1.0 GENERAL NOTES

1. This drawing is to be read in conjunction with all relevant Architects drawings, Engineers drawings and contract documentation.
2. Dimensions are in millimetres. Levels are in meters.
3. All setting out, levels and dimensions to be confirmed on site and against architects and specialist suppliers drawings prior to fabrication or construction.
4. The contractor shall be responsible for the structure during the course of the works.
5. Drawings are not to be scaled, if in doubt ask.
6. All proprietary products to be installed in accordance with the Manufacturers Recommendations.
7. Underside of foundations to obtain a minimum bearing pressure of 100kN/m2 to the satisfaction of the Building Control/ Structural Engineer.
8. Where temporary works are required the Contractor shall allow in his pricing for a competent temporary works Engineer to design all necessary supports for the structure during the course of the works.

2.0 CONCRETE NOTES

1. All materials and workmanship to be in accordance with BS 8110 Parts 1 & 2 and B.S. 8500 Parts 1 & 2 – The structural use of concrete.
2. Concrete quality to be 40N/mm² at 28 days unless noted otherwise, Max nominal aggregate to be 20mm. Minimum cement content 380kg/m³. Maximum free water cement ratio 0.55
3. Reinforcement to be placed in accordance with BS 8110
   Reinforcement type H to BS4449 : 2005
   Mesh fabric reinforcement to BS4483
4. Concrete cubes to be taken and crushed at 7 & 28 days to obtain required crushing strengths (one cube to be taken as a spare cube.)
5. Concrete qualities for Mass Concrete foundations to low rise structures in non–aggressive soils to be C25 OR GEN3. Minimum cement content not less than 220kg/m³
6. No reinforcement to be cut displaced or omitted without prior written agreement of the engineer.
7. Cover to reinforcement to be 50mm minimum unless otherwise noted.
8. The ground is to be blinded prior to reinforcement being placed in position, blinded concrete mix to be GEN1. Min 50mm thick to all reinforcement bases etc.
9. Reinforcement notation

   10 H25 36 – 200 B

   Number of bars
   Reinforcement type
   Bar diameter
   Bar mark
   Bar spacing
   Location of reinforcement
10. Abbreviations

T = top	B = bottom	STGD = staggered
NF = near face	FF = far face	EF = each face
ALT = alternate bars	ABR = alternate bars reversed	

11. Lap lengths unless otherwise noted to be min:

H10 – 490mm	H20 – 980mm
H12 – 590mm	H25 – 1225mm
H16 – 785mm	H32 – 1570mm

3.0 TIMBER NOTES

1. All timber materials and workmanship to be in accordance with BS 5268: Part 2 – Structural Use of Timber.
2. All timbers to be a minimum strength class 'C16' (unless noted otherwise) and have max. moisture content of 18%.
3. Multiple timbers to be bolted together at 600 centres with 12mm dia. bolts and 50x30x5 washer plates.
4. No notches, holes or rebates etc. to be cut in any member without the written agreement of the Engineers.
5. Site storage, handling and erection procedures of trusses is to be in accordance with BS 5268: Part 3.
6. All structural timber to be adequately protected against adverse weather conditions during stacking and after erection.
7. All structural timber is to be treated by vacuum pressure impregnation of organic or water bourne preservative, to a dry salt retention in accordance with the manufacturers recommendations. Type of treatment may be:– 'Tanalith', 'Celcure', 'Protim', or other only with the prior approval of the Architect.
8. Finger joints are not acceptable.
9. All fixings in roof space (nails, screws, bolts, hangers etc.) are to be galvanised unless noted otherwise.

4.0 BRICKWORK AND BLOCKWORK NOTES

1. All materials and workmanship to be in accordance with BS 5628 Code of Practise for the Structural Use of Brickwork.
2. Bricks to have average crushing strength of 20.5 N/mm2 (Class 3 min) unless noted otherwise.
3. Block work above ground to be 7.0N/mm2 minimum unless otherwise noted.
4. Block work below ground to be 7.0N/mm2 minimum unless otherwise noted.
5. Mortar designation above ground to be 1:1:6 Cement/Lime/Sand Unless noted otherwise.
6. Mortar designation below ground to be 1:3 Cement/Sand unless noted otherwise.
7. 'Hyload' DPC or similar approved to all walls. All waterproofing in accordance with architects details.
8. Wall ties to be stainless steel vertical twist type ties to comply with BS 1243. Max spacing to be 900mm horizontally, 450mm vertically and with a 50mm embedment in the mortar joint of each leaf, unless noted otherwise. Wall ties to be placed in walls where cavities exceed 90mm to be placed at 450cts vertically, 450cts horizontally. Additional ties are to be provided at the sides of all openings so that there is at least one tie at 300crs maximum.
9. Brickwork restraints to be in accordance with BS 5628 Part 1 at 1200mm crs horizontally and 1200mm crs for vertical straps.
10. Movement joints to be provided in masonry walls where indicated 'MJ' on the drawings. At 6.0m maximum internally, 12.0m for brickwork.
11. At brick/block junctions, brickwork is to be block bonded into blockwork unless noted otherwise.
12. Wall ties shall not slope inwards.
13. All brickwork is to be laid with frogs, if any, uppermost.
14. Where 215mm Blocks are laid flat no shell bedding shall be allowed
15. Lintel Bearings to be in accordance with the Manufacturers recommendations or as noted on the drawings or directed otherwise by the engineer.
16. All steel bearing onto walls to have a minimum 215x100x215mm deep engineering brick or concrete padstone centered on steel unless noted otherwise.

5.0 STRUCTURAL STEELWORK NOTES

1. All materials and workmanship to be in accordance with BS5950. The structural use of steelwork in building.
2. Structural steelwork sections to be Grade S275 mild steel in accordance with BS 4360.
3. Bolts to be grade 8.8 unless noted otherwise.
4. Welds to be 6mm continuous fillet, unless noted otherwise.
5. Contractor must verify all dimensions on site before commencing any work or making any shop drawings. No dimensions to be scaled from drawings. Discrepancies must be reported to the engineer prior to proceeding. 7 working days are required by the Engineer to check and comment on any working drawings prior to fabrication.
6. Steelwork which is not required to be encased in concrete blast cleaned to SA2½ free from mill scale, rust and other contamination and painted with two coats of zinc phosphate primer 85 microns thick as soon as practicable but not more than four hours after cleaning.
7. Bolted connections to have a minimum connection of 4 N°. M20 bolts per member, unless noted otherwise.
8. Minimum bearing of steels to be 100mm Unless noted otherwise
9. Where indicated galvanised steel to be a minimum of 85 microns thickness unless noted otherwise in accordance with BS 728.
10. Workmanship erection and tolerances to be in accordance with the National structural steelwork specification for building construction.
11. HSFG Bolt connections are to be metal to metal and painted on site after the connection has been completed and load indicating washers in final position

LEGEND

DIRECTION OF SPAN

? — DETAIL/SECTION NUMBER
? — DRAWING NUMBER ('–' DENOTES SAME DRAWING)

LEVEL ▼ LEVEL +
FFL = FINISHED FLOOR LEVEL
SSL = STRUCTURAL SLAB LEVEL
FGL = FINISHED GROUND LEVEL
SCL = STRUCTURAL CEILING LEVEL
TOC = TOP OF CONCRETE

MJ — MOVEMENT JOINT

TBC — TO BE CONFIRMED (BY FURTHER INVESTIGATION ON SITE)

203 UC 25 (B3 p35) — STEEL BEAM REFERENCE
SECTION SIZE 203 UC 25
(REFER TO CALCULATIONS BEAM B3 PAGE 35 FOR FURTHER DETAILS)

ENGINEERS DRAWINGS

15.139.00	NOTES
01	BASEMENT DETAILS

PRELIMINARY

Rev.	Description	Date
P1	Preliminary for checking	13/07/15

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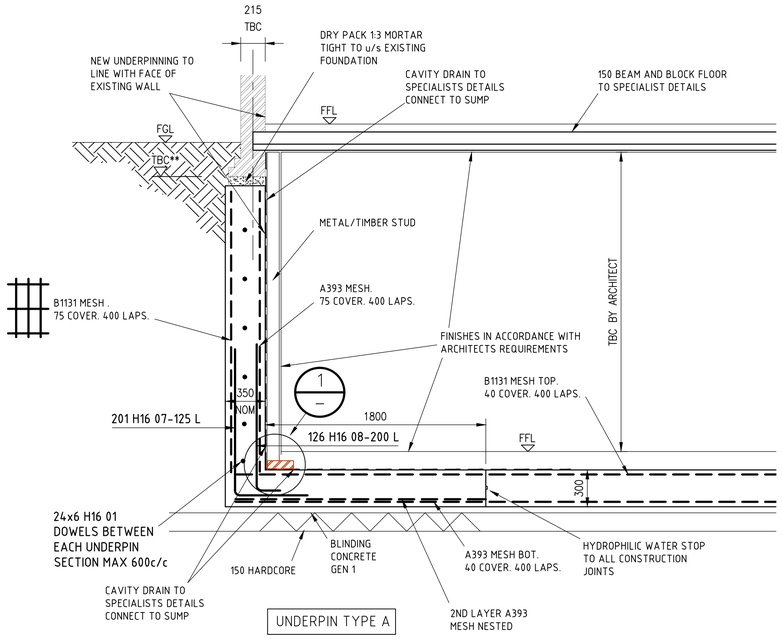
Project
PROPOSED ALTERATIONS
269 GOLDHURST TERRACE

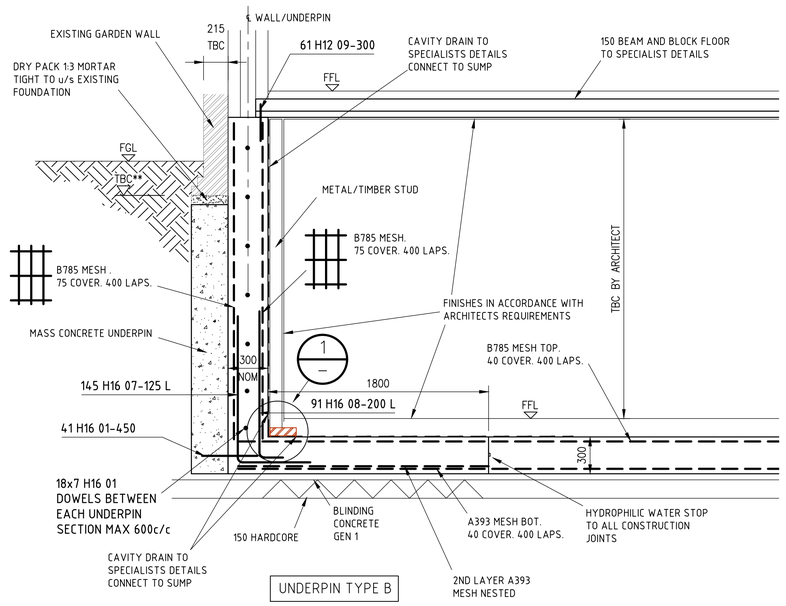
Title
NOTES

Scale: AS SHOWN AT A1		Job No.: 15.139
Date: JUL 2015		
Dwn. by: MT	Chkd. by: JW	Dwg. No.: 00 P1

01/02/2012 mt
15-139.DWG



SECTION A
SCALE 1:25

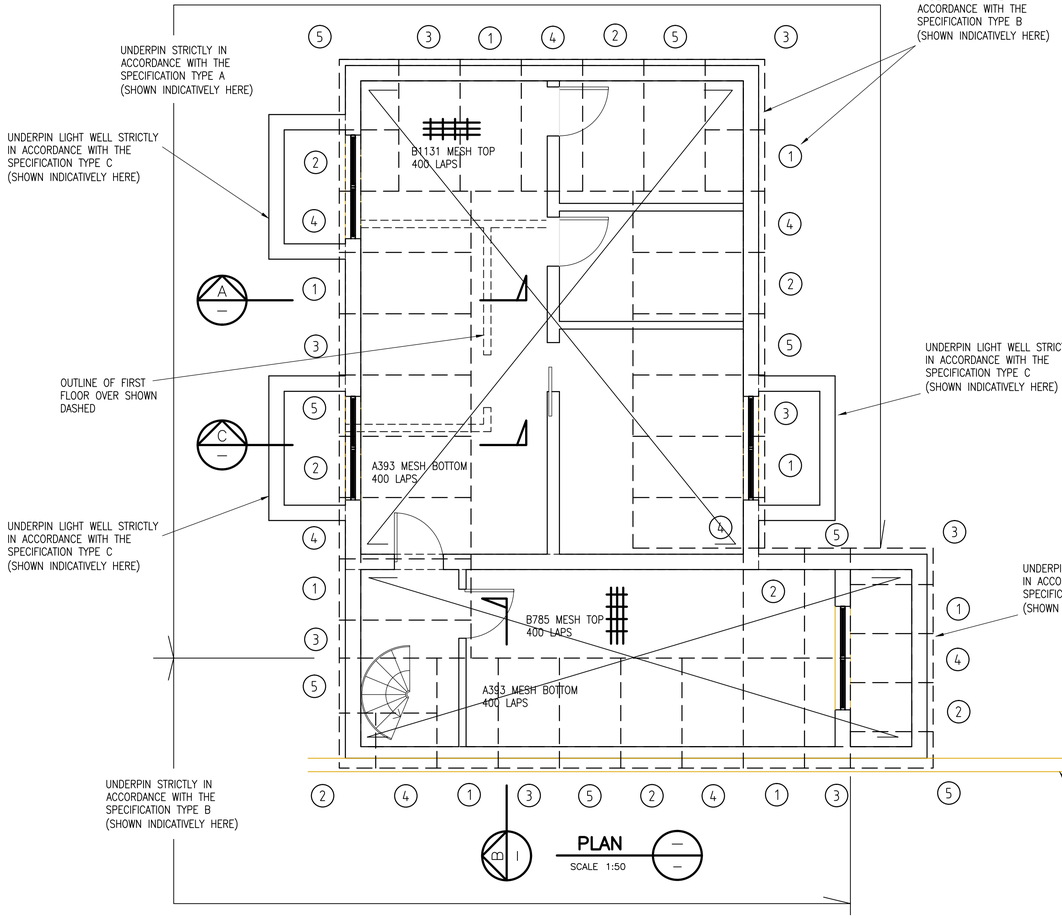


SECTION B
SCALE 1:25

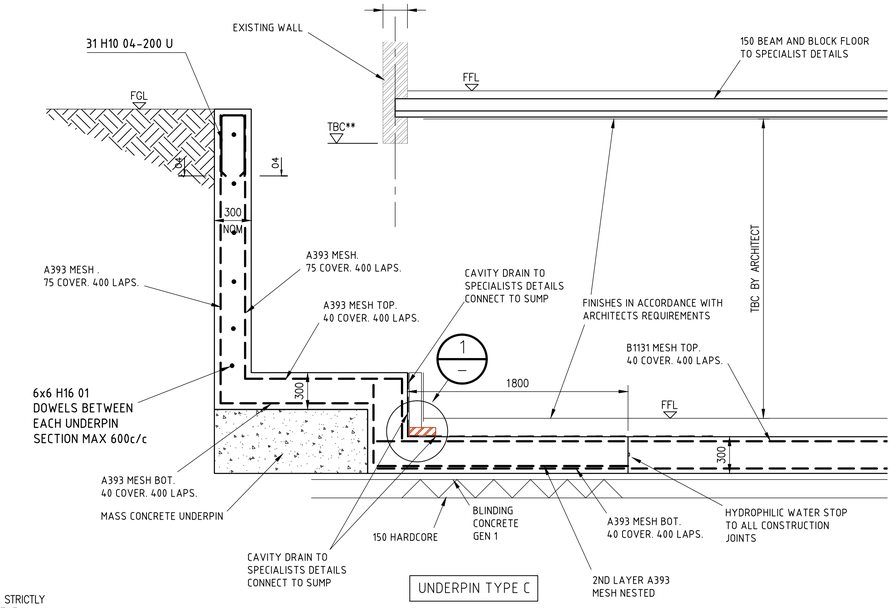
NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS DRAWINGS, ENGINEERS DRAWINGS AND CONTRACT DOCUMENTATION.
2. FOR GENERAL NOTES SEE DRAWING 15.139.00

