A condition survey of the adjacent buildings will be carried out prior to the works being commenced on site to assess and record the condition of the adjacent structures. This information will be included within the party wall awards.

5.3 Movement Monitoring

There will be a set of movement monitoring targets required to each adjoining and adjacent building during the construction phase. Targets will be set up prior to works commencing and remain in place throughout the works. Any significant movement beyond the agreed threshold trigger/action levels will be reviewed during the works to establish if these are in line with those predicted in the design phase.

Monitoring targets well be placed onto the adjoining buildings and boundary walls to allow monitoring of movements during the works. These targets will be monitored on a weekly basis throughout the building process for 3 dimensional movements. This will act as an early warning system to identify any unexpected movement allowing time for remedial action to be taken.

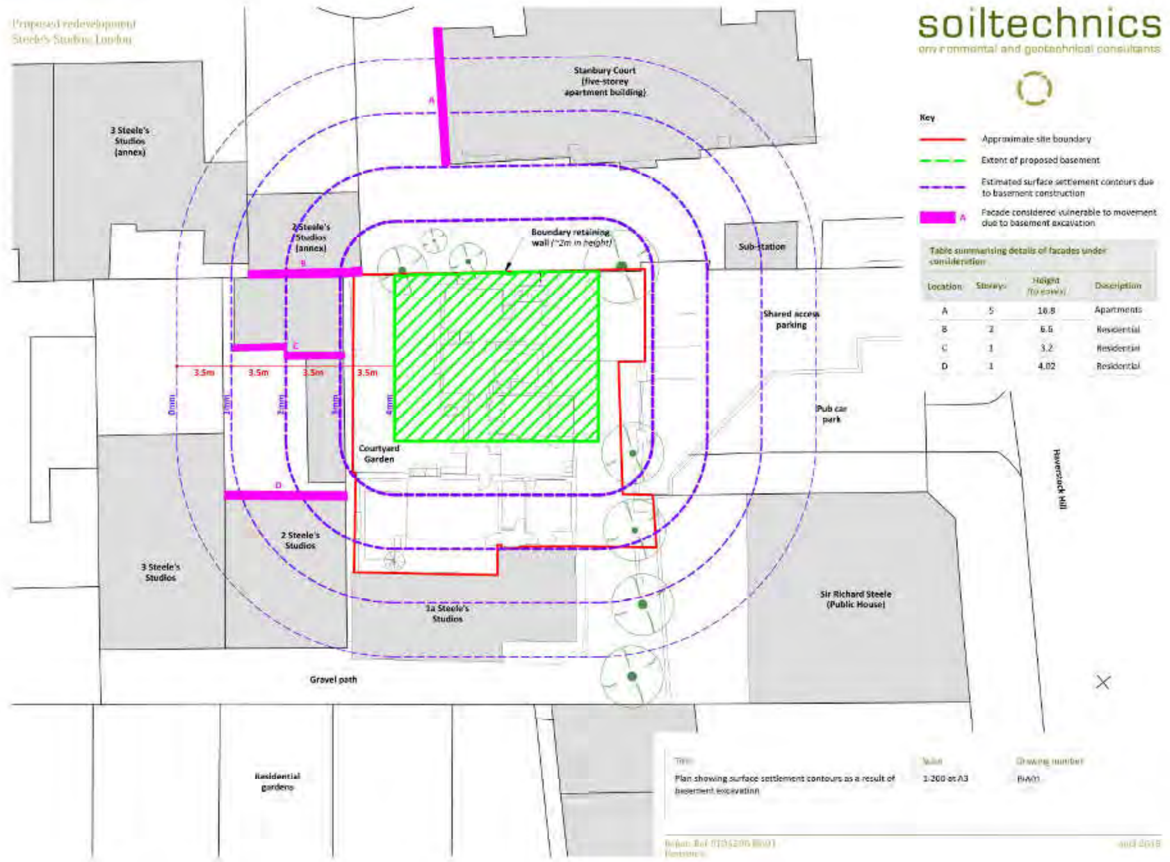


Figure 20 Predicted movements due to excavation works

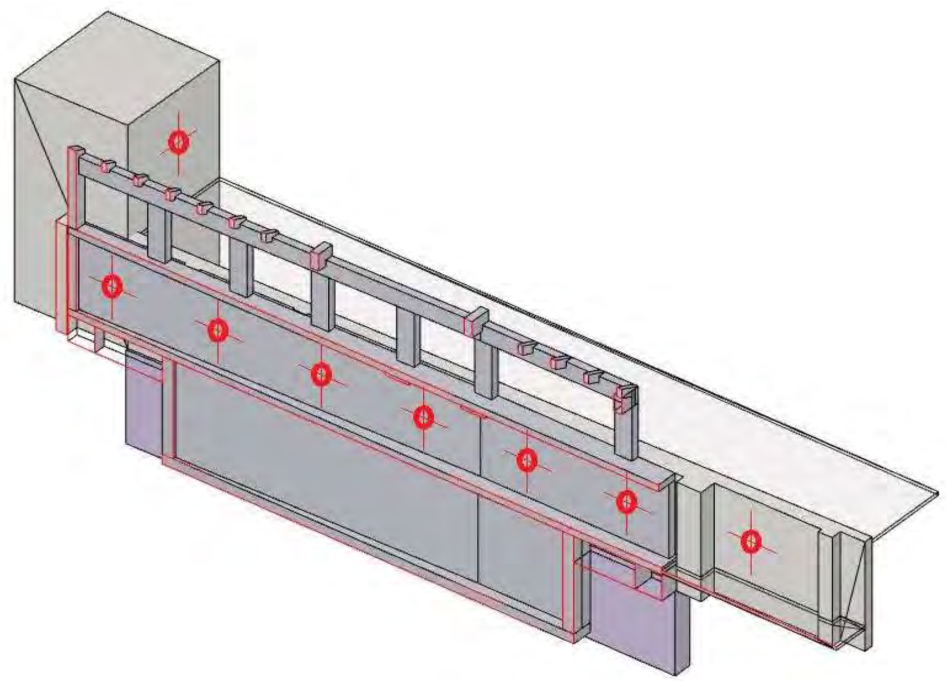


Figure 21 Proposed Monitoring Targets during demolition and construction works

6 Structural Report Conclusions

6.1 Conclusions

A structural report and basement impact assessment, backed by site investigations, have been completed in line with Camden policy documents. This report and supporting documents indicate that the proposed development of the site will not cause harm to the built and natural environment and local amenity and does not result in flooding or ground instability.

The report also confirms that the scheme will not cause harm to:

— neighbouring properties;
— the structural, ground, or water conditions of the area;
— the character and amenity of the area;
— the architectural character of the building; and
— the significance of heritage assets.

Appendix A – Outline Specification

General:

The following design elements should be in accordance with the Architects details:

- Setting-out
- Fire protection
- Floor separation and acoustic isolation
- External works
- Finishes
- Internal partitions

Concrete:

The concrete grades to be used are as follows:

- Blinding, Gen1
- Mass concrete to underpinning, Gen3
- Insitu RC concrete slabs, underpinning and walls, RC40
- All formed surfaces to be Type A (basic) finish in accordance with BS-8110. Tops of ground beams and floor slabs to be uniformly leveled and tamped to type 1u finish, subject to agreement with raised flooring manufacturer.
- Caltite Waterproof concrete for the retaining walls and basement slab.

Steelwork:

- All steelwork to be grade S355 to BS EN 10025 and in accordance with BS-5950 UNO.
- All connections to have minimum 2no. M16 bolts, with minimum 6mm leg length continuous fillet welds, unless specifically noted.
- All steelwork to be blast cleaned to SA2.5. Internal steelwork painted with 75 µm of zinc phosphate primer, 75 µm sealant. External steelwork to be galvanised to 140µm
- Reinforcement for profiled composite slabs to be minimum A252 mesh in the top reinforcement layer. For single spans (not continuous) 2 No. H8 bars are to be placed in all decking troughs.
- All profiled composite slabs are to be formed using RC40 lightweight concrete.

Timber:

- All timber members are to be grade C16 to BS 5268 unless noted otherwise. Timber to be pressure impregnated with preservative and cut ends brush treated
- Lateral restraint straps for floors are to be minimum 900 long 30 x 5 galvanized MS straps at 1200crs with 150 bobend.

Temporary Works:

- The contractor is responsible for the design, installation and maintenance of all necessary temporary works to ensure the strength and stability of the building throughout the construction process

Appendix B – Design Parameters

Codes of Practice:	Eurocodes:
— Loading	BSEN 1991
— Concrete	BSEN 1992
— Foundations	BSEN 1997
— Steelwork	BSEN 1993
— Masonry	BSEN 1996
— Timber	BSEN 1995

Building Regulations 2000:

- Approved Document A – Structure (2004 edition)
- Approved Document H – Drainage & Waste Disposal (2002 edition)

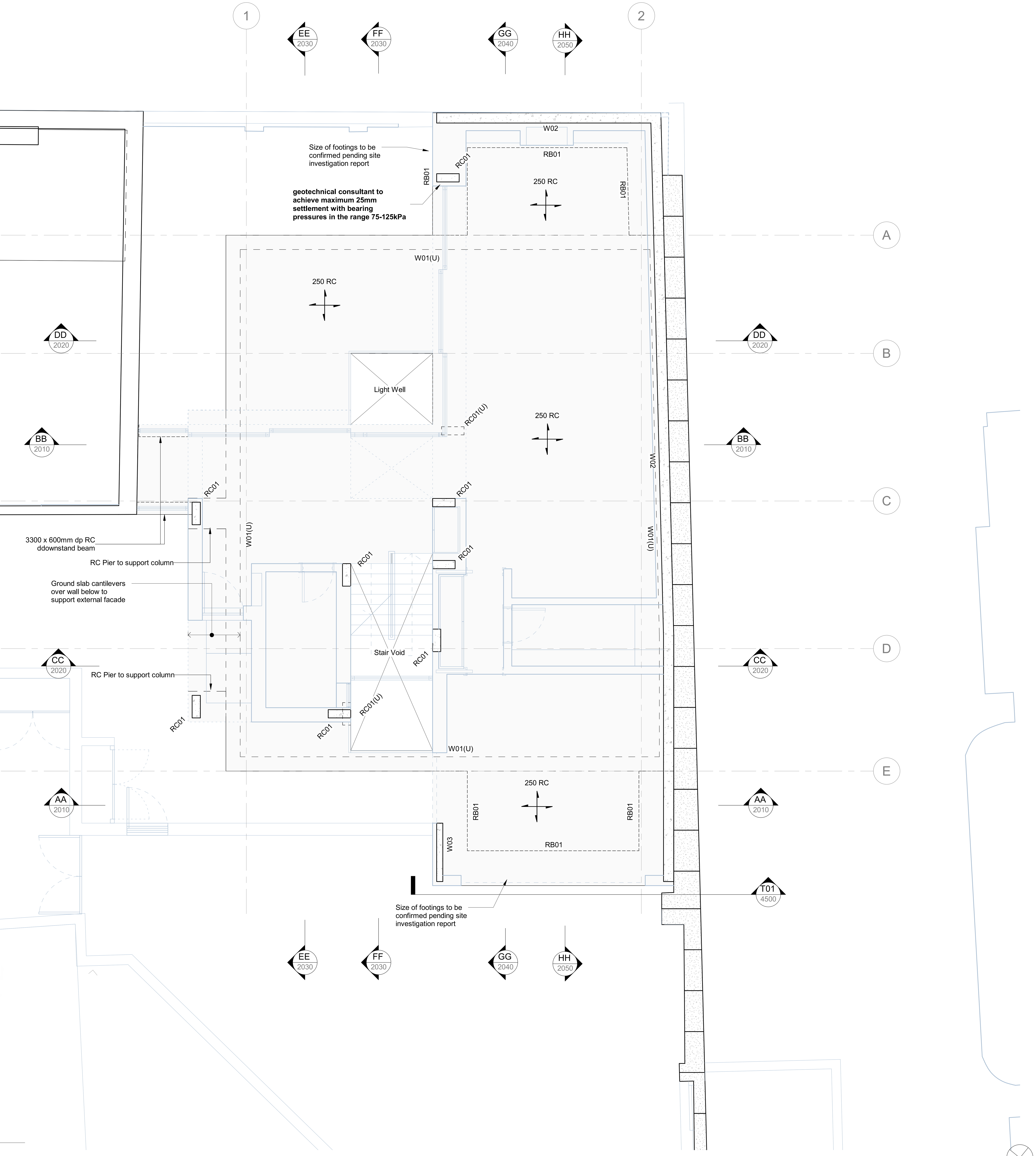
Temporary Works

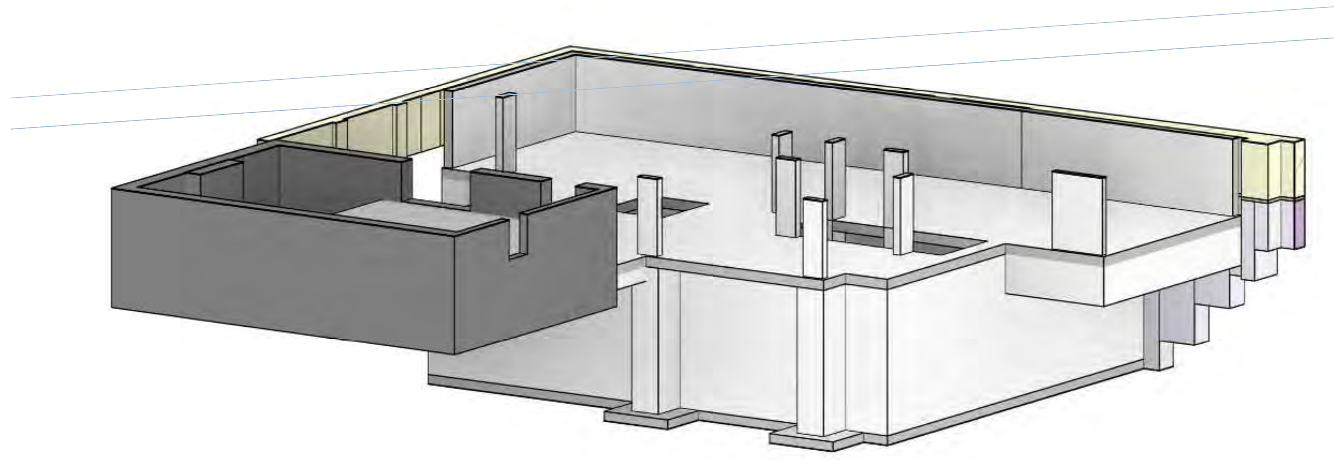
- Façade retention works should be designed in accordance with the recommendations set out in CIRIA guide C579 (2003 'Retention of Masonry Facades).
- Demolition Works to be carried out in line with ICE Demolition Protocol 2008.
- The deflection of the retained façade should be limited to Span/750 under full loading.

