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3 ARNHILL ROAD

GRETTON

STRUCTURAL CALCULATIONS

Prepared by: OAM / DS

Date:

Februray 2021

Reference: 20 / 41512

VAT Registration No.: 670 8636 12

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Design Notes

Job Ref: 20 / 41512

RE: **3 ARNHILL ROAD, GRETTON**

The following calculations are in respect of our clients brief relating to specific structural elements listed on the following page(s). No responsibility is accepted in respect of other elements of the building. Any assumed bearing stresses must be confirmed on site to the satisfaction of the Building Control Officer.

Dimensions have been obtained from information provided and where no figured dimensions have been provided, scaling has been used. Dimensions indicated on the following calculations are for design purposes only and must not be used for constructional purposes. All dimensions for construction are to be obtained by site measurements prior to manufacture / building.

Appended sketches are to demonstrate certain features of the design and are not intended as working drawings. Where shown, details are intended to identify the main structural features. It is assumed that the work will be carried out by experienced and competent personnel, therefore exhaustive detailing is not required.

Where constructional connection details are indicated on these calculations, these shall not be varied. Any proposed changes should be substantiated by calculation, submitted and approved in writing by the Engineer before fabrication is commenced.

Where Building Control approval is required it is essential that this be obtained before the works proceed or materials are ordered. The contractor must ensure the stability of each element, and overall stability of the construction is maintained until all the works are completed.

These calculations and designs are copyright and must not be reproduced, defaced or passed to any other person or persons for any purpose other than as originally intended

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REFERENCES

British Standards and Codes of Practice indicated below have been used in the preparation of these calculations - all constructional details must be in accordance with all relevant clauses contained in these same standards, associated standards or manufacturer's recommendations and details and normal good practice.

Loadings	[BS 6399 - Part 1:1996, Part 2:1997, Part 3:1988] [BS 648:1964]
Concrete	[BS 8110 - Part 1:1997, Part 3:1985] [BS 8007 : 1987]
Foundations	[BS 8004:1986] [BS 8002 : 1994]
Timber	[BS 5268 - Part 2:2002]
Masonry	[BS 5628 - Part 1:2005, Part 2:2005, Part 3:2005]
Industrial Floor Slabs	[Concrete Society Technical Report 34 (2nd Edition)] [C & CA Technical Report 550] [BCA Tech Note 11]
Steelwork	[BS 5950 - Part 1:2000, Part 3:1990, Part 5:1987, Part 8:1990] [BS 2853:1957]

ISSUE RECORD

Prep. by	Chkd by	Documents / Sheets / Drawings Issued	Description of Relating Structural Elements	lssue Date
OAM) }	Structural Calculations Pages 1-41	EXTERNAL RETAINING WALLS.	08/02/2021



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HEALTH & SAFETY

Where appropriate, the Client will be the/or appoint a, Principal Designer to act on his behalf who will ensure that where applicable the "Construction (Design and Management) Regulations 2015" are adhered to.

The Principal Contractor must at all times ensure safe working practices, maintain the integrity of the existing structures and conform to all the appropriate requirements of the Health and Safety Executive including the "Construction (Design and Management) Regulations 2015".

The working methods of any hazardous operations must first be discussed with the Principal Designer and the designer prior to commencement.

Below are identified hazards that are either impractical or uneconomic to eliminate at the design stage. The list is not exhaustive and must be read in conjunction with the main contractors own Health & Safety policy.

Hazard	Solution/Precaution/Sequence		
Demolition and creation of new openings	To be carried out in accordance with prepared demolition statement ensuring structural integrity of existing building at all times. Openings should follow published procedure in Building Research Establishment publication GBG20 "Removing internal loadbearing walls in older dwellings".		
Scaffolds	Scaffolds erected and used in accordance with BS5973. Scaffolds and propping must be inspected by a qualified person before use and at least once per week to ensure they are fit for use.		
Personnel working at height	Works to be properly supervised with personnel provided with safe working platforms.		
Lifting	Adequate means for moving and positioning elements to be available. Handling and construction to be carried out in accordance with relevant HSE 7 BS guidelines. Individuals are not to manually lift more than 25kg.		
Deep excavation	No one shall enter an excavation deeper than 1.2m without adequately designed temporary shoring being in place. Where foundations are deeper than 2.5m they should be constructed in two pours.		
Open trenched footings	Access to unattended trenches to be protected.		

VAT Registration No.: 670 8636 12

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Project No:	20 / 41512	Sheet No:	1
Made By:	OAM	Revision:	
Date:	Feb-21	Checked By:	ΤG
			4

Project: 3 ARNHILL ROAD, GRETTON

DIMENSIONS IN THESE CALCULATIONS ARE ONLY APPROXIMATE AND THE CONTRACTOR MUST CHECK THE LATEST ARCHITECTURAL DRAWINGS AND MEASURE UP ON SITE BEFORE ORDERING ANY MATERIALS.

RETAINING WALL TYPE	1							
FOR H 2.5 TO 3 M	Μ							
SEC 1 H= 103.5	5-100.98= 2.52 m	design for	H1	=	2.52+ .3=	2.82	m	SEC 1
SEC 2 H= 10	04-101.3= 2.70 m	design for	H2	=	2.70+ .3=	3.00	m	SEC 2
SEC 4 H= 10	03-100.6= 2.40 m	design for	H4	=	2.40+ .3=	2.70	m	SEC 4
SEC 8 H= 103.5	5-100.95= 2.55 m	design for	H8	=	2.55+ .4=	2.95	m	SEC 8
			SEE PAGE	2	- 1	1		
RETAINING WALL TYPE	2							
FOR H 2 TO 2.5 M								
SEC 3 H= 103	.5-101.6= 1.90 m	design for	H3	=	1.90+ .3=	2.20	m	SEC 3
SEC 6 H=	0.5= 0.50 m	design for	H6	=	0.50+ 2=	2.50	m	SEC 6
SEC 7 H= 103.2	2-101.16= 2.04 m	design for	H7	=	2.04+ .3=	2.34	m	SEC 7
			SEE PAGE	12	- 2	21		
RETAINING WALL TYPE	3							
FOR H 1.5 TO 2 M								
SEC 5 H= 101.6	6-100.08= 1.52 m	design for	H5	=	1.52+ .3=	1.82	m	SEC 5
			SEE PAGE	22	- 3	31		
RETAINING WALL TYPE	4							

FOR H 2.4m ADJACENT TO PUBLIC ROAD

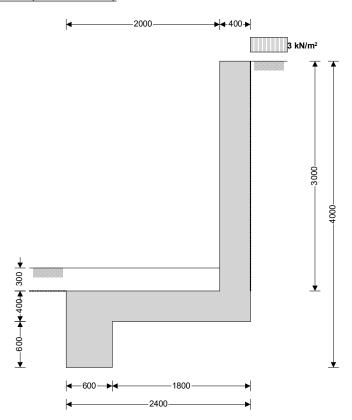
SEE PAGE 32 - 41

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All design calculations have been author reviewed and subject to additional review by the project team, as required by David Smith Associates Quality Assurance procedures.