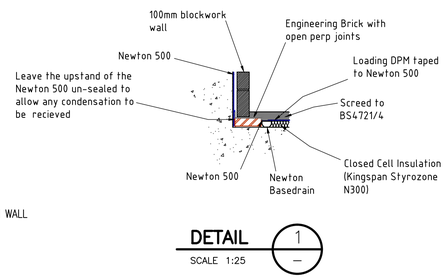
Member	Bar mark	Type and size	No. of mbrs.	No. of bars in each	Total no.	Length of each bar + mm	Shape code	A* mm	B* mm	C* mm	D* mm	E/R* mm	Rev letter
TYPE A	01	H16	1	144	144	450	00						
	07	H16	1	201	201	1775	11	600	(1200)				
	08	H16	1	126	126	1375	11	1200	(200)				
TYPE B	01	H16	1	167	167	450	00						
	07	H16	1	145	145	1775	11	600	(1200)				
	08	H16	1	91	91	1375	11	1200	(200)				
	09	H12	1	61	61	300	00						
TYPE C	01	H16	4	36	144	450	00						
	04	H10	4	31	124	1175	21	500	200	(500)			



PLAN
SCALE 1:50



SECTION C
SCALE 1:25



DETAIL 1
SCALE 1:25

PRELIMINARY

Rev.	Description	Date
P1	Preliminary for checking	13/07/15

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Project
PROPOSED ALTERATIONS
269 GOLDHURST TERRACE

Title
BASEMENT DETAILS

Scale	Job No.
AS SHOWN AT A1	15.139
Date: JUL 2015	
Dwn. by: MT / Chkd. by: JW	Dwg. No. 01 P1

01/02/2012 mt
15-139.DWG

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Project: 269 GOLDHURST TERRACE				Job Ref. 15.139	
Part of Structure: LOADS				Sheet No./rev. 01	
Calc. by: JW	Date: June 10	Chck'd by:	Date:	App'd by:	Date:

Ref.	Calculations	Output

LOADINGS

Pitched Roof:

Tiles	= 0.70
Felt & battens	= 0.05
Roof timber	= 0.15
Insulation & ceiling	= 0.20
	+ 1.10
I.L. Roof	= 0.75
I.L Loft	= 0.25
	+ 2.10 kN/m^2

Upper Floors – Timber:

Boards	= 0.15
Joists	= 0.15
Ceiling	= 0.20
	0.50
I.L Floor	+ 1.50
	+ 2.00 kN/m^2

External walls:

Brickwork	= 2.20
Blockwork	= 1.00
Plaster	= 0.20
	+ 3.40 kN/m^2

Block partitions:

100 blocks	= 1.00
Plaster (both side)	= 0.40
	+ 1.40 kN/m^2

Upper Floors – PC Conc:

Screed	= 1.80
PC Planks	= 3.0
Ceiling	= 0.2
	+ 5.00
I.L Floor	= 1.50
Partitions	= 1.30
	+ 7.80 kN/m^2

Flat Roof:

Chippings	= 0.20
3 layer felt	= 0.10
Boards	= 0.15
Joists	= 0.15
Insulation + ceiling	= 0.20
	+ 0.80
I.L. Roof	= 0.75
	+ 1.55 kN/m^2

Ground Floor:

50 screed	= 1.20
150 p.c. units	= 2.20
	+ 3.40
I.L. Floor	= 1.50
Partitions	= 1.30
	+ 6.20 kN/m^2

Stud partitions:

Studs	= 0.10
Plasterboard	= 0.30
	+ 0.40 kN/m^2
225 dense blocks	= 4.60
Plaster (both sides)	= 0.40
	+ 5.00 kN/m^2

Tile Hung Stud:

Tiles	= 0.70
Battens	= 0.05
12mm ply	= 0.10
50 x 150 Studs	= 0.10
Plaster Bd + insul.	=0.20
	+ 1.15 kN/m^2

Steel design to	B.S. 5950	225 th brick walls	5.0 kN/m^2
Concrete design to	B.S. 8110	330 th brick walls	7.5 kN/m^2
Masonry design to	B.S. 5628	450 th brick walls	10.0 kN/m^2
Timber design to	B.S. 5268		

Foundations are designed for a maximum ground bearing capacity of 100 kN/m^2, which is to be verified on site.

The Institution of Structural Engineers

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Project				Job Ref.	
269 GOLDHURST TERRACE				15.139	
Part of Structure				Sheet No./rev.	
PROPOSED BASEMENT				2	
Calc. by	Date	Chck'd by	Date	App'd by	Date
JW	JULY 15				

Ref.	Calculations	Output

The property is a three story property converted to apartments from ground to first floor is brickwork assumed 215mm wide (Under the building acts) and a mansard roof/second floor The property is situated close to Swiss cottage .

Some of the properties have had basement conversions completed and it is intended to construct a 2.9-3.0m basement to Flat 3 /269 Goldhurst terrace

It is intended to excavate and underpin the existing foundations in an underpinning sequence with reinforced underpins no greater than 1,0m to prevent any cracking other than fine as directed by the BRE (Building Research Establishment).

The local geology consists of Blue fissured clay on underlying London Clay It is anticipated that heave will take place and generally will be in the region of 20mm in a single story of 3.5m The basement slab will be designed to take full hydrostatic pressure and heave

50% of heave will take place during construction and therefore we would consider a upward heave pressure of 31Kpa from heave and 20Kpa from a full hydrostatic pressure there use heave as the criteria.

Assumptions have been made as to the span of the upper floors and assumed to be timber Loadbearing walls have been considered as solid 102mm walls or 215mm solid walls for the purposes of loading calculations with 20% reduction due to window/door openings.

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Project: 269 GOLDHURST TERRACE				Job Ref. 15.139	
Part of Structure: PROPOSED BASEMENT DESIGN				Sheet No./Rev. 03	
Calc. by: JW	Date JULY 15	Chck'd by:	Date	App'd by:	Date

WIND LOADINGS (TO GRND FLOOR)

kN/m | kN

WIND LOADING (A) & (C)

ROOF =	3/2 × 1.5 × .05 & .075	1.2	0.8
2ND =	1.5 × .05 & 1.5	0.8	2.3
1ST =	1.5 × .05 & 1.5	0.8	2.3
GRND =	1.5 × 4.4 & 2.5	6.6	3.8
WIN =	6.5 × 5.2 − 20% =	27.0	
		36.4	9.2

WIND (B)

DL | LL

ROOF =	3.0 × 0.8 & .075	2.4	2.3
2ND =	3.0 × .05 & 1.5	1.5	4.5
1ST =	3.0 × .05 & 1.5	1.5	4.5
GRND =	3.0 × 4.4 & 2.5	13.2	7.5
WIN =	2.2 × 6.0	13.2	
BSM'T-GRND =	0.2 × 16 × 3.0	9.6	
		41.4	19.8

WIND (D) & (E)

m | kN

ROOF =	1.0 × 0.8 & 0.75	0.8	0.75
2ND =	1.0 × .05 & 1.5	0.5	1.5
1ST =	1.0 × 0.5 & 1.5	0.5	1.5
GRND =	1.0 × 4.4 & 2.5	4.4	2.5
WIN =	8.5 × 5.2.	44.2	
		50.4	6.25.

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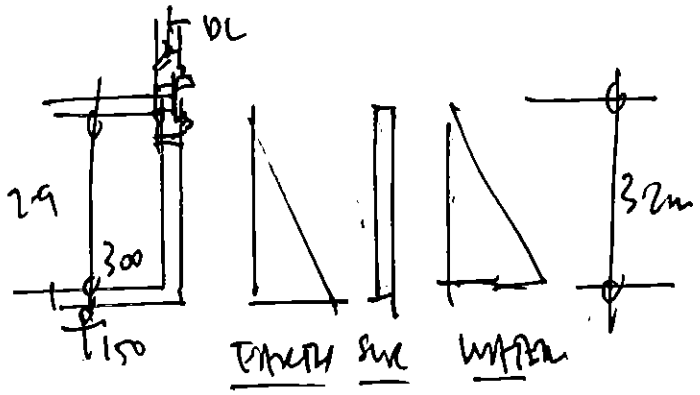
Project: 269 GOLDHURST TERRACE				Job Ref. 15.139	
Part of Structure: PROPOSED BASEMENT DESIGN				Sheet No./Rev. 04	
Calc. by: JW	Date JULY 15	Chck'd by:	Date	App'd by:	Date

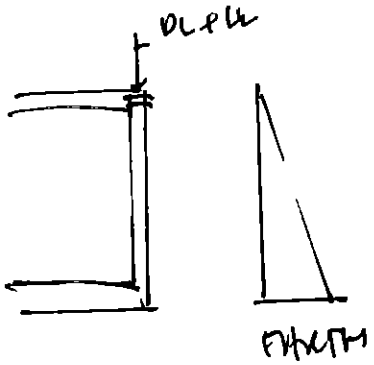
DESIGN OF PROPOSED RETAINING WALLS

DESIGN OF WALL (A) & WALL (C)



EARTH SURCHARGE WATER

CASE (1)



EARTH

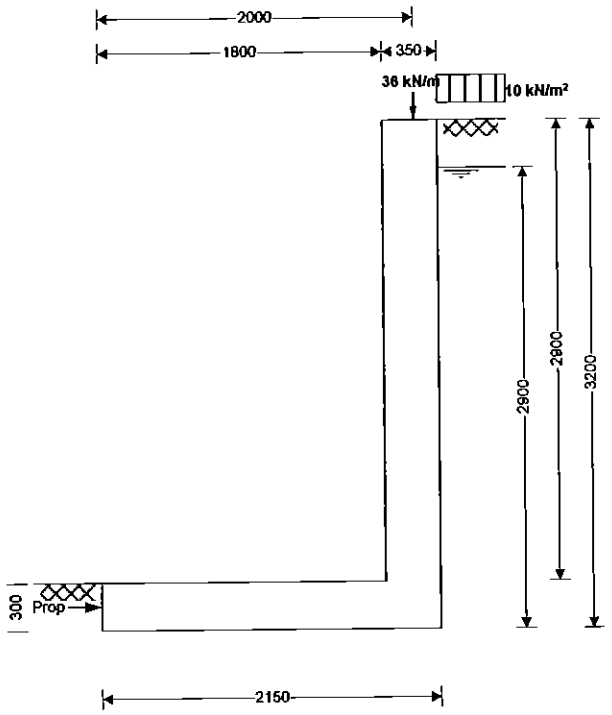
CASE (2)

TEKLA Tedds AND Designs Ltd 90 Meadrow Way GODALMING GU7 3HY	Project 269 GOLDHURST TERRACE				Job Ref. 15.139	
	Section PROPOSED BASEMENT DESIGN				Sheet no./rev. 5	
	Calc. by J	Date 06/07/2015	Chk'd by	Date	App'd by	Date

RETAINING WALL ANALYSIS & DESIGN (BS8002)

RETAINING WALL ANALYSIS (BS 8002:1994) CASE 1

TEDDS calculation version 1.2.01.06



Wall details

Retaining wall type	**Cantilever propped at base**
Height of retaining wall stem	h_{stem} = **2900** mm
Thickness of wall stem	t_{wall} = **350** mm
Length of toe	l_{toe} = **1800** mm
Length of heel	l_{heel} = **0** mm
Overall length of base	$l_{base} = l_{toe} + l_{heel} + t_{wall}$ = **2150** mm
Thickness of base	t_{base} = **300** mm
Depth of downstand	d_{ds} = **0** mm
Position of downstand	l_{ds} = **900** mm
Thickness of downstand	t_{ds} = **300** mm
Height of retaining wall	$h_{wall} = h_{stem} + t_{base} + d_{ds}$ = **3200** mm
Depth of cover in front of wall	d_{cover} = **0** mm
Depth of unplanned excavation	d_{exc} = **0** mm
Height of ground water behind wall	h_{water} = **2900** mm
Height of saturated fill above base	$h_{sat} = \max(h_{water} - t_{base} - d_{ds}, 0\ mm)$ = **2600** 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	$h_{eff} = h_{wall} + l_{heel} \times \tan(\beta)$ = **3200** 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