Design Loadings:

Imposed Loadings (new build areas):	kN/m2
— Residential	1.5+1
— Roof, access / including snow	0.75
— Plant area	2.5
— Balconies and terraces	2.5

Appendix C – Structural Concept Drawings & Calcs





00 **Isometric View at Ground Floor**

General Notes

1. This drawing is to be read in conjunction with all relevant Architects & Engineers drawings & specifications.
2. The Contractor is to be responsible for all dimensions & for the correct setting out of the works on site.
3. Do not scale from this drawing.

Floor Schedule

Ref.	Type
250 RC	250mm thk RC Slab

Concrete Beam Schedule

Ref.	Type
RB01	850x1200mm dp RC beam
RB02	250x600mm dp RC beam
RB03	250x950mm dp RC beam
RB04	150x300mm dp RC beam

Concrete Columns

Ref.	Type
RC01	550x200mm RC Column

Wall Schedule

Type Mark	Type
W01	350mm thk RC Retaining Wall
W02	250mm thk RC Wall
W03	150mm thk RC Wall
W04	200mm thk RC Wall

Steel Beam Schedule

Ref.	Type

Steel Column Schedule

Ref.	Type

Rev	Date	By	Chkd	Description
P02	01.10.18	SP	DW	Issued for Coordination
P01	18.05.18	SP	DW	Issued for Coordination

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Project Title
Haverstock Hill

Drawing Title
Ground Floor Plan

Project No
18011

Scale
1 : 50 [A1]

Drawn By
SP

Date
April 2018

Drawing Suitability
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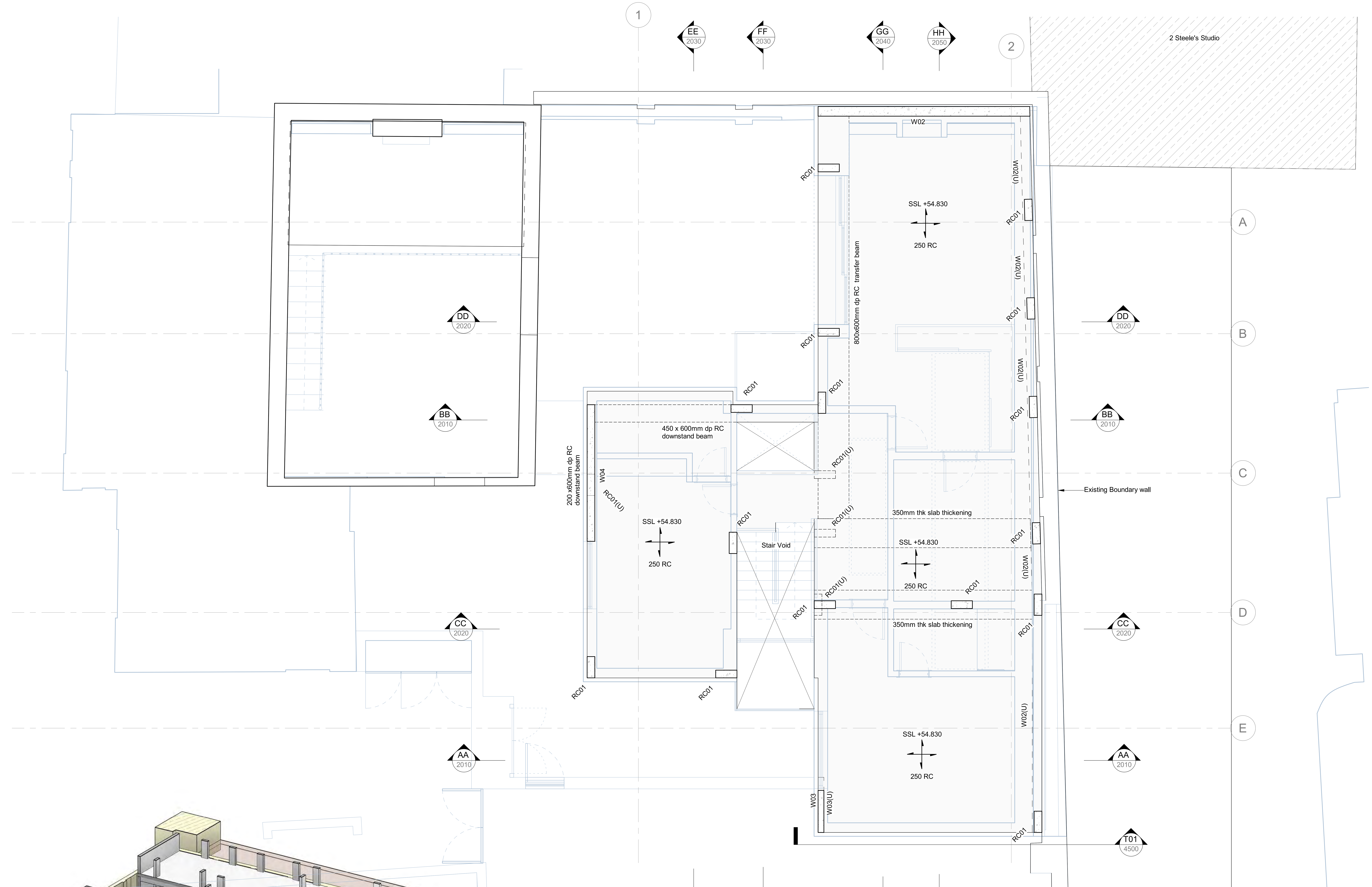
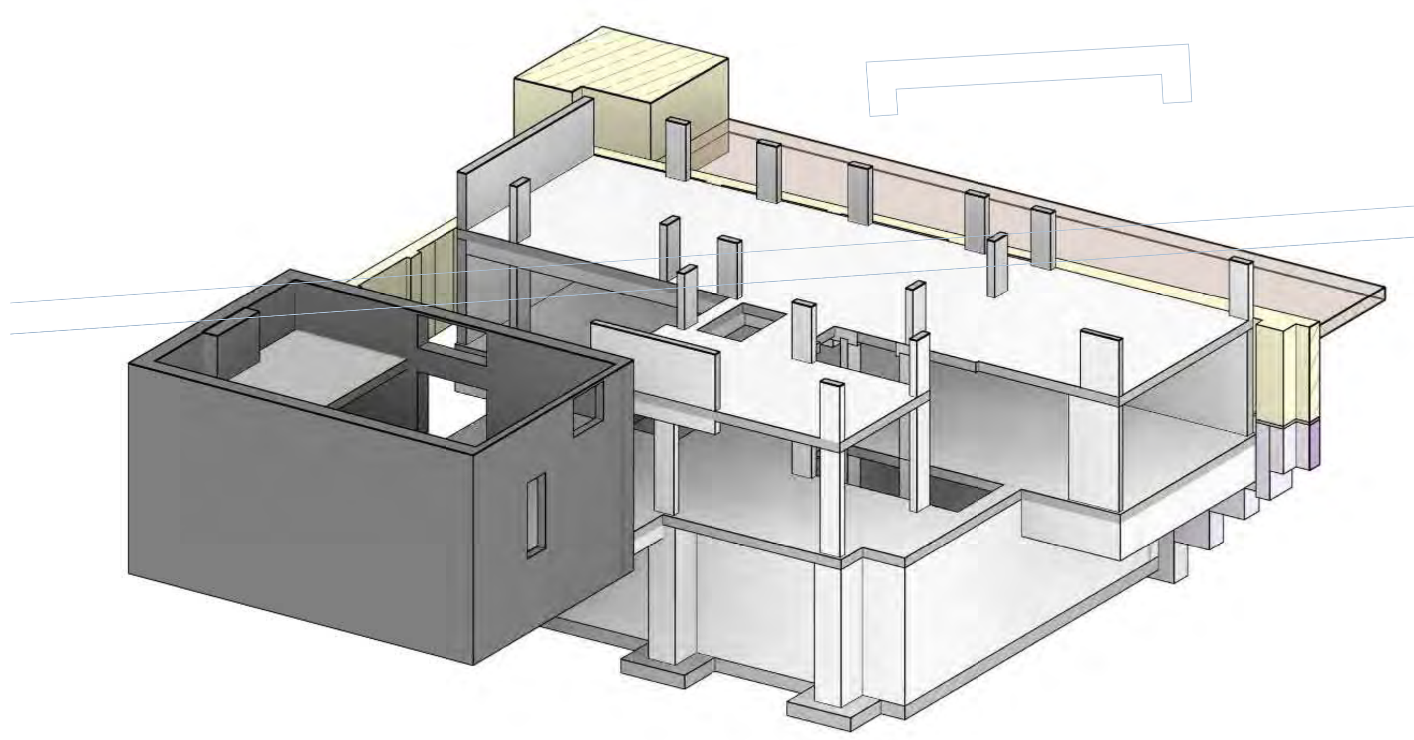
Version

Drawing Number
HVS-EOC-V1-00-DR-S-1020

Revision
P02





01 **Isometric View at First Floor**

General Notes

1. This drawing is to be read in conjunction with all relevant Architects & Engineers drawings & specifications.
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Concrete Columns

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Wall Schedule

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W02	250mm thk RC Wall
W03	150mm thk RC Wall
W04	200mm thk RC Wall

Steel Beam Schedule

Ref.	Type

Steel Column Schedule

Ref.	Type

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P02	01.10.18	SP	DW	Issued for Coordination
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Drawing Title: First Floor Plan

Project No: 18011

Scale: 1 : 50 [A1]

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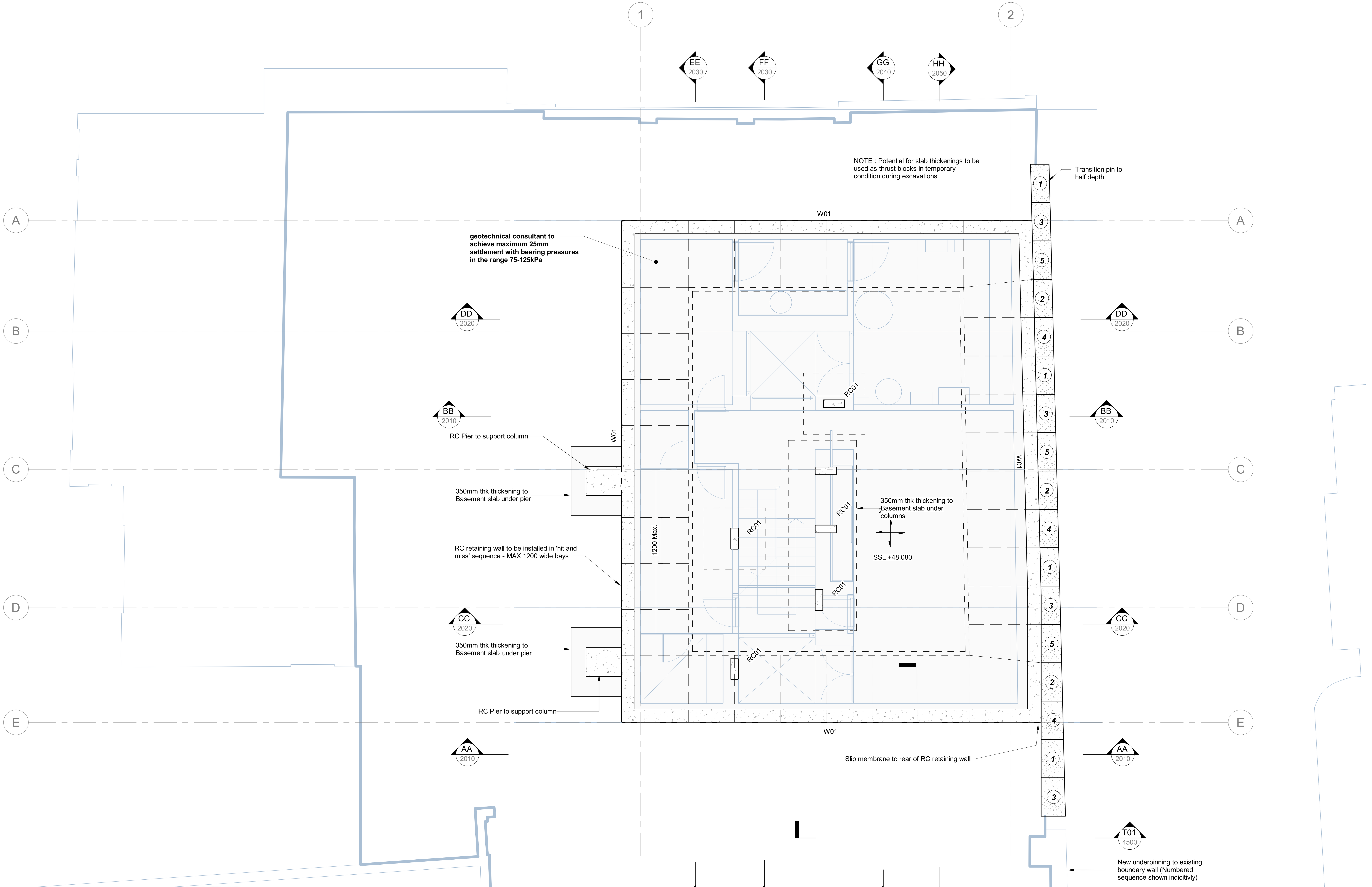
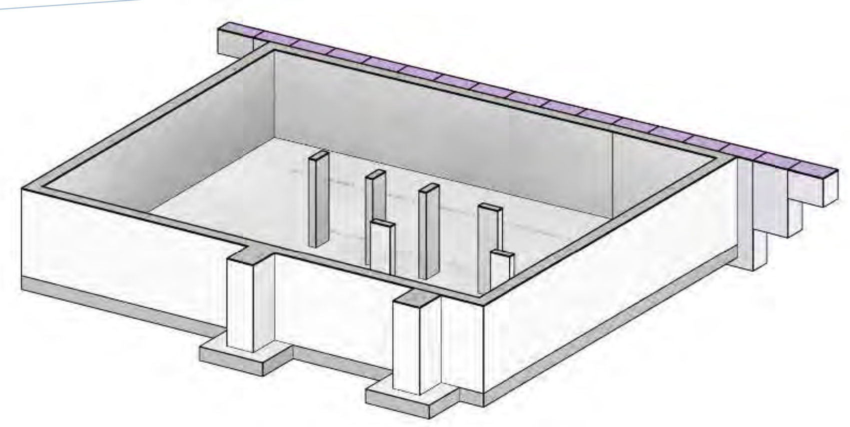
Drawing Suitability: S1 - Suitable for Coordination

