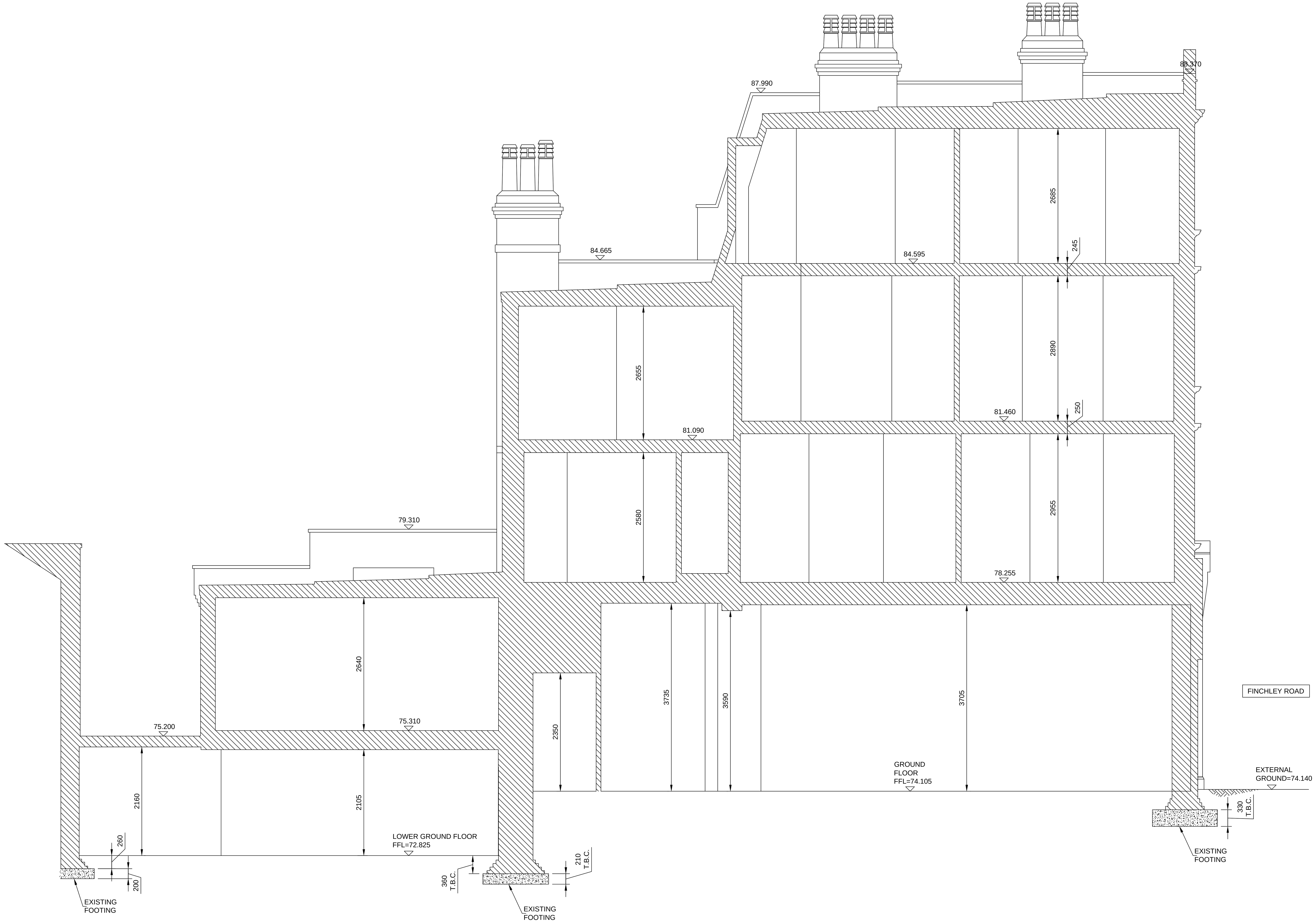
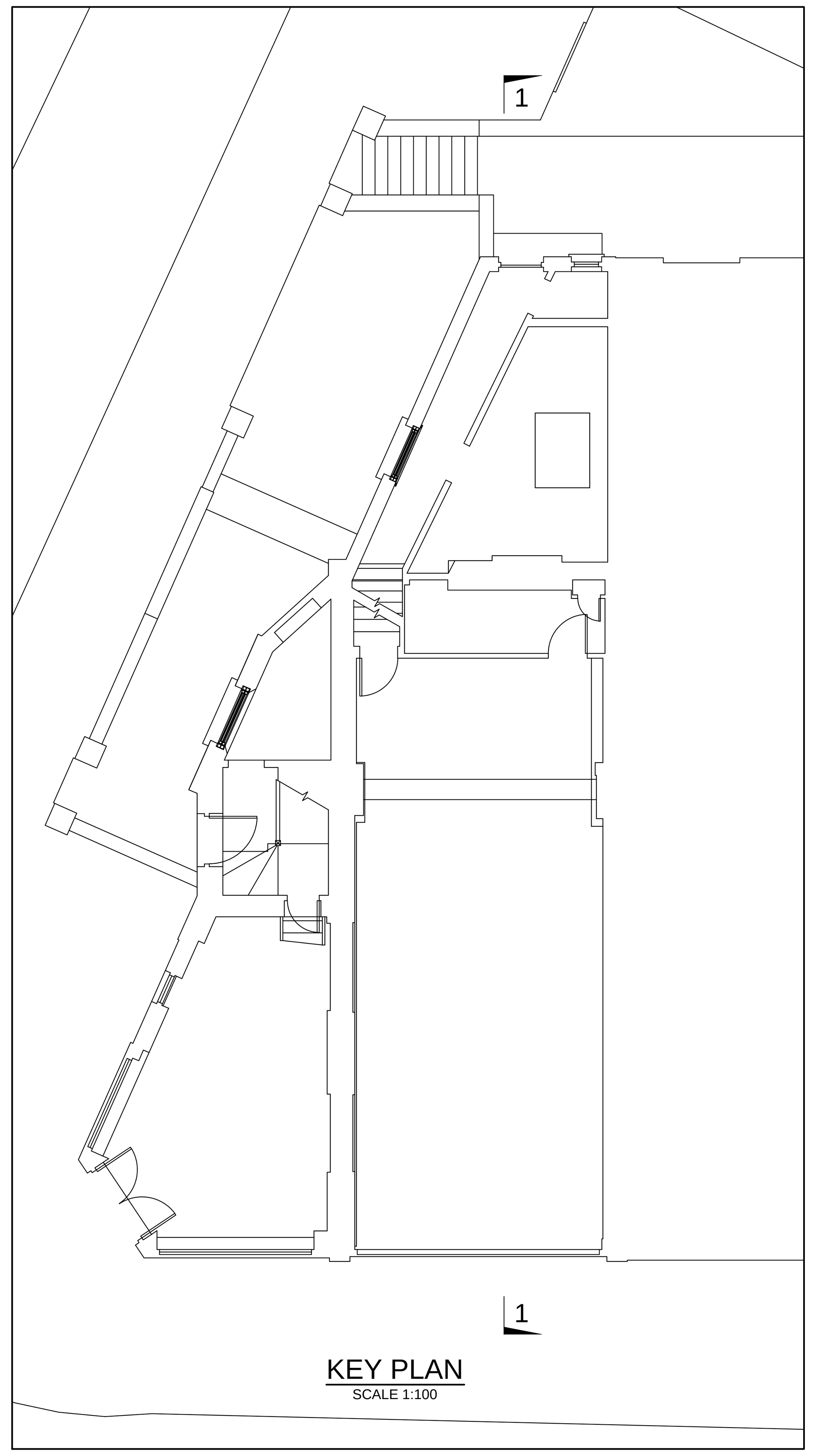


SECTION 1-1 AS EXISTING

SCALE 1:50



KEY PLAN

SCALE 1:100

NOTES

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CDM REGULATIONS 2007 RESIDUAL HAZARDS

RESIDUAL HAZARDS IDENTIFIED ▲

1. NONE

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Mark	Date	By	Chkd.	Revision notes
-	16/03/15	PO	AB	FOR INFORMATION

FOR INFORMATION ONLY

abstruct consulting engineers
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LONDON + SEVENOAKS Tel: 03330 113 401 info@abstruct-llp.com

Job Title

4No NEW RESIDENTIAL UNITS
465-467 FINCHLEY ROAD
NW3 6HS

Drawing Title

SECTION 1-1
AS EXISTING

Client

A.GOVANI

Scale at A1:	Drawn:	Checked:
1:100, 1:50	PO	AB
	Date: March 2015	Date: 17/03/2015

Drawing No.:	Revision:
AB1115_0102	-

DISPROPORTIONATE COLLAPSE -BUILDING REGS.