D S A	Structural & Civil Engineering Design & Detailing Party Wall I CDM I Structural Surveys I Expert Witness Reports	Project No:	20 / 41512	Sheet No:	2
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Calcs for: RETAINING WALL RW1		Date:	20/01/2021	Checked by:	TG
Project: 3 ARNHILL ROAD, GRETTON					

RETAINING WALL ANALYSIS (BS 8002:1994)



Wall details

Retaining wall type	Unpropped cantilever
Height of retaining wall stem	h _{stem} = 3000 mm
Thickness of wall stem	t _{wall} = 400 mm
Length of toe	I _{toe} = 2000 mm
Length of heel	I _{heel} = 0 mm
Overall length of base	$I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 2400 \text{ mm}$
Thickness of base	t _{base} = 400 mm
Depth of downstand	d _{ds} = 600 mm
Position of downstand	I _{ds} = 0 mm
Thickness of downstand	t _{ds} = 600 mm
Height of retaining wall	h_{wall} = h_{stem} + t_{base} + d_{ds} = 4000 mm
Depth of cover in front of wall	d _{cover} = 300 mm
Depth of unplanned excavation	d _{exc} = 300 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	$h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 4000 \text{ mm}$

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London london@dsagroup.co.uk Birmingham birmingham@dsagroup.co.uk TEDDS calculation version 1.2.01.06

DSA	Structural & Civil Engineering Design & Detailing Party Wall I CDM I Structural Surveys I Expert Witness Reports	Project No:	20 / 41512	Sheet No:	3
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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	γs = 21.0 kN/m ³
Design shear strength	∳' = 28.0 deg
Angle of wall friction	δ = 0.0 deg
Base material details	
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

 $\mathsf{K}_{\mathsf{a}} = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))}]^2) = \mathbf{0.361}$

Passive pressure coefficient for base material

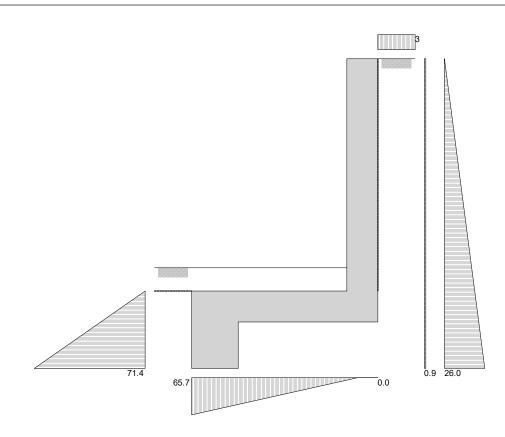
 $K_{p} = \sin(90 - \phi'_{b})^{2} / (\sin(90 - \delta_{b}) \times [1 - \sqrt{(\sin(\phi'_{b} + \delta_{b}) \times \sin(\phi'_{b}) / (\sin(90 + \delta_{b})))}]^{2}) = 4.187$

At-rest pressure

At-rest pressure for retained material	K ₀ = 1 – sin(φ') = 0.531
Loading details	
Surcharge load on plan	Surcharge = 2.5 kN/m ²
Applied vertical dead load on wall	W _{dead} = 0.0 kN/m
Applied vertical live load on wall	W _{live} = 0.0 kN/m
Position of applied vertical load on wall	I _{load} = 0 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

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

	Loads shown in kivin, pressures shown in kivin-
Vertical forces on wall	
Wall stem	$w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall} = 28.3 \text{ kN/m}$
Wall base	$w_{base} = I_{base} \times t_{base} \times \gamma_{base} = 22.7 \text{ kN/m}$
Wall downstand	$w_{ds} = d_{ds} \times t_{ds} \times \gamma_{base} = 8.5 \text{ kN/m}$
Soil in front of wall	$w_p = I_{toe} \times d_{cover} \times \gamma_{mb} = 10.8 \text{ kN/m}$
Total vertical load	$W_{total} = W_{wall} + W_{base} + W_{ds} + W_p = 70.3 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	F_{sur} = K _a × Surcharge × h _{eff} = 3.6 kN/m
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times \gamma_m \times (h_{eff} - h_{water})^2 = 52 \text{ kN/m}$
Total horizontal load	F _{total} = F _{sur} + F _{m_a} = 55.6 kN/m
Calculate stability against sliding	
Passive resistance of soil in front of wall	$F_{p} = 0.5 \times K_{p} \times cos(\delta_{b}) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^{2} \times \gamma_{mb} = 35.7 \text{ kN/m}$
Resistance to sliding	$F_{res} = F_p + (W_{total} - w_p) \times tan(\delta_b) = 55.7 \text{ kN/m}$
	PASS - Resistance force is greater than sliding force
Overturning moments	
Surcharge	M_{sur} = $F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 5.1 \text{ kNm/m}$
Moist backfill above water table	M_{m_a} = $F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 38.1 \text{ kNm/m}$
Soil in front of wall	$M_{p_o} = F_p \times [2 \times d_{ds} - t_{base} - d_{cover} + d_{exc}] / 3 = \textbf{9.5 kNm/m}$
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{p_o} = 52.7 \text{ kNm/m}$
Restoring moments	
Wall stem	M_{wall} = $w_{wall} \times (I_{toe} + t_{wall} / 2)$ = 62.3 kNm/m

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Wall bass	
Wall base	$M_{base} = W_{base} \times I_{base} / 2 = 27.2 \text{ kNm/m}$
Wall downstand	$M_{ds} = w_{ds} \times (I_{ds} + t_{ds} / 2) = 2.5 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{ds} = 92 \text{ kNm/m}$
Check stability against overturning	
Total overturning moment	M _{ot} = 52.7 kNm/m
Total restoring moment	M _{rest} = 92.0 kNm/m
	PASS - Restoring moment is greater than overturning moment
Check bearing pressure	
Soil in front of wall	M _{p_r} = w _p × I _{toe} / 2 = 10.8 kNm/m
Total moment for bearing	$M_{total} = M_{rest} - M_{ot} + M_{p_r} = 50.1 \text{ kNm/m}$
Total vertical reaction	R = W _{total} = 70.3 kN/m
Distance to reaction	x _{bar} = M _{total} / R = 713 mm
Eccentricity of reaction	e = abs((I _{base} / 2) - x _{bar}) = 487 mm
	Reaction acts outside middle third of base
Bearing pressure at toe	p _{toe} = R / (1.5 × x _{bar}) = 65.7 kN/m ²
Bearing pressure at heel	$p_{heel} = 0 \text{ kN/m}^2 = 0 \text{ kN/m}^2$