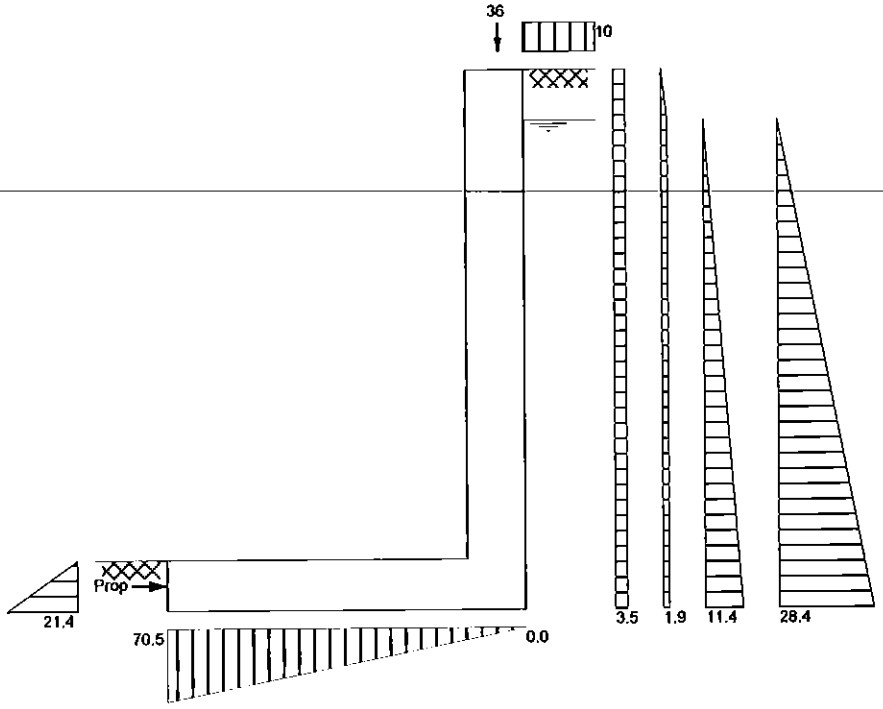
$$K_p = \sin(90 - \phi'_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi'_b + \delta_b) \times \sin(\phi'_b) / (\sin(90 + \delta_b)))}]^2) = \mathbf{4.187}$$

At-rest pressure

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

Loading details

Surcharge load on plan	Surcharge = **10.0** kN/m^2
Applied vertical dead load on wall	W_{dead} = **36.4** kN/m
Applied vertical live load on wall	W_{live} = **0.0** kN/m
Position of applied vertical load on wall	l_{load} = **2000** 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/m^2

TEKLA Tedds	Project				Job Ref.	
	269 GOLDHURST TERRACE				15.139	
AND Designs Ltd 90 Meadrow Way GODALMING GU7 3HY	Section				Sheet no./rev.	
	PROPOSED BASEMENT DESIGN				7	
	Calc. by	Date	Chk'd by	Date	App'd by	Date
	J	06/07/2015				

Vertical forces on wall

Wall stem	$w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall}$ = **24** kN/m
Wall base	$w_{base} = l_{base} \times t_{base} \times \gamma_{base}$ = **15.2** kN/m
Applied vertical load	$W_v = W_{dead} + W_{live}$ = **36.4** kN/m
Total vertical load	$W_{total} = w_{wall} + w_{base} + W_v$ = **75.6** kN/m

Horizontal forces on wall

Surcharge	$F_{sur} = K_a \times \cos(90 - \alpha + \delta) \times \text{Surcharge} \times h_{eff}$ = **11.2** kN/m
Moist backfill above water table	$F_{m\_a} = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2$ = **0.3** kN/m
Moist backfill below water table	$F_{m\_b} = K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water}$ = **5.5** kN/m
Saturated backfill	$F_s = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times (\gamma_s - \gamma_{water}) \times h_{water}^2$ = **16.5** kN/m
Water	$F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water}$ = **41.3** kN/m
Total horizontal load	$F_{total} = F_{sur} + F_{m\_a} + F_{m\_b} + F_s + F_{water}$ = **74.7** kN/m

Calculate propping force

Passive resistance of soil in front of wall	$F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **3.2** kN/m
Propping force	$F_{prop} = \max(F_{total} - F_p - (W_{total}) \times \tan(\delta_b), 0\ \text{kN/m})$
	F_{prop} = **46.0** kN/m

Overturning moments

Surcharge	$M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **17.9** kNm/m
Moist backfill above water table	$M_{m\_a} = F_{m\_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **0.9** kNm/m
Moist backfill below water table	$M_{m\_b} = F_{m\_b} \times (h_{water} - 2 \times d_{ds}) / 2$ = **7.9** kNm/m
Saturated backfill	$M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3$ = **15.9** kNm/m
Water	$M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3$ = **39.9** kNm/m
Total overturning moment	$M_{ot} = M_{sur} + M_{m\_a} + M_{m\_b} + M_s + M_{water}$ = **82.5** kNm/m

Restoring moments

Wall stem	$M_{wall} = w_{wall} \times (l_{toe} + t_{wall} / 2)$ = **47.3** kNm/m
Wall base	$M_{base} = w_{base} \times l_{base} / 2$ = **16.4** kNm/m
Design vertical dead load	$M_{dead} = W_{dead} \times l_{load}$ = **72.8** kNm/m
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{dead}$ = **136.5** kNm/m

Check bearing pressure

Total moment for bearing	$M_{total} = M_{rest} - M_{ot}$ = **54** kNm/m
Total vertical reaction	$R = W_{total}$ = **75.6** kN/m
Distance to reaction	$x_{bar} = M_{total} / R$ = **714** mm
Eccentricity of reaction	$e = \text{abs}((l_{base} / 2) - x_{bar})$ = **361** mm
	Reaction acts outside middle third of base
Bearing pressure at toe	$p_{toe} = R / (1.5 \times x_{bar})$ = **70.5** kN/m^2
Bearing pressure at heel	p_{heel} = **0** kN/m^2 = **0** kN/m^2

PASS - Maximum bearing pressure is less than allowable bearing pressure

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor $\gamma_{f\_d} = 1.4$

Live load factor $\gamma_{f\_l} = 1.6$

Earth and water pressure factor $\gamma_{f\_e} = 1.4$

Factored vertical forces on wall

Wall stem $w_{wall\_f} = \gamma_{f\_d} \times h_{stem} \times t_{wall} \times \gamma_{wall} = 33.5$ kN/m

Wall base $w_{base\_f} = \gamma_{f\_d} \times l_{base} \times t_{base} \times \gamma_{base} = 21.3$ kN/m

Applied vertical load $W_{v\_f} = \gamma_{f\_d} \times W_{dead} + \gamma_{f\_l} \times W_{live} = 51$ kN/m

Total vertical load $W_{total\_f} = w_{wall\_f} + w_{base\_f} + W_{v\_f} = 105.8$ kN/m

Factored horizontal at-rest forces on wall

Surcharge $F_{sur\_f} = \gamma_{f\_l} \times K_0 \times \text{Surcharge} \times h_{eff} = 30.2$ kN/m

Moist backfill above water table $F_{m\_a\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times \gamma_m \times (h_{eff} - h_{water})^2 = 0.7$ kN/m

Moist backfill below water table $F_{m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 12.9$ kN/m

Saturated backfill $F_{s\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times (\gamma_s - \gamma_{water}) \times h_{water}^2 = 38.9$ kN/m

Water $F_{water\_f} = \gamma_{f\_e} \times 0.5 \times h_{water}^2 \times \gamma_{water} = 57.8$ kN/m

Total horizontal load $F_{total\_f} = F_{sur\_f} + F_{m\_a\_f} + F_{m\_b\_f} + F_{s\_f} + F_{water\_f} = 140.4$ kN/m

Calculate propping force

Passive resistance of soil in front of wall kN/m $F_{p\_f} = \gamma_{f\_e} \times 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 4.5$

Propping force $F_{prop\_f} = \max(F_{total\_f} - F_{p\_f} - (W_{total\_f}) \times \tan(\delta_b), 0 \text{ kN/m})$

$F_{prop\_f} = 100.3$ kN/m

Factored overturning moments

Surcharge $M_{sur\_f} = F_{sur\_f} \times (h_{eff} - 2 \times d_{ds}) / 2 = 48.3$ kNm/m

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

Moist backfill below water table $M_{m\_b\_f} = F_{m\_b\_f} \times (h_{water} - 2 \times d_{ds}) / 2 = 18.8$ kNm/m

Saturated backfill $M_{s\_f} = F_{s\_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 37.6$ kNm/m

Water $M_{water\_f} = F_{water\_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 55.8$ kNm/m

Total overturning moment $M_{ot\_f} = M_{sur\_f} + M_{m\_a\_f} + M_{m\_b\_f} + M_{s\_f} + M_{water\_f} = 162.5$ kNm/m

Restoring moments

Wall stem $M_{wall\_f} = w_{wall\_f} \times (l_{toe} + t_{wall} / 2) = 66.2$ kNm/m

Wall base $M_{base\_f} = w_{base\_f} \times l_{base} / 2 = 22.9$ kNm/m

Design vertical load $M_{v\_f} = W_{v\_f} \times l_{load} = 101.9$ kNm/m

Total restoring moment $M_{rest\_f} = M_{wall\_f} + M_{base\_f} + M_{v\_f} = 191.1$ kNm/m

Factored bearing pressure

Total moment for bearing $M_{total\_f} = M_{rest\_f} - M_{ot\_f} = 28.6$ kNm/m

Total vertical reaction $R_f = W_{total\_f} = 105.8$ kN/m

Distance to reaction $x_{bar\_f} = M_{total\_f} / R_f = 270$ mm

Eccentricity of reaction $e_f = \text{abs}((l_{base} / 2) - x_{bar\_f}) = 805$ mm

Reaction acts outside middle third of base

Bearing pressure at toe $p_{toe\_f} = R_f / (1.5 \times x_{bar\_f}) = 261.4$ kN/m^2

Bearing pressure at heel $p_{heel\_f} = 0$ kN/m^2 $= 0$ kN/m^2

Rate of change of base reaction $\text{rate} = p_{toe\_f} / (3 \times x_{bar\_f}) = 322.83$ kN/m^2/m

Bearing pressure at stem / toe $p_{stem\_toe\_f} = \max(p_{toe\_f} - (\text{rate} \times l_{toe}), 0\ kN/m^2) = 0\ kN/m^2$

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

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

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

Material properties

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

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

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 $V_{toe\_bear} = 3 \times p_{toe\_f} \times x_{bar\_f} / 2 = 105.8\ kN/m$

Shear from weight of base $V_{toe\_wt\_base} = \gamma_{f\_d} \times \gamma_{base} \times l_{toe} \times t_{base} = 17.8\ kN/m$

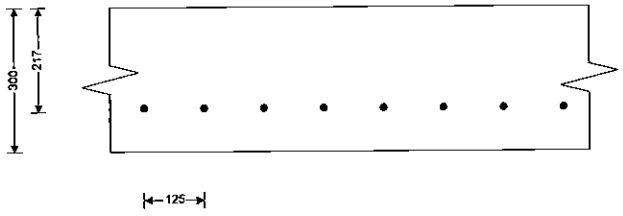
Total shear for toe design $V_{toe} = V_{toe\_bear} - V_{toe\_wt\_base} = 88\ kN/m$

Calculate moment for toe design

Moment from bearing pressure $M_{toe\_bear} = 3 \times p_{toe\_f} \times x_{bar\_f} \times (l_{toe} - x_{bar\_f} + t_{wall} / 2) / 2 = 180.4\ kNm/m$

Moment from weight of base $M_{toe\_wt\_base} = (\gamma_{f\_d} \times \gamma_{base} \times t_{base} \times (l_{toe} + t_{wall} / 2)^2 / 2) = 19.3\ kNm/m$

Total moment for toe design $M_{toe} = M_{toe\_bear} - M_{toe\_wt\_base} = 161.1\ kNm/m$



Check toe in bending

Width of toe $b = 1000\ mm/m$

Depth of reinforcement $d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2) = 217.0\ mm$

Constant $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu}) = 0.086$

Compression reinforcement is not required

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

$z_{toe} = 194\ mm$

Area of tension reinforcement required $A_{s\_toe\_des} = M_{toe} / (0.87 \times f_y \times z_{toe}) = 1909\ mm^2/m$

Minimum area of tension reinforcement $A_{s\_toe\_min} = k \times b \times t_{base} = 390\ mm^2/m$

Area of tension reinforcement required $A_{s\_toe\_req} = \text{Max}(A_{s\_toe\_des}, A_{s\_toe\_min}) = 1909\ mm^2/m$

Reinforcement provided **16 mm dia.bars @ 125 mm centres**

Area of reinforcement provided $A_{s\_toe\_prov} = 1608\ mm^2/m$

FAIL - Reinforcement provided at the retaining wall toe is inadequate

Check shear resistance at toe

Design shear stress $v_{toe} = V_{toe} / (b \times d_{toe}) = 0.405\ N/mm^2$

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

PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress $v_{c\_toe} = 0.779\ N/mm^2$

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

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

Material properties

Characteristic strength of concrete f_{cu} = **40** N/mm^2

Characteristic strength of reinforcement f_y = **500** N/mm^2

Wall details

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

Cover to reinforcement in stem c_{stem} = **50** mm

Cover to reinforcement in wall c_{wall} = **75** mm

Factored horizontal at-rest forces on stem

Surcharge $F_{s\_sur\_f} = \gamma_{f\_f} \times K_0 \times \text{Surcharge} \times (h_{eff} - t_{base} - d_{ds})$ = **27.4** kN/m

Moist backfill above water table $F_{s\_m\_a\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2$ = **0.7** kN/m

Moist backfill below water table $F_{s\_m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat}) \times h_{sat}$ = **11.6** kN/m

Saturated backfill $F_{s\_s\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times (\gamma_s - \gamma_{water}) \times h_{sat}^2$ = **31.2** kN/m

Water $F_{s\_water\_f} = 0.5 \times \gamma_{f\_e} \times \gamma_{water} \times h_{sat}^2$ = **46.4** kN/m

Calculate shear for stem design

Shear at base of stem $V_{stem} = F_{s\_sur\_f} + F_{s\_m\_a\_f} + F_{s\_m\_b\_f} + F_{s\_s\_f} + F_{s\_water\_f} - F_{prop\_f}$ = **17** kN/m

Calculate moment for stem design

Surcharge $M_{s\_sur} = F_{s\_sur\_f} \times (h_{stem} + t_{base}) / 2$ = **43.8** kNm/m

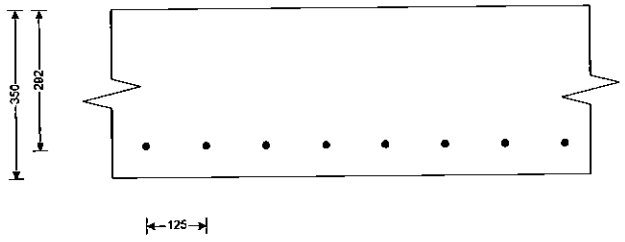
Moist backfill above water table $M_{s\_m\_a} = F_{s\_m\_a\_f} \times (2 \times h_{sat} + h_{eff} - d_{ds} + t_{base} / 2) / 3$ = **1.9** kNm/m