Version:

Drawing Number: HVS-EOC-V1-01-DR-S-1030

Revision: P02





B1 Isometric View at Basement

General Notes

1. This drawing is to be read in conjunction with all relevant Architects & Engineers drawings & specifications.
2. The Contractor is to be responsible for all dimensions & for the correct setting out of the works on site.
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W03	150mm thk RC Wall
W04	200mm thk RC Wall

Steel Beam Schedule

Ref.	Type

Steel Column Schedule

Ref.	Type

Rev	Date	By	Chkd	Description
P02	01.10.18	SP	DW	Issued for Coordination
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HVS-EOC-V1-B1-DR-S-1010

Revision
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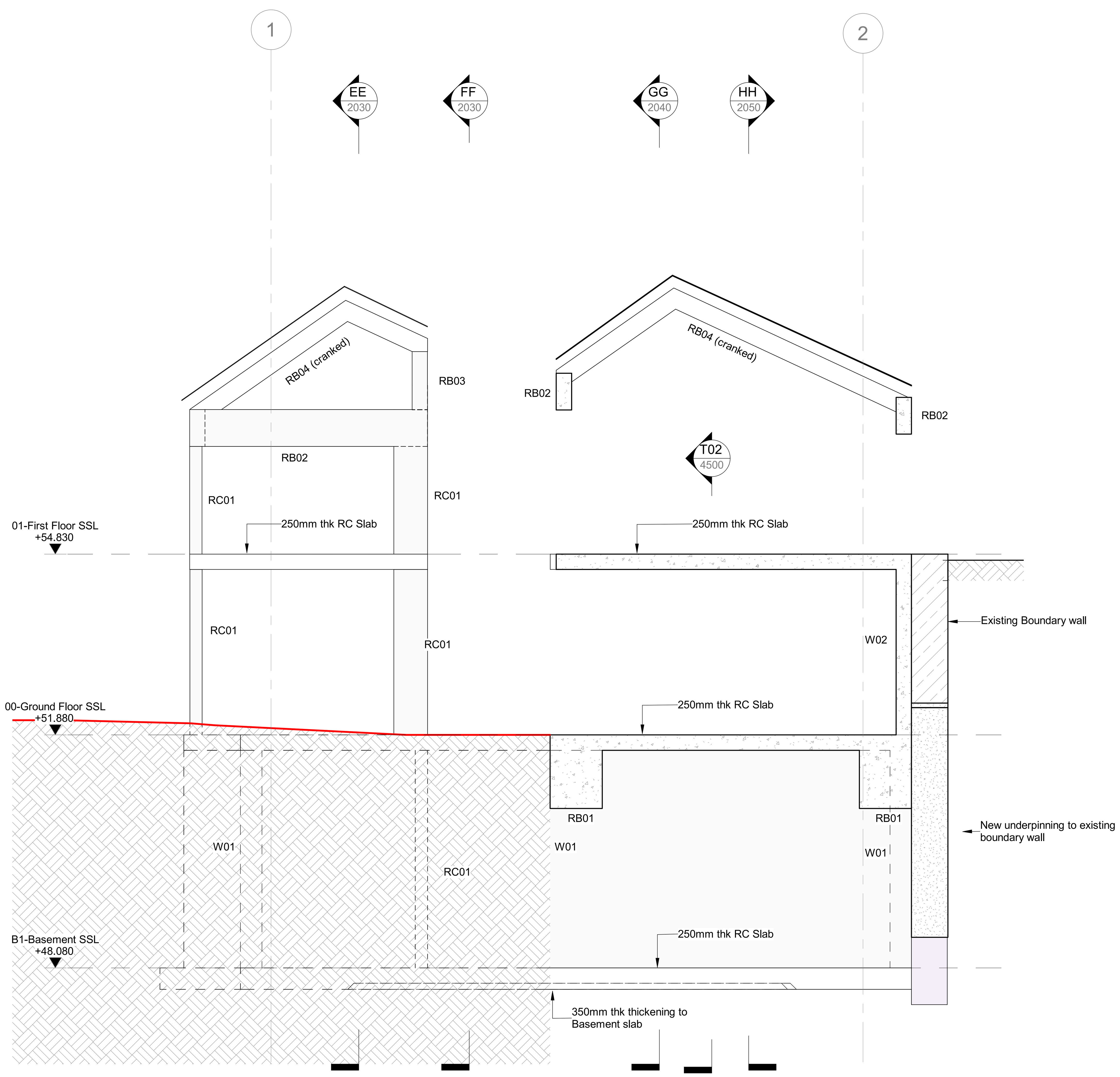

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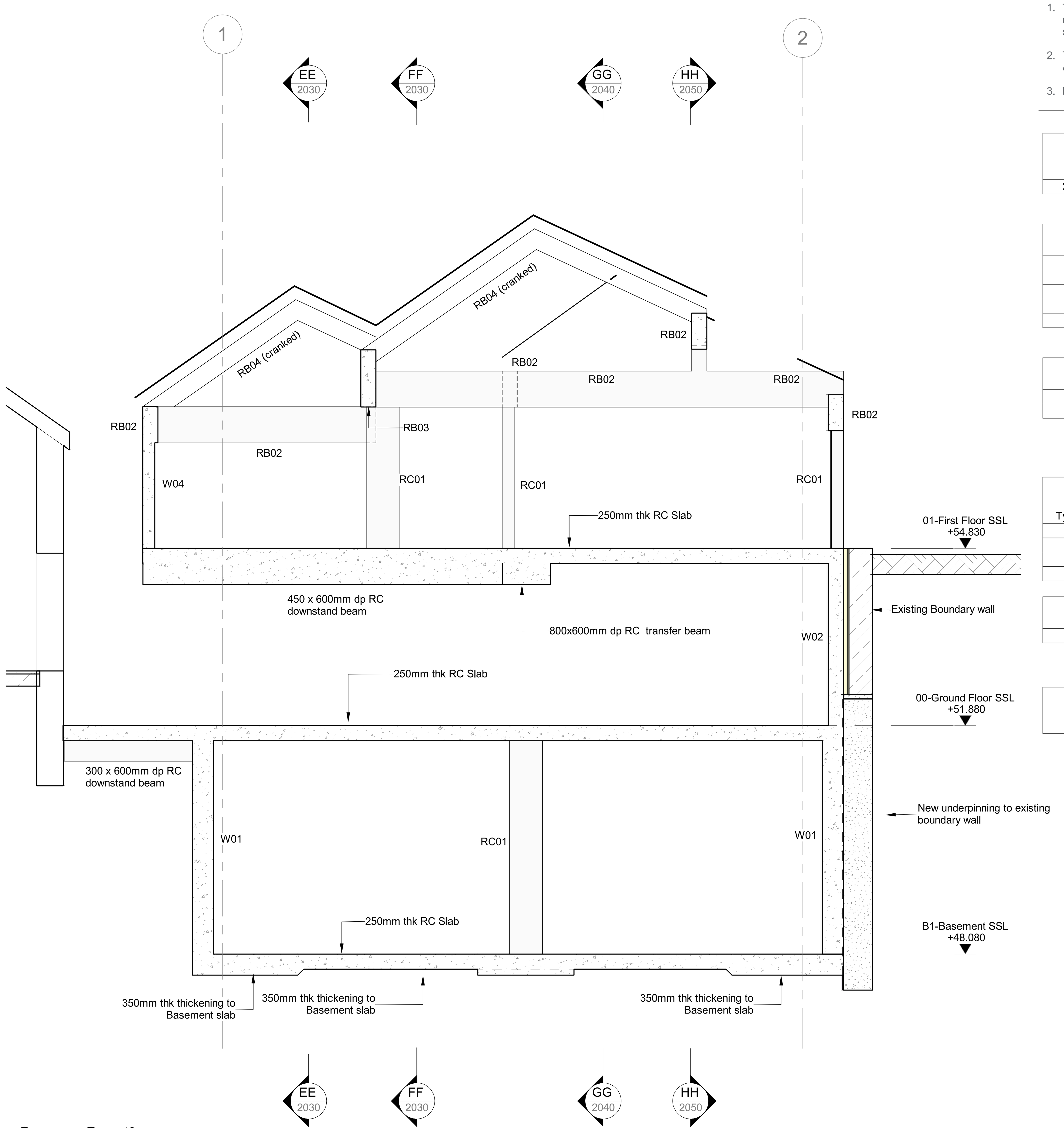

BB **Cross-Section**
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General Notes
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Steel Beam Schedule

Ref.	Type

Steel Column Schedule

Ref.	Type

Rev	Date	By	Chkd	Description
P02	01.10.18	SP	DW	Issued for Coordination
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Version

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HVS-EOC-V1-ZZ-DR-S-2010

Revision
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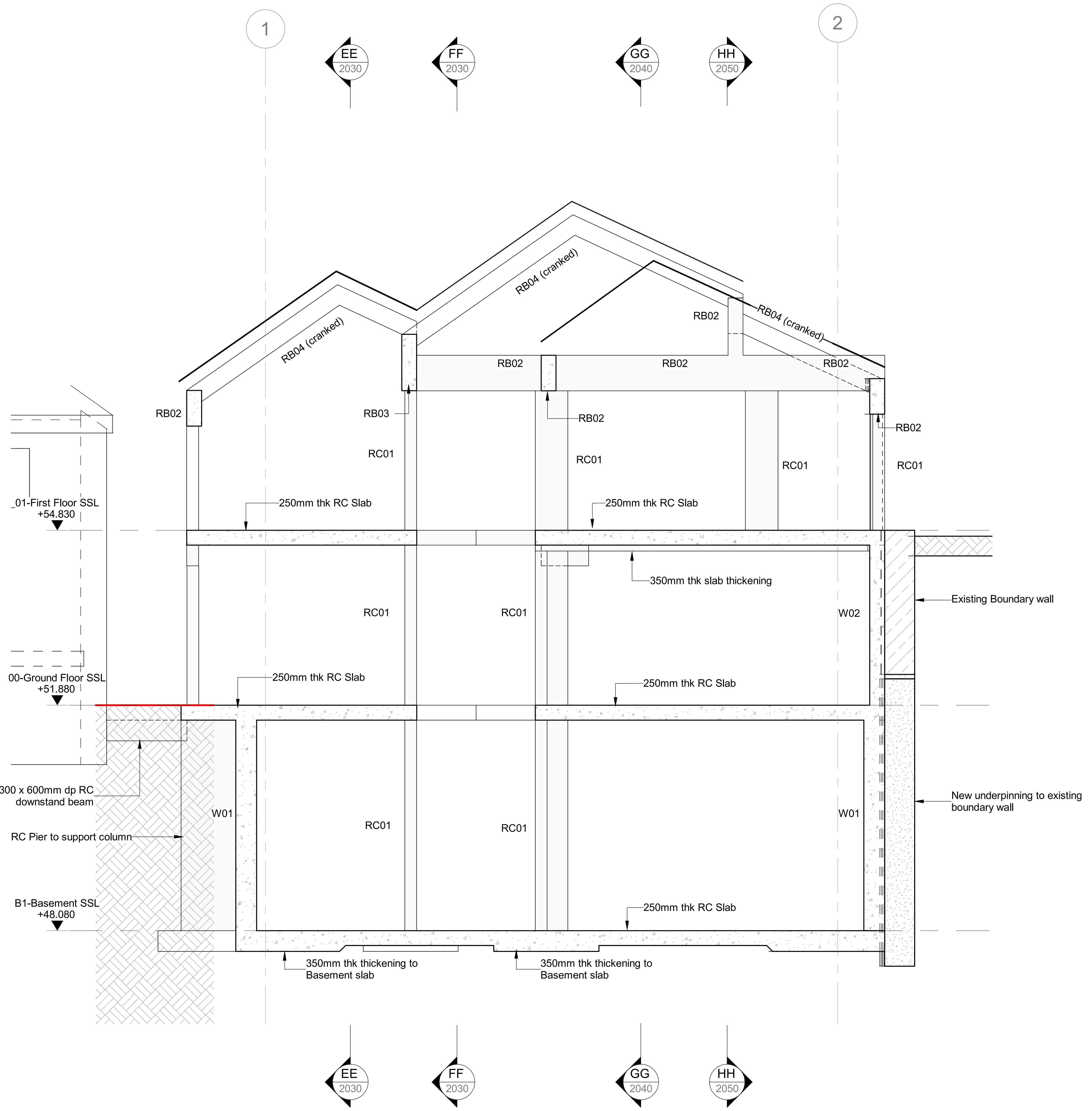