PASS - Maximum bearing pressure is less than allowable bearing pressure

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s for: RETAININ	NG WALL RW1		Date:	20/01/2021	Checked by:	TG
ect: 3 ARNHIL	L ROAD, GRETTON					
RETAINING	WALL DESIGN (BS 8002:1994)					
l lltim ata lina	it state load factors				TEDDS calcu	lation version 1.2.0
Dead load fa			4.4			
		$\gamma_{f_d} = \prime$				
Live load fac		γ _{f_l} = 1				
Earth and wa	ater pressure factor	γ _{f_e} = ′	1.4			
Factored ve	ertical forces on wall					
Wall stem		Wwall_f	= $\gamma_{f_d} \times h_{stem} \times f_{stem}$	$t_{wall} \times \gamma_{wall} = 39.6$	kN/m	
Wall base		Wbase_f	= $\gamma_{f_d} \times I_{base} \times I_{base}$	t _{base} × γ _{base} = 31.	7 kN/m	
Wall downsta	and	W _{ds_f} =	$\gamma_{f_d} \times d_{ds} \times t_{ds}$	$\times \gamma_{\text{base}}$ = 11.9 kN	/m	
Soil in front of	of wall	w _{p_f} =	$\gamma_{f_d} \times I_{toe} \times d_{cov}$	er × γmb = 15.1 kN	l/m	
Total vertical	lload	W _{total_t}	$f = W_{wall_f} + W_{bas}$	$se_f + W_{ds_f} + W_{p_f} =$	98.4 kN/m	
Factored ho	prizontal at-rest forces on wall					
Surcharge		F _{sur_f} =	= $\gamma_{f_{-}I} \times K_0 \times Sur$	charge × h _{eff} = 8.	5 kN/m	
Moist backfill	l above water table	Fmaf	= $\gamma_{f e} \times 0.5 \times K$	$X_0 imes \gamma_m imes$ (h _{eff} - h _{wa}	_{ter}) ² = 107 kN/m	
Total horizon	ntal load	F _{total} f	= F _{sur f} + F _{m a f}	f = 115.4 kN/m		
Passive resis	stance of soil in front of wall	$F_{p f} = $	γ _{fe} × 0.5 × K _p :	$\times \cos(\delta_b) \times (d_{cover})$	+ t _{base} + d _{ds} - d _e	_(c) ² × γ _{mb} = 50
kN/m						, ,
Factored ov	verturning moments					
Surcharge		Msur f	= F _{sur f} x (h _{eff} -	$2 \times d_{ds}) / 2 = 11.$	9 kNm/m	
•	l above water table	_		+ 2 \times h _{water} - 3 \times 0		Jm/m
Soil in front o			、	ls - t _{base} - d _{cover} + c	,	
	ning moment			$+ M_{p_0_f} = 103.6$	-	
	•			· wp_o_r = 100.0		
Restoring m	ioments		4		N I (
Wall stem			- •	+ t _{wall} / 2) = 87.2 k		
Wall base				e / 2 = 38.1 kNm/		
Wall downsta			- •	_{ds} / 2) = 3.6 kNm/	m	
Soil in front o				= 15.1 kNm/m		
Total restorir	ng moment	Mrest_f	= M _{wall_f} + M _{bas}	_{e_f} + M _{ds_f} + M _{p_r_f}	= 144 kNm/m	
Factored be	earing pressure					
Total momer	nt for bearing	M _{total_f}	= M _{rest_f} - M _{ot_f}	= 40.3 kNm/m		
Total vertical	l reaction	R _f = V	√ _{total_f} = 98.4 kN	N/m		
Distance to r			= M _{total_f} / R _f = 4			
Eccentricity of	of reaction	e _f = at	os((I _{base} / 2) - Xi	_{bar_f}) = 790 mm		
					cts outside mid	ldle third of b
Bearing pres				r_f) = 160 kN/m ²		
Bearing pres		• -	= 0 kN/m ² = 0		•	
Rate of chan	nge of base reaction			_{r_f}) = 130.12 kN/n		
	ssure at stem / toe	p _{stem_to}	_{pe_f} = max(p _{toe_f}	$_{\rm f}$ - (rate $ imes$ I _{toe}), 0 k	N/m²) = 0 kN/m²	2
Bearing pres				((0)) 0 1 1 (2)	• • • • • • • • •
	ssure at mid stem	p _{stem_} rr	hid_f = max(p _{toe} _	$f - (rate \times (l_{toe} + t_w))$	all / 2)), 0 KN/m ²)) = 0 kN/m²

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	David Smith Associates Structural & Civil Engineering Design & Detailing	Project No:	20 / 41512	Sheet No:	7
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Calcs for: RETAIN	ING WALL RW1	Date:	20/01/2021	Checked by:	TG
Project: 3 ARNH	Project: 3 ARNHILL ROAD, GRETTON				

 $f_{cu} = 35 \text{ N/mm}^2$ $f_v = 500 \text{ N/mm}^2$

Material properties

Characteristic strength of concrete
Characteristic strength of reinforcement

Base details

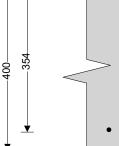
Minimum area of reinforcement Cover to reinforcement in toe

Calculate shear for toe design

Shear from bearing pressure Shear from weight of base Shear from weight of downstand Total shear for toe design

Calculate moment for toe design

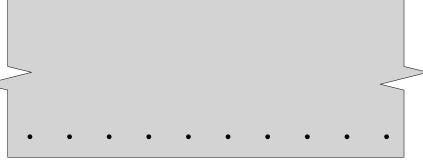
Moment from bearing pressure Moment from weight of base Moment from weight of downstand Total moment for toe design



$$\begin{split} & \texttt{k} = \textbf{0.13} \ \% \\ & \texttt{c}_{toe} = \textbf{40} \ \texttt{mm} \\ & \texttt{V}_{toe_bear} = 3 \times p_{toe_f} \times x_{bar_f} \ / \ 2 = \textbf{98.4} \ \texttt{kN/m} \\ & \texttt{V}_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times \textbf{I}_{toe} \times \textbf{t}_{base} = \textbf{26.4} \ \texttt{kN/m} \\ & \texttt{V}_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times \texttt{d}_{ds} \times \textbf{t}_{ds} = \textbf{11.9} \ \texttt{kN/m} \end{split}$$

Vtoe = Vtoe_bear - Vtoe_wt_base - Vtoe_wt_ds = 60.1 kN/m

$$\begin{split} M_{toe_bear} &= 3 \times p_{toe_f} \times x_{bar_f} \times (I_{toe} - x_{bar_f} + t_{wall} / 2) / 2 = \textbf{176.1 kNm/m} \\ M_{toe_wt_base} &= (\gamma_{f_d} \times \gamma_{base} \times t_{base} \times (I_{toe} + t_{wall} / 2)^2 / 2) = \textbf{32 kNm/m} \\ M_{toe_wt_ds} &= \gamma_{f_d} \times \gamma_{base} \times d_{ds} \times t_{ds} \times (I_{toe} - I_{ds} + (t_{wall} - t_{ds}) / 2) = \textbf{22.6 kNm/m} \\ M_{toe} &= M_{toe_bear} - M_{toe_wt_base} - M_{toe_wt_ds} = \textbf{121.5 kNm/m} \end{split}$$



|**∢**-100-**▶**|

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Allowable shear stress	v_{adm} = min(0.8 × $\sqrt{(f_{cu} / 1 N/mm^2)}$, 5) × 1 N/mm ² = 4.733 N/mm ²
Design shear stress	$v_{toe} = V_{toe} / (b \times d_{toe}) = 0.170 \text{ N/mm}^2$
Check shear resistance at toe	
	PASS - Reinforcement provided at the retaining wall toe is adequate
Area of reinforcement provided	$A_{s_toe_prov} = 1131 \text{ mm}^2/\text{m}$
Reinforcement provided	B1131 mesh
Area of tension reinforcement required	$A_{s_toe_req} = Max(A_{s_toe_des}, A_{s_toe_min}) = 831 \text{ mm}^2/\text{m}$
Minimum area of tension reinforcement	$A_{s_toe_min} = k \times b \times t_{base} = 520 \text{ mm}^2/\text{m}$
Area of tension reinforcement required	$A_{s_toe_des} = M_{toe} / (0.87 \times f_y \times z_{toe}) = 831 \text{ mm}^2/\text{m}$
	z _{toe} = 336 mm
Lever arm	$z_{toe} = min(0.5 + \sqrt{(0.25 - (min(K_{toe}, 0.225) / 0.9)), 0.95)} \times d_{toe}$
	Compression reinforcement is not required
Constant	$K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu}) = 0.028$
Depth of reinforcement	$d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2) = 354.0 \text{ mm}$
Width of toe	b = 1000 mm/m
Check toe in bending	

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rt 1:1997 – Table 3.8	PASS - Design	i shear stress is les	ss than maxim	um shear stres
	v _{c_toe} = 0.498 N/mn	n²		
		v _{toe} < v _{c_toe} - No	shear reinfor	cement required
2	DAD, GRETTON art 1:1997 – Table 3.8 shear stress	PASS - Design art 1:1997 – Table 3.8	PASS - Design shear stress is lesart 1:1997 – Table 3.8shear stress $v_{c_toe} = 0.498 \text{ N/mm}^2$	PASS - Design shear stress is less than maxim art 1:1997 – Table 3.8

Characteristic strength of concrete	f _{cu} = 35 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 downstand	c _{ds} = 40 mm