Moist backfill below water table $M_{s\_m\_b} = F_{s\_m\_b\_f} \times h_{sat} / 2$ = **15.1** kNm/m

Saturated backfill $M_{s\_s} = F_{s\_s\_f} \times h_{sat} / 3$ = **27.1** kNm/m

Water $M_{s\_water} = F_{s\_water\_f} \times h_{sat} / 3$ = **40.2** kNm/m

Total moment for stem design $M_{stem} = M_{s\_sur} + M_{s\_m\_a} + M_{s\_m\_b} + M_{s\_s} + M_{s\_water}$ = **128.1** kNm/m



Check wall stem in bending

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

Depth of reinforcement $d_{stem} = t_{wall} - c_{stem} - (\phi_{stem} / 2)$ = **292.0** mm

Constant $K_{stem} = M_{stem} / (b \times d_{stem}^2 \times f_{cu})$ = **0.038**

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} = **277** mm

Area of tension reinforcement required $A_{s\_stem\_des} = M_{stem} / (0.87 \times f_y \times z_{stem})$ = **1062** mm^2/m

Minimum area of tension reinforcement $A_{s\_stem\_min} = k \times b \times t_{wall}$ = **455** mm^2/m

Area of tension reinforcement required $A_{s\_stem\_req} = \text{Max}(A_{s\_stem\_des}, A_{s\_stem\_min})$ = **1062** mm^2/m

Reinforcement provided **16 mm dia.bars @ 125 mm centres**

Area of reinforcement provided $A_{s\_stem\_prov}$ = **1608** mm^2/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress $v_{stem} = V_{stem} / (b \times d_{stem})$ = **0.058** N/mm^2

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

PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress $v_{c\_stem} = \mathbf{0.656}\ N/mm^2$

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

Check retaining wall deflection

Basic span/effective depth ratio $ratio_{bas} = \mathbf{7}$

Design service stress $f_s = 2 \times f_y \times A_{s\_stem\_req} / (3 \times A_{s\_stem\_prov}) = \mathbf{220.0}\ N/mm^2$

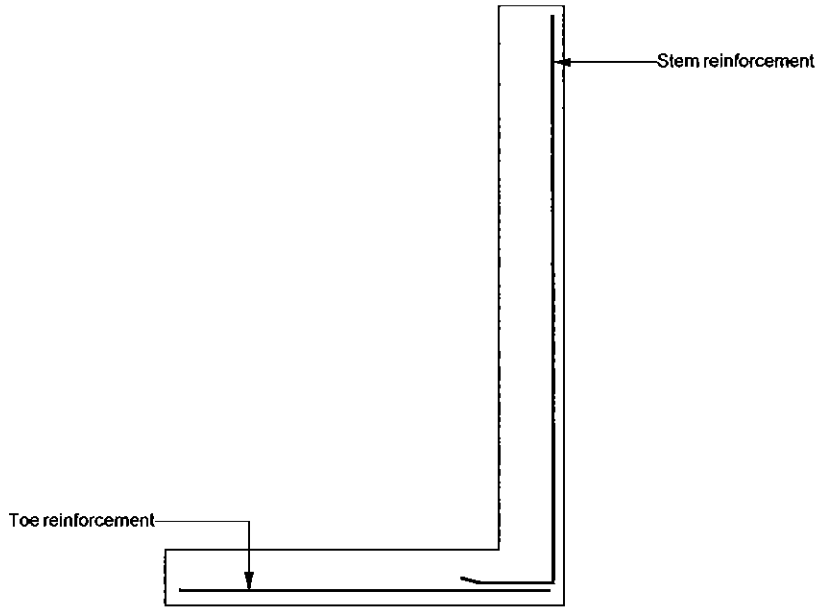
Modification factor $factor_{tens} = \min(0.55 + (477\ N/mm^2 - f_s)/(120 \times (0.9\ N/mm^2 + (M_{stem}/(b \times d_{stem}^2)))),2) = \mathbf{1.44}$

Maximum span/effective depth ratio $ratio_{max} = ratio_{bas} \times factor_{tens} = \mathbf{10.09}$

Actual span/effective depth ratio $ratio_{act} = h_{stem} / d_{stem} = \mathbf{9.93}$

PASS - Span to depth ratio is acceptable

Indicative retaining wall reinforcement diagram



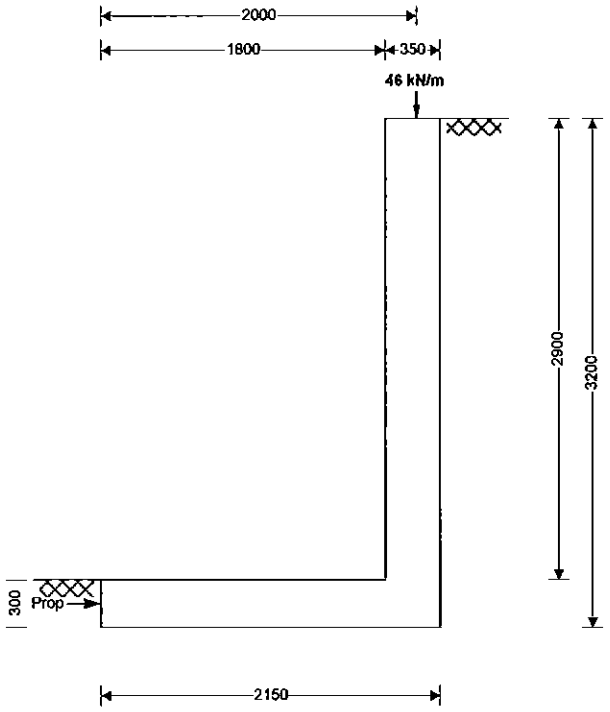
Toe bars - 16 mm dia.@ 125 mm centres - (1608 mm^2/m)
Stem bars - 16 mm dia.@ 125 mm centres - (1608 mm^2/m)

TEKLA Tedds AND Designs Ltd 90 Meadrow Way GODALMING GU7 3HY	Project 269 GOLDHURST TERRACE				Job Ref. 15.139	
	Section PROPOSED BASEMENT DESIGN				Sheet no./rev. 13	
	Calc. by J	Date 06/07/2015	Chk'd by	Date	App'd by	Date

RETAINING WALL ANALYSIS & DESIGN (BS8002) CASE II WALL A & C

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06



Wall details

Retaining wall type	**Cantilever propped at base**
Height of retaining wall stem	h_{stem} = **2900** mm
Thickness of wall stem	t_{wall} = **350** mm
Length of toe	l_{toe} = **1800** mm
Length of heel	l_{heel} = **0** mm
Overall length of base	$l_{base} = l_{toe} + l_{heel} + t_{wall}$ = **2150** mm
Thickness of base	t_{base} = **300** mm
Depth of downstand	d_{ds} = **0** mm
Position of downstand	l_{ds} = **900** mm
Thickness of downstand	t_{ds} = **300** mm
Height of retaining wall	$h_{wall} = h_{stem} + t_{base} + d_{ds}$ = **3200** mm
Depth of cover in front of wall	d_{cover} = **0** mm
Depth of unplanned excavation	d_{exc} = **0** mm
Height of ground water behind wall	h_{water} = **0** mm
Height of saturated fill above base	$h_{sat} = \max(h_{water} - t_{base} - d_{ds}, 0\ mm)$ = **0** 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	$h_{eff} = h_{wall} + l_{heel} \times \tan(\beta)$ = **3200** 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

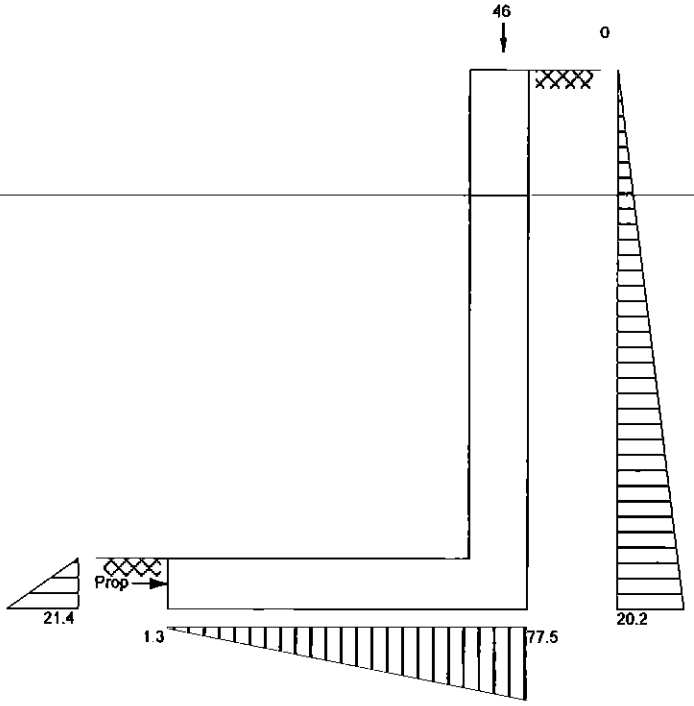
$$K_p = \sin(90 - \phi'_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi'_b + \delta_b) \times \sin(\phi'_b) / (\sin(90 + \delta_b)))}]^2) = \mathbf{4.187}$$

At-rest pressure

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

Loading details

Surcharge load on plan	Surcharge = **0.0** kN/m^2
Applied vertical dead load on wall	W_{dead} = **36.4** kN/m
Applied vertical live load on wall	W_{live} = **9.2** kN/m
Position of applied vertical load on wall	l_{load} = **2000** 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/m^2

Vertical forces on wall

Wall stem — $w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall}$ = **24** kN/m

Wall base — $w_{base} = l_{base} \times t_{base} \times \gamma_{base}$ = **15.2** kN/m

Applied vertical load — $W_v = W_{dead} + W_{live}$ = **45.6** kN/m

Total vertical load — $W_{total} = w_{wall} + w_{base} + W_v$ = **84.8** kN/m

Horizontal forces on wall

Moist backfill above water table — $F_{m\_a} = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2$ = **32.2** kN/m

Total horizontal load — $F_{total} = F_{m\_a}$ = **32.2** kN/m

Calculate propping force

Passive resistance of soil in front of wall — $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **3.2** kN/m

Propping force — $F_{prop} = \max(F_{total} - F_p - (W_{total} - W_{live}) \times \tan(\delta_b), 0$ kN/m)

F_{prop} = **3.6** kN/m

Overturning moments

Moist backfill above water table — $M_{m\_a} = F_{m\_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **34.4** kNm/m

Total overturning moment — $M_{ot} = M_{m\_a}$ = **34.4** kNm/m

Restoring moments

Wall stem — $M_{wall} = w_{wall} \times (l_{toe} + t_{wall} / 2)$ = **47.3** kNm/m

Wall base — $M_{base} = w_{base} \times l_{base} / 2$ = **16.4** kNm/m

Design vertical dead load — $M_{dead} = W_{dead} \times l_{load}$ = **72.8** kNm/m

Total restoring moment — $M_{rest} = M_{wall} + M_{base} + M_{dead}$ = **136.5** kNm/m

Check bearing pressure

Design vertical live load — $M_{live} = W_{live} \times l_{load}$ = **18.4** kNm/m

Total moment for bearing — $M_{total} = M_{rest} - M_{ot} + M_{live}$ = **120.5** kNm/m

Total vertical reaction — $R = W_{total}$ = **84.8** kN/m

Distance to reaction — $x_{bar} = M_{total} / R$ = **1421** mm

Eccentricity of reaction — $e = \text{abs}((l_{base} / 2) - x_{bar})$ = **346** mm

Reaction acts within middle third of base

Bearing pressure at toe — $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2)$ = **1.3** kN/m^2

Bearing pressure at heel — $p_{heel} = (R / l_{base}) + (6 \times R \times e / l_{base}^2)$ = **77.5** kN/m^2

PASS - Maximum bearing pressure is less than allowable bearing pressure

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor $\gamma_{f\_d} = 1.4$

Live load factor $\gamma_{f\_l} = 1.6$

Earth and water pressure factor $\gamma_{f\_e} = 1.4$

Factored vertical forces on wall

Wall stem $w_{wall\_f} = \gamma_{f\_d} \times h_{stem} \times t_{wall} \times \gamma_{wall} = 33.5$ kN/m

Wall base $w_{base\_f} = \gamma_{f\_d} \times l_{base} \times t_{base} \times \gamma_{base} = 21.3$ kN/m

Applied vertical load $W_{v\_f} = \gamma_{f\_d} \times W_{dead} + \gamma_{f\_l} \times W_{live} = 65.7$ kN/m

Total vertical load $W_{total\_f} = w_{wall\_f} + w_{base\_f} + W_{v\_f} = 120.5$ kN/m

Factored horizontal at-rest forces on wall

Moist backfill above water table $F_{m\_a\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times \gamma_m \times (h_{eff} - h_{water})^2 = 76.1$ kN/m

Total horizontal load $F_{total\_f} = F_{m\_a\_f} = 76.1$ kN/m

Calculate propping force

Passive resistance of soil in front of wall $F_{p\_f} = \gamma_{f\_e} \times 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 4.5$ 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)

$F_{prop\_f} = 36.0$ kN/m

Factored overturning moments

Moist backfill above water table $M_{m\_a\_f} = F_{m\_a\_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 81.2$ kNm/m

Total overturning moment $M_{ot\_f} = M_{m\_a\_f} = 81.2$ kNm/m

Restoring moments

Wall stem $M_{wall\_f} = w_{wall\_f} \times (l_{toe} + t_{wall} / 2) = 66.2$ kNm/m

Wall base $M_{base\_f} = w_{base\_f} \times l_{base} / 2 = 22.9$ kNm/m

Design vertical load $M_{v\_f} = W_{v\_f} \times l_{load} = 131.4$ kNm/m

Total restoring moment $M_{rest\_f} = M_{wall\_f} + M_{base\_f} + M_{v\_f} = 220.5$ kNm/m