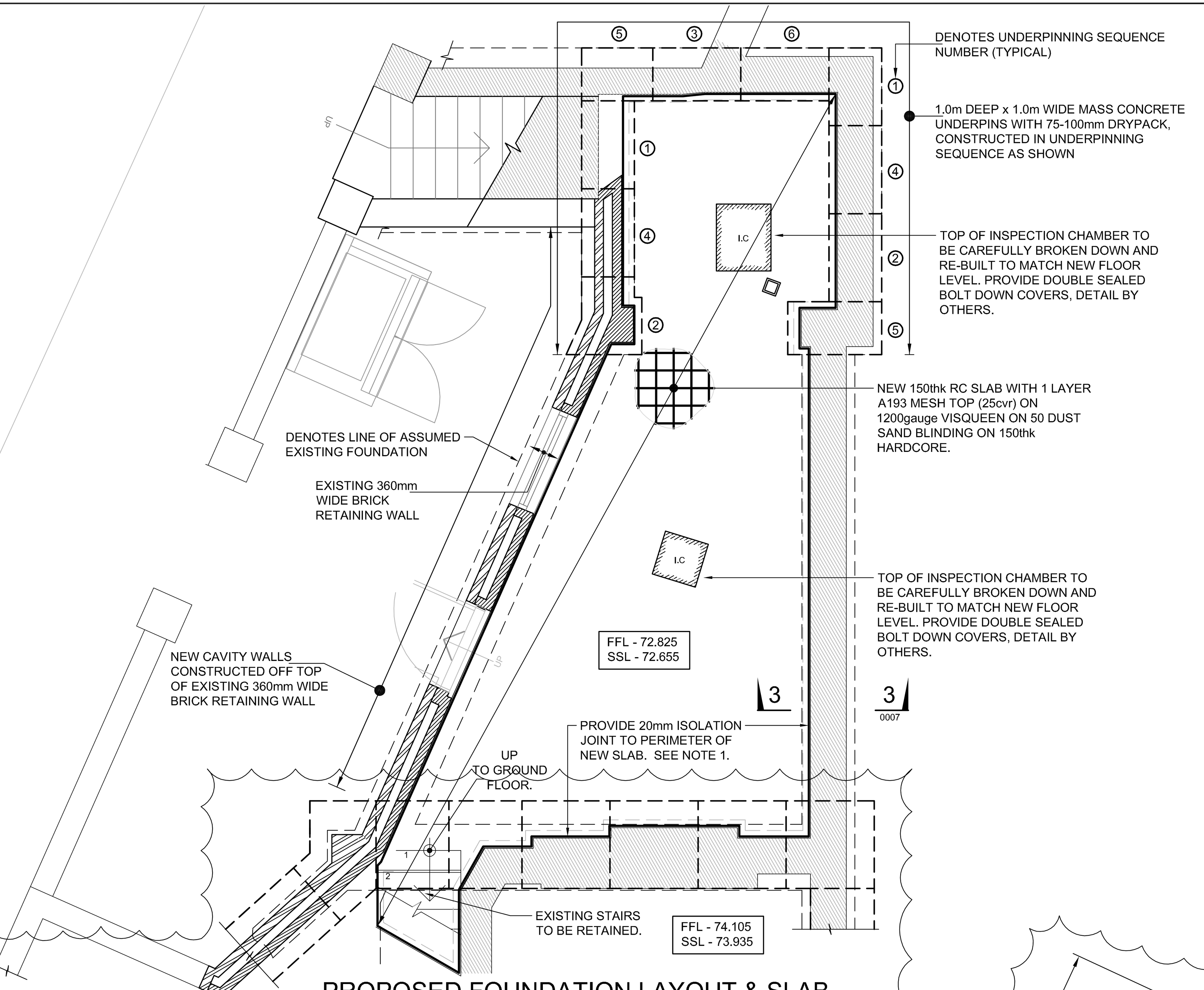
PROVISION OF BASEMENT CHANGES CLASS OF BUILDING TO 2B.
THEREFORE PROVIDE RC BASEMENT 'BOX' WITH RC WALLS AND GROUND FLOOR SLAB SO GROUND FLOOR TO ROOF REMAINS CLASS 2A.

BASEMENT RETAINING WALLS WILL REQUIRE APPROVAL FROM LOCAL COUNCIL HIGHWAYS DEPARTMENT & STATUTORY AUTHORITIES PARTY WALL NOTICES WILL BE REQUIRED

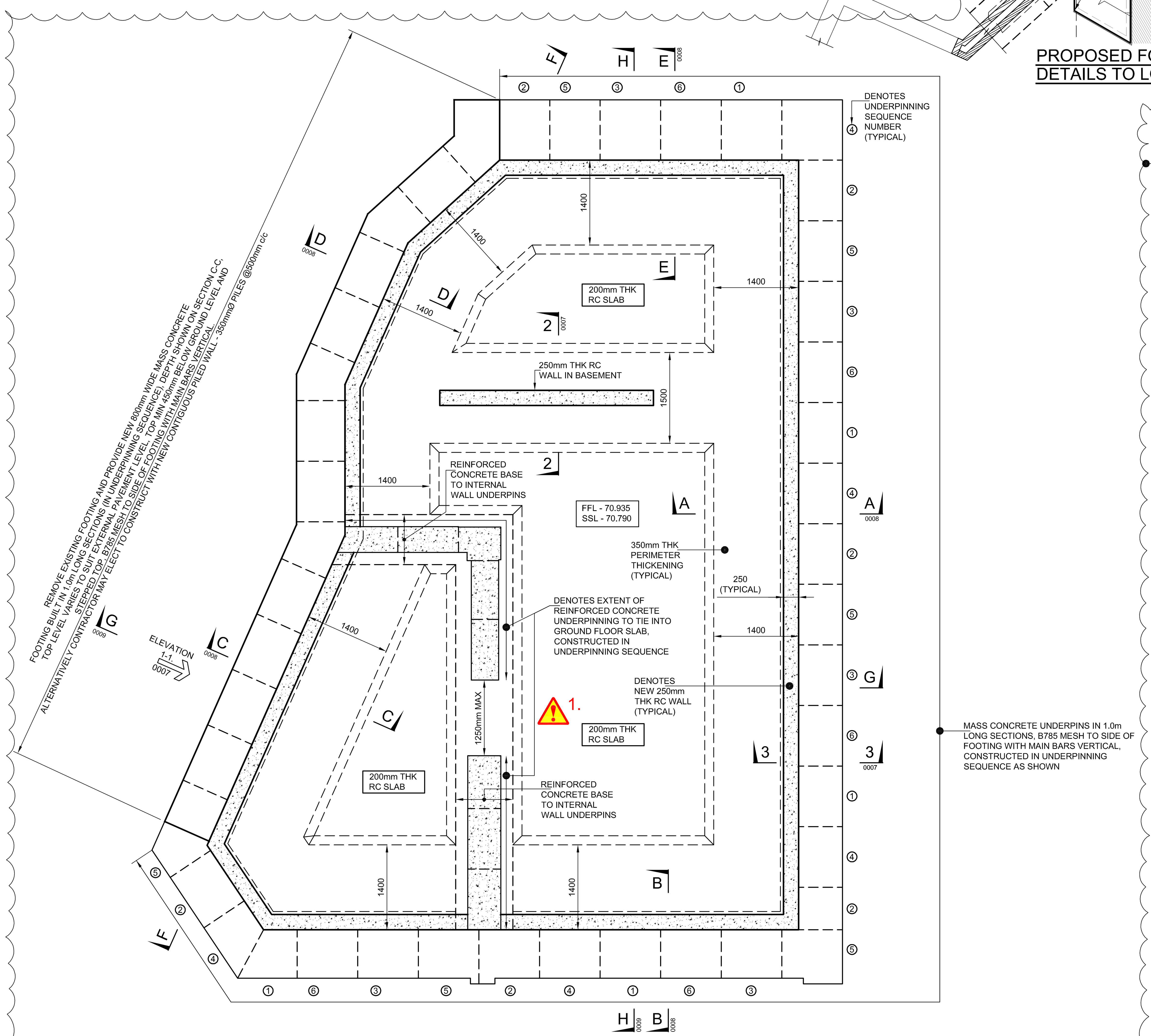
LEGEND

LBW. DENOTES NEW 215thk LOADBEARING MEDIUM DENSE 7.0N/mm2 BLOCKWORK IN 1:1:6 MORTAR.

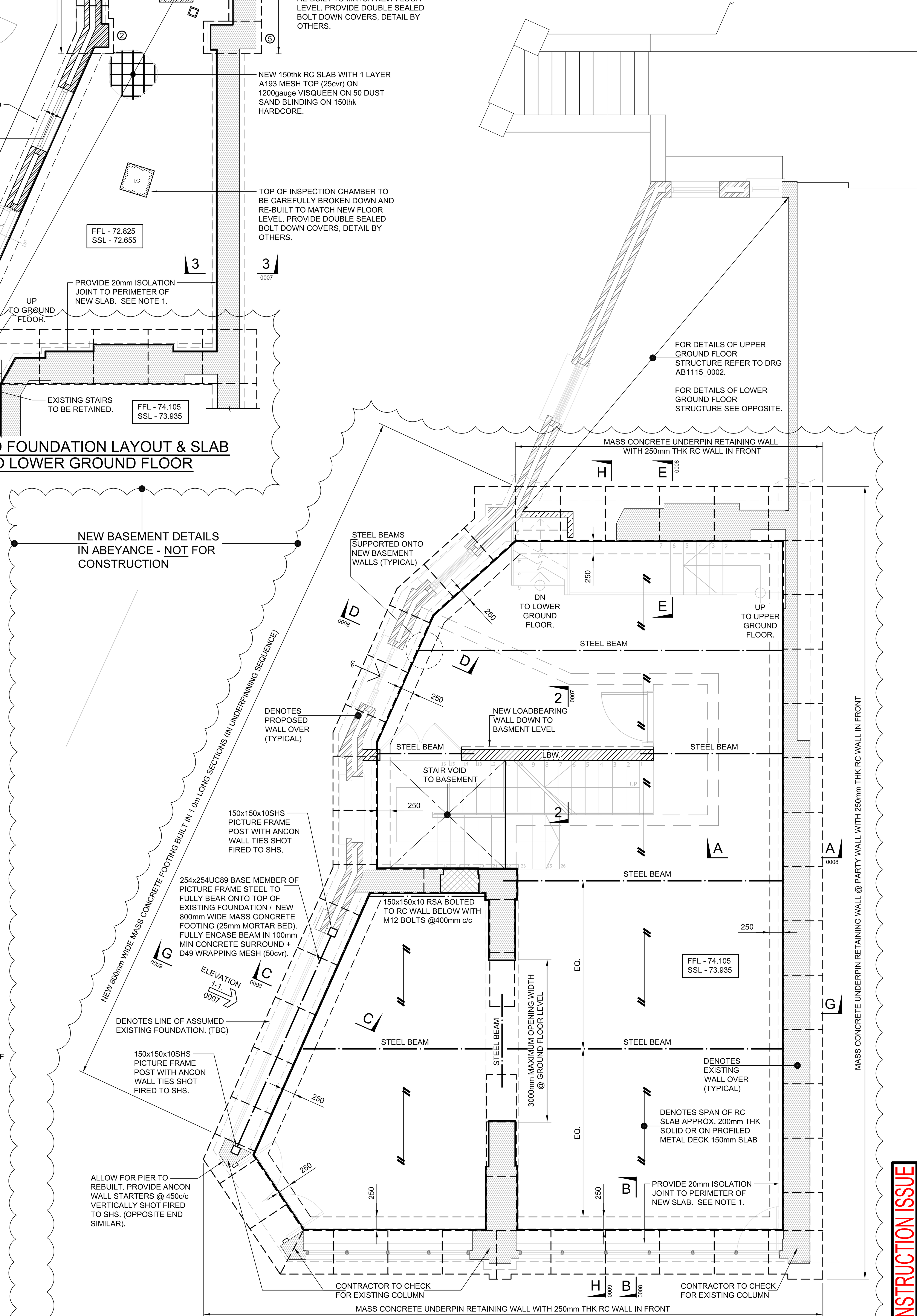
20wd ISOLATION JOINT TO BE PROVIDED BETWEEN NEW AND EXISTING SLAB STRUCTURE WITH 20mm COMPRESSIBLE FILLER AND TOP 20mm OF JOINT CLOSED WITH MASTIC SEALANT TO ARCHITECTS SPECIFICATION.