Calculate shear for downstand design

Total shear for downstand design

 $V_{down} = \gamma_{f_{-}e} \times K_{p} \times cos(\delta_{b}) \times \gamma_{m} \times d_{ds} \times (d_{cover} + t_{base} + d_{ds} / 2) = 60 \text{ kN/m}$

Calculate moment for downstand design

Total moment for downstand design

 $M_{down} = \gamma_{f_{-}e} \times K_p \times \cos(\delta_b) \times \gamma_m \times d_{ds} \times [(d_{cover} + t_{base}) \times (t_{base} + d_{ds}) + d_{ds} \times (t_{base} / 2 + 2 \times d_{ds} / 3)] / 2 = 31.8 \text{ kNm/m}$

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Check downstand in bending	
Width of downstand	b = 1000 mm/m
Depth of reinforcement	$d_{down} = t_{ds} - c_{ds} - (\phi_{down} / 2) = 555.0 \text{ mm}$
Constant	$K_{down} = M_{down} / (b \times d_{down}^2 \times f_{cu}) = 0.003$
	Compression reinforcement is not required
Lever arm	z_{down} = Min(0.5 + $\sqrt{(0.25 - (min(K_{down}, 0.225) / 0.9)), 0.95)} \times d_{down}$
	z _{down} = 527 mm
Area of tension reinforcement required	$A_{s_down_des}$ = M_{down} / (0.87 × f _y × z _{down}) = 139 mm ² /m
Minimum area of tension reinforcement	$A_{s_down_min} = k \times b \times t_{ds} = 780 \text{ mm}^2/\text{m}$
Area of tension reinforcement required	A _{s_down_req} = Max(A _{s_down_des} , A _{s_down_min}) = 780 mm ² /m
Reinforcement provided	B785 mesh
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Area of rei	nforcement provided	_	n_prov = 785 mr			
		S - Reinfor	cement provi	ded at the retaini	ng wall downs	tand is adequa
Design she	ear resistance at downstand	V	- \/. / (b v d	l _{down}) = 0.108 N/mn	n ²	
-	shear stress		•	$_{cu}$ / 1 N/mm ²), 5) ×		3 N/mm ²
Allowable				shear stress is le		
From BS8	110:Part 1:1997 – Table 3.8					
Design cor	ncrete shear stress	Vc_dowr	. = 0.368 N/mi	m²		
Ū				Vdown < Vc_down - N	o shear reinfor	cement require
Design of	reinforced concrete retaining wa	ll stem (BS	8002:1994)			
Material p			<u> </u>			
-	stic strength of concrete	f _{cu} = 3	5 N/mm ²			
Characteri	stic strength of reinforcement	f _y = 5 0)0 N/mm ²			
Wall detai	ls					
Minimum a	area of reinforcement	k = 0 .	13 %			
Cover to re	einforcement in stem	C _{stem} =	40 mm			
Cover to re	einforcement in wall	c _{wall} =	40 mm			
Factored	horizontal at-rest forces on stem					
Surcharge		Fs_sur_	$_{\rm f} = \gamma_{\rm f_l} \times {\rm K}_0 \times {\rm S}_0$	Surcharge $ imes$ (h _{eff} - t	_{base} - d _{ds}) = 6.4 k	kN/m
Moist back	fill above water table	Fs_m_a	_f = $0.5 \times \gamma_{f_e} >$	${}^{\!$	_{se} - d _{ds} - h _{sat}) ² =	60.2 kN/m
Calculate	shear for stem design					
Shear at b	ase of stem	V _{stem} =	= Fs_sur_f + Fs_n	_{n_a_f} = 66.5 kN/m		
Calculate	moment for stem design					
Surcharge		Ms_sur	= $F_{s_{sur_f}} \times (h_{st})$	_{tem} + t _{base}) / 2 = 10.	8 kNm/m	
Moist back	fill above water table	Ms_m_a	a = Fs_m_a_f × (2	$2 \times h_{sat}$ + h_{eff} - d_{ds} +	t _{base} / 2) / 3 = 7	2.2 kNm/m
Total mom	ent for stem design	M _{stem}	= Ms_sur + Ms_n	_{n_a} = 83 kNm/m		
		• •	• •	• •		>

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Check wall stem in bending					
Width of wall stem	b = 1000	mm/m			
Depth of reinforcement	d _{stem} = t _w	$d_{stem} = t_{wall} - c_{stem} - (\phi_{stem} / 2) = 355.0 \text{ mm}$			
Constant	K _{stem} = N	$K_{stem} = M_{stem} / (b \times d_{stem}^2 \times f_{cu}) = 0.019$			
		Compression re	einforcement is not required		
Lever arm	z_{stem} = min(0.5 + $\sqrt{(0.25 - (min(K_{stem}, 0.225) / 0.9)), 0.95)} \times d_{stem}$				
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	z _{stem} = 337 mm
Area of tension reinforcement required	$A_{s_stem_des} = M_{stem} / (0.87 \times f_y \times z_{stem}) = 566 \text{ mm}^2/\text{m}$
Minimum area of tension reinforcement	$A_{s_stem_min} = k \times b \times t_{wall} = 520 \text{ mm}^2/\text{m}$
Area of tension reinforcement required	As stem req = Max(As stem des, As stem min) = 566 mm ² /m
Reinforcement provided	B785 mesh
Area of reinforcement provided	A _{s_stem_prov} = 785 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 × d _{stem}) = 0.187 N/mm ²
Allowable shear stress	v_{adm} = min(0.8 × $\sqrt{(f_{cu} / 1 N/mm^2)}$, 5) × 1 N/mm ² = 4.733 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} = 0.441 N/mm ²
	v _{stem} < v _{c_stem} - No shear reinforcement required
Check retaining wall deflection	
Basic span/effective depth ratio	ratio _{bas} = 7
Design service stress	$f_s = 2 \times f_y \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = 240.2 \text{ N/mm}^2$
Modification factor factor _{tens} = min	(0.55 + (477 N/mm² - f _s)/(120 × (0.9 N/mm² + (M _{stem} /(b × d _{stem} ²)))),2) = 1.82
Maximum span/effective depth ratio	ratio _{max} = ratio _{bas} × factor _{tens} = 12.71
Actual span/effective depth ratio	ratio _{act} = h _{stem} / d _{stem} = 8.45
	PASS - Span to depth ratio is acceptable

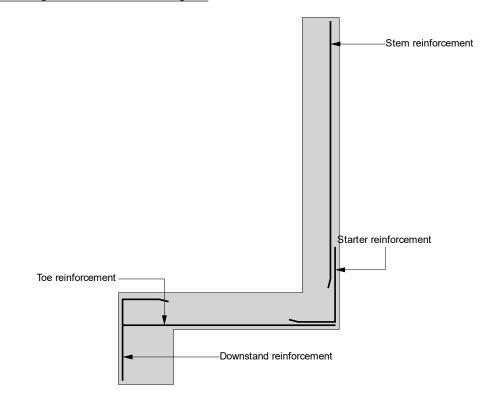
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Indicative retaining wall reinforcement diagram

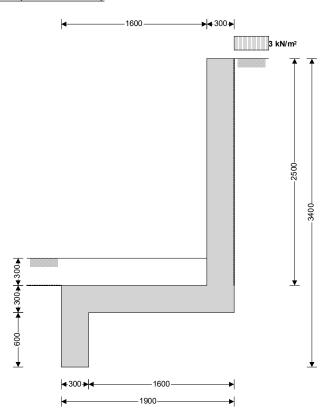


Toe mesh - B1131 - (1131 mm²/m) Downstand mesh - B785 - (785 mm²/m) Stem mesh - B785 - (785 mm²/m)

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RETAINING WALL ANALYSIS (BS 8002:1994)