Factored bearing pressure

Total moment for bearing $M_{total\_f} = M_{rest\_f} - M_{ot\_f} = 139.3$ kNm/m

Total vertical reaction $R_f = W_{total\_f} = 120.5$ kN/m

Distance to reaction $x_{bar\_f} = M_{total\_f} / R_f = 1156$ mm

Eccentricity of reaction $e_f = \text{abs}((l_{base} / 2) - x_{bar\_f}) = 81$ mm

Reaction acts within middle third of base

Bearing pressure at toe $p_{toe\_f} = (R_f / l_{base}) - (6 \times R_f \times e_f / l_{base}^2) = 43.4$ kN/m^2

Bearing pressure at heel $p_{heel\_f} = (R_f / l_{base}) + (6 \times R_f \times e_f / l_{base}^2) = 68.7$ kN/m^2

Rate of change of base reaction $\text{rate} = (p_{toe\_f} - p_{heel\_f}) / l_{base} = -11.74$ kN/m^2/m

Bearing pressure at stem / toe $p_{stem\_toe\_f} = \max(p_{heel\_f} + (\text{rate} \times (l_{heel} + t_{wall})), 0$ kN/m^2) $= 64.6$ kN/m^2

Bearing pressure at mid stem $p_{stem\_mid\_f} = \max(p_{heel\_f} + (\text{rate} \times (l_{heel} + t_{wall} / 2)), 0$ kN/m^2) $= 66.6$ kN/m^2

Bearing pressure at stem / heel $p_{stem\_heel\_f} = \max(p_{heel\_f} + (\text{rate} \times l_{heel}), 0$ kN/m^2) $= 68.7$ kN/m^2

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

Material properties

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

Characteristic strength of reinforcement $f_y = 500$ N/mm^2

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 — $V_{toe\_bear} = (p_{toe\_f} + p_{stem\_toe\_f}) \times l_{toe} / 2$ = **97.2** kN/m

Shear from weight of base — $V_{toe\_wt\_base} = \gamma_{f\_d} \times \gamma_{base} \times l_{toe} \times t_{base}$ = **17.8** kN/m

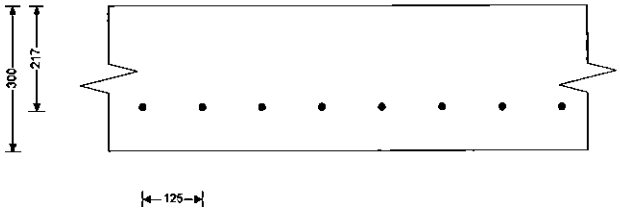
Total shear for toe design — $V_{toe} = V_{toe\_bear} - V_{toe\_wt\_base}$ = **79.4** kN/m

Calculate moment for toe design

Moment from bearing pressure — $M_{toe\_bear} = (2 \times p_{toe\_f} + p_{stem\_mid\_f}) \times (l_{toe} + t_{wall} / 2)^2 / 6$ = **99.8** kNm/m

Moment from weight of base — $M_{toe\_wt\_base} = (\gamma_{f\_d} \times \gamma_{base} \times t_{base} \times (l_{toe} + t_{wall} / 2)^2 / 2)$ = **19.3** kNm/m

Total moment for toe design — $M_{toe} = M_{toe\_bear} - M_{toe\_wt\_base}$ = **80.5** kNm/m



Check toe in bending

Width of toe — b = **1000** mm/m

Depth of reinforcement — $d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2)$ = **217.0** mm

Constant — $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu})$ = **0.043**

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} = **206** mm

Area of tension reinforcement required — $A_{s\_toe\_des} = M_{toe} / (0.87 \times f_y \times z_{toe})$ = **897** mm²/m

Minimum area of tension reinforcement — $A_{s\_toe\_min} = k \times b \times t_{base}$ = **390** mm²/m

Area of tension reinforcement required — $A_{s\_toe\_req} = \max(A_{s\_toe\_des}, A_{s\_toe\_min})$ = **897** mm²/m

Reinforcement provided — **16 mm dia.bars @ 125 mm centres**

Area of reinforcement provided — $A_{s\_toe\_prov}$ = **1608** mm²/m

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress — $v_{toe} = V_{toe} / (b \times d_{toe})$ = **0.366** N/mm²

Allowable shear stress — $v_{adm} = \min(0.8 \times \sqrt{(f_{cu} / 1\ N/mm^2)}, 5) \times 1\ N/mm^2$ = **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_toe} = **0.779** 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} = **40** 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} = **50** mm

Cover to reinforcement in wall — c_{wall} = **75** mm

Factored horizontal at-rest forces on stem

Moist backfill above water table $F_{s\_m\_a\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2 = \mathbf{62.5}$ kN/m

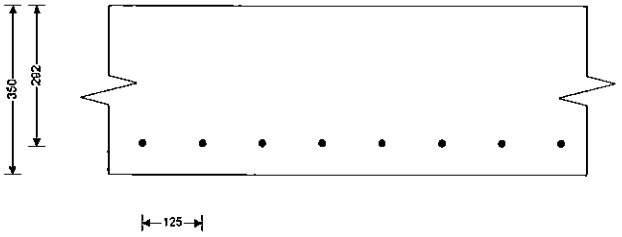
Calculate shear for stem design

Shear at base of stem $V_{stem} = F_{s\_m\_a\_f} - F_{prop\_f} = \mathbf{26.5}$ kN/m

Calculate moment for stem design

Moist backfill above water table $M_{s\_m\_a} = F_{s\_m\_a\_f} \times (2 \times h_{sat} + h_{eff} - d_{ds} + t_{base} / 2) / 3 = \mathbf{69.8}$ kNm/m

Total moment for stem design $M_{stem} = M_{s\_m\_a} = \mathbf{69.8}$ kNm/m



Check wall stem in bending

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

Depth of reinforcement $d_{stem} = t_{wall} - c_{stem} - (\phi_{stem} / 2) = \mathbf{292.0}$ mm

Constant $K_{stem} = M_{stem} / (b \times d_{stem}^2 \times f_{cu}) = \mathbf{0.020}$

Compression reinforcement is not required

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

$z_{stem} = \mathbf{277}$ mm

Area of tension reinforcement required $A_{s\_stem\_des} = M_{stem} / (0.87 \times f_y \times z_{stem}) = \mathbf{579}$ mm^2/m

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

Area of tension reinforcement required $A_{s\_stem\_req} = \max(A_{s\_stem\_des}, A_{s\_stem\_min}) = \mathbf{579}$ mm^2/m

Reinforcement provided **16 mm dia.bars @ 125 mm centres**

Area of reinforcement provided $A_{s\_stem\_prov} = \mathbf{1608}$ mm^2/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress $v_{stem} = V_{stem} / (b \times d_{stem}) = \mathbf{0.091}$ 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 $v_{c\_stem} = \mathbf{0.656}$ N/mm^2

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

Check retaining wall deflection

Basic span/effective depth ratio $ratio_{bas} = \mathbf{7}$

Design service stress $f_s = 2 \times f_y \times A_{s\_stem\_req} / (3 \times A_{s\_stem\_prov}) = \mathbf{119.9}$ N/mm^2

Modification factor $factor_{tens} = \min(0.55 + (477\ \text{N/mm}^2 - f_s)/(120 \times (0.9\ \text{N/mm}^2 + (M_{stem}/(b \times d_{stem}^2)))), 2) = \mathbf{2.00}$

Maximum span/effective depth ratio $ratio_{max} = ratio_{bas} \times factor_{tens} = \mathbf{14.00}$

Actual span/effective depth ratio $ratio_{act} = h_{stem} / d_{stem} = \mathbf{9.93}$

PASS - Span to depth ratio is acceptable

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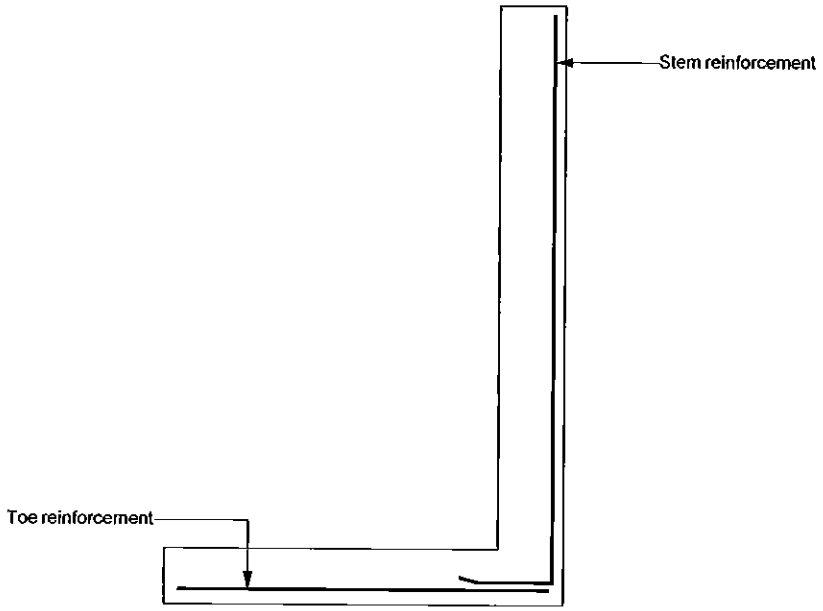
	Calc. by	Date	Chk'd by	Date	App'd by	Date
	J	06/07/2015				

Indicative retaining wall reinforcement diagram



Toe bars - 16 mm dia.@ 125 mm centres - (1608 mm^2/m)
Stem bars - 16 mm dia.@ 125 mm centres - (1608 mm^2/m)

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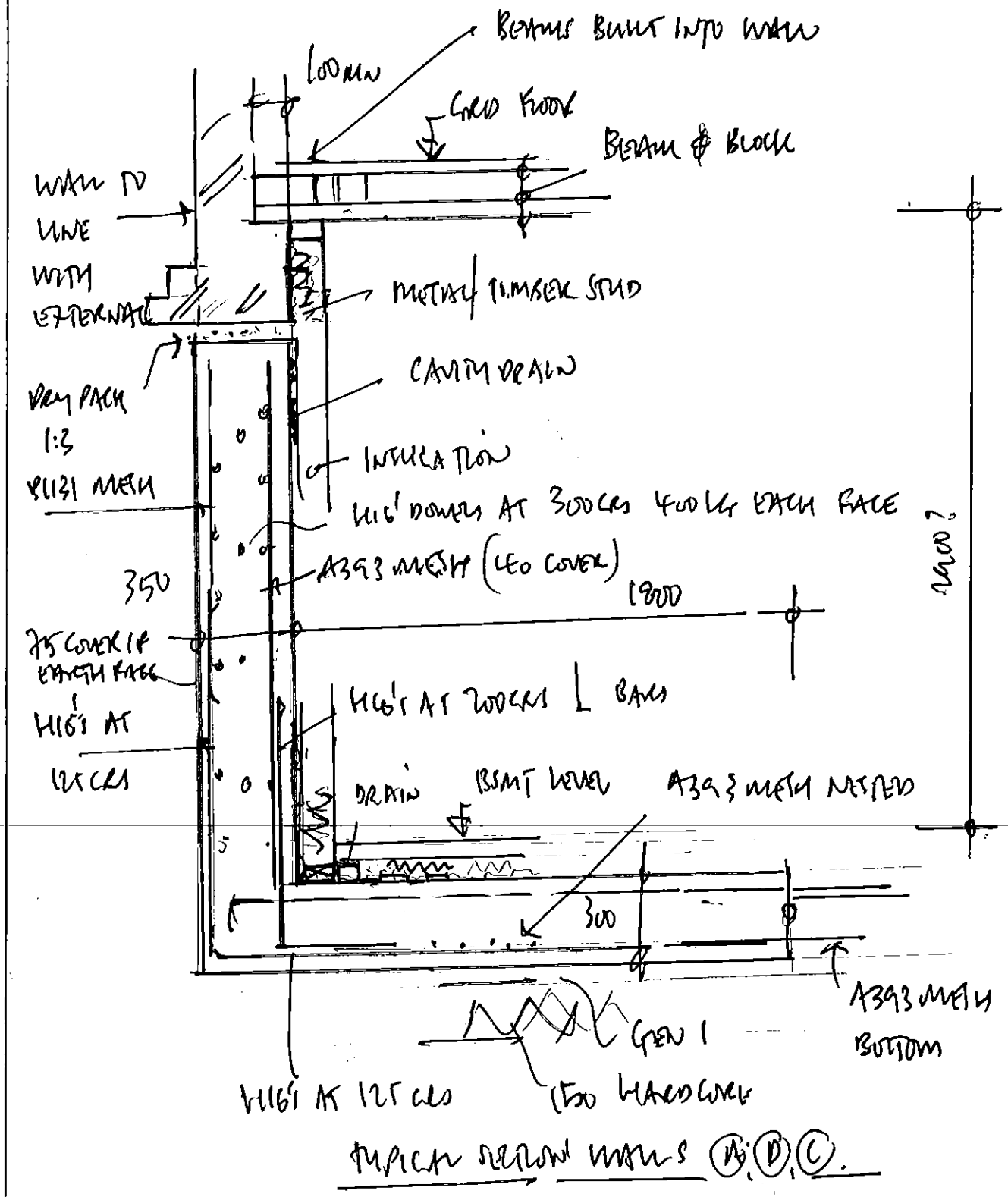
90 MEADROW GODALMING, SURREY GU7 3HY Tel: 01483 418 140 Fax: 01483 421 304 e-mail: info@anddesigns.co.uk	Part of Structure: PROPOSED BASEMENT DESIGN				Sheet No./Rev. 20	
	Calc. by: JW	Date JULY 15	Chck'd by:	Date	App'd by:	Date



TYPICAL SECTION WALLS (A), (B), (C).