PROPOSED FOUNDATION LAYOUT & SLAB DETAILS TO LOWER GROUND FLOOR



BASEMENT FOUNDATIONS PLAN



BASEMENT WITH GROUND FLOOR STRUCTURE OVER

NOTES

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6. FOR MATERIAL NOTES REFER TO DRAWING GEN.01

UNDERPINNING:

1. UNDERPINNING IS TO BE CARRIED OUT IN THE SEQUENCE SHOWN. ANY CHANGES IN THE SEQUENCE IS TO BE AGREED WITH THE ENGINEER PRIOR TO COMMENCEMENT OF THE WORKS.
2. NO SECTION SHALL BE COMMENCED UNTIL THE PREVIOUSLY NUMBERED SECTION HAS BEEN TOTALLY COMPLETED.
3. 24 HOURS MUST ELAPSE BETWEEN CONCRETING OF UNDERPINNED WALL SECTION & DRY PACKING BETWEEN UNDERPINNING AND EXISTING FOUNDATIONS.
4. A PERIOD OF 12 HOURS MUST ELAPSE FROM COMPLETION OF DRY PACKING ONE SECTION TO COMMENCEMENT OF EXCAVATION OF NEXT NUMBERED SECTION.
5. THE UNDERSIDE OF THE EXISTING FOUNDATIONS ARE TO BE THOROUGHLY CLEANED BEFORE CONCRETING OR DRY PACKING.
6. EACH SECTION OF UNDERPINNING IS TO BE LINKED WITH H20 DOWEL BARS 600mm LONG @350CRS TOP & BOTTOM & EACH FACE (MIN 60mm COVER ALL FACES).
7. THE CONTRACTOR MUST PROTECT ALL DRAINAGE/ GAS/ WATER/ ELECTRICAL SERVICES WITHIN THE AREAS OF WORKING. THE CONTRACTOR WILL BE FULLY RESPONSIBLE FOR THE REPAIR OF ANY DAMAGED SERVICES & FOR MAKING GOOD ANY AFFECTED AREAS AS A RESULT OF DAMAGED SERVICES.
8. ALL WORK TO BE CARRIED OUT TO THE SATISFACTION OF THE LOCAL AUTHORITY & THE STRUCTURAL ENGINEER.
9. CONCRETE FOR UNDERPINNING SECTIONS TO HAVE A 28 DAY CUBE STRENGTH OF 35N/MM2.
10. DRY PACK TO BE 1:3 CEMENT:SHARP SAND WITH A MOISTURE CONTENT SUFFICIENT ONLY TO BIND THE MATERIAL ONLY UNDER HAND PRESSURE. THE DRY PACK SHOULD BE WELL RAMMED INTO PLACE & SHOULD FULLY FILL THE GAP BETWEEN THE EXISTING FOUNDATIONS & THE NEW UNDERPINNING SECTIONS.
11. FORMATION LEVEL OF THE UNDERPINNING TO BE TAKEN 300mm BELOW THE LAST LINE OF ACTIVE ROOTS ENCOUNTERED OR MIN 150mm INTO APPROVED BEARING STRATA TO THE SATISFACTION OF THE LOCAL AUTHORITY & THE ENGINEER.

CDM REGULATIONS 2007 RESIDUAL HAZARDS

RESIDUAL HAZARDS IDENTIFIED

1. COLLAPSE OF SPINE WALL - CONTRACTOR TO FULLY SUPPORT SUPERSTRUCTURE PRIOR TO CENTRAL WALL UNDERPINNING.

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Mark	Date	By	Chkd.	Revision notes
C	17/03/15	PO	APB	REVISED TO NEW BASEMENT SCHEME
B	10/07/14	DJE	MW	AMENDMENTS TO EXTERNAL WALL AS CLOUDED. ISSUED FOR CONSTRUCTION.
A	12/06/14	DJE	MW	MINOR REVISIONS TO PICTURE FRAME. SECTION MARKS ADDED. CENTRAL FOUNDATION INCREASED TO 1200wd. WALL REV'D.
-	15/05/14	DJE	MW	PRELIMINARY ISSUE

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Job Title
4No NEW RESIDENTIAL UNITS
465-467 FINCHLEY ROAD
NW3 6HS

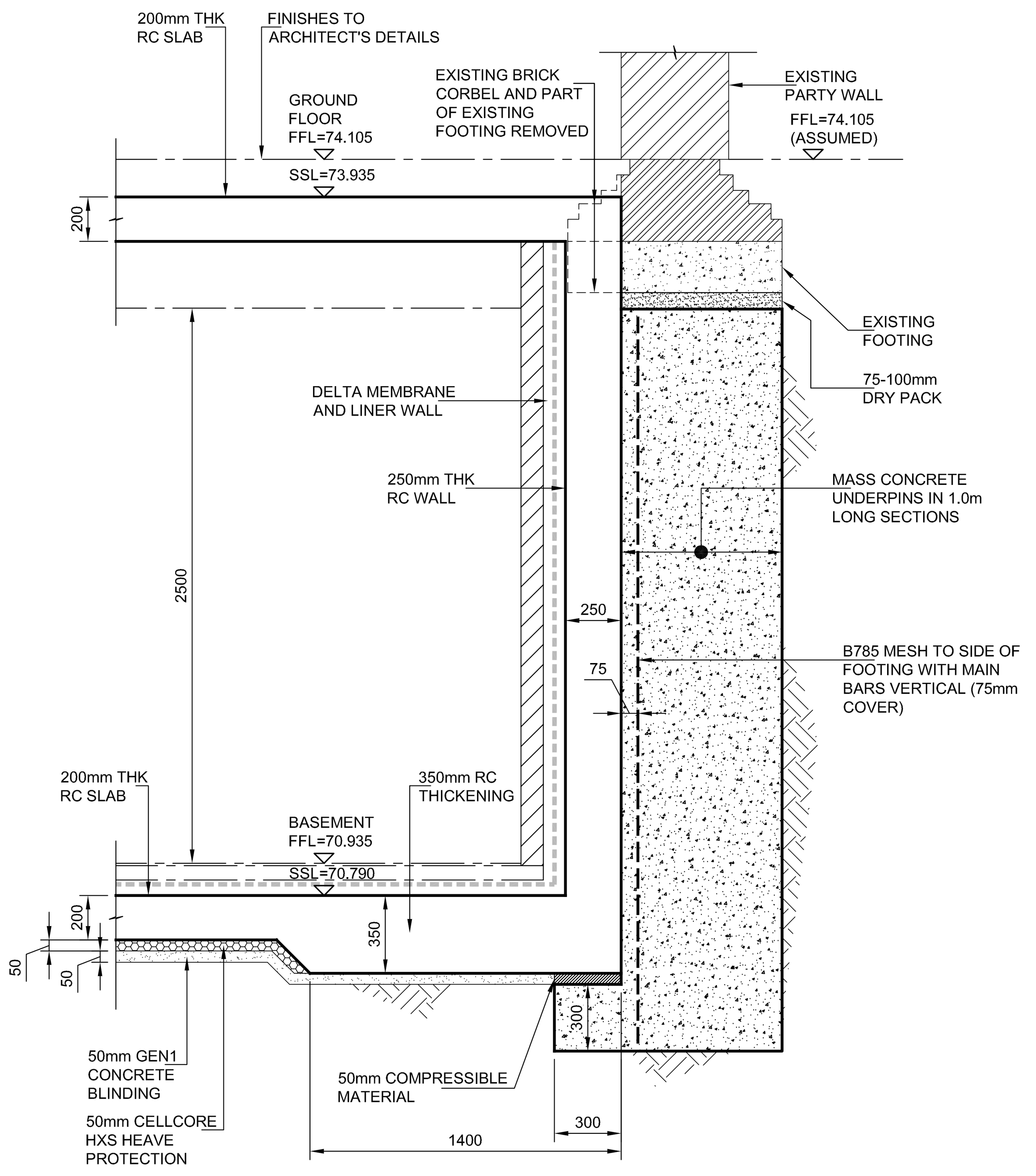
Drawing Title
PROPOSED BASEMENT, BASEMENT WITH GROUND FLOOR STRUCTURE OVER AND LOWER GROUND FLOOR LAYOUT SHOWING FOUNDATIONS UNDER