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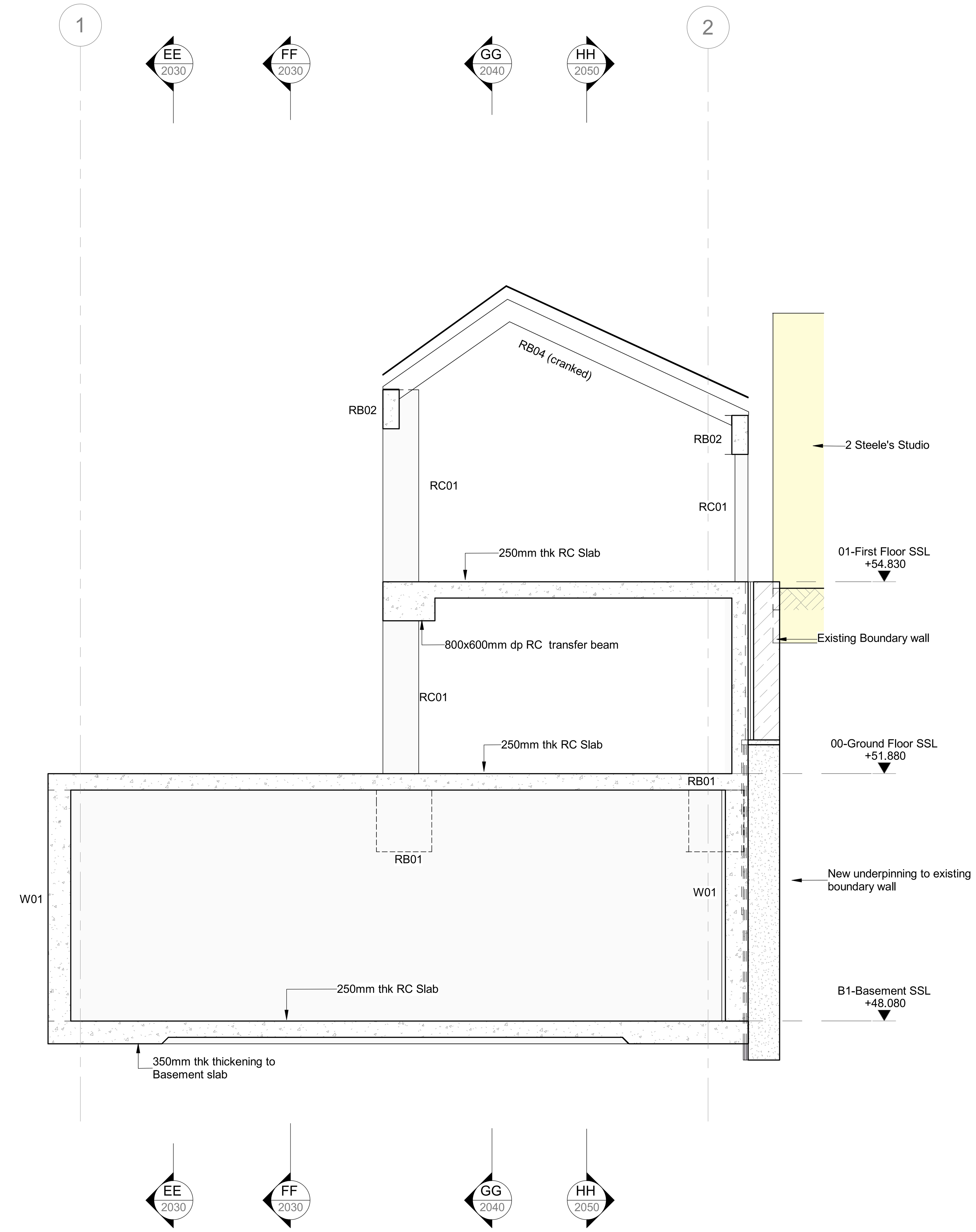

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General Notes

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Steel Column Schedule

Ref.	Type

Rev	Date	By	Chkd	Description
P02	01.10.18	SP	DW	Issued for Coordination
P01	18.05.18	SP	DW	Issued for Coordination

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HVS-EOC-V1-ZZ-DR-S-2020

Revision
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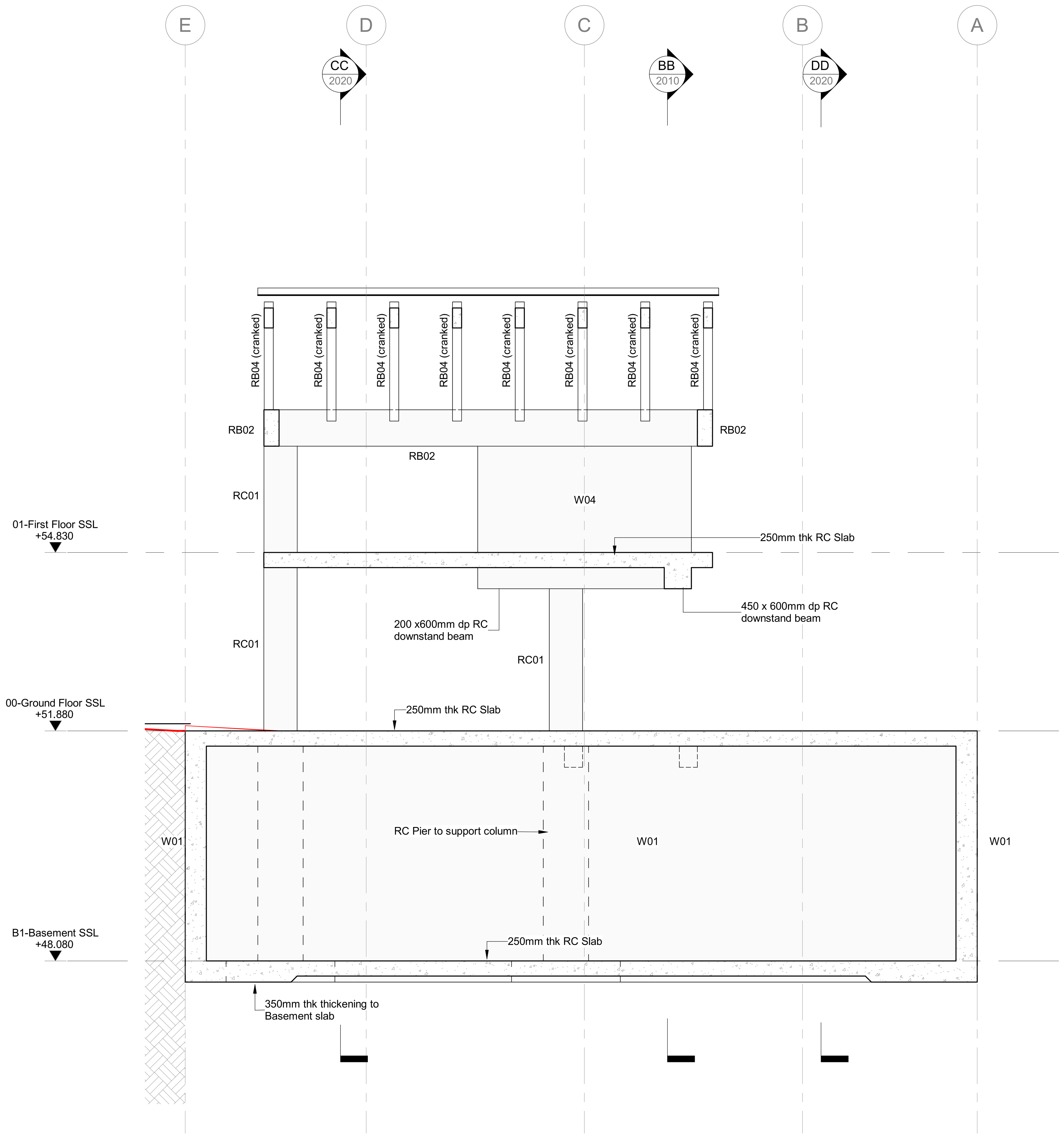

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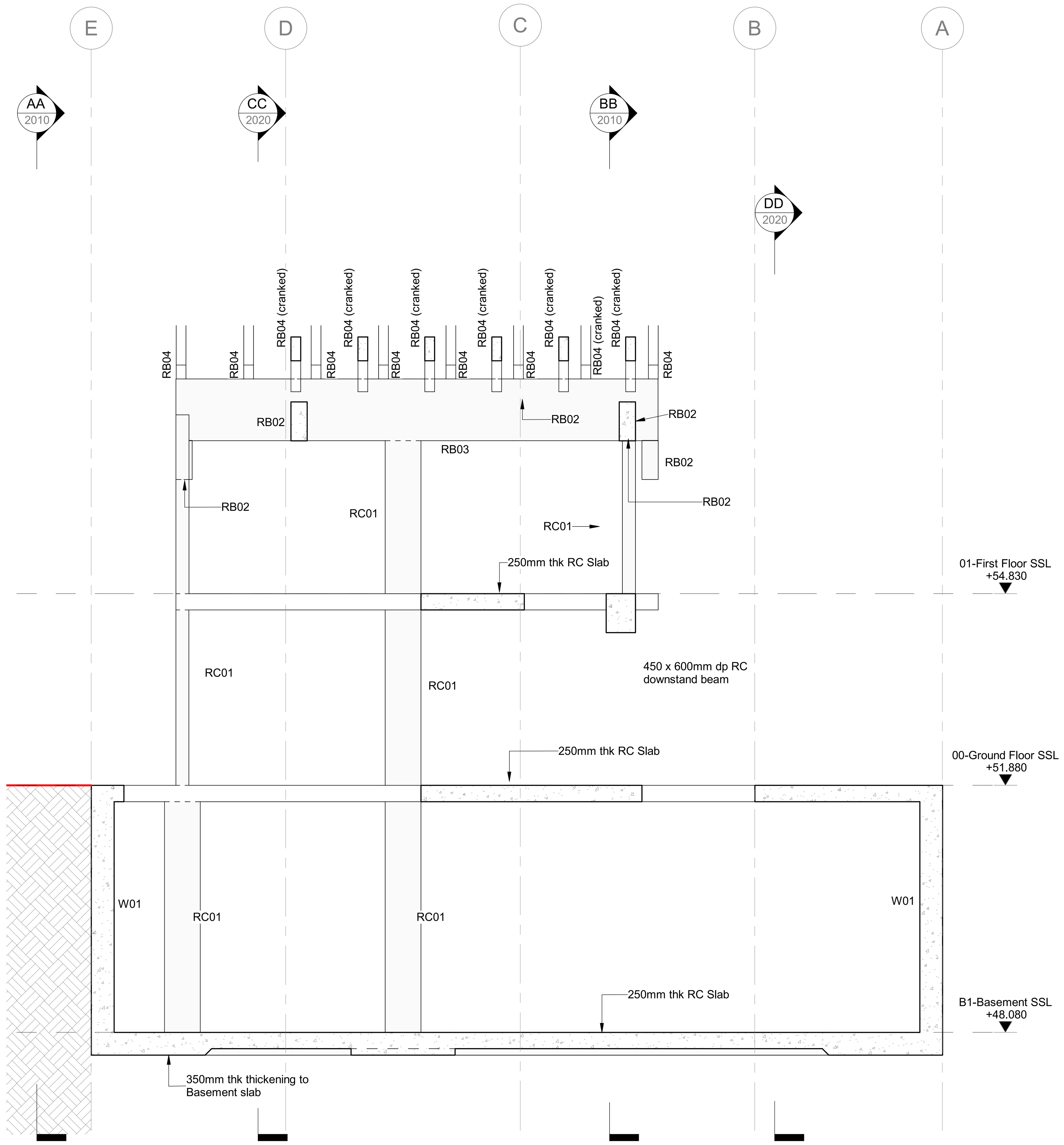

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Steel Beam Schedule

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Steel Column Schedule

Ref.	Type

Rev	Date	By	Chkd	Description
P02	01.10.18	SP	DW	Issued for Coordination
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Drawing Title
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Project No 18011
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Date May 2018