TEDDS calculation version 1.2.01.06

Wall details

Retaining wall type **Unpropped cantilever** h_{stem} = **2500** mm Height of retaining wall stem Thickness of wall stem twall = 300 mm Length of toe I_{toe} = **1600** mm Length of heel I_{heel} = 0 mm Overall length of base $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 1900 \text{ mm}$ Thickness of base t_{base} = **300** mm d_{ds} = **600** mm Depth of downstand Position of downstand I_{ds} = **0** mm t_{ds} = **300** mm Thickness of downstand $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3400 \text{ mm}$ Height of retaining wall Depth of cover in front of wall d_{cover} = 300 mm Depth of unplanned excavation d_{exc} = 300 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 γwall = 23.6 kN/m³ Density of base construction γ_{base} = 23.6 kN/m³ Angle of rear face of wall α = **90.0** deg Angle of soil surface behind wall $\beta = 0.0 \text{ deg}$ Effective height at virtual back of wall $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3400 \text{ mm}$

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Mobilisation factor Moist density of retained material	M = 1.5 γ _m = 18.0 kN/m ³
Saturated density of retained material	$\gamma_{\rm s} = 21.0 \text{ kN/m}^3$
Design shear strength	∳' = 28.0 deg
Angle of wall friction	δ = 0.0 deg
Base material details	
Base material details Moist density	γ _{mb} = 18.0 kN/m ³
	γ _{mb} = 18.0 kN/m³ φ' _b = 24.2 deg
Moist density	
Moist density Design shear strength	φ' _b = 24.2 deg

Using Coulomb theory

Retained material details

Active pressure coefficient for retained material

 $\mathsf{K}_{\mathsf{a}} = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))}]^2) = \mathbf{0.361}$

Passive pressure coefficient for base material

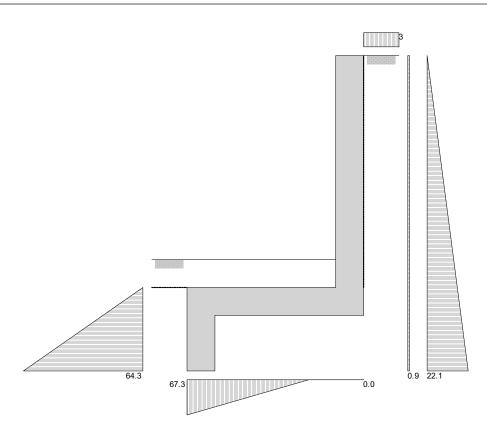
$$K_{\rm P} = \sin(90 - \phi_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi_b + \delta_b) \times \sin(\phi_b) / (\sin(90 + \delta_b)))}]^2) = 4.187$$

At-rest pressure

At-rest pressure for retained material	K ₀ = 1 – sin(φ') = 0.531
Loading details	
Surcharge load on plan	Surcharge = 2.5 kN/m ²
Applied vertical dead load on wall	W _{dead} = 0.0 kN/m
Applied vertical live load on wall	W _{live} = 0.0 kN/m
Position of applied vertical load on wall	I _{load} = 0 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

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

Vertical forces on wall

Wall stem

Wall base Wall downstand Soil in front of wall Total vertical load **Horizontal forces on wall** Surcharge Moist backfill above water table Total horizontal load **Calculate stability against sliding** Passive resistance of soil in front of wall Resistance to sliding

Overturning moments

Surcharge Moist backfill above water table Soil in front of wall Total overturning moment

Restoring moments

Wall stem

$$\begin{split} & \mathsf{w}_{\mathsf{wall}} = \mathsf{h}_{\mathsf{stem}} \times \mathsf{t}_{\mathsf{wall}} \times \gamma_{\mathsf{Wall}} = \mathbf{17.7} \; \mathsf{kN/m} \\ & \mathsf{w}_{\mathsf{base}} = \mathsf{l}_{\mathsf{base}} \times \mathsf{t}_{\mathsf{base}} \times \gamma_{\mathsf{base}} = \mathbf{13.5} \; \mathsf{kN/m} \\ & \mathsf{w}_{\mathsf{ds}} = \mathsf{d}_{\mathsf{ds}} \times \mathsf{t}_{\mathsf{ds}} \times \gamma_{\mathsf{base}} = \mathbf{4.2} \; \mathsf{kN/m} \\ & \mathsf{w}_{\mathsf{p}} = \mathsf{l}_{\mathsf{toe}} \times \mathsf{d}_{\mathsf{cover}} \times \gamma_{\mathsf{mb}} = \mathbf{8.6} \; \mathsf{kN/m} \\ & \mathsf{W}_{\mathsf{total}} = \mathsf{w}_{\mathsf{wall}} + \mathsf{w}_{\mathsf{base}} + \mathsf{w}_{\mathsf{ds}} + \mathsf{w}_{\mathsf{p}} = \mathbf{44} \; \mathsf{kN/m} \end{split}$$

$$\begin{split} F_{sur} &= K_a \times Surcharge \times h_{eff} = \textbf{3.1 kN/m} \\ F_{m_a} &= 0.5 \times K_a \times \gamma_m \times (h_{eff} - h_{water})^2 = \textbf{37.6 kN/m} \\ F_{total} &= F_{sur} + F_{m_a} = \textbf{40.6 kN/m} \end{split}$$

$$\begin{split} F_{p} &= 0.5 \times K_{p} \times cos(\delta_{b}) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^{2} \times \gamma_{mb} = \textbf{28.9 kN/m} \\ F_{res} &= F_{p} + (W_{total} - w_{p}) \times tan(\delta_{b}) = \textbf{40.8 kN/m} \\ \textbf{PASS - Resistance force is greater than sliding force} \end{split}$$

$$\begin{split} M_{sur} &= F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = \textbf{3.4 kNm/m} \\ M_{m_a} &= F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = \textbf{20 kNm/m} \\ M_{p_o} &= F_p \times [2 \times d_{ds} - t_{base} - d_{cover} + d_{exc}] / 3 = \textbf{8.7 kNm/m} \\ M_{ot} &= M_{sur} + M_{m_a} + M_{p_o} = \textbf{32.1 kNm/m} \end{split}$$

 $M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 31 \text{ kNm/m}$

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Wall base	$M_{base} = W_{base} \times I_{base} / 2 = 12.8 \text{ kNm/m}$
Wall downstand	$M_{ds} = w_{ds} \times (I_{ds} + t_{ds} / 2) = \textbf{0.6 kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{ds} = 44.4 \text{ kNm/m}$
Check stability against overturning	
Total overturning moment	M _{ot} = 32.1 kNm/m
Total restoring moment	M _{rest} = 44.4 kNm/m
	PASS - Restoring moment is greater than overturning moment
Check bearing pressure	
Soil in front of wall	$M_{p_r} = w_p \times I_{toe} / 2 = 6.9 \text{ kNm/m}$
Total moment for bearing	$M_{total} = M_{rest} - M_{ot} + M_{p_r} = 19.2 \text{ kNm/m}$
Total vertical reaction	R = W _{total} = 44.0 kN/m
Distance to reaction	x _{bar} = M _{total} / R = 436 mm
Eccentricity of reaction	e = abs((I _{base} / 2) - x _{bar}) = 514 mm
	Reaction acts outside middle third of base
Bearing pressure at toe	p _{toe} = R / (1.5 × x _{bar}) = 67.3 kN/m ²
Bearing pressure at heel	$p_{heel} = 0 \text{ kN/m}^2 = 0 \text{ kN/m}^2$
	PASS - Maximum bearing pressure is less than allowable bearing pressure