Client
A.GOVANI

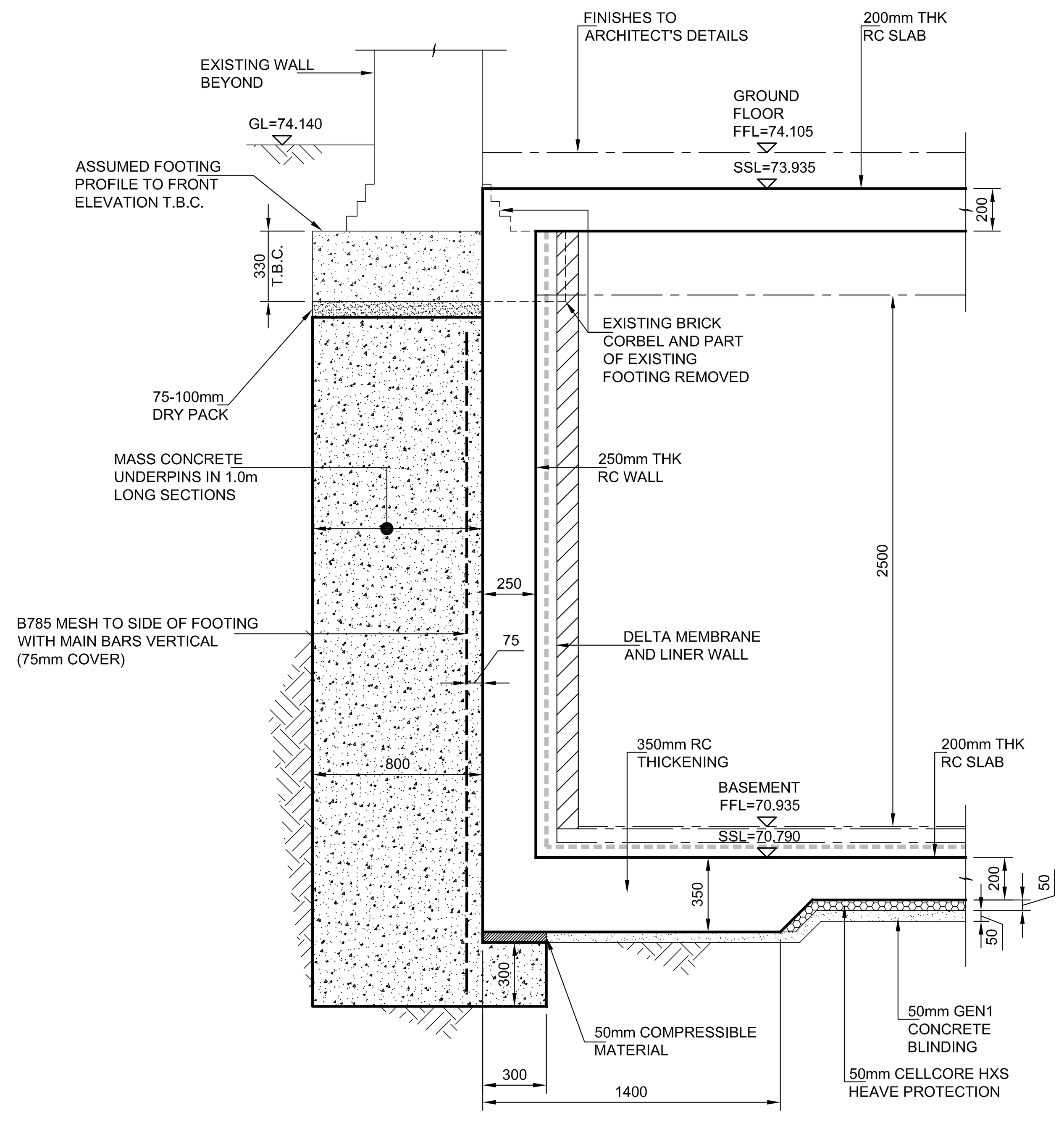
Scale at A1:	Drawn:	Checked:
1:50	DJE Date: May 2014	APB Date: 14/05/2014