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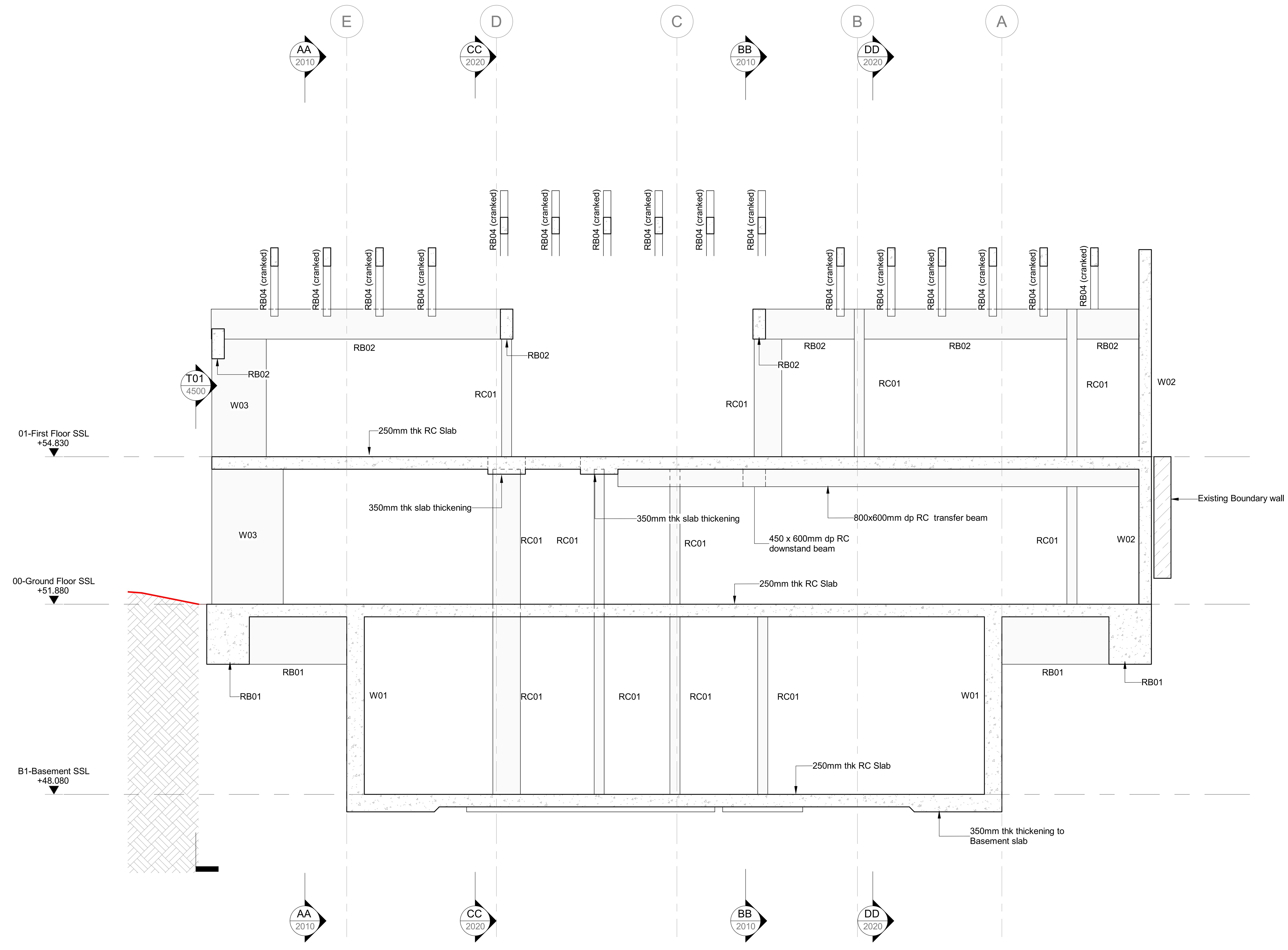
Version

Drawing Number HVS-EOC-V1-ZZ-DR-S-2030
Revision P02



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General Notes

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Steel Beam Schedule

Ref.	Type

Steel Column Schedule

Ref.	Type

Rev	Date	By	Chkd	Description
P02	01.10.18	SP	DW	Issued for Coordination
P01	18.05.18	SP	DW	Issued for Coordination

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Drawing Title
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Project No
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Scale
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Author

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May 2018

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Version

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Revision
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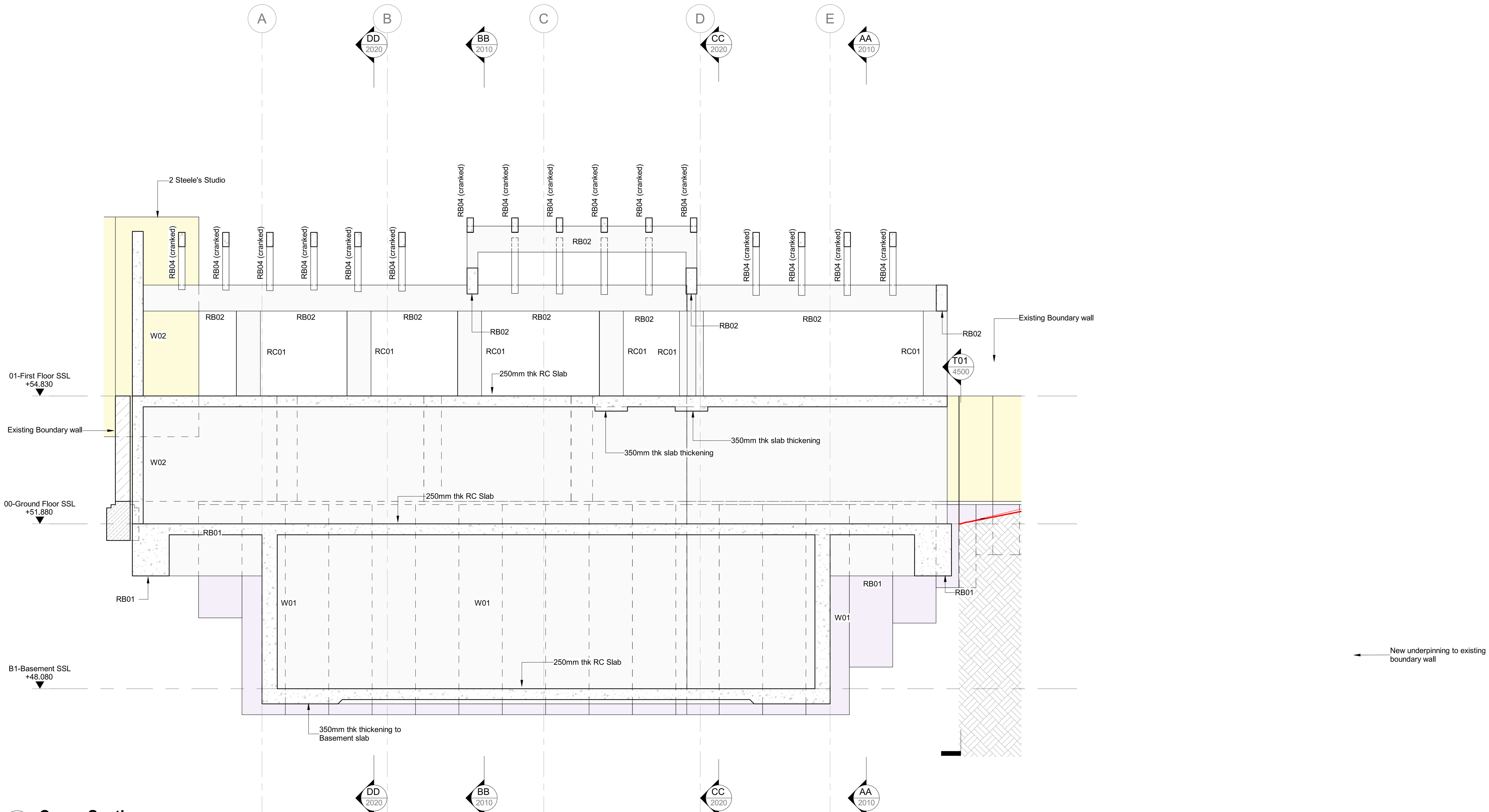

HH **Cross-Section**
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General Notes

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Steel Beam Schedule	
Ref.	Type

Steel Column Schedule	
Ref.	Type

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P02	01.10.18	SP	DW	Issued for Coordination
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Project Title
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Drawing Title
Cross-Sections

Project No
18011

Scale
1 : 50 [A1]

Drawn By
Author

Date
May 2018

Drawing Suitability
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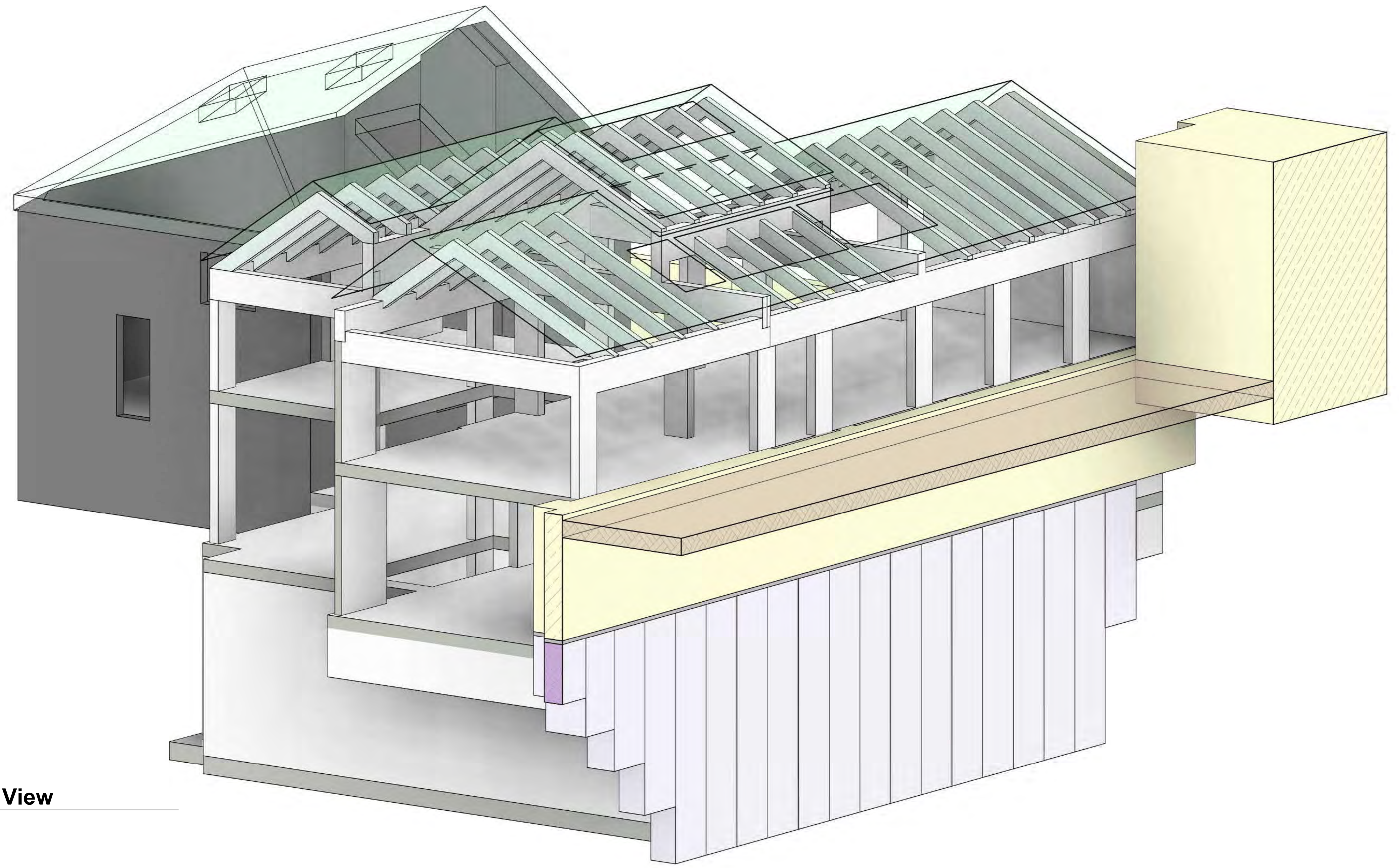