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Project: 269 GOLDHURST TERRACE				Job Ref. 15.139	
Part of Structure: PROPOSED BASEMENT DESIGN				Sheet No./Rev. 21.	
Calc. by: JW	Date JULY 15	Chck'd by:	Date	App'd by:	Date

DESIGN TO WALL (F)

LOADING ON WALL

		kN/m DL	kN/m LL.
ROOF	3/2 × 0.8 & 0.75	1.3	1.1
FLOOR	3/2 × 4.4 & 2.5	6.6	3.8
WALL FLOOR - ROOF	3.5 × 5.2	18.2	
		26.1	4.9
WALL REMOVED FLOOR	0.35 × 24 × 3.0	25.2	
(FOR HEIGHT)		51.3	

WALL (E)

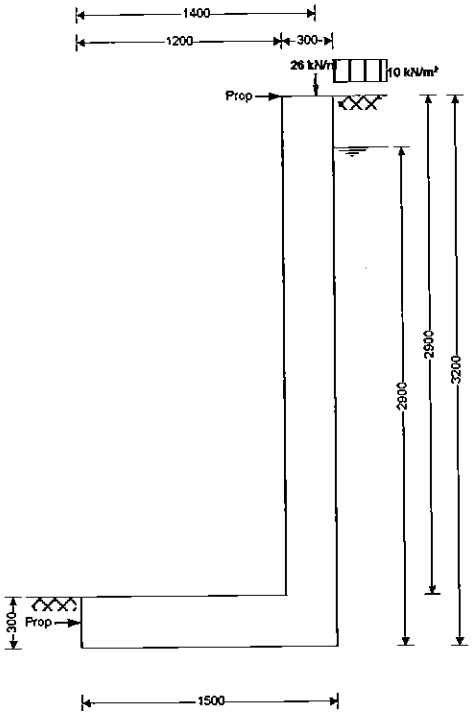
AS WALL (A) & (C) FOR DESIGN

TEKLA Tedds AND Designs Ltd 90 Meadrow Way GODALMING GU7 3HY	Project 269 GOLDHURST TERRACE				Job Ref. 15.139	
	Section PROPOSED BASEMENT DESIGN				Sheet no./rev. 22	
	Calc. by J	Date 07/07/2015	Chk'd by	Date	App'd by	Date

RETAINING WALL ANALYSIS & DESIGN (BS8002)

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} = **2900** mm
Thickness of wall stem	t_{wall} = **300** mm
Length of toe	l_{toe} = **1200** mm
Length of heel	l_{heel} = **0** mm
Overall length of base	$l_{base} = l_{toe} + l_{heel} + t_{wall}$ = **1500** mm
Thickness of base	t_{base} = **300** mm
Depth of downstand	d_{ds} = **0** mm
Position of downstand	l_{ds} = **900** mm
Thickness of downstand	t_{ds} = **300** mm
Height of retaining wall	$h_{wall} = h_{stem} + t_{base} + d_{ds}$ = **3200** mm
Depth of cover in front of wall	d_{cover} = **0** mm
Depth of unplanned excavation	d_{exc} = **0** mm
Height of ground water behind wall	h_{water} = **2900** mm
Height of saturated fill above base	$h_{sat} = \max(h_{water} - t_{base} - d_{ds}, 0\ mm)$ = **2600** 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	$h_{eff} = h_{wall} + l_{heel} \times \tan(\beta)$ = **3200** 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

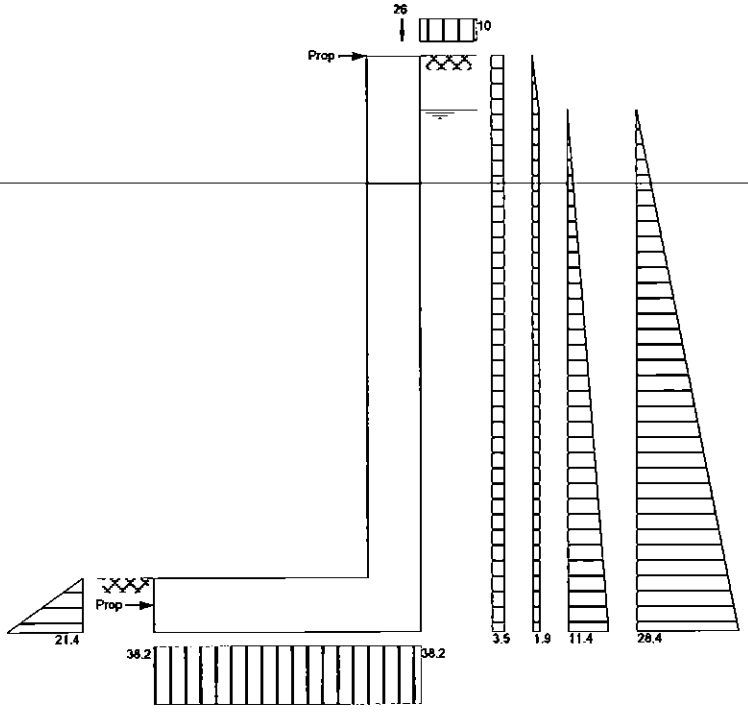
$$K_p = \sin(90 - \phi'_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi'_b + \delta_b) \times \sin(\phi'_b) / (\sin(90 + \delta_b)))}]^2) = \mathbf{4.187}$$

At-rest pressure

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

Loading details

Surcharge load on plan	Surcharge = **10.0** kN/m^2
Applied vertical dead load on wall	W_{dead} = **26.1** kN/m
Applied vertical live load on wall	W_{live} = **0.0** kN/m
Position of applied vertical load on wall	l_{load} = **1400** 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/m^2

Vertical forces on wall

Wall stem — $w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall}$ = **20.5** kN/m

Wall base — $w_{base} = l_{base} \times t_{base} \times \gamma_{base}$ = **10.6** kN/m

Applied vertical load — $W_v = W_{dead} + W_{live}$ = **26.1** kN/m

Total vertical load — $W_{total} = w_{wall} + w_{base} + W_v$ = **57.3** kN/m

Horizontal forces on wall

Surcharge — $F_{sur} = K_a \times \cos(90 - \alpha + \delta) \times Surcharge \times h_{eff}$ = **11.2** kN/m

Moist backfill above water table — $F_{m\_a} = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2$ = **0.3** kN/m

Moist backfill below water table — $F_{m\_b} = K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water}$ = **5.5** kN/m

Saturated backfill — $F_s = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times (\gamma_s - \gamma_{water}) \times h_{water}^2$ = **16.5** kN/m

Water — $F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water}$ = **41.3** kN/m

Total horizontal load — $F_{total} = F_{sur} + F_{m\_a} + F_{m\_b} + F_s + F_{water}$ = **74.7** kN/m

Calculate total propping force

Passive resistance of soil in front of wall — $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **3.2** kN/m

Propping force — $F_{prop} = \max(F_{total} - F_p - (W_{total}) \times \tan(\delta_b), 0\ kN/m)$

F_{prop} = **52.2** kN/m

Overturning moments

Surcharge — $M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **17.9** kNm/m

Moist backfill above water table — $M_{m\_a} = F_{m\_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **0.9** kNm/m

Moist backfill below water table — $M_{m\_b} = F_{m\_b} \times (h_{water} - 2 \times d_{ds}) / 2$ = **7.9** kNm/m

Saturated backfill — $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3$ = **15.9** kNm/m

Water — $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3$ = **39.9** kNm/m

Total overturning moment — $M_{ot} = M_{sur} + M_{m\_a} + M_{m\_b} + M_s + M_{water}$ = **82.5** kNm/m

Restoring moments

Wall stem — $M_{wall} = w_{wall} \times (l_{toe} + t_{wall} / 2)$ = **27.7** kNm/m

Wall base — $M_{base} = w_{base} \times l_{base} / 2$ = **8** kNm/m

Design vertical dead load — $M_{dead} = W_{dead} \times l_{load}$ = **36.5** kNm/m

Total restoring moment — $M_{rest} = M_{wall} + M_{base} + M_{dead}$ = **72.2** kNm/m

Check bearing pressure

Total vertical reaction — $R = W_{total}$ = **57.3** kN/m

Distance to reaction — $x_{bar} = l_{base} / 2$ = **750** mm

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

Reaction acts within middle third of base

Bearing pressure at toe — $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2)$ = **38.2** kN/m^2

Bearing pressure at heel — $p_{heel} = (R / l_{base}) + (6 \times R \times e / l_{base}^2)$ = **38.2** kN/m^2

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

$F_{prop\_top} = (M_{ot} - M_{rest} + R \times l_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2)$ = **14.880** kN/m

Propping force to base of wall — $F_{prop\_base} = F_{prop} - F_{prop\_top}$ = **37.309** kN/m

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor $\gamma_{f\_d} = 1.4$

Live load factor $\gamma_{f\_l} = 1.6$

Earth and water pressure factor $\gamma_{f\_e} = 1.4$

Factored vertical forces on wall

Wall stem $w_{wall\_f} = \gamma_{f\_d} \times h_{stem} \times t_{wall} \times \gamma_{wall} = 28.7$ kN/m

Wall base $w_{base\_f} = \gamma_{f\_d} \times l_{base} \times t_{base} \times \gamma_{base} = 14.9$ kN/m

Applied vertical load $W_{v\_f} = \gamma_{f\_d} \times W_{dead} + \gamma_{f\_l} \times W_{live} = 36.5$ kN/m

Total vertical load $W_{total\_f} = w_{wall\_f} + w_{base\_f} + W_{v\_f} = 80.2$ kN/m

Factored horizontal at-rest forces on wall

Surcharge $F_{sur\_f} = \gamma_{f\_l} \times K_0 \times \text{Surcharge} \times h_{eff} = 30.2$ kN/m

Moist backfill above water table $F_{m\_a\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times \gamma_m \times (h_{eff} - h_{water})^2 = 0.7$ kN/m

Moist backfill below water table $F_{m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 12.9$ kN/m

Saturated backfill $F_{s\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times (\gamma_s - \gamma_{water}) \times h_{water}^2 = 38.9$ kN/m

Water $F_{water\_f} = \gamma_{f\_e} \times 0.5 \times h_{water}^2 \times \gamma_{water} = 57.8$ kN/m

Total horizontal load $F_{total\_f} = F_{sur\_f} + F_{m\_a\_f} + F_{m\_b\_f} + F_{s\_f} + F_{water\_f} = 140.4$ kN/m

Calculate total propping force

Passive resistance of soil in front of wall $F_{p\_f} = \gamma_{f\_e} \times 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 4.5$ kN/m

Propping force $F_{prop\_f} = \max(F_{total\_f} - F_{p\_f} - (W_{total\_f}) \times \tan(\delta_b), 0 \text{ kN/m})$

$F_{prop\_f} = 109.0$ kN/m

Factored overturning moments

Surcharge $M_{sur\_f} = F_{sur\_f} \times (h_{eff} - 2 \times d_{ds}) / 2 = 48.3$ kNm/m

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

Moist backfill below water table $M_{m\_b\_f} = F_{m\_b\_f} \times (h_{water} - 2 \times d_{ds}) / 2 = 18.8$ kNm/m

Saturated backfill $M_{s\_f} = F_{s\_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 37.6$ kNm/m

Water $M_{water\_f} = F_{water\_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 55.8$ kNm/m

Total overturning moment $M_{ot\_f} = M_{sur\_f} + M_{m\_a\_f} + M_{m\_b\_f} + M_{s\_f} + M_{water\_f} = 162.5$ kNm/m

Restoring moments

Wall stem $M_{wall\_f} = w_{wall\_f} \times (l_{toe} + t_{wall} / 2) = 38.8$ kNm/m

Wall base $M_{base\_f} = w_{base\_f} \times l_{base} / 2 = 11.2$ kNm/m

Design vertical load $M_{v\_f} = W_{v\_f} \times l_{load} = 51.2$ kNm/m

Total restoring moment $M_{rest\_f} = M_{wall\_f} + M_{base\_f} + M_{v\_f} = 101.1$ kNm/m

Factored bearing pressure

Total vertical reaction $R_f = W_{total\_f} = 80.2$ kN/m

Distance to reaction $x_{bar\_f} = l_{base} / 2 = 750$ mm

Eccentricity of reaction $e_f = \text{abs}((l_{base} / 2) - x_{bar\_f}) = 0$ mm

Reaction acts within middle third of base

Bearing pressure at toe $p_{toe\_f} = (R_f / l_{base}) - (6 \times R_f \times e_f / l_{base}^2) = 53.4$ kN/m^2

Bearing pressure at heel $p_{heel\_f} = (R_f / l_{base}) + (6 \times R_f \times e_f / l_{base}^2) = 53.4$ kN/m^2

Rate of change of base reaction $\text{rate} = (p_{toe\_f} - p_{heel\_f}) / l_{base} = 0.00$ kN/m^2/m

Bearing pressure at stem / toe $p_{stem\_toe\_f} = \max(p_{toe\_f} - (\text{rate} \times l_{toe}), 0 \text{ kN/m}^2) = 53.4$ kN/m^2

Bearing pressure at mid stem $p_{stem\_mid\_f} = \max(p_{toe\_f} - (\text{rate} \times (l_{toe} + t_{wall} / 2)), 0\ kN/m^2) = 53.4\ kN/m^2$

Bearing pressure at stem / heel $p_{stem\_heel\_f} = \max(p_{toe\_f} - (\text{rate} \times (l_{toe} + t_{wall})), 0\ kN/m^2) = 53.4\ kN/m^2$

Calculate propping forces to top and base of wall

Propping force to top of wall

$$F_{prop\_top\_f} = (M_{ot\_f} - M_{rest\_f} + R_f \times l_{base} / 2 - F_{prop\_f} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = 34.480\ kN/m$$

Propping force to base of wall $F_{prop\_base\_f} = F_{prop\_f} - F_{prop\_top\_f} = 74.487\ kN/m$

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

Material properties

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

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

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 $V_{toe\_bear} = (p_{toe\_f} + p_{stem\_toe\_f}) \times l_{toe} / 2 = 64.1\ kN/m$

Shear from weight of base $V_{toe\_wt\_base} = \gamma_{f\_d} \times \gamma_{base} \times l_{toe} \times t_{base} = 11.9\ kN/m$

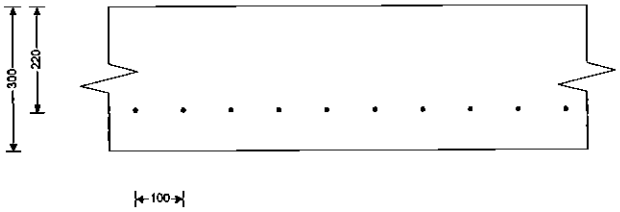
Total shear for toe design $V_{toe} = V_{toe\_bear} - V_{toe\_wt\_base} = 52.2\ kN/m$

Calculate moment for toe design

Moment from bearing pressure $M_{toe\_bear} = (2 \times p_{toe\_f} + p_{stem\_mid\_f}) \times (l_{toe} + t_{wall} / 2)^2 / 6 = 48.7\ kNm/m$

Moment from weight of base $M_{toe\_wt\_base} = (\gamma_{f\_d} \times \gamma_{base} \times t_{base} \times (l_{toe} + t_{wall} / 2)^2 / 2) = 9\ kNm/m$

Total moment for toe design $M_{toe} = M_{toe\_bear} - M_{toe\_wt\_base} = 39.7\ kNm/m$