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RETAININ	G WALL DESIGN (BS 8002:1994)					
					TEDDS calcu	ation version 1.2.0
	imit state load factors					
Dead load		$\gamma_{f_d} =$				
Live load fa		γ _{f_l} = 1				
Earth and	water pressure factor	γ _{f_e} =	1.4			
Factored v	vertical forces on wall					
Wall stem		Wwall_f	= $\gamma_{f_d} \times h_{stem} \times f_{stem}$	$t_{wall} \times \gamma_{wall} = 24.8$	kN/m	
Wall base		Wbase_t	$= \gamma_{f_d} \times I_{base} \times I_{base}$	t _{base} × γ _{base} = 18.8	3 kN/m	
Wall down:	stand	W _{ds_f} =	$\gamma_{f_d} \times d_{ds} \times t_{ds}$	$\times \gamma_{base}$ = 5.9 kN/n	n	
Soil in fron	t of wall	w _{p_f} =	$\gamma_{f_d} \times I_{toe} \times d_{cov}$	$_{er} \times \gamma_{mb}$ = 12.1 kN	l/m	
Total vertic	al load	W _{total}	$_{\rm f}$ = $W_{\rm wall_f}$ + $W_{\rm bas}$	$e_f + W_{ds_f} + W_{p_f} =$	61.7 kN/m	
Factored I	horizontal at-rest forces on wall					
Surcharge		F _{sur f} =	= γ _{f I} × K ₀ × Sur	charge × h _{eff} = 7.	2 kN/m	
Moist back	fill above water table			$0 \times \gamma_m \times (h_{eff} - h_{wat})$		
Total horiz	ontal load		= F _{sur f} + F _{m a f}		,	
Passive re	sistance of soil in front of wall	_		$\times \cos(\delta_b) \times (d_{cover})$	+ t _{base} + d _{ds} - d _{ex}	$(c)^2 \times \gamma_{mb} = 40.5$
kN/m						, .
Factored of	overturning moments					
Surcharge	-	Msur f	= F _{sur_f} × (h _{eff} -	2 × d _{ds}) / 2 = 7.9	kNm/m	
Ũ	fill above water table	-	= (+ 2 \times h _{water} - 3 \times c		lm/m
Soil in fron				s - t _{base} - d _{cover} + d		
	urning moment			+ M _{p o f} = 61.3 kl		
	-					
Restoring Wall stem	moments	Μ		- t _{wall} / 2) = 43.4 kl	Nm/m	
Wall base		_		• (waii / 2) – 43.4 ki ∍ / 2 = 17.9 kNm/r		
	ato a d	_	_			
Wall down			- •	_{is} / 2) = 0.9 kNm/r	n	
Soil in fron			$= W_{p_f} \times I_{toe} / 2$		74.0 100 100 100	
	ring moment	IVIrest_f	= IVIwall_f + IVIbas	e_f + M _{ds_f} + M _{p_r_f}	= /1.8 KINM/M	
	bearing pressure					
	ent for bearing	_		= 10.5 kNm/m		
	cal reaction		V _{total_f} = 61.7 kN			
Distance to			= M _{total_f} / R _f = 1			
Eccentricity	y of reaction	$e_f = a_f$	OS((Ibase / Z) - Xi	_{par_f}) = 779 mm	cts outside mia	Idle third of h
Rearing pr	essure at toe	Du c	= R ₂ / (1.5 × v	f) = 240.8 kN/m ²		
	essure at heel		$= 0 \text{ kN/m}^2 = 0$			
	ange of base reaction	• -		<u>r_</u> f) = 470.06 kN/m	² /m	
	-					!
bearing pro	essure at stem / toe			- (rate × I _{toe}), 0 kI _f - (rate × (I _{toe} + t _{wa}		
Decrine -		[]		t - [[2][2] X [[too +]w	<u>∍∥////////////////////////////////////</u>	
Bearing pro	essure at stem / heel			$_{f}$ - (rate × (I_{toe} + I_{w}		

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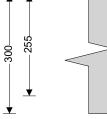
Material properties

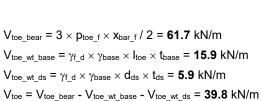
Characteristic strength of concrete	f _{cu} = 35 N/mm ²
Characteristic strength of reinforcement	f _y = 500 N/mm ²
Base details	
Minimum area of reinforcement	k = 0.13 %
Cover to reinforcement in toe	c _{toe} = 40 mm
Calculate shear for toe design	
Shear from bearing pressure	V_{toe_bear} = 3 × p_{toe_f} × x_{bar_f} / 2 = 61.7 kN/m
Shear from weight of base	$V_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times I_{toe} \times t_{base} = \textbf{15.9 kN}.$

Shear from weight of downstand Total shear for toe design

Calculate moment for toe design

Moment from bearing pressure Moment from weight of base Moment from weight of downstand Total moment for toe design





 $M_{toe_bear} = 3 \times p_{toe_f} \times x_{bar_f} \times (I_{toe} - x_{bar_f} + t_{wall} / 2) / 2 = 97.4 \text{ kNm/m}$ $M_{toe_wt_base} = (\gamma_{f_d} \times \gamma_{base} \times t_{base} \times (I_{toe} + t_{wall} / 2)^2 / 2) = 15.2 \text{ kNm/m}$ $M_{toe_wt_ds} = \gamma_{f_d} \times \gamma_{base} \times d_{ds} \times t_{ds} \times (I_{toe} - I_{ds} + (t_{wall} - t_{ds}) / 2) = 9.5 \text{ kNm/m}$ $M_{toe} = M_{toe_bear} - M_{toe_wt_base} - M_{toe_wt_ds} = 72.7 \text{ kNm/m}$



↓100-**▶**

Check toe in bending	
Width of toe	b = 1000 mm/m
Depth of reinforcement	$d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2) = 255.0 \text{ mm}$
Constant	$K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu}) = 0.032$
	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} = 242 mm
Area of tension reinforcement required	$A_{s_toe_des} = M_{toe} / (0.87 \times f_y \times z_{toe}) = 690 \text{ mm}^2/\text{m}$
Minimum area of tension reinforcement	$A_{s_toe_min} = k \times b \times t_{base} = 390 \text{ mm}^2/\text{m}$
Area of tension reinforcement required	$A_{s_toe_req} = Max(A_{s_toe_des}, A_{s_toe_min}) = 690 \text{ mm}^2/\text{m}$
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 × d _{toe}) = 0.156 N/mm ²
Allowable shear stress	v_{adm} = min(0.8 × $\sqrt{(f_{cu} / 1 N/mm^2)}$, 5) × 1 N/mm ² = 4.733 N/mm ²

PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 - Table 3.8

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vc_toe = 0.534 N/mm²

Design of reinforced concrete retaining wall downstand (BS 8002:1994)						
Material properties						
Characteristic strength of concrete	f _{cu} = 35 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 downstand	c _{ds} = 40 mm					

 $V_{down} = \gamma_{f_e} \times K_p \times cos(\delta_b) \times \gamma_m \times d_{ds} \times (d_{cover} + t_{base} + d_{ds} / 2) = 54 \text{ kN/m}$

 $v_{toe} < v_{c_{toe}}$ - No shear reinforcement required

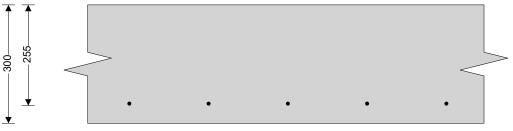
Calculate moment for downstand design

Calculate shear for downstand design Total shear for downstand design

Total moment for downstand design

Design concrete shear stress

 $M_{down} = \gamma_{f_e} \times K_p \times cos(\delta_b) \times \gamma_m \times d_{ds} \times \left[(d_{cover} + t_{base}) \times (t_{base} + d_{ds}) + d_{ds} \times (t_{base} / 2 + 2 \times d_{ds} / 3) \right] / 2 = 26.1 \text{ kNm/m}$