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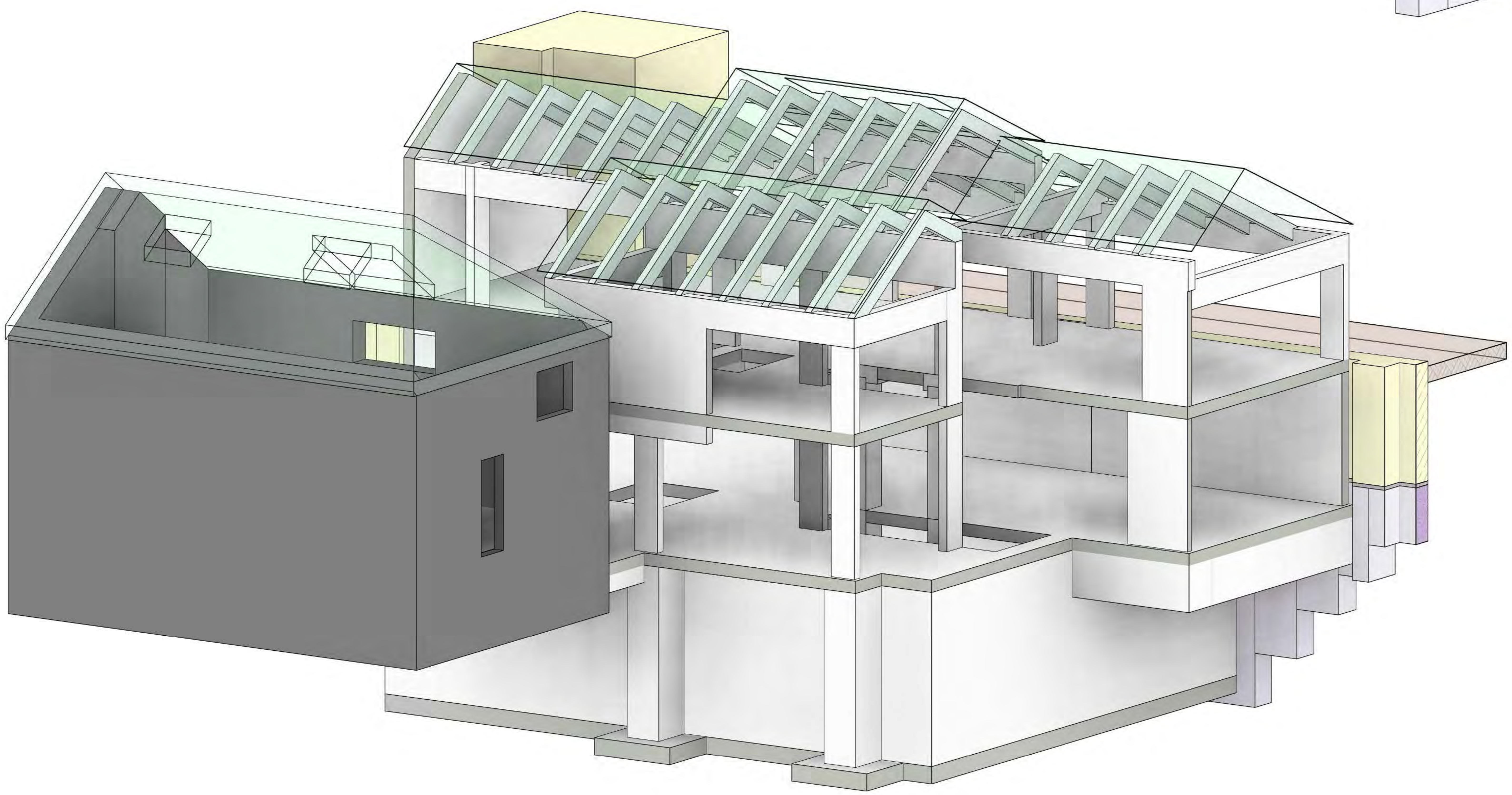

02 **3D View**

General Notes

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3. Do not scale from this drawing.

Rev	Date	By	Chkd	Description
P02	01.10.18	SP	DW	Issued for Coordination
P01	18.05.18	SP	DW	Issued for Coordination

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Project Title
Haverstock Hill

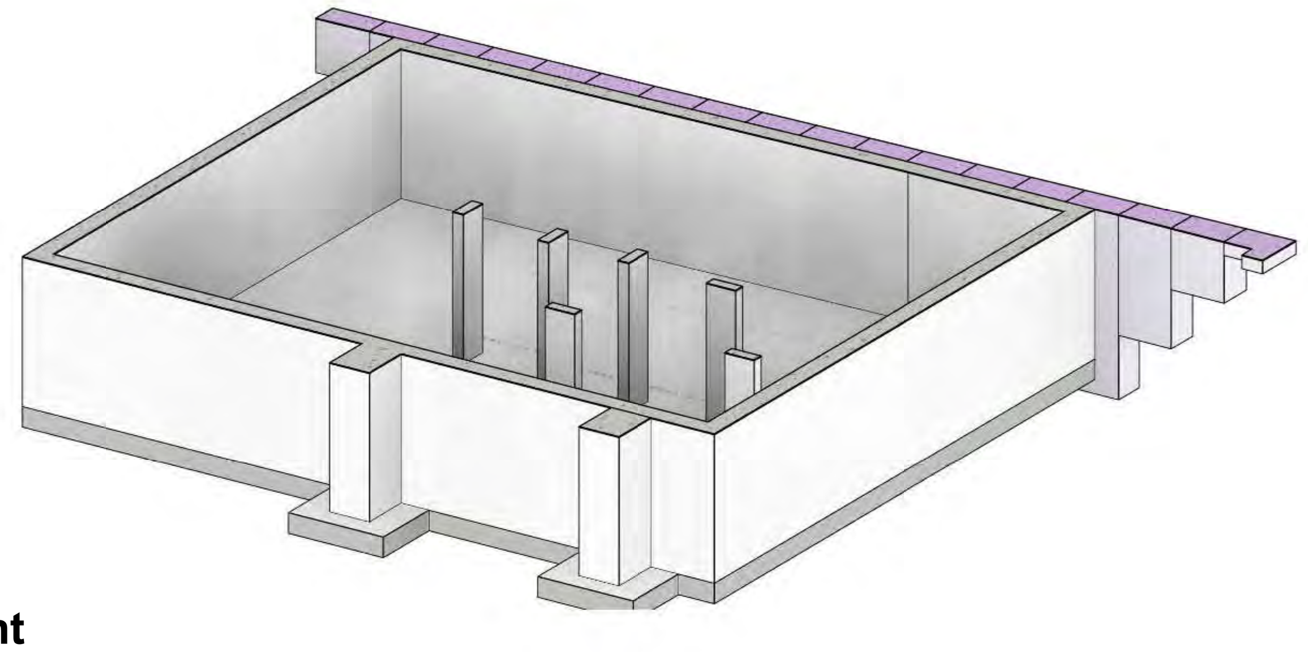
Drawing Title
3D Views

Project No 18011
Scale [A1]

Drawn By SP
Date May 2018

Drawing Suitability S1 - Suitable for Coordination
Version

Drawing Number HVS-EOC-V1-ZZ-DR-S-6010
Revision P02



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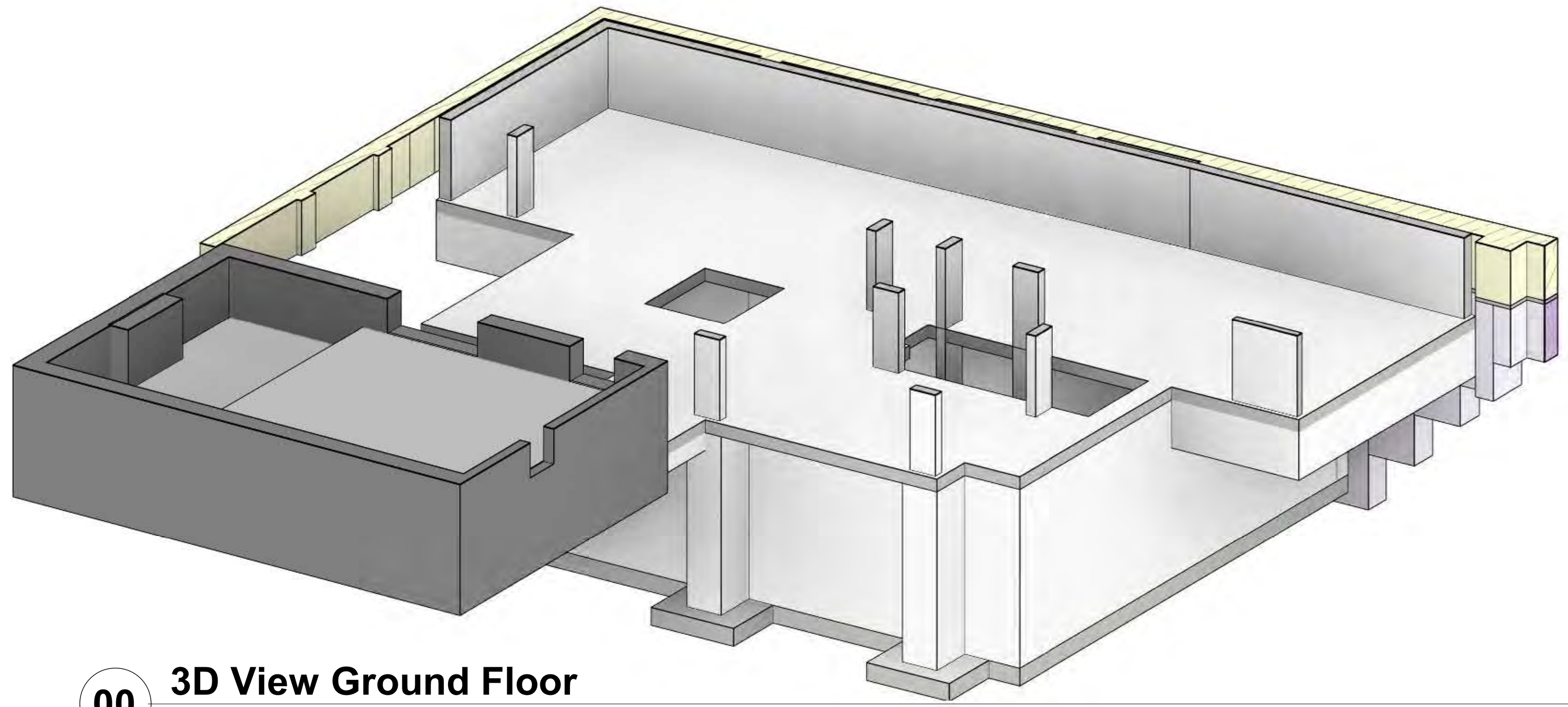
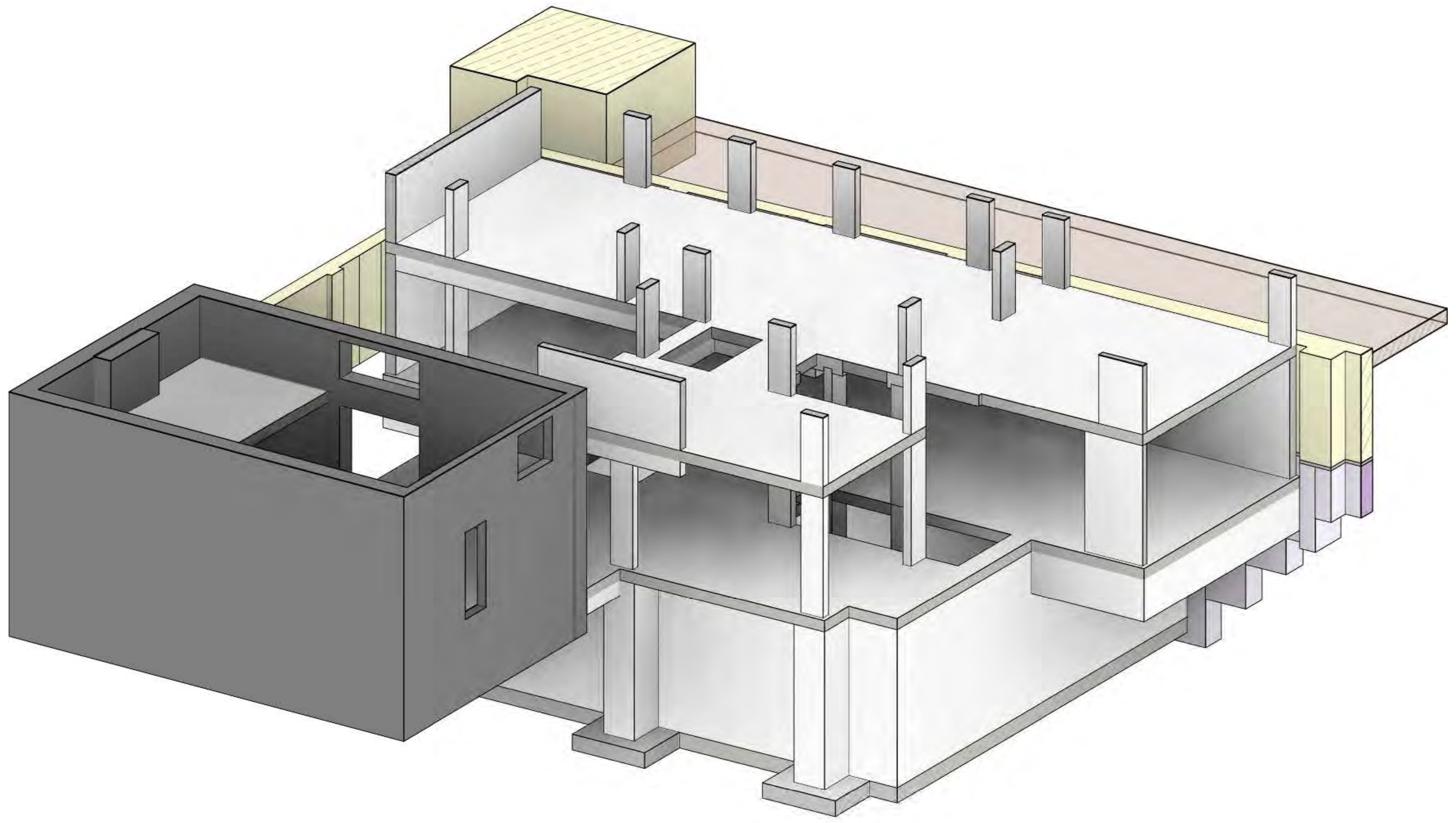