Drawing No.:	Revision:
AB1115_0001	C

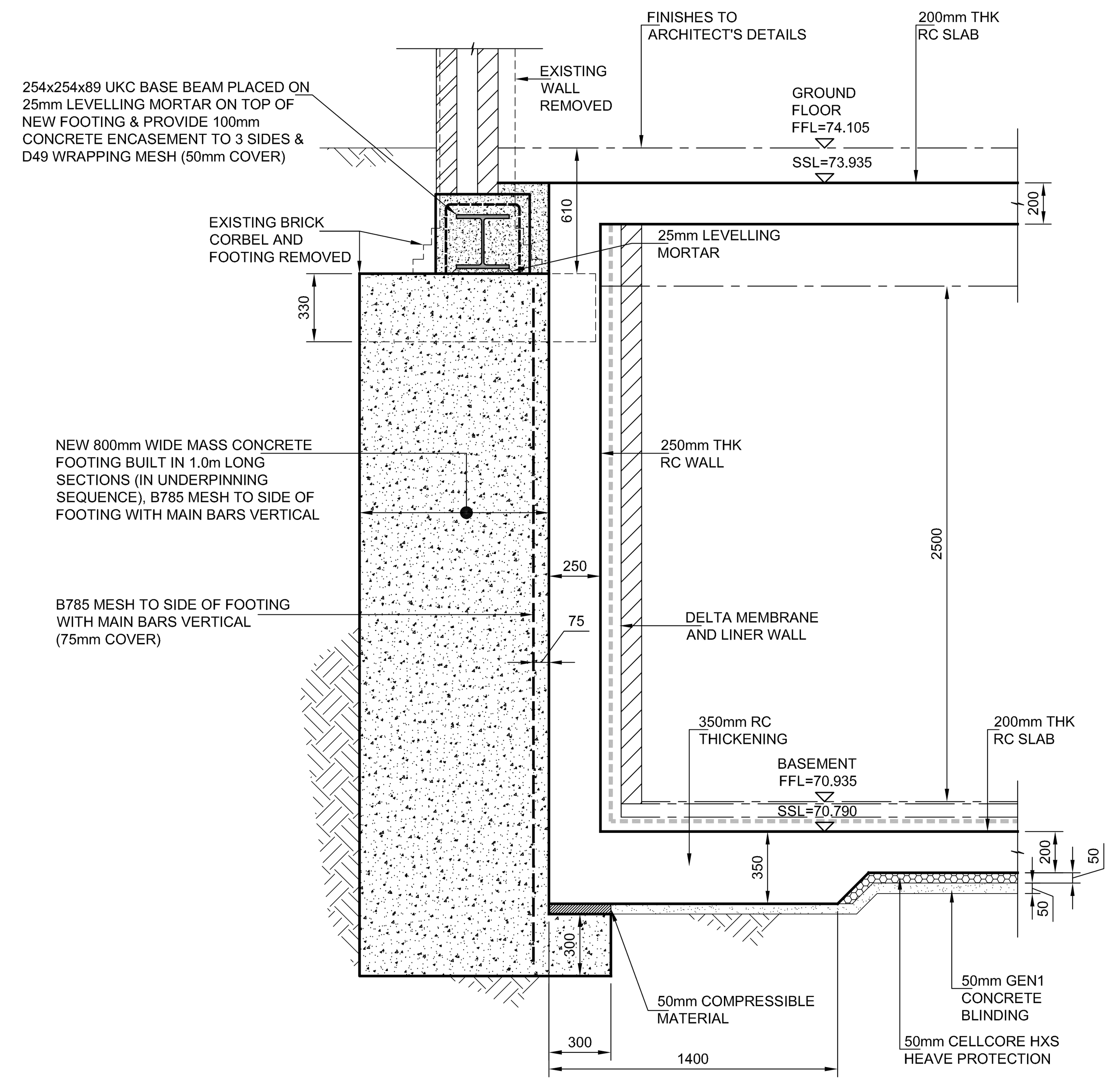
CONSTRUCTION ISSUE



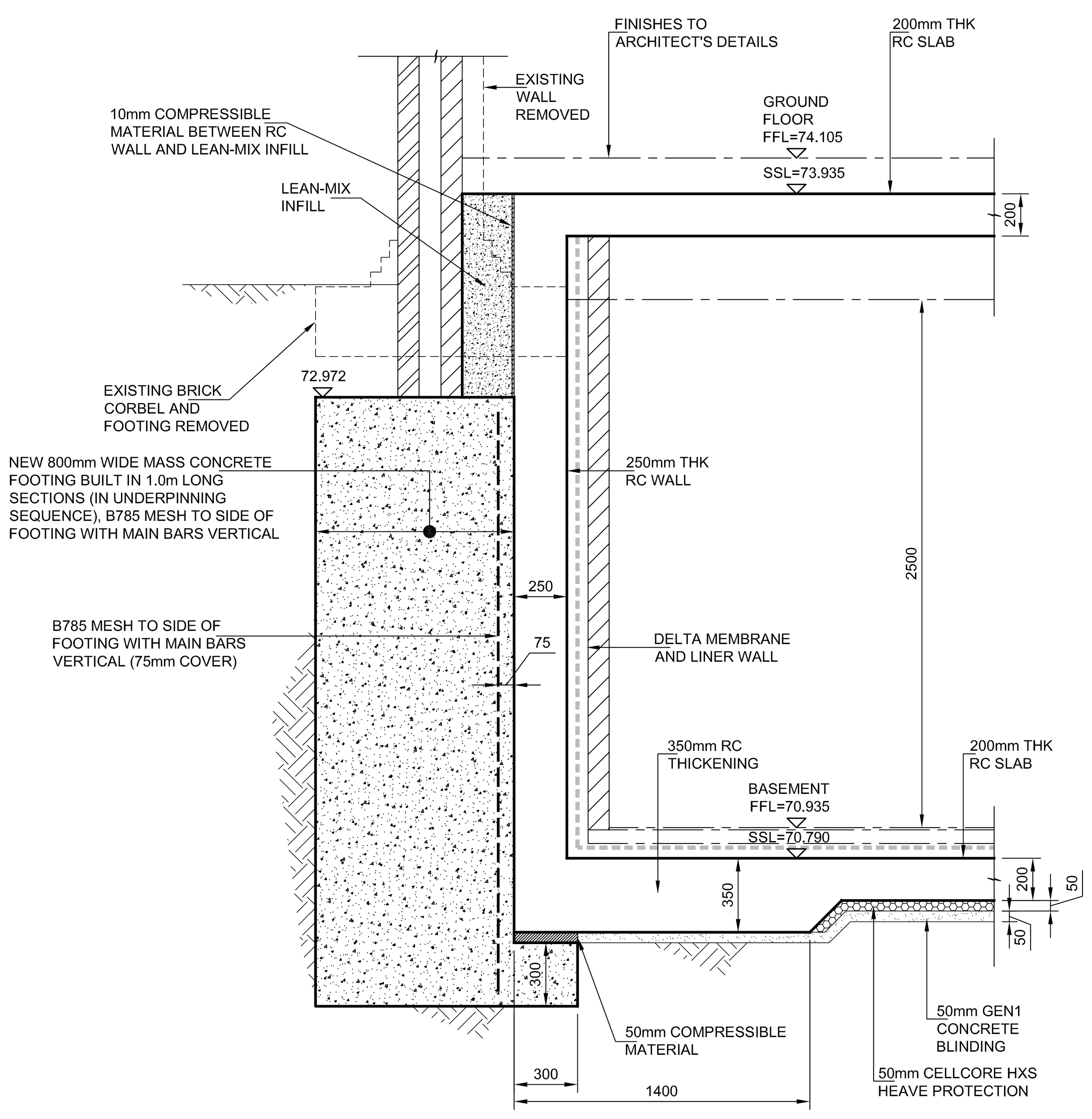
SECTION A-A
SCALE 1:25



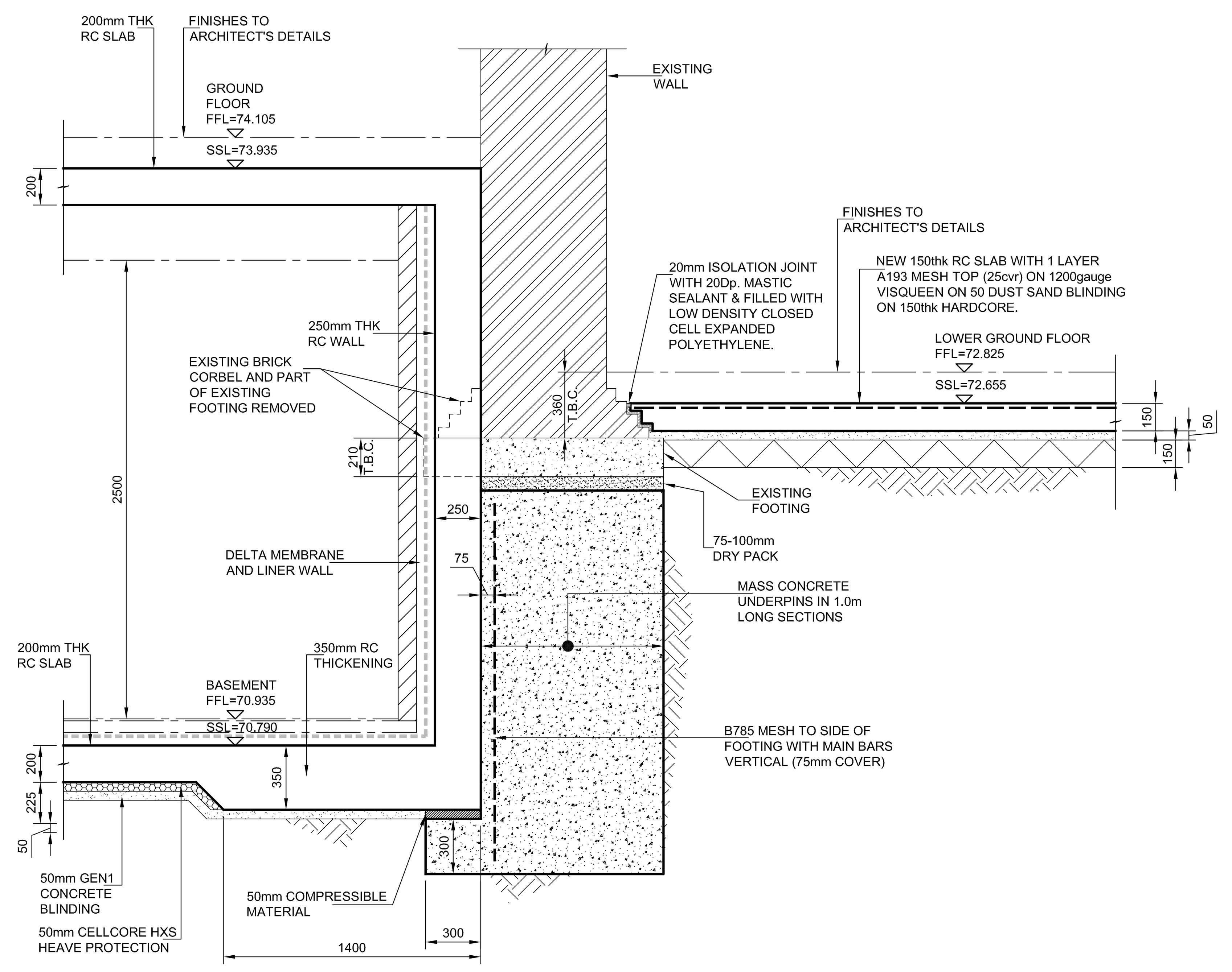
SECTION B-B
SCALE 1:25



SECTION C-C
SCALE 1:25



SECTION D-D
SCALE 1:25



SECTION E-E
SCALE 1:25

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CDM REGULATIONS 2007 RESIDUAL HAZARDS

RESIDUAL HAZARDS IDENTIFIED ⚠

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Mark	Date	By	Chkd.	Revision notes
-	17/03/15	PO	APB	PRELIMINARY ISSUE

PRELIMINARY ISSUE

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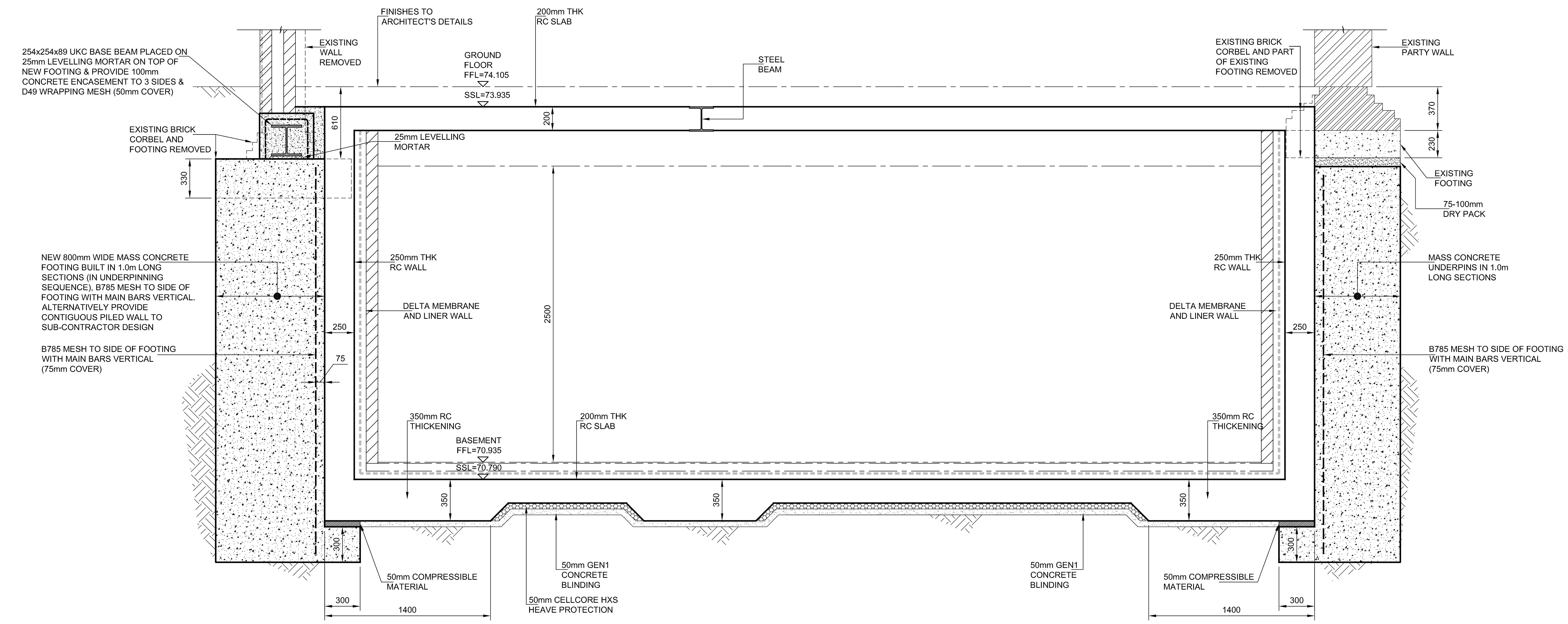
Job Title
4No NEW RESIDENTIAL UNITS
465-467 FINCHLEY ROAD
NW3 6HS

Drawing Title
BASEMENT SECTIONS AND DETAILS - SHEET 1

Client
A.GOVANI

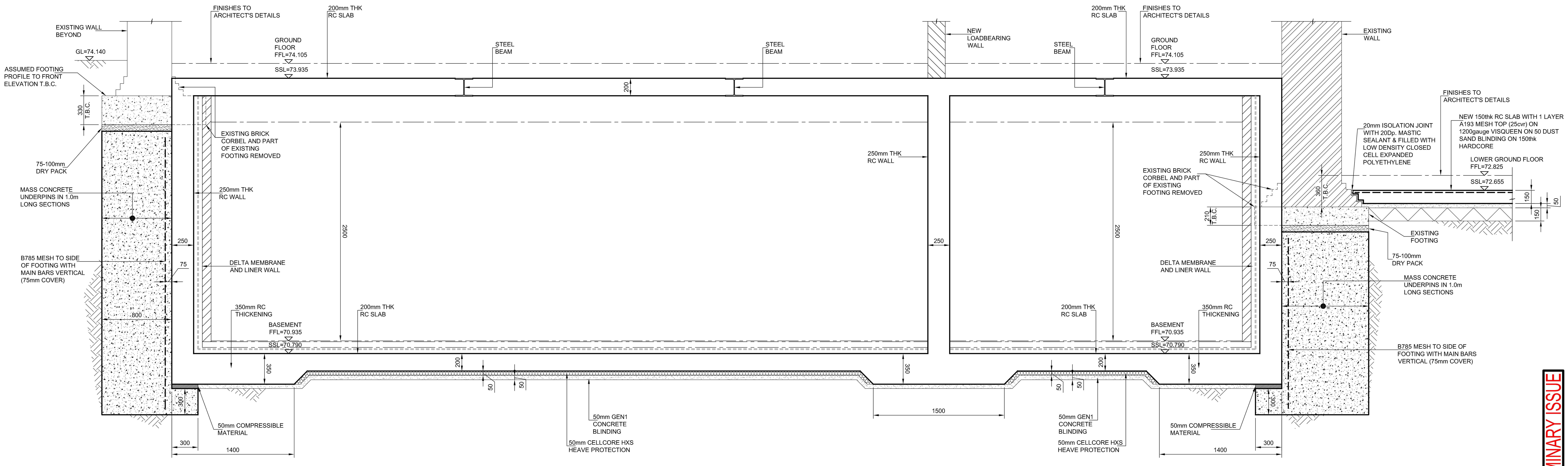
Scale at A1:	Drawn:	Checked:
1:25	PO Date: March 2015	APB Date: 17/03/2015

Drawing No.:	Revision:
AB1115_0008	-



SECTION G-G

SCALE 1:25



SECTION H-H

SCALE 1:25

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CDM REGULATIONS 2007 RESIDUAL HAZARDS

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Mark	Date	By	Chkd.	Revision notes
-	17/03/15	PO	APB	PRELIMINARY ISSUE

PRELIMINARY ISSUE

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Job Title
4No NEW RESIDENTIAL UNITS
465-467 FINCHLEY ROAD
NW3 6HS

Drawing Title
BASEMENT SECTIONS AND DETAILS - SHEET 2

Client
A.GOVANI

Scale at A1:	Drawn:	Checked:
1:25	PO Date: March 2015	APB Date: 17/03/2015
Drawing No.: AB1115_0009		Revision: -