Check toe in bending

Width of toe $b = 1000\ mm/m$

Depth of reinforcement $d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2) = 220.0\ mm$

Constant $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu}) = 0.020$

Compression reinforcement is not required

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

$z_{toe} = 209\ mm$

Area of tension reinforcement required $A_{s\_toe\_des} = M_{toe} / (0.87 \times f_y \times z_{toe}) = 436\ mm^2/m$

Minimum area of tension reinforcement $A_{s\_toe\_min} = k \times b \times t_{base} = 390\ mm^2/m$

Area of tension reinforcement required $A_{s\_toe\_req} = \text{Max}(A_{s\_toe\_des}, A_{s\_toe\_min}) = 436\ mm^2/m$

Reinforcement provided **B785 mesh**

Area of reinforcement provided $A_{s\_toe\_prov} = 785\ mm^2/m$

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress $v_{toe} = V_{toe} / (b \times d_{toe}) = 0.237\ N/mm^2$

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

PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress $v_{c\_toe} = 0.609$ 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 $f_{cu} = 40$ N/mm^2

Characteristic strength of reinforcement $f_y = 500$ N/mm^2

Wall details

Minimum area of reinforcement $k = 0.13$ %

Cover to reinforcement in stem $c_{stem} = 50$ mm

Cover to reinforcement in wall $c_{wall} = 75$ mm

Factored horizontal at-rest forces on stem

Surcharge $F_{s\_sur\_f} = \gamma_{f\_l} \times K_0 \times \text{Surcharge} \times (h_{eff} - t_{base} - d_{ds}) = 27.4$ kN/m

Moist backfill above water table $F_{s\_m\_a\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2 = 0.7$ kN/m

Moist backfill below water table $F_{s\_m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat}) \times h_{sat} = 11.6$ kN/m

Saturated backfill $F_{s\_s\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times (\gamma_s - \gamma_{water}) \times h_{sat}^2 = 31.2$ kN/m

Water $F_{s\_water\_f} = 0.5 \times \gamma_{f\_e} \times \gamma_{water} \times h_{sat}^2 = 46.4$ kN/m

Calculate shear for stem design

Surcharge $V_{s\_sur\_f} = 5 \times F_{s\_sur\_f} / 8 = 17.1$ kN/m

Moist backfill above water table $V_{s\_m\_a\_f} = F_{s\_m\_a\_f} \times b_l \times ((5 \times L^2) - b_l^2) / (5 \times L^3) = 0.1$ kN/m

Moist backfill below water table $V_{s\_m\_b\_f} = F_{s\_m\_b\_f} \times (8 - (n^2 \times (4 - n))) / 8 = 7.9$ kN/m

Saturated backfill $V_{s\_s\_f} = F_{s\_s\_f} \times (1 - (a_l^2 \times ((5 \times L) - a_l) / (20 \times L^3))) = 26$ kN/m

Water $V_{s\_water\_f} = F_{s\_water\_f} \times (1 - (a_l^2 \times ((5 \times L) - a_l) / (20 \times L^3))) = 38.7$ kN/m

Total shear for stem design $V_{stem} = V_{s\_sur\_f} + V_{s\_m\_a\_f} + V_{s\_m\_b\_f} + V_{s\_s\_f} + V_{s\_water\_f} = 89.9$ kN/m

Calculate moment for stem design

Surcharge $M_{s\_sur} = F_{s\_sur\_f} \times L / 8 = 10.4$ kNm/m

Moist backfill above water table $M_{s\_m\_a} = F_{s\_m\_a\_f} \times b_l \times ((5 \times L^2) - (3 \times b_l^2)) / (15 \times L^2) = 0.1$ kNm/m

Moist backfill below water table $M_{s\_m\_b} = F_{s\_m\_b\_f} \times a_l \times (2 - n)^2 / 8 = 4.8$ kNm/m

Saturated backfill $M_{s\_s} = F_{s\_s\_f} \times a_l \times ((3 \times a_l^2) - (15 \times a_l \times L) + (20 \times L^2)) / (60 \times L^2) = 12.8$ kNm/m

Water $M_{s\_water} = F_{s\_water\_f} \times a_l \times ((3 \times a_l^2) - (15 \times a_l \times L) + (20 \times L^2)) / (60 \times L^2) = 19$ kNm/m

Total moment for stem design $M_{stem} = M_{s\_sur} + M_{s\_m\_a} + M_{s\_m\_b} + M_{s\_s} + M_{s\_water} = 47$ kNm/m

Calculate moment for wall design

Surcharge $M_{w\_sur} = 9 \times F_{s\_sur\_f} \times L / 128 = 5.9$ kNm/m

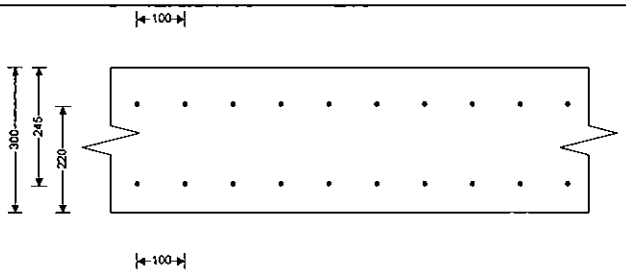
Moist backfill above water table $M_{w\_m\_a} = F_{s\_m\_a\_f} \times 0.577 \times b_l \times [(b_l^3 + 5 \times a_l \times L^2) / (5 \times L^3) - 0.577^2 / 3] = 0.1$ kNm/m

Moist backfill below water table $M_{w\_m\_b} = F_{s\_m\_b\_f} \times a_l \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)] / 8 = 2.7$ kNm/m

Saturated backfill $M_{w\_s} = F_{s\_s\_f} \times [a_l^2 \times x \times ((5 \times L) - a_l) / (20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = 5.5$ kNm/m

Water $M_{w\_water} = F_{s\_water\_f} \times [a_l^2 \times x \times ((5 \times L) - a_l) / (20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = 8.1$ kNm/m

Total moment for wall design $M_{wall} = M_{w\_sur} + M_{w\_m\_a} + M_{w\_m\_b} + M_{w\_s} + M_{w\_water} = 22.2$ kNm/m



Check wall stem in bending

Width of wall stem — $b = 1000$ mm/m

Depth of reinforcement — $d_{stem} = t_{wall} - c_{stem} - (\phi_{stem} / 2) = 245.0$ mm

Constant — $K_{stem} = M_{stem} / (b \times d_{stem}^2 \times f_{cu}) = 0.020$

Compression reinforcement is not required

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

$z_{stem} = 233$ mm

Area of tension reinforcement required — $A_{s\_stem\_des} = M_{stem} / (0.87 \times f_y \times z_{stem}) = 465$ mm^2/m

Minimum area of tension reinforcement — $A_{s\_stem\_min} = k \times b \times t_{wall} = 390$ mm^2/m

Area of tension reinforcement required — $A_{s\_stem\_req} = \max(A_{s\_stem\_des}, A_{s\_stem\_min}) = 465$ mm^2/m

Reinforcement provided — **B785 mesh**

Area of reinforcement provided — $A_{s\_stem\_prov} = 785$ mm^2/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress — $v_{stem} = V_{stem} / (b \times d_{stem}) = 0.367$ N/mm^2

Allowable shear stress — $v_{adm} = \min(0.8 \times \sqrt{(f_{cu} / 1 \text{ N/mm}^2)}, 5) \times 1 \text{ N/mm}^2 = 5.000$ 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 — $v_{c\_stem} = 0.572$ N/mm^2

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

Check mid height of wall in bending

Depth of reinforcement — $d_{wall} = t_{wall} - c_{wall} - (\phi_{wall} / 2) = 220.0$ mm

Constant — $K_{wall} = M_{wall} / (b \times d_{wall}^2 \times f_{cu}) = 0.011$

Compression reinforcement is not required

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

$z_{wall} = 209$ mm

Area of tension reinforcement required — $A_{s\_wall\_des} = M_{wall} / (0.87 \times f_y \times z_{wall}) = 244$ mm^2/m

Minimum area of tension reinforcement — $A_{s\_wall\_min} = k \times b \times t_{wall} = 390$ mm^2/m

Area of tension reinforcement required — $A_{s\_wall\_req} = \max(A_{s\_wall\_des}, A_{s\_wall\_min}) = 390$ mm^2/m

Reinforcement provided — **B785 mesh**

Area of reinforcement provided — $A_{s\_wall\_prov} = 785$ mm^2/m

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

Check retaining wall deflection

Basic span/effective depth ratio — $\text{ratio}_{bas} = 20$

Design service stress — $f_s = 2 \times f_y \times A_{s\_stem\_req} / (3 \times A_{s\_stem\_prov}) = 197.2$ N/mm^2

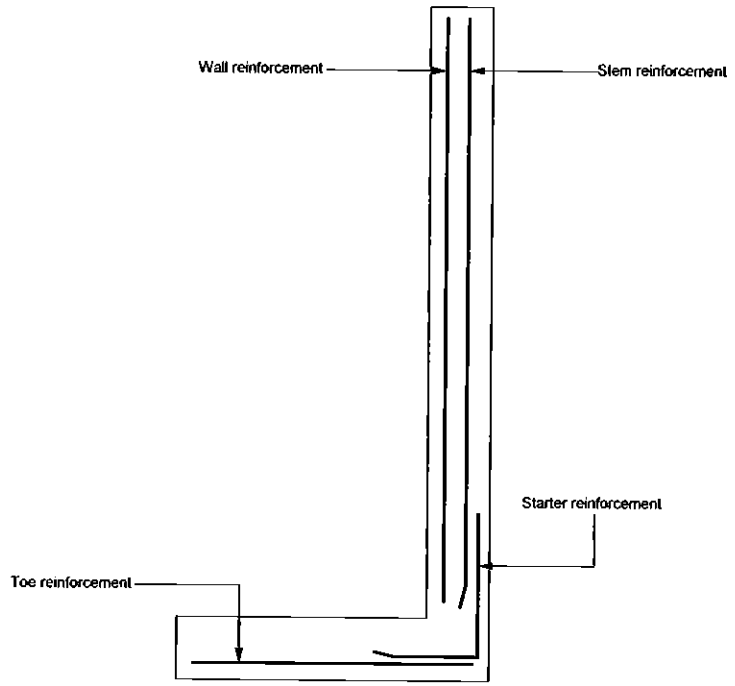
Modification factor — $\text{factor}_{tens} = \min(0.55 + (477 \text{ N/mm}^2 - f_s)/(120 \times (0.9 \text{ N/mm}^2 + (M_{stem}/(b \times d_{stem}^2)))), 2) = 1.93$

Maximum span/effective depth ratio — $\text{ratio}_{max} = \text{ratio}_{bas} \times \text{factor}_{tens} = 38.69$

Actual span/effective depth ratio — $\text{ratio}_{act} = h_{stem} / d_{stem} = 11.84$

PASS - Span to depth ratio is acceptable

Indicative retaining wall reinforcement diagram



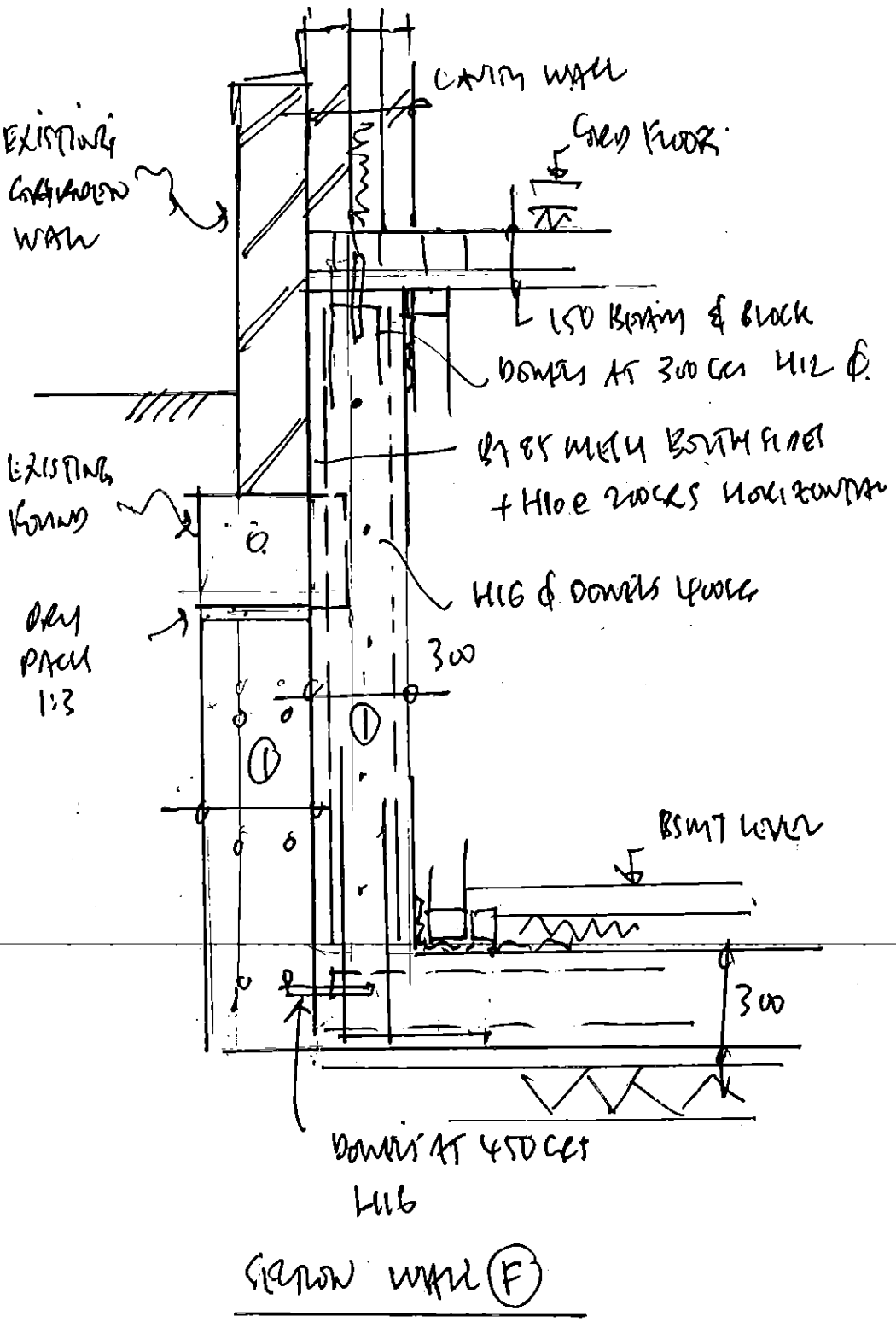
Toe mesh - B785 - (785 mm^2/m)
Wall mesh - B785 - (785 mm^2/m)
Stem mesh - B785 - (785 mm^2/m)