00 **3D View Ground Floor**



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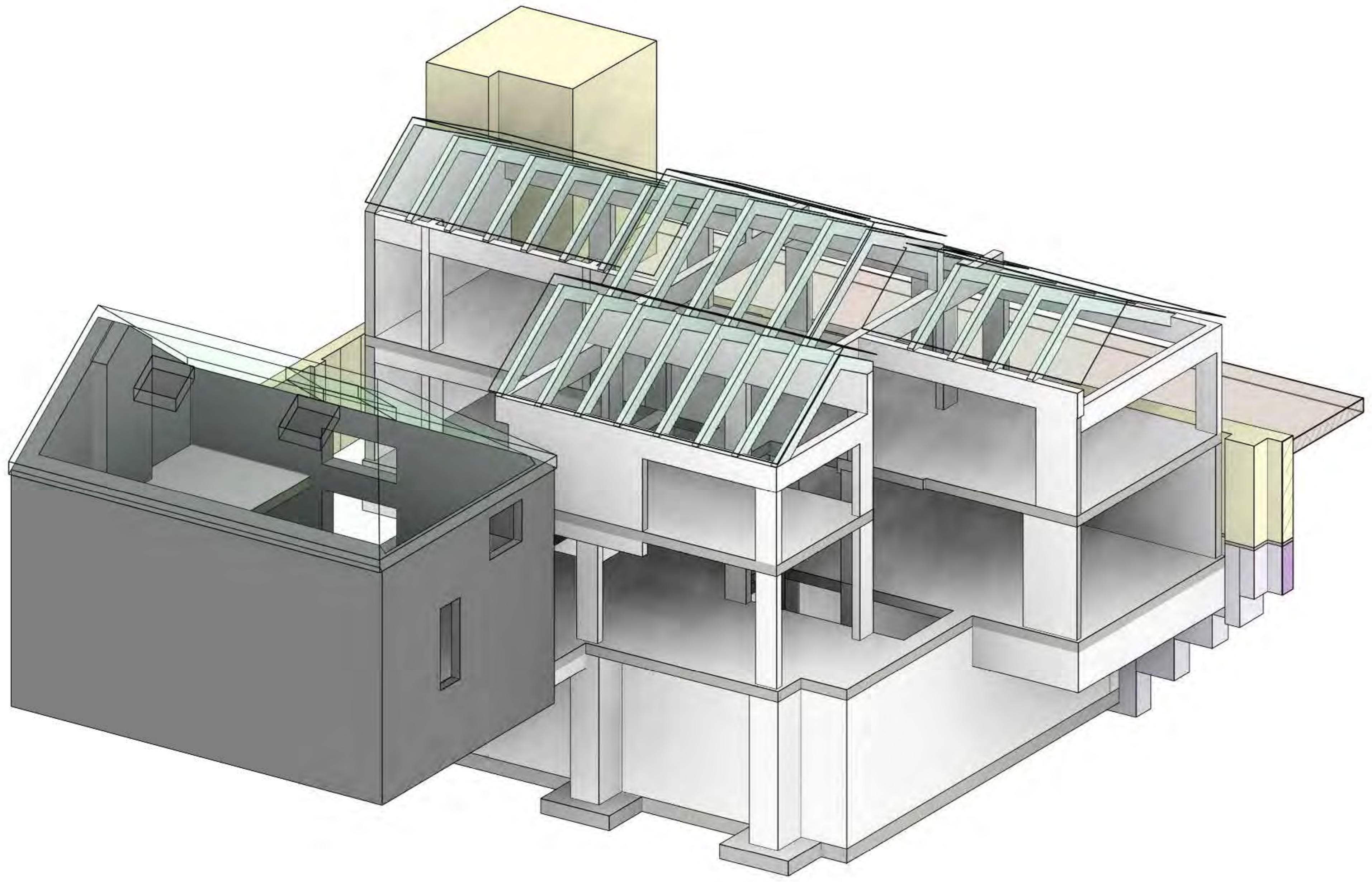

03 **3D View Roof**

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P01	18.05.18	SP	DW	Issued for Coordination

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Drawing Title
3D Views

Project No
18011

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[A1]

Drawn By
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Date
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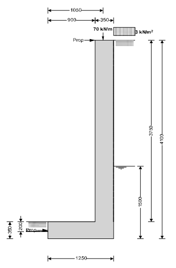
Drawing Number
HVS-EOC-V1-ZZ-DR-S-6011

Revision
P02

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06



Wall details

Retaining wall type — **Cantilever propped at both**
Height of retaining wall stem — h_{stem} = **3750** mm
Thickness of wall stem — t_{wall} = **350** mm
Length of toe — l_{toe} = **900** mm
Length of heel — l_{heel} = **0** mm
Overall length of base — $l_{base} = l_{toe} + l_{heel} + t_{wall}$ = **1250** mm
Thickness of base — t_{base} = **350** mm
Depth of downstand — d_{ds} = **0** mm
Position of downstand — l_{ds} = **850** mm
Thickness of downstand — t_{ds} = **350** mm
Height of retaining wall — $h_{wall} = h_{stem} + t_{base} + d_{ds}$ = **4100** mm
Depth of cover in front of wall — d_{cover} = **0** mm
Depth of unplanned excavation — d_{exc} = **200** mm
Height of ground water behind wall — h_{water} = **1500** mm
Height of saturated fill above base — $h_{sat} = \max(h_{water} - t_{base} - d_{ds}, 0\ mm)$ = **1150** mm
Density of wall construction — γ_{wall} = **23.6** kN/m³
Density of base construction — γ_{base} = **23.6** kN/m³
Angle of rear face of wall — α = **90.0** deg
Angle of soil surface behind wall — β = **0.0** deg
Effective height at virtual back of wall — $h_{eff} = h_{wall} + l_{heel} \times \tan(\beta)$ = **4100** mm

Retained material details

Mobilisation factor — M = **1.5**
Moist density of retained material — γ_m = **17.5** kN/m³

Saturated density of retained material — γ_s = **21.0** kN/m³
Design shear strength — ϕ' = **24.2** deg
Angle of wall friction — δ = **18.6** deg

Base material details

Moist density — γ_{mb} = **18.0** kN/m³
Design shear strength — ϕ'_b = **24.2** deg
Design base friction — δ_b = **18.6** deg
Allowable bearing pressure — $P_{bearing}$ = **150** kN/m²

Using Coulomb theory

Active pressure coefficient for retained material

$K_a = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))}]^2)$ = **0.369**

Passive pressure coefficient for base material

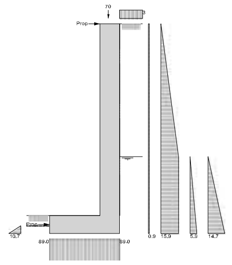
$K_p = \sin(90 - \phi'_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi'_b + \delta_b) \times \sin(\phi'_b) / (\sin(90 + \delta_b)))}]^2)$ = **4.187**

At-rest pressure

At-rest pressure for retained material — $K_0 = 1 - \sin(\phi')$ = **0.590**

Loading details

Surcharge load on plan — Surcharge = **2.5** kN/m²
Applied vertical dead load on wall — W_{dead} = **70.0** kN/m
Applied vertical live load on wall — W_{live} = **0.0** kN/m
Position of applied vertical load on wall — l_{load} = **1050** mm
Applied horizontal dead load on wall — F_{dead} = **0.0** kN/m
Applied horizontal live load on wall — F_{live} = **0.0** kN/m
Height of applied horizontal load on wall — h_{load} = **0** mm



Loads shown in kN/m, pressures shown in kN/m²

Vertical forces on wall

Wall stem — $w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall}$ = **31** kN/m

Wall base — $w_{base} = l_{base} \times t_{base} \times \gamma_{base}$ = **10.3** kN/m
Applied vertical load — $W_v = W_{dead} + W_{live}$ = **70** kN/m
Total vertical load — $W_{total} = w_{wall} + w_{base} + W_v$ = **111.3** kN/m

Horizontal forces on wall

Surcharge — $F_{sur} = K_a \times \cos(90 - \alpha + \delta) \times Surcharge \times h_{eff}$ = **3.6** kN/m
Moist backfill above water table — $F_{m\_a} = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2$ = **20.7** kN/m
Moist backfill below water table — $F_{m\_b} = K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water}$ = **23.9** kN/m
Saturated backfill — $F_s = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times (\gamma_s - \gamma_{water}) \times h_{water}^2$ = **4.4** kN/m
Water — $F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water}$ = **11** kN/m
Total horizontal load — $F_{total} = F_{sur} + F_{m\_a} + F_{m\_b} + F_s + F_{water}$ = **63.6** kN/m

Calculate total propping force

Passive resistance of soil in front of wall — $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **0.8** kN/m
Propping force — $F_{prop} = \max(F_{total} - F_p - (W_{total}) \times \tan(\delta_b), 0\ kN/m)$
F_{prop} = **25.3** kN/m

Overturning moments

Surcharge — $M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **7.4** kNm/m
Moist backfill above water table — $M_{m\_a} = F_{m\_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **49** kNm/m
Moist backfill below water table — $M_{m\_b} = F_{m\_b} \times (h_{water} - 2 \times d_{ds}) / 2$ = **17.9** kNm/m
Saturated backfill — $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3$ = **2.2** kNm/m
Water — $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3$ = **5.5** kNm/m
Total overturning moment — $M_{ot} = M_{sur} + M_{m\_a} + M_{m\_b} + M_s + M_{water}$ = **82** kNm/m

Restoring moments

Wall stem — $M_{wall} = w_{wall} \times (l_{toe} + t_{wall} / 2)$ = **33.3** kNm/m
Wall base — $M_{base} = w_{base} \times l_{base} / 2$ = **6.5** kNm/m
Design vertical load — $M_v = W_v \times l_{load}$ = **73.5** kNm/m
Total restoring moment — $M_{rest} = M_{wall} + M_{base} + M_v$ = **113.3** kNm/m

Check bearing pressure

Total vertical reaction — $R = W_{total}$ = **111.3** kN/m
Distance to reaction — $x_{bar} = l_{base} / 2$ = **625** mm
Eccentricity of reaction — $e = abs((l_{base} / 2) - x_{bar})$ = **0** mm

Reaction acts within middle third of base

Bearing pressure at toe — $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2)$ = **89** kN/m²
Bearing pressure at heel — $p_{heel} = (R / l_{base}) + (6 \times R \times e / l_{base}^2)$ = **89** kN/m²

PASS - Maximum bearing pressure is less than allowable bearing pressure

Calculate propping forces to top and base of wall

Propping force to top of wall

$F_{prop\_top} = (M_{ot} - M_{rest} + R \times l_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2)$ = **8.619** kN/m

Propping force to base of wall — $F_{prop\_base} = F_{prop} - F_{prop\_top}$ = **16.718** kN/m

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor — γ_{f_d} = **1.4**
Live load factor — γ_{f_l} = **1.6**
Earth and water pressure factor — γ_{f_e} = **1.4**

Factored vertical forces on wall

Wall stem — $w_{wall\_f} = \gamma_{f\_d} \times h_{stem} \times t_{wall} \times \gamma_{wall}$ = **43.4** kN/m
Wall base — $w_{base\_f} = \gamma_{f\_d} \times l_{base} \times t_{base} \times \gamma_{base}$ = **14.5** kN/m
Applied vertical load — $W_{v\_f} = \gamma_{f\_d} \times W_{dead} + \gamma_{f\_l} \times W_{live}$ = **98** kN/m
Total vertical load — $W_{total\_f} = w_{wall\_f} + w_{base\_f} + W_{v\_f}$ = **155.8** kN/m

Factored horizontal active forces on wall

Surcharge — $F_{sur\_f} = \gamma_{f\_l} \times K_a \times \cos(90 - \alpha + \delta) \times Surcharge \times h_{eff}$ = **5.7** kN/m
Moist backfill above water table — $F_{m\_a\_f} = \gamma_{f\_e} \times 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2$ = **29** kN/m
Moist backfill below water table — $F_{m\_b\_f} = \gamma_{f\_e} \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water}$ = **33.4** kN/m
Saturated backfill — $F_{s\_f} = \gamma_{f\_e} \times 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times (\gamma_s - \gamma_{water}) \times h_{water}^2$ = **6.2** kN/m
Water — $F_{water\_f} = \gamma_{f\_e} \times 0.5 \times h_{water}^2 \times \gamma_{water}$ = **15.5** kN/m
Total horizontal load — $F_{total\_f} = F_{sur\_f} + F_{m\_a\_f} + F_{m\_b\_f} + F_{s\_f} + F_{water\_f}$ = **89.8** kN/m

Calculate total propping force

Passive resistance of soil in front of wall — $F_{p\_f} = \gamma_{f\_e} \times 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **1.1** kN/m
Propping force — $F_{prop\_f} = \max(F_{total\_f} - F_{p\_f} - (W_{total\_f}) \times \tan(\delta_b), 0\ kN/m)$
F_{prop_f} = **36.2** kN/m

Factored overturning moments

Surcharge — $M_{sur\_f} = F_{sur\_f} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **11.8** kNm/m
Moist backfill above water table — $M_{m\_a\_f} = F_{m\_a\_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **68.6** kNm/m
Moist backfill below water table — $M_{m\_b\_f} = F_{m\_b\_f} \times (h_{water} - 2 \times d_{ds}) / 2$ = **25.1** kNm/m
Saturated backfill — $M_{s\_f} = F_{s\_f} \times (h_{water} - 3 \times d_{ds}) / 3$ = **3.1** kNm/m
Water — $M_{water\_f} = F_{water\_f} \times (h_{water} - 3 \times d_{ds}) / 3$ = **7.7** kNm/m
Total overturning moment — $M_{ot\_f} = M_{sur\_f} + M_{m\_a\_f} + M_{m\_b\_f} + M_{s\_f} + M_{water\_f}$ = **116.2** kNm/m

Restoring moments

Wall stem — $M_{wall\_f} = w_{wall\_f} \times (l_{toe} + t_{wall} / 2)$ = **46.6** kNm/m
Wall base — $M_{base\_f} = w_{base\_f} \times l_{base} / 2$ = **9** kNm/m
Design vertical load — $M_{v\_f} = W_{v\_f} \times l_{load}$ = **102.9** kNm/m
Total restoring moment — $M_{rest\_f} = M_{wall\_f} + M_{base\_f} + M_{v\_f}$ = **158.6** kNm/m