Appendix B – ABSTRUCT Basement Retaining Wall Calculations

RETAINING WALL DESIGN

CONSIDER 1.0M WIDTH OF WALL

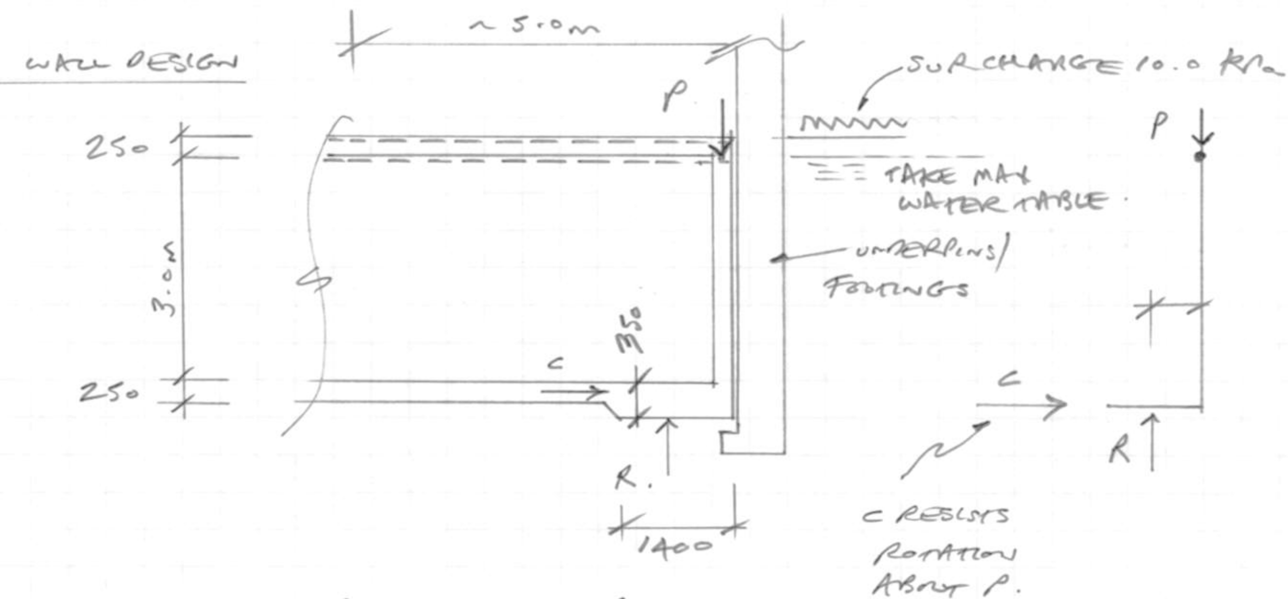
GROUND FLOOR LOADING

DL	=	FINISHES 75mm	= 1.80
		250 RC SLAB	= 6.00
		CEILINGS & SERVICES	= 0.20
			8.00 kPa.

LL = RETAIL SHOP FLOOR (4.0 kPa) BUT ALLOW = 5.00 kPa

EXTERNAL PAVEMENT LOADING (HIGHWAY) ALLOW = 10.0 kPa

WALL DESIGN



CALCULATE P. FROM BEAM (SPREAD IN WALL).

P DL = GND FLOOR (8.0 kPa × 5m/2 × 6.4m/2)/3.25m = 19.7 kN/m
WALL S/WT (0.25 × 24) × 3.5M = 21.0
40.7 kN/m

LL = GND FLOOR (5.0kPa × 5m/2 + 6.4m/2)/3.25m = 12.3kN/M.

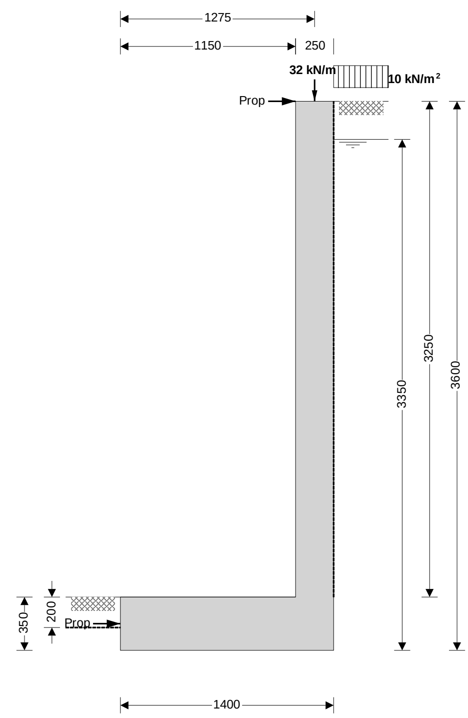
REFER TO ATTACHED TEDDS CALCULATION.

PRESSURE BELOW BASE < 100 kPa OK

abstruct consulting engineers ABSTRUCT LLP LONDON + SEVENOAKS	Project 465-467 Finchley Rod				Job no. 1115	
	Calcs for Basement Retaining Wall RW1				Start page no./Revision RW1 / 1	
	Calcs by AB	Calcs date 04/03/2015	Checked by	Checked date	Approved by	Approved date

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} = **3250** mm
Thickness of wall stem	t_{wall} = **250** mm
Length of toe	l_{toe} = **1150** mm
Length of heel	l_{heel} = **0** mm
Overall length of base	$l_{base} = l_{toe} + l_{heel} + t_{wall}$ = **1400** mm
Thickness of base	t_{base} = **350** mm
Depth of downstand	d_{ds} = **0** mm
Position of downstand	l_{ds} = **1050** mm
Thickness of downstand	t_{ds} = **350** mm
Height of retaining wall	$h_{wall} = h_{stem} + t_{base} + d_{ds}$ = **3600** 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} = **3350** mm
Height of saturated fill above base	$h_{sat} = \max(h_{water} - t_{base} - d_{ds}, 0\ \text{mm})$ = **3000** mm
Density of wall construction	γ_{wall} = **23.6** kN/m^3
Density of base construction	γ_{base} = **23.6** kN/m^3
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	$h_{eff} = h_{wall} + l_{heel} \times \tan(\beta)$ = **3600** mm

Retained material details

Mobilisation factor	M = **1.5**

Moist density of retained material γ_m = **18.0** kN/m^3

Saturated density of retained material γ_s = **21.0** kN/m^3

Design shear strength ϕ' = **24.2** deg

Angle of wall friction δ = **18.6** deg

Base material details

Stiff clay

Moist density γ_{mb} = **18.0** kN/m^3

Design shear strength ϕ'_b = **24.2** deg

Design base friction δ_b = **18.6** deg

Allowable bearing pressure $P_{bearing}$ = **100** kN/m^2

Using Coulomb theory

Active pressure coefficient for retained material

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

Passive pressure coefficient for base material

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

At-rest pressure

At-rest pressure for retained material $K_0 = 1 - \sin(\phi') = \mathbf{0.590}$

Loading details

Surcharge load on plan Surcharge = **10.0** kN/m^2

Applied vertical dead load on wall W_{dead} = **20.0** kN/m

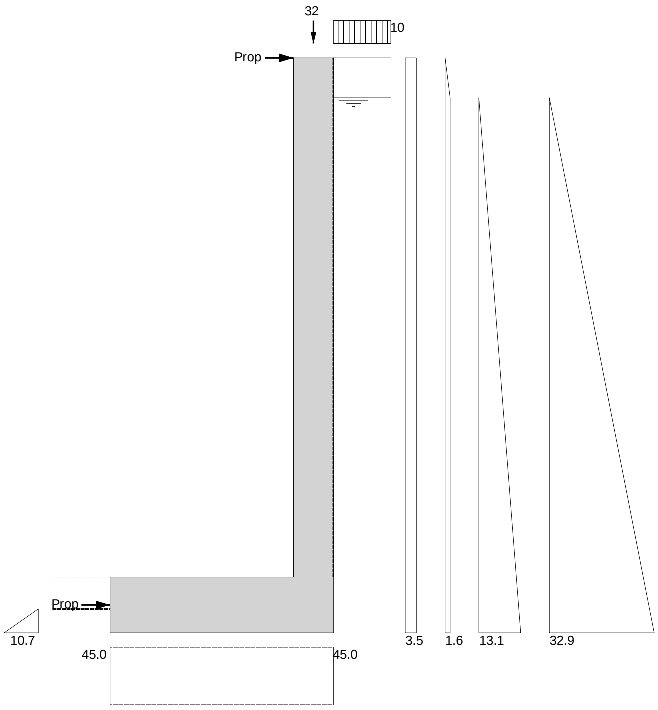
Applied vertical live load on wall W_{live} = **12.3** kN/m

Position of applied vertical load on wall l_{load} = **1275** 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 $w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall}$ = **19.2** kN/m

Wall base $w_{base} = l_{base} \times t_{base} \times \gamma_{base}$ = **11.6** kN/m

Applied vertical load $W_v = W_{dead} + W_{live}$ = **32.3** kN/m

Total vertical load $W_{total} = w_{wall} + w_{base} + W_v$ = **63** kN/m

Horizontal forces on wall

Surcharge $F_{sur} = K_a \times \cos(90 - \alpha + \delta) \times Surcharge \times h_{eff}$ = **12.6** kN/m

Moist backfill above water table $F_{m\_a} = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2$ = **0.2** kN/m

Moist backfill below water table $F_{m\_b} = K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water}$ = **5.3** kN/m

Saturated backfill $F_s = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times (\gamma_s - \gamma_{water}) \times h_{water}^2$ = **22** kN/m

Water $F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water}$ = **55** kN/m

Total horizontal load $F_{total} = F_{sur} + F_{m\_a} + F_{m\_b} + F_s + F_{water}$ = **95.1** 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 $F_{prop} = \max(F_{total} - F_p - (W_{total} - W_{live}) \times \tan(\delta_b), 0\ kN/m)$

F_{prop} = **77.2** kN/m

Overturning moments

Surcharge $M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **22.7** kNm/m

Moist backfill above water table $M_{m\_a} = F_{m\_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **0.7** kNm/m

Moist backfill below water table $M_{m\_b} = F_{m\_b} \times (h_{water} - 2 \times d_{ds}) / 2$ = **8.8** kNm/m

Saturated backfill $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3$ = **24.5** kNm/m

Water $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3$ = **61.5** kNm/m

Total overturning moment $M_{ot} = M_{sur} + M_{m\_a} + M_{m\_b} + M_s + M_{water}$ = **118.2** kNm/m