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Check downstand in bending	
Width of downstand	b = 1000 mm/m
Depth of reinforcement	$d_{down} = t_{ds} - c_{ds} - (\phi_{down} / 2) = 255.0 \text{ mm}$
Constant	K_{down} = M_{down} / (b × d_{down}^2 × f_{cu}) = 0.011
	Compression reinforcement is not required
Lever arm	z_{down} = Min(0.5 + $\sqrt{(0.25 - (min(K_{down}, 0.225) / 0.9)), 0.95)} \times d_{down}$
	z _{down} = 242 mm
Area of tension reinforcement required	$A_{s_down_des}$ = M_{down} / (0.87 × f_y × z_{down}) = 248 mm ² /m
Minimum area of tension reinforcement	$A_{s_down_min} = k \times b \times t_{ds} = 390 \text{ mm}^2/\text{m}$
Area of tension reinforcement required	A _{s_down_req} = Max(A _{s_down_des} , A _{s_down_min}) = 390 mm ² /m
Reinforcement provided	A393 mesh
Area of reinforcement provided	As_down_prov = 393 mm ² /m
PASS -	Reinforcement provided at the retaining wall downstand is adequate
Check shear resistance at downstand	
Design shear stress	v _{down} = V _{down} / (b × d _{down}) = 0.212 N/mm ²
Allowable shear stress	v_{adm} = min(0.8 × $\sqrt{(f_{cu} / 1 N/mm^2)}$, 5) × 1 N/mm ² = 4.733 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_down} = 0.424 N/mm ²
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$v_{down} < v_{c_down}$ - No shear reinforcement required

Material properties			
Characteristic strength of concrete	f _{cu} = 35 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} = 40 mm		
Cover to reinforcement in wall	c _{wall} = 40 mm		
Factored horizontal at-rest forces on stem			
Surcharge	$F_{s_sur_f} = \gamma_{f_i} \times K_0 \times Surcharge \times (h_{eff} - t_{base} - d_{ds}) = 5.3 \text{ kN/m}$		
Moist backfill above water table	$F_{s_m_a_f} = 0.5 \times \gamma_{f_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2 = \textbf{41.8 kN/m}$		
Calculate shear for stem design			
Shear at base of stem	V _{stem} = F _{s_sur_f} + F _{s_m_a_f} = 47.1 kN/m		
Calculate moment for stem design			
Surcharge	$M_{s_sur} = F_{s_sur_f} \times (h_{stem} + t_{base}) / 2 = 7.4 \text{ kNm/m}$		
Moist backfill above water table	Ms_m_a = Fs_m_a_f × (2 × hsat + heff - dds + tbase / 2) / 3 = 41.1 kNm/n		
Total moment for stem design	M _{stem} = M _{s_sur} + M _{s_m_a} = 48.5 kNm/m		

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Check wall stem in bending						
Width of wall stem	b = 1000 i	nm/m				
Depth of reinforcement	d _{stem} = t _{wall}	- c _{stem} - (φ _{stem} / 2) = 256.0 mm				
Constant	K _{stem} = M _s	_{tem} / (b × d _{stem} ² × f _{cu}) = 0.021				
		Compression re	inforcement is not required			
Lever arm	z _{stem} = mir	$1(0.5 + \sqrt{0.25} - (min(K_{stem}, 0.225)))$	5) / 0.9)),0.95) × d _{stem}			
	Zstem = 243	3 mm				
Area of tension reinforcement red	quired As_stem_des	$A_{s_stem_des} = M_{stem} / (0.87 \times f_y \times z_{stem}) = 459 \text{ mm}^2/\text{m}$				
Minimum area of tension reinforc	ement As_stem_min	$A_{s_stem_min} = k \times b \times t_{wall} = 390 \text{ mm}^2/\text{m}$				
Area of tension reinforcement red	quired As_stem_req	A _{s_stem_req} = Max(A _{s_stem_des} , A _{s_stem_min}) = 459 mm ² /m				
Reinforcement provided	B503 mes	B503 mesh				
Area of reinforcement provided	As_stem_prov	= 503 mm²/m				
	PASS - Reinf	orcement provided at the reta	ining wall stem is adequate			
Check shear resistance at wall	stem					
Design shear stress	v _{stem} = V _{ste}	_m / (b × d _{stem}) = 0.184 N/mm ²				
Allowable shear stress $v_{adm} = min(0.8 \times \sqrt{(f_{cu} / 1 N/mm^2), 5)} \times 1 N/mm^2 = 4.733 N/mm^2$						
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PASS - Design shear stress is less than maximum shear stress From BS8110:Part 1:1997 – Table 3.8

 $f_{s} = 2 \times f_{y} \times A_{s_stem_req} \ / \ (3 \times A_{s_stem_prov}) = \textbf{304.1} \ N/mm^{2}$

Design concrete shear stress

vc_stem = 0.459 N/mm²

ratio_{bas} = 7

v_{stem} < v_{c_stem} - No shear reinforcement required

Check retaining wall deflection

Basic span/effective depth ratio

Design service stress

Modification factor

Maximum span/effective depth ratio

Actual span/effective depth ratio

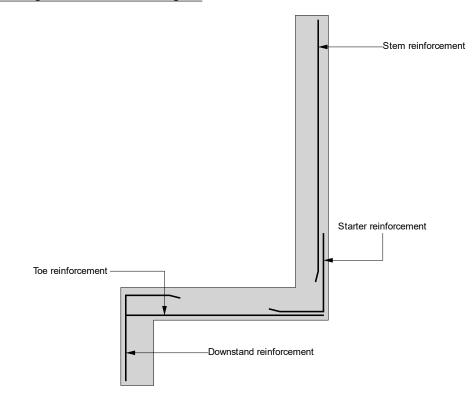
factor_{tens} = min(0.55 + (477 N/mm² - f_s)/(120 × (0.9 N/mm² + (M_{stem}/(b × d_{stem}²)))),2) = **1.43** ratio ratio_{max} = ratio_{bas} × factor_{tens} = **10.00** ratio_{act} = h_{stem} / d_{stem} = **9.77**

PASS - Span to depth ratio is acceptable

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Indicative retaining wall reinforcement diagram

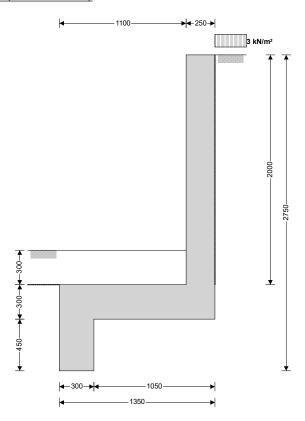


Toe mesh - B785 - (785 mm²/m) Downstand mesh - A393 - (393 mm²/m) Stem mesh - B503 - (503 mm²/m)

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RETAINING WALL ANALYSIS (BS 8002:1994)



Wall details

Retaining wall type	Unpropped cantilever
Height of retaining wall stem	h _{stem} = 2000 mm
Thickness of wall stem	t _{wall} = 250 mm
Length of toe	I _{toe} = 1100 mm
Length of heel	I _{heel} = 0 mm
Overall length of base	$I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 1350 \text{ mm}$
Thickness of base	t _{base} = 300 mm
Depth of downstand	d _{ds} = 450 mm
Position of downstand	l _{ds} = 0 mm
Thickness of downstand	t _{ds} = 300 mm
Height of retaining wall	h_{wall} = h_{stem} + t_{base} + d_{ds} = 2750 mm
Depth of cover in front of wall	d _{cover} = 300 mm
Depth of unplanned excavation	d _{exc} = 300 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	$\beta = 0.0 \text{ deg}$
Effective height at virtual back of wall	$h_{\text{eff}} = h_{\text{wall}} + I_{\text{heel}} \times \tan(\beta) = 2750 \text{ mm}$