Factored bearing pressure

Total vertical reaction — $R_f = W_{total\_f}$ = **155.8** kN/m
Distance to reaction — $x_{bar\_f} = l_{base} / 2$ = **625** mm
Eccentricity of reaction — $e_f = abs((l_{base} / 2) - x_{bar\_f})$ = **0** mm

Reaction acts within middle third of base

Bearing pressure at toe — $p_{toe\_f} = (R_f / l_{base}) - (6 \times R_f \times e_f / l_{base}^2)$ = **124.7** kN/m²
Bearing pressure at heel — $p_{heel\_f} = (R_f / l_{base}) + (6 \times R_f \times e_f / l_{base}^2)$ = **124.7** kN/m²
Rate of change of base reaction — $rate = (p_{toe\_f} - p_{heel\_f}) / l_{base}$ = **0.00** kN/m²/m

Bearing pressure at stem / toe — $p_{stem\_toe\_f} = \max(p_{toe\_f} - (rate \times l_{toe}), 0\ kN/m^2)$ = **124.7** kN/m²
Bearing pressure at mid stem — $p_{stem\_mid\_f} = \max(p_{toe\_f} - (rate \times (l_{toe} + t_{wall} / 2)), 0\ kN/m^2)$ = **124.7** kN/m²
Bearing pressure at stem / heel — $p_{stem\_heel\_f} = \max(p_{toe\_f} - (rate \times (l_{toe} + t_{wall})), 0\ kN/m^2)$ = **124.7** kN/m²

Calculate propping forces to top and base of wall

Propping force to top of wall

$F_{prop\_top\_f} = (M_{ot\_f} - M_{rest\_f} + R_f \times l_{base} / 2 - F_{prop\_f} \times t_{base} / 2) / (h_{stem} + t_{base} / 2)$ = **12.410** kN/m

Propping force to base of wall — $F_{prop\_base\_f} = F_{prop\_f} - F_{prop\_top\_f}$ = **23.779** kN/m

Design of reinforced concrete retaining wall toe (BS 8002:1994)

Material properties

Characteristic strength of concrete — f_{cu} = **35** N/mm²
Characteristic strength of reinforcement — f_y = **500** N/mm²

Base details

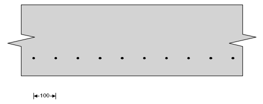
Minimum area of reinforcement — k = **0.13** %
Cover to reinforcement in toe — c_{toe} = **75** mm

Calculate shear for toe design

Shear from bearing pressure — $V_{toe\_bear} = (p_{toe\_f} + p_{stem\_toe\_f}) \times l_{toe} / 2$ = **112.2** kN/m
Shear from weight of base — $V_{toe\_wt\_base} = \gamma_{f\_d} \times \gamma_{base} \times l_{toe} \times t_{base}$ = **10.4** kN/m
Total shear for toe design — $V_{toe} = V_{toe\_bear} - V_{toe\_wt\_base}$ = **101.8** kN/m

Calculate moment for toe design

Moment from bearing pressure — $M_{toe\_bear} = (2 \times p_{toe\_f} + p_{stem\_mid\_f}) \times (l_{toe} + t_{wall} / 2)^2 / 6$ = **72** kNm/m
Moment from weight of base — $M_{toe\_wt\_base} = (\gamma_{f\_d} \times \gamma_{base} \times t_{base} \times (l_{toe} + t_{wall} / 2)^2 / 2)$ = **6.7** kNm/m
Total moment for toe design — $M_{toe} = M_{toe\_bear} - M_{toe\_wt\_base}$ = **65.3** kNm/m



Check toe in bending

Width of toe — b = **1000** mm/m
Depth of reinforcement — $d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2)$ = **269.0** mm
Constant — $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu})$ = **0.026**

Compression reinforcement is not required

Lever arm — $z_{toe} = \min(0.5 + \sqrt{(0.25 - (\min(K_{toe}, 0.225) / 0.9))}, 0.95) \times d_{toe}$
z_{toe} = **256** mm

Area of tension reinforcement required — $As_{toe\_des} = M_{toe} / (0.87 \times f_y \times z_{toe})$ = **588** mm²/m
Minimum area of tension reinforcement — $As_{toe\_min} = k \times b \times t_{base}$ = **455** mm²/m
Area of tension reinforcement required — $As_{toe\_req} = \max(As_{toe\_des}, As_{toe\_min})$ = **588** mm²/m
Reinforcement provided — **B1131 mesh**
Area of reinforcement provided — As_{toe_prov} = **1131** mm²/m

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress — $v_{toe} = V_{toe} / (b \times d_{toe})$ = **0.378** N/mm²
Allowable shear stress — $v_{adm} = \min(0.8 \times \sqrt{(f_{cu} / 1\ N/mm^2)}, 5) \times 1\ N/mm^2$ = **4.733** N/mm²

PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress — v_{c_toe} = **0.585** N/mm²

$v_{toe} < v_{c\_toe}$ - No shear reinforcement required

Design of reinforced concrete retaining wall stem (BS 8002:1994)

Material properties

Characteristic strength of concrete — f_{cu} = **35** N/mm²
Characteristic strength of reinforcement — f_y = **500** N/mm²

Wall details

Minimum area of reinforcement — k = **0.13** %
Cover to reinforcement in stem — c_{stem} = **75** mm
Cover to reinforcement in wall — c_{wall} = **75** mm

Factored horizontal active forces on stem

Surcharge — $F_{s\_sur\_f} = \gamma_{f\_l} \times K_a \times \cos(90 - \alpha + \delta) \times Surcharge \times (h_{eff} - t_{base} - d_{ds})$ = **5.2** kN/m
Moist backfill above water table — $F_{s\_m\_a\_f} = 0.5 \times \gamma_{f\_e} \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2$ = **29** kN/m
Moist backfill below water table — $F_{s\_m\_b\_f} = \gamma_{f\_e} \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat}) \times h_{sat}$ = **25.6** kN/m
Saturated backfill — $F_{s\_s\_f} = 0.5 \times \gamma_{f\_e} \times K_a \times \cos(90 - \alpha + \delta) \times (\gamma_s - \gamma_{water}) \times h_{sat}^2$ = **3.6** kN/m
Water — $F_{s\_water\_f} = 0.5 \times \gamma_{f\_e} \times \gamma_{water} \times h_{sat}^2$ = **9.1** kN/m

Calculate shear for stem design

Surcharge — $V_{s\_sur\_f} = 5 \times F_{s\_sur\_f} / 8$ = **3.3** kN/m
Moist backfill above water table — $V_{s\_m\_a\_f} = F_{s\_m\_a\_f} \times b_l \times ((5 \times L^2) - b_l^2) / (5 \times L^3)$ = **17.5** kN/m
Moist backfill below water table — $V_{s\_m\_b\_f} = F_{s\_m\_b\_f} \times (8 - (n^2 \times (4 - n))) / 8$ = **24.3** kN/m
Saturated backfill — $V_{s\_s\_f} = F_{s\_s\_f} \times (1 - (a_l^2 \times ((5 \times L) - a_l) / (20 \times L^3)))$ = **3.5** kN/m
Water — $V_{s\_water\_f} = F_{s\_water\_f} \times (1 - (a_l^2 \times ((5 \times L) - a_l) / (20 \times L^3)))$ = **8.8** kN/m
Total shear for stem design — $V_{stem} = V_{s\_sur\_f} + V_{s\_m\_a\_f} + V_{s\_m\_b\_f} + V_{s\_s\_f} + V_{s\_water\_f}$ = **57.4** kN/m

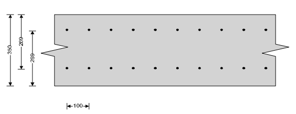
Calculate moment for stem design

Surcharge — $M_{s\_sur} = F_{s\_sur\_f} \times L / 8$ = **2.6** kNm/m
Moist backfill above water table — $M_{s\_m\_a} = F_{s\_m\_a\_f} \times b_l \times ((5 \times L^2) - (3 \times b_l^2)) / (15 \times L^2)$ = **18.5** kNm/m
Moist backfill below water table — $M_{s\_m\_b} = F_{s\_m\_b\_f} \times a_l \times (2 - n)^2 / 8$ = **11.7** kNm/m
Saturated backfill — $M_{s\_s} = F_{s\_s\_f} \times a_l \times ((3 \times a_l^2) - (15 \times a_l \times L) + (20 \times L^2)) / (60 \times L^2)$ = **1.2** kNm/m
Water — $M_{s\_water} = F_{s\_water\_f} \times a_l \times ((3 \times a_l^2) - (15 \times a_l \times L) + (20 \times L^2)) / (60 \times L^2)$ = **3.1** kNm/m
Total moment for stem design — $M_{stem} = M_{s\_sur} + M_{s\_m\_a} + M_{s\_m\_b} + M_{s\_s} + M_{s\_water}$ = **37.1** kNm/m

Calculate moment for wall design

Surcharge — $M_{w\_sur} = 9 \times F_{s\_sur\_f} \times L / 128$ = **1.4** kNm/m
Moist backfill above water table — $M_{w\_m\_a} = F_{s\_m\_a\_f} \times 0.577 \times b_l \times [(b_l^3 + 5 \times a_l \times L^2)/(5 \times L^3) - 0.577^2/3]$ = **12.4** kNm/m
Moist backfill below water table — $M_{w\_m\_b} = F_{s\_m\_b\_f} \times a_l \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)] / 8$ = **3.5** kNm/m
Saturated backfill — $M_{w\_s} = F_{s\_s\_f} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)]$ = **0.3** kNm/m

Water — $M_{w\_water} = F_{s\_water\_f} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)]$ = **0.7** kNm/m
Total moment for wall design — $M_{wall} = M_{w\_sur} + M_{w\_m\_a} + M_{w\_m\_b} + M_{w\_s} + M_{w\_water}$ = **18.3** kNm/m



Check wall stem in bending

Width of wall stem — b = **1000** mm/m
Depth of reinforcement — $d_{stem} = t_{wall} - c_{stem} - (\phi_{stem} / 2)$ = **269.0** mm
Constant — $K_{stem} = M_{stem} / (b \times d_{stem}^2 \times f_{cu})$ = **0.015**

Compression reinforcement is not required

Lever arm — $z_{stem} = \min(0.5 + \sqrt{(0.25 - (\min(K_{stem}, 0.225) / 0.9))}, 0.95) \times d_{stem}$
z_{stem} = **256** mm

Area of tension reinforcement required — $As_{stem\_des} = M_{stem} / (0.87 \times f_y \times z_{stem})$ = **334** mm²/m
Minimum area of tension reinforcement — $As_{stem\_min} = k \times b \times t_{wall}$ = **455** mm²/m
Area of tension reinforcement required — $As_{stem\_req} = \max(As_{stem\_des}, As_{stem\_min})$ = **455** mm²/m
Reinforcement provided — **B1131 mesh**
Area of reinforcement provided — As_{stem_prov} = **1131** mm²/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress — $v_{stem} = V_{stem} / (b \times d_{stem})$ = **0.214** N/mm²
Allowable shear stress — $v_{adm} = \min(0.8 \times \sqrt{(f_{cu} / 1\ N/mm^2)}, 5) \times 1\ N/mm^2$ = **4.733** N/mm²

PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress — v_{c_stem} = **0.585** N/mm²

$v_{stem} < v_{c\_stem}$ - No shear reinforcement required

Check mid height of wall in bending

Depth of reinforcement — $d_{wall} = t_{wall} - c_{wall} - (\phi_{wall} / 2)$ = **269.0** mm
Constant — $K_{wall} = M_{wall} / (b \times d_{wall}^2 \times f_{cu})$ = **0.007**

Compression reinforcement is not required

Lever arm — $z_{wall} = \min(0.5 + \sqrt{(0.25 - (\min(K_{wall}, 0.225) / 0.9))}, 0.95) \times d_{wall}$
z_{wall} = **256** mm

Area of tension reinforcement required — $As_{wall\_des} = M_{wall} / (0.87 \times f_y \times z_{wall})$ = **164** mm²/m
Minimum area of tension reinforcement — $As_{wall\_min} = k \times b \times t_{wall}$ = **455** mm²/m
Area of tension reinforcement required — $As_{wall\_req} = \max(As_{wall\_des}, As_{wall\_min})$ = **455** mm²/m
Reinforcement provided — **B1131 mesh**
Area of reinforcement provided — As_{wall_prov} = **1131** mm²/m

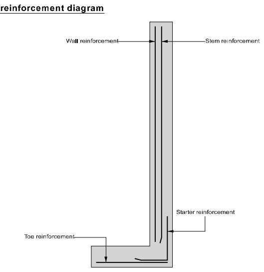
PASS - Reinforcement provided to the retaining wall at mid height is adequate

Check retaining wall deflection

Basic span/effective depth ratio — $ratio_{bas}$ = **20**
Design service stress — $f_s = 2 \times f_y \times As_{stem\_req} / (3 \times As_{stem\_prov})$ = **134.1** N/mm²
Modification factor — $factor_{tens} = \min(0.55 + (477\ N/mm^2 - f_s)/(120 \times (0.9\ N/mm^2 + (M_{stem}/(b \times d_{stem}^2)))), 2)$ = **2.00**
Maximum span/effective depth ratio — $ratio_{max} = ratio_{bas} \times factor_{tens}$ = **40.00**
Actual span/effective depth ratio — $ratio_{act} = h_{stem} / d_{stem}$ = **13.94**

PASS - Span to depth ratio is acceptable

Indicative retaining wall reinforcement diagram



Toe mesh - B1131 - (1131 mm²/m)
Wall mesh - B1131 - (1131 mm²/m)
Stem mesh - B1131 - (1131 mm²/m)