Restoring moments

Wall stem $M_{wall} = w_{wall} \times (l_{toe} + t_{wall} / 2)$ = **24.4** kNm/m

Wall base $M_{base} = w_{base} \times l_{base} / 2$ = **8.1** kNm/m

Design vertical dead load $M_{dead} = W_{dead} \times l_{load}$ = **25.5** kNm/m

Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead}$ = **58** kNm/m

Check bearing pressure

Total vertical reaction $R = W_{total}$ = **63.0** kN/m

Distance to reaction $x_{bar} = l_{base} / 2$ = **700** mm

Eccentricity of reaction $e = \mathrm{abs}((l_{base} / 2) - x_{bar})$ = **0** mm

Reaction acts within middle third of base

Bearing pressure at toe $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2)$ = **45** kN/m²

Bearing pressure at heel $p_{heel} = (R / l_{base}) + (6 \times R \times e / l_{base}^2)$ = **45** 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

$F_{prop\_top} = (M_{ot} - M_{rest} + R \times l_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2)$ = **26.497** kN/m

Propping force to base of wall $F_{prop\_base} = F_{prop} - F_{prop\_top}$ = **50.703** 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 $W_{wall\_f} = \gamma_{f\_d} \times h_{stem} \times t_{wall} \times \gamma_{wall}$ = **26.8** kN/m

Wall base $W_{base\_f} = \gamma_{f\_d} \times l_{base} \times t_{base} \times \gamma_{base}$ = **16.2** kN/m

Applied vertical load $W_{v\_f} = \gamma_{f\_d} \times W_{dead} + \gamma_{f\_l} \times W_{live}$ = **47.7** kN/m

Total vertical load $W_{total\_f} = W_{wall\_f} + W_{base\_f} + W_{v\_f}$ = **90.7** kN/m

Factored horizontal at-rest forces on wall

Surcharge $F_{sur\_f} = \gamma_{f\_l} \times K_0 \times Surcharge \times h_{eff}$ = **34** kN/m

Moist backfill above water table $F_{m\_a\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times \gamma_m \times (h_{eff} - h_{water})^2$ = **0.5** kN/m

Moist backfill below water table $F_{m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water}$ = **12.5** kN/m

Saturated backfill $F_{s\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times (\gamma_s - \gamma_{water}) \times h_{water}^2$ = **51.9** kN/m

Water $F_{water\_f} = \gamma_{f\_e} \times 0.5 \times h_{water}^2 \times \gamma_{water}$ = **77.1** kN/m

Total horizontal load $F_{total\_f} = F_{sur\_f} + F_{m\_a\_f} + F_{m\_b\_f} + F_{s\_f} + F_{water\_f}$ = **175.8** 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 $F_{prop\_f} = \max(F_{total\_f} - F_{p\_f} - (W_{total\_f} - \gamma_{f\_l} \times W_{live}) \times \tan(\delta_b), 0\ kN/m)$

F_{prop_f} = **150.8** kN/m

Factored overturning moments

Surcharge $M_{sur\_f} = F_{sur\_f} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **61.2** kNm/m

Moist backfill above water table $M_{m\_a\_f} = F_{m\_a\_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **1.6** kNm/m

Moist backfill below water table $M_{m\_b\_f} = F_{m\_b\_f} \times (h_{water} - 2 \times d_{ds}) / 2$ = **20.9** kNm/m

Saturated backfill $M_{s\_f} = F_{s\_f} \times (h_{water} - 3 \times d_{ds}) / 3$ = **57.9** kNm/m

Water $M_{water\_f} = F_{water\_f} \times (h_{water} - 3 \times d_{ds}) / 3$ = **86.1** kNm/m

Total overturning moment $M_{ot\_f} = M_{sur\_f} + M_{m\_a\_f} + M_{m\_b\_f} + M_{s\_f} + M_{water\_f}$ = **227.6** kNm/m

Restoring moments

Wall stem $M_{wall\_f} = W_{wall\_f} \times (l_{toe} + t_{wall} / 2)$ = **34.2** kNm/m

Wall base $M_{base\_f} = W_{base\_f} \times l_{base} / 2$ = **11.3** kNm/m

Design vertical load $M_{v\_f} = W_{v\_f} \times l_{load}$ = **60.8** kNm/m

Total restoring moment $M_{rest\_f} = M_{wall\_f} + M_{base\_f} + M_{v\_f}$ = **106.4** kNm/m

Factored bearing pressure

Total vertical reaction $R_f = W_{total\_f}$ = **90.7** kN/m

Distance to reaction $x_{bar\_f} = l_{base} / 2$ = **700** 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 $p_{toe\_f} = (R_f / l_{base}) - (6 \times R_f \times e_f / l_{base}^2)$ = **64.8** kN/m²

Bearing pressure at heel $p_{heel\_f} = (R_f / l_{base}) + (6 \times R_f \times e_f / l_{base}^2)$ = **64.8** 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 $p_{stem\_toe\_f} = \max(p_{toe\_f} - (rate \times l_{toe}), 0\ kN/m^2)$ = **64.8** kN/m²

Bearing pressure at mid stem $p_{stem\_mid\_f} = \max(p_{toe\_f} - (rate \times (l_{toe} + t_{wall} / 2)), 0\ kN/m^2) = \mathbf{64.8}\ kN/m^2$

Bearing pressure at stem / heel $p_{stem\_heel\_f} = \max(p_{toe\_f} - (rate \times (l_{toe} + t_{wall})), 0\ kN/m^2) = \mathbf{64.8}\ kN/m^2$

Calculate propping forces to top and base of wall

Propping force to top of wall

$F_{prop\_top\_f} = (M_{ot\_f} - M_{rest\_f} + R_f \times l_{base} / 2 - F_{prop\_f} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = \mathbf{46.239}\ kN/m$

Propping force to base of wall $F_{prop\_base\_f} = F_{prop\_f} - F_{prop\_top\_f} = \mathbf{104.573}\ kN/m$

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

Material properties

Characteristic strength of concrete $f_{cu} = \mathbf{40}\ N/mm^2$

Characteristic strength of reinforcement $f_y = \mathbf{500}\ N/mm^2$

Base details

Minimum area of reinforcement $k = \mathbf{0.13}\ \%$

Cover to reinforcement in toe $c_{toe} = \mathbf{75}\ mm$

Calculate shear for toe design

Shear from bearing pressure $V_{toe\_bear} = (p_{toe\_f} + p_{stem\_toe\_f}) \times l_{toe} / 2 = \mathbf{74.5}\ kN/m$

Shear from weight of base $V_{toe\_wt\_base} = \gamma_{f\_d} \times \gamma_{base} \times l_{toe} \times t_{base} = \mathbf{13.3}\ kN/m$

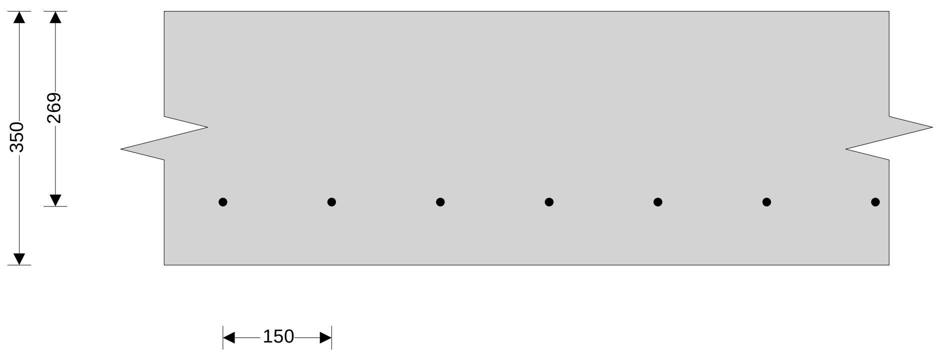
Total shear for toe design $V_{toe} = V_{toe\_bear} - V_{toe\_wt\_base} = \mathbf{61.2}\ kN/m$

Calculate moment for toe design

Moment from bearing pressure $M_{toe\_bear} = (2 \times p_{toe\_f} + p_{stem\_mid\_f}) \times (l_{toe} + t_{wall} / 2)^2 / 6 = \mathbf{52.7}\ kNm/m$

Moment from weight of base $M_{toe\_wt\_base} = (\gamma_{f\_d} \times \gamma_{base} \times t_{base} \times (l_{toe} + t_{wall} / 2)^2 / 2) = \mathbf{9.4}\ kNm/m$

Total moment for toe design $M_{toe} = M_{toe\_bear} - M_{toe\_wt\_base} = \mathbf{43.3}\ kNm/m$



Check toe in bending

Width of toe $b = \mathbf{1000}\ mm/m$

Depth of reinforcement $d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2) = \mathbf{269.0}\ mm$

Constant $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu}) = \mathbf{0.015}$

Compression reinforcement is not required

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

$z_{toe} = \mathbf{256}\ mm$

Area of tension reinforcement required $A_{s\_toe\_des} = M_{toe} / (0.87 \times f_y \times z_{toe}) = \mathbf{389}\ mm^2/m$

Minimum area of tension reinforcement $A_{s\_toe\_min} = k \times b \times t_{base} = \mathbf{455}\ mm^2/m$

Area of tension reinforcement required $A_{s\_toe\_req} = \max(A_{s\_toe\_des}, A_{s\_toe\_min}) = \mathbf{455}\ mm^2/m$

Reinforcement provided **12 mm dia.bars @ 150 mm centres**

Area of reinforcement provided $A_{s\_toe\_prov} = \mathbf{754}\ mm^2/m$

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress $v_{toe} = V_{toe} / (b \times d_{toe}) = \mathbf{0.228}$ N/mm^2

Allowable shear stress $v_{adm} = \min(0.8 \times \sqrt{(f_{cu} / 1 \text{ N/mm}^2)}, 5) \times 1 \text{ N/mm}^2 = \mathbf{5.000}$ N/mm^2

PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress $v_{c\_toe} = \mathbf{0.534}$ N/mm^2

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

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

Material properties

Characteristic strength of concrete $f_{cu} = \mathbf{40}$ N/mm^2

Characteristic strength of reinforcement $f_y = \mathbf{500}$ N/mm^2

Wall details

Minimum area of reinforcement k = **0.13** %

Cover to reinforcement in stem $c_{stem} = \mathbf{40}$ mm

Cover to reinforcement in wall $c_{wall} = \mathbf{40}$ mm

Factored horizontal at-rest forces on stem

Surcharge $F_{s\_sur\_f} = \gamma_{f\_l} \times K_0 \times \text{Surcharge} \times (h_{eff} - t_{base} - d_{ds}) = \mathbf{30.7}$ kN/m