WALL (F)

IT CAN BE SEEN LATE I WORST CASE

AND DESIGNS LTD
90 MEADROW
GODALMING, SURREY GU7 3HY
Tel: 01483 418 140 Fax: 01483 421 304
e-mail: info@anddesigns.co.uk

Project: 269 GOLDHURST TERRACE				Job Ref. 15.139	
Part of Structure: PROPOSED BASEMENT DESIGN				Sheet No./Rev. 30.	
Calc. by: JW	Date JULY 15	Chck'd by:	Date	App'd by:	Date



RETAINING WALL (F)

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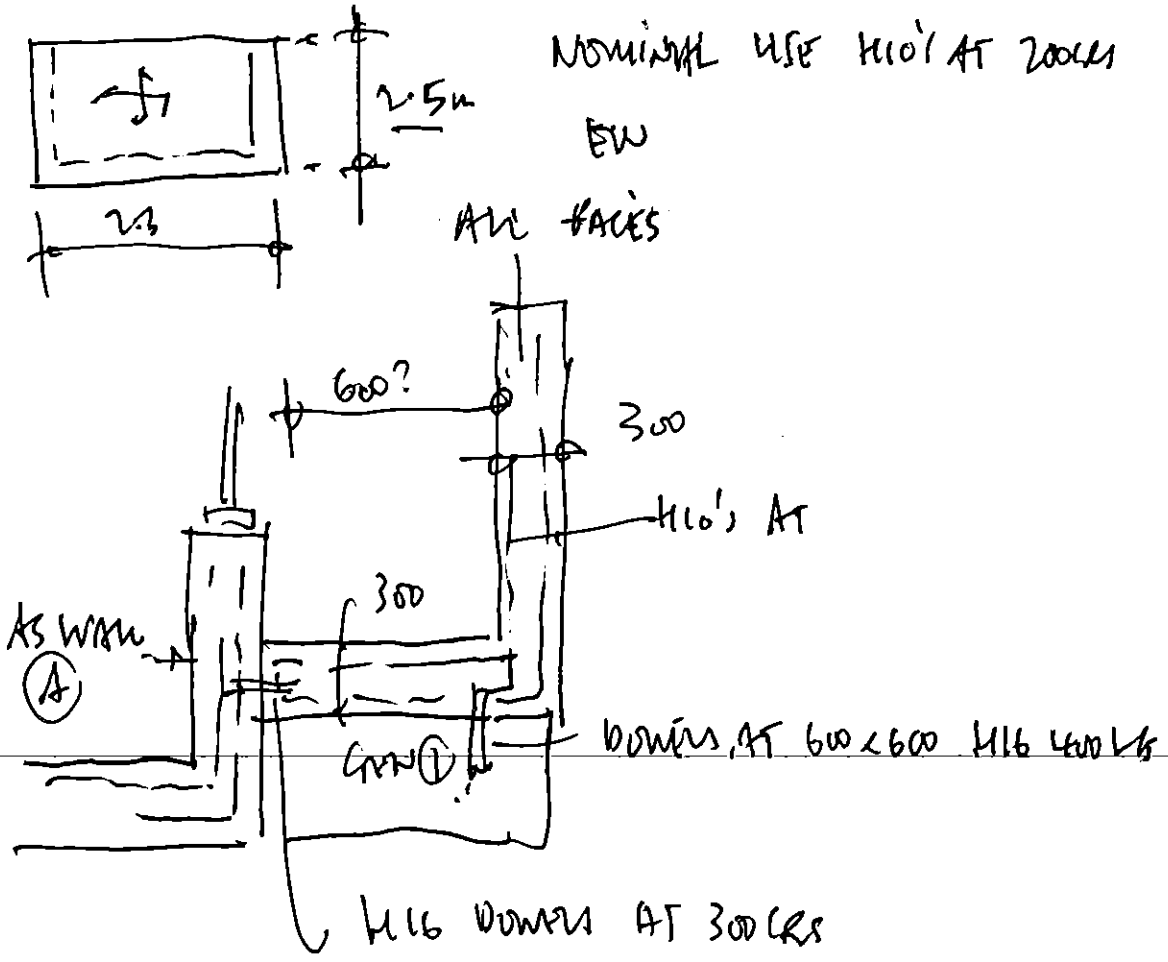
Project: 269 GOLDHURST TERRACE				Job Ref. 15.139	
Part of Structure: PROPOSED BASEMENT DESIGN				Sheet No./Rev. 31	
Calc. by: JW	Date JULY 15	Chck'd by:	Date	App'd by:	Date

DESIGN OF LIGHT WELLS

IT CAN BE SEEN LIGHTWELLS ACT AS HORIZONTAL SPAN WITH BUTTRESS ALLOW FOR H16's AT 200 CRS EF. T & B.



SECTION THRO LIGHT WELL

AND DESIGNS LTD
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Tel: 01483 418 140 Fax: 01483 421 304
e-mail: info@anddesigns.co.uk

Project: 269 GOLDHURST TERRACE				Job Ref. 15.139	
Part of Structure: PROPOSED BASEMENT DESIGN				Sheet No./Rev. 32	
Calc. by: JW	Date JULY 15	Chck'd by:	Date	App'd by:	Date

DESIGN FOR FLOTATION.

LOADING

VERTICAL

SLAB = 0.3 × 24 = 7.2 kN/m²
BUILDING = 0.07 × 23 = 1.72
SCREED = 0.05 × 23 = 1.15
10.07 kN/m²

UPLIFT

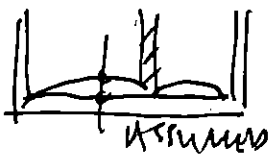
FLOTATION 29 × 10 = 29 kN/m²
− DEAD LOAD = 10
19.0 kN/m²

HEAVE (CLAY)

BASEMENT DEPTH, 3.0m. HEAVE = 18 × 3 = 54 kN/m² HEAVE

ALLOW FOR 50% RELIEF DURING CONSTRUCTION

∴ 50% × 54 = 27 kN/m² ↑



SEE HEAVE CALCULATIONS FOR HEAVE

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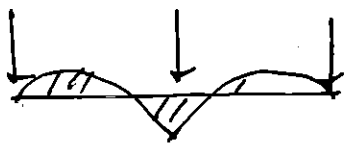
e-mail: info@anddesigns.co.uk

Project: 269 GOLDHURST TERRACE				Job Ref. 15.139	
Part of Structure: PROPOSED BASEMENT DESIGN				Sheet No./Rev. 33	
Calc. by: JW	Date JULY 15	Chck'd by:	Date	App'd by:	Date

HEAVE / RETENTION CONT'D

∴ ULTIMATE LOAD $27 \times 1.4 = 38 kN/m$ (ULT) ($27 kN/m$)

DESIGN AS CONTINUOUS BEAM



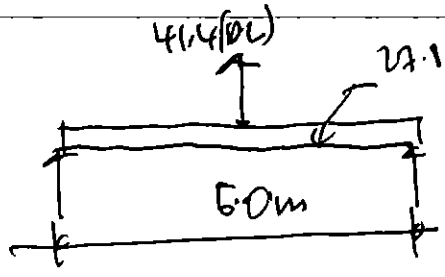
BM(ULT) $38 \times 3.0^2/10 = 34.2 kNm/m$

SPAN - $38 \times 3.0^2/9 = 38 kN/m/m$

$A_{s,req} = 388 \times 10^6 / 0.87 \times 500 \times 0.94 \times 240 = 395 mm^2/m$

USE H10's AT 200 CRS EW. TOP & BOTTOM

$R = 60 \times 27.1 \times 5/8 = 101.6 kN/m$ NG!!



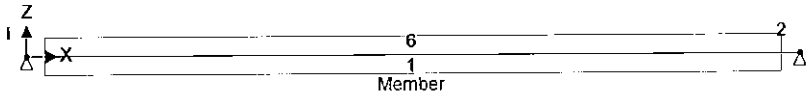
BEAM ANALYSIS (BRITISH STANDARDS)

ANALYSIS

Tedds calculation version 1.0.10

Geometry

Geometry



Nodes

Node	Co-ordinates		Freedom			Coordinate system		Spring		
	X (m)	Z (m)	X	Z	Rot.	Name	Angle (°)	X (kN/m)	Z (kN/m)	Rot. kNm/°
1	0	0	Fixed	Fixed	Free		0	0	0	0
2	6	0	Fixed	Fixed	Free		0	0	0	0

Materials

Name	Density (kg/m^3)	Youngs Modulus kN/mm^2	Shear Modulus kN/mm^2	Thermal Coefficient $°C^{-1}$
Concrete (BS8110 normal)	2400	29	12	0.00001

Sections

Name	Area (cm^2)	Moment of inertia		Shear area	
		Major (cm^4)	Minor (cm^4)	A_y (cm^2)	A_z (cm^2)
R 1000x300	3000	225000	2500000	2500	2500

Elements

Element	Length (m)	Nodes		Section	Material	Releases			Rotated
		Start	End			Start moment	End moment	Axial	
1	6	1	2	R 1000x300	Concrete (BS8110 normal)	Fixed	Fixed	Fixed	

Members

Name	Elements	
	Start	End
Member	1	1

Loading

Load cases

Name	Enabled	Self weight factor	Patternable
Self Weight	no	1	no
Permanent	yes	0	no
Imposed	yes	0	no

Load combinations

Load combination	Type	Enabled	Patterned
DL + LL	Strength	yes	no
DL + LL 1.4	Strength	yes	no

Load combination: DL + LL (Strength)

Load case	Factor
Permanent	1
Imposed	1

Load combination: DL + LL 1.4 (Strength)

Load case	Factor
Permanent	1.4
Imposed	1.4

Member point loads

Member	Load case	Position		Load	Orientation
		Type	Start	(kN)	
Member	Permanent	Absolute	3 m	-41	GlobalZ

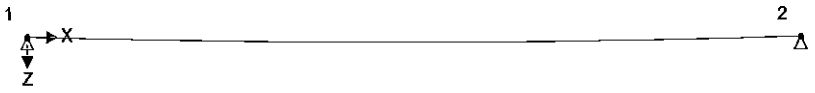
Member UDL loads

Member	Load case	Position			Load	Orientation
		Type	Start	End	(kN/m)	
Member	Permanent	Ratio	0	1	27.1	GlobalZ

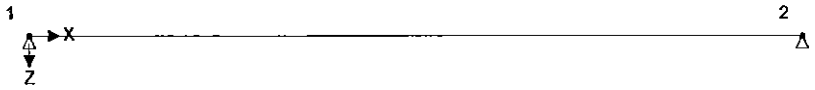
Results

Total deflection

Permanent - Total deflection @ 10x



Imposed - Total deflection @ 10x



Node deflections

Load case: Permanent

Node	Deflection		Rotation	Co-ordinate system
	X (mm)	Z (mm)	(°)	
1	0	0	0.13316	
2	0	0	-0.13316	

Load case: Imposed

Node	Deflection		Rotation	Co-ordinate system
	X (mm)	Z (mm)	(°)	
1	0	0	0	
2	0	0	0	

Total base reactions

Load case/combination	Force	
	FX (kN)	FZ (kN)
Permanent	0	121.6
Imposed	0	0

Element end forces

Load case: Permanent

Element	Length (m)	Nodes Start/End	Axial force (kN)	Shear force (kN)	Moment (kNm)
1	6	1	0	-60.8	0
		2	0	-60.8	0

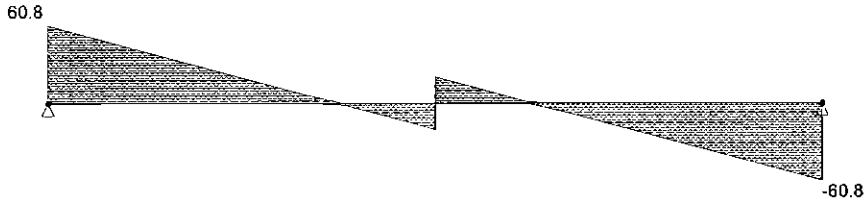
Load case: Imposed

Element	Length (m)	Nodes Start/End	Axial force (kN)	Shear force (kN)	Moment (kNm)
1	6	1	0	0	0
		2	0	0	0

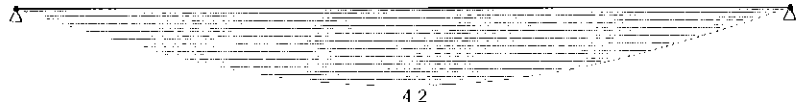
Forces

All load cases - Moment envelope (kNm)

All load cases - Shear envelope (kN)



All load cases - Deflection envelope (mm)



Member results

Envelope - All load cases

Member	Shear force		Moment			
	Pos (m)	Max abs (kN)	Pos (m)	Max (kNm)	Pos (m)	Min (kNm)
Member	6	60.8	3.756	68.2	0	0

Envelope - All load cases

Member	Deflection			
	Pos (m)	Max (mm)	Pos (m)	Min (mm)
Member	2.993	4.2	6	0

Member results

Load case: Permanent

Member	Deflection			
	Pos (m)	Max (mm)	Pos (m)	Min (mm)
Member	2.993	4.2	6	0

TEKLA Tedds	Project				Job Ref.	
AND Designs Ltd 90 Meadrow Way GODALMING GU7 3HY	269 GOLDHURST TERRACE				15.139	
	Section				Sheet no./rev.	
	PROPOSED BASEMENT DESIGN				38	
	Calc. by	Date	Chk'd by	Date	App'd by	Date
	J	07/07/2015				

Member results

Load case: Imposed

Member	Deflection			
	Pos (m)	Max (mm)	Pos (m)	Min (mm)
Member	0	0	6	0

ULT MOMENT $68 \times 1.4 = 95.5$ kNm/m

$d = 300 - 40 - 10 = 250$mm

$M/bd^2f_{cu} = 95.5 \times 10^6 / 10^3 \times 250^2 \times 40 = 0.03$ $q = 0.94$

$A_{st} = 95.5 \times 10^6 / 0.94 \times 0.87 \times 500 \times 250 = 934 mm^2/m$

USE B1131 MESH TOP. (40mm COVER) + H10 AT 200CRS

BOTTOM A393 MESH