Moist backfill above water table $F_{s\_m\_a\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2 = \mathbf{0.5}$ kN/m

Moist backfill below water table $F_{s\_m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat}) \times h_{sat} = \mathbf{11.2}$ kN/m

Saturated backfill $F_{s\_s\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times (\gamma_s - \gamma_{water}) \times h_{sat}^2 = \mathbf{41.6}$ kN/m

Water $F_{s\_water\_f} = 0.5 \times \gamma_{f\_e} \times \gamma_{water} \times h_{sat}^2 = \mathbf{61.8}$ kN/m

Calculate shear for stem design

Surcharge $V_{s\_sur\_f} = 5 \times F_{s\_sur\_f} / 8 = \mathbf{19.2}$ kN/m

Moist backfill above water table $V_{s\_m\_a\_f} = F_{s\_m\_a\_f} \times b_l \times ((5 \times L^2) - b_l^2) / (5 \times L^3) = \mathbf{0}$ kN/m

Moist backfill below water table $V_{s\_m\_b\_f} = F_{s\_m\_b\_f} \times (8 - (n^2 \times (4 - n))) / 8 = \mathbf{7.5}$ kN/m

Saturated backfill $V_{s\_s\_f} = F_{s\_s\_f} \times (1 - (a_l^2 \times ((5 \times L) - a_l) / (20 \times L^3))) = \mathbf{34.3}$ kN/m

Water $V_{s\_water\_f} = F_{s\_water\_f} \times (1 - (a_l^2 \times ((5 \times L) - a_l) / (20 \times L^3))) = \mathbf{51}$ kN/m

Total shear for stem design $V_{stem} = V_{s\_sur\_f} + V_{s\_m\_a\_f} + V_{s\_m\_b\_f} + V_{s\_s\_f} + V_{s\_water\_f} = \mathbf{112}$ kN/m

Calculate moment for stem design

Surcharge $M_{s\_sur} = F_{s\_sur\_f} \times L / 8 = \mathbf{13.1}$ kNm/m

Moist backfill above water table $M_{s\_m\_a} = F_{s\_m\_a\_f} \times b_l \times ((5 \times L^2) - (3 \times b_l^2)) / (15 \times L^2) = \mathbf{0}$ kNm/m

Moist backfill below water table $M_{s\_m\_b} = F_{s\_m\_b\_f} \times a_l \times (2 - n)^2 / 8 = \mathbf{5.1}$ kNm/m

Saturated backfill $M_{s\_s} = F_{s\_s\_f} \times a_l \times ((3 \times a_l^2) - (15 \times a_l \times L) + (20 \times L^2)) / (60 \times L^2) = \mathbf{19.1}$ kNm/m

Water $M_{s\_water} = F_{s\_water\_f} \times a_l \times ((3 \times a_l^2) - (15 \times a_l \times L) + (20 \times L^2)) / (60 \times L^2) = \mathbf{28.4}$

kNm/m

Total moment for stem design $M_{stem} = M_{s\_sur} + M_{s\_m\_a} + M_{s\_m\_b} + M_{s\_s} + M_{s\_water} = \mathbf{65.7}$ kNm/m

Calculate moment for wall design

Surcharge $M_{w\_sur} = 9 \times F_{s\_sur\_f} \times L / 128 = \mathbf{7.4}$ kNm/m

Moist backfill above water table $M_{w\_m\_a} = F_{s\_m\_a\_f} \times 0.577 \times b_l \times [(b_l^3 + 5 \times a_l \times L^2)/(5 \times L^3) - 0.577^2/3] = \mathbf{0.1}$

kNm/m

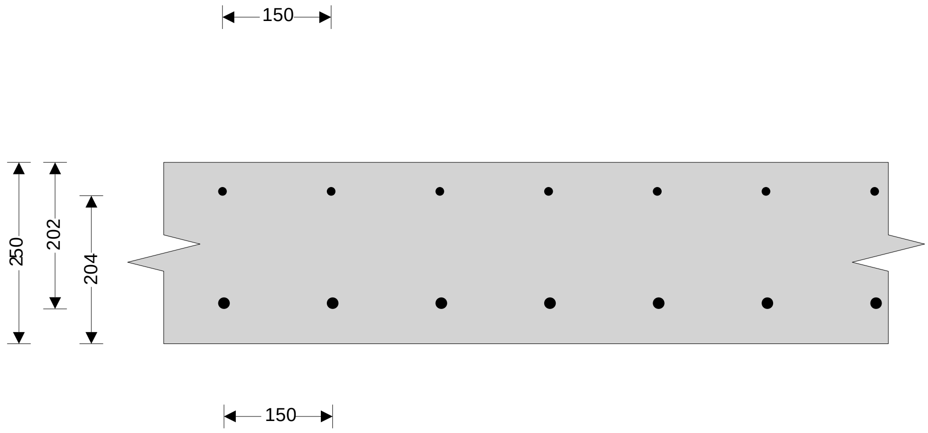
Moist backfill below water table $M_{w\_m\_b} = F_{s\_m\_b\_f} \times a_l \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = \mathbf{2.8}$ kNm/m

Saturated backfill $M_{w\_s} = F_{s\_s\_f} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = \mathbf{8.3}$ kNm/m

Water $M_{w\_water} = F_{s\_water\_f} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = \mathbf{12.3}$

kNm/m

Total moment for wall design $M_{wall} = M_{w\_sur} + M_{w\_m\_a} + M_{w\_m\_b} + M_{w\_s} + M_{w\_water}$ = **30.8** kNm/m



Check wall stem in bending

Width of wall stem: b = **1000** mm/m

Depth of reinforcement: $d_{stem} = t_{wall} - c_{stem} - (\phi_{stem} / 2)$ = **202.0** mm

Constant: $K_{stem} = M_{stem} / (b \times d_{stem}^2 \times f_{cu})$ = **0.040**

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} = **192** mm

Area of tension reinforcement required: $As_{\_stem\_des} = M_{stem} / (0.87 \times f_y \times z_{stem})$ = **787** mm²/m

Minimum area of tension reinforcement: $As_{\_stem\_min} = k \times b \times t_{wall}$ = **325** mm²/m

Area of tension reinforcement required: $As_{\_stem\_req} = \text{Max}(As_{\_stem\_des}, As_{\_stem\_min})$ = **787** mm²/m

Reinforcement provided: **16 mm dia.bars @ 150 mm centres**

Area of reinforcement provided: $As_{\_stem\_prov}$ = **1340** mm²/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress: $v_{stem} = V_{stem} / (b \times d_{stem})$ = **0.554** N/mm²

Allowable shear stress: $v_{adm} = \min(0.8 \times \sqrt{(f_{cu} / 1 \text{ N/mm}^2)}, 5) \times 1 \text{ N/mm}^2$ = **5.000** 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} = **0.765** N/mm²

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

Check mid height of wall in bending

Depth of reinforcement: $d_{wall} = t_{wall} - c_{wall} - (\phi_{wall} / 2)$ = **204.0** mm

Constant: $K_{wall} = M_{wall} / (b \times d_{wall}^2 \times f_{cu})$ = **0.019**

Compression reinforcement is not required

Lever arm: $z_{wall} = \text{Min}(0.5 + \sqrt{(0.25 - (\min(K_{wall}, 0.225) / 0.9))},0.95) \times d_{wall}$

z_{wall} = **194** mm

Area of tension reinforcement required: $As_{\_wall\_des} = M_{wall} / (0.87 \times f_y \times z_{wall})$ = **366** mm²/m

Minimum area of tension reinforcement: $As_{\_wall\_min} = k \times b \times t_{wall}$ = **325** mm²/m

Area of tension reinforcement required: $As_{\_wall\_req} = \text{Max}(As_{\_wall\_des}, As_{\_wall\_min})$ = **366** mm²/m

Reinforcement provided: **12 mm dia.bars @ 150 mm centres**

Area of reinforcement provided: $As_{\_wall\_prov}$ = **754** 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 $f_s = 2 \times f_y \times A_{s\_stem\_req} / (3 \times A_{s\_stem\_prov})$ = **195.8** N/mm^2

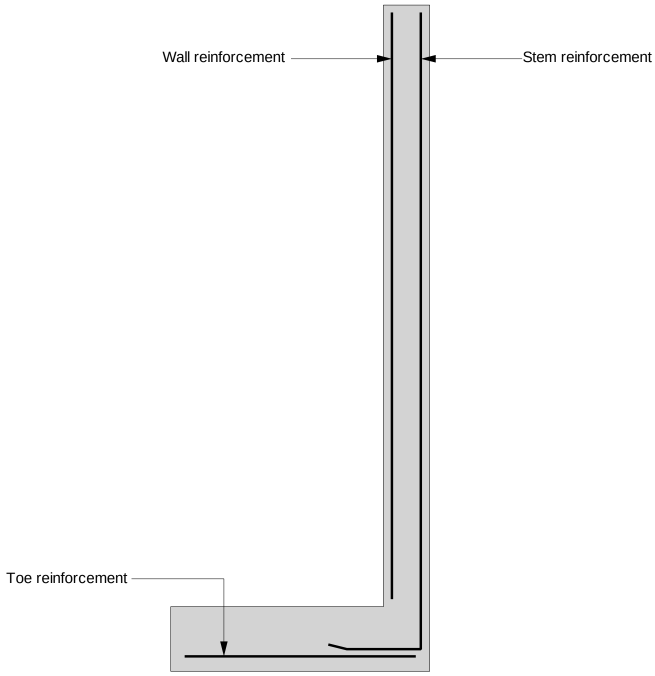
Modification factor $factor_{tens} = \min(0.55 + (477 \text{ N/mm}^2 - f_s)/(120 \times (0.9 \text{ N/mm}^2 + (M_{stem}/(b \times d_{stem}^2)))),2)$ = **1.48**

Maximum span/effective depth ratio $ratio_{max} = ratio_{bas} \times factor_{tens}$ = **29.67**

Actual span/effective depth ratio $ratio_{act} = h_{stem} / d_{stem}$ = **16.09**

PASS - Span to depth ratio is acceptable

Indicative retaining wall reinforcement diagram



Toe bars - 12 mm dia.@ 150 mm centres - (754 mm^2/m)
Wall bars - 12 mm dia.@ 150 mm centres - (754 mm^2/m)
Stem bars - 16 mm dia.@ 150 mm centres - (1340 mm^2/m)

Appendix C - Southern Testing Laboratories Ltd (Report No. STL: J12147 dated March 2015).