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Mobilisation factor	M = 1.5
Moist density of retained material	γm = 18.0 kN/m ³
Saturated density of retained material	γs = 21.0 kN/m ³
Design shear strength	φ' = 28.0 deg
Angle of wall friction	δ = 0.0 deg
Base material details	
Base material details Moist density	γ _{mb} = 18.0 kN/m ³
	_{γmb} = 18.0 kN/m³ φ' _b = 24.2 deg
Moist density	

Using Coulomb theory

Retained material details

Active pressure coefficient for retained material

 $\mathsf{K}_{\mathsf{a}} = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))}]^2) = \mathbf{0.361}$

Passive pressure coefficient for base material

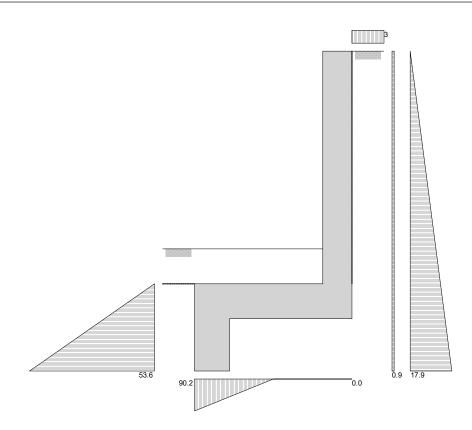
$$K_{p} = \sin(90 - \phi'_{b})^{2} / (\sin(90 - \delta_{b}) \times [1 - \sqrt{(\sin(\phi'_{b} + \delta_{b}) \times \sin(\phi'_{b})} / (\sin(90 + \delta_{b})))]^{2}) = 4.187$$

At-rest pressure

At-rest pressure for retained material	$K_0 = 1 - \sin(\phi') = 0.531$
Loading details	
Surcharge load on plan	Surcharge = 2.5 kN/m ²
Applied vertical dead load on wall	W _{dead} = 0.0 kN/m
Applied vertical live load on wall	W _{live} = 0.0 kN/m
Position of applied vertical load on wall	I _{load} = 0 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

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

Vertical forces on wall

Wall stem Wall base Wall downstand Soil in front of wall Total vertical load

Horizontal forces on wall

Surcharge Moist backfill above water table Total horizontal load

Calculate stability against sliding

Passive resistance of soil in front of wall Resistance to sliding

Overturning moments

Surcharge Moist backfill above water table Soil in front of wall Total overturning moment

Restoring moments

Wall stem

$$\begin{split} & w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall} = \textbf{11.8 kN/m} \\ & w_{base} = l_{base} \times t_{base} \times \gamma_{base} = \textbf{9.6 kN/m} \\ & w_{ds} = d_{ds} \times t_{ds} \times \gamma_{base} = \textbf{3.2 kN/m} \\ & w_{p} = l_{toe} \times d_{cover} \times \gamma_{mb} = \textbf{5.9 kN/m} \\ & W_{total} = w_{wall} + w_{base} + w_{ds} + w_{p} = \textbf{30.5 kN/m} \end{split}$$

$$\begin{split} F_{sur} &= K_a \times Surcharge \times h_{eff} = \textbf{2.5 kN/m} \\ F_{m_a} &= 0.5 \times K_a \times \gamma_m \times (h_{eff} - h_{water})^2 = \textbf{24.6 kN/m} \\ F_{total} &= F_{sur} + F_{m_a} = \textbf{27.1 kN/m} \end{split}$$

$$\begin{split} F_{p} &= 0.5 \times K_{p} \times cos(\delta_{b}) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^{2} \times \gamma_{mb} = \textbf{20.1 kN/m} \\ F_{res} &= F_{p} + (W_{total} - w_{p}) \times tan(\delta_{b}) = \textbf{28.3 kN/m} \\ \textbf{PASS - Resistance force is greater than sliding force} \end{split}$$

$$\begin{split} M_{sur} &= F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = \textbf{2.3 kNm/m} \\ M_{m_a} &= F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = \textbf{11.5 kNm/m} \\ M_{p_o} &= F_p \times [2 \times d_{ds} - t_{base} - d_{cover} + d_{exc}] / 3 = \textbf{4 kNm/m} \\ M_{ot} &= M_{sur} + M_{m_a} + M_{p_o} = \textbf{17.8 kNm/m} \end{split}$$

 $M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 14.5 \text{ kNm/m}$

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Wall base	$M_{base} = W_{base} \times I_{base} / 2 = 6.5 \text{ kNm/m}$
Wall downstand	$M_{ds} = w_{ds} \times (I_{ds} + t_{ds} / 2) = 0.5 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{ds} = 21.4 \text{ kNm/m}$
Check stability against overturning	
Total overturning moment	M _{ot} = 17.8 kNm/m
Total restoring moment	M _{rest} = 21.4 kNm/m
	PASS - Restoring moment is greater than overturning moment
Check bearing pressure	
Soil in front of wall	$M_{p_r} = w_p \times I_{toe} / 2 = 3.3 \text{ kNm/m}$
Total moment for bearing	$M_{total} = M_{rest} - M_{ot} + M_{p_r} = 6.9 \text{ kNm/m}$
Total vertical reaction	R = W _{total} = 30.5 kN/m
Distance to reaction	x _{bar} = M _{total} / R = 225 mm
Eccentricity of reaction	e = abs((I _{base} / 2) - x _{bar}) = 450 mm
	Reaction acts outside middle third of base
Bearing pressure at toe	p _{toe} = R / (1.5 × x _{bar}) = 90.2 kN/m ²
Bearing pressure at heel	$p_{\text{heel}} = 0 \text{ kN/m}^2 = 0 \text{ kN/m}^2$
	PASS - Maximum bearing pressure is less than allowable bearing pressure

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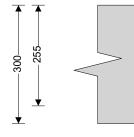
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RETAININ	G WALL DESIGN (BS 8002:1994)					
l IItimato li	mit state load factors				TEDDS calcul	ation version 1.2.01
Dead load		$\gamma_{f_d} = 1$	1 4			
Live load fa		γι_a – γ _{f I} = 1				
	water pressure factor	$\gamma_{f_i} = 1$ $\gamma_{f_e} = 1$				
	-	γf_e −	1.4			
	vertical forces on wall					
Wall stem				t _{wall} × γ _{wall} = 16.5 Ι		
Wall base		-	• =	$t_{base} \times \gamma_{base} = 13.4$		
Wall down	stand	Wds_f =	$\gamma_{f_d} \times d_{ds} \times t_{ds}$	$\times \gamma_{\text{base}} = 4.5 \text{ kN/m}$	n	
Soil in fron	t of wall	w _{p_f} =	$\gamma_{f_d} \times I_{toe} \times d_{cov}$	er × γmb = 8.3 kN/i	n	
Total vertic	cal load	W _{total} _	$f = W_{wall_f} + W_{bas}$	$se_f + W_{ds_f} + W_{p_f} =$	42.7 kN/m	
Factored I	horizontal at-rest forces on wall					
Surcharge		F _{sur_f} =	= $\gamma_{f_l} \times K_0 \times Sur$	charge × h _{eff} = 5.8	3 kN/m	
Moist back	fill above water table	$F_{m_a_f}$	= $\gamma_{f_e} \times 0.5 \times K$	$K_0 imes \gamma_m imes$ (h _{eff} - h _{wat}	_{er})² = 50.6 kN/m	
Total horiz	ontal load	F _{total_f}	= F _{sur_f} + F _{m_a_t}	_f = 56.4 kN/m		
Passive re kN/m	sistance 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 _{ex}	c) ² × γ _{mb} = 28.1
Factored of	overturning moments					
Surcharge	-	Msur f	= F _{sur f} × (h _{eff} -	2 × d _{ds}) / 2 = 5.4	kNm/m	
Ũ	fill above water table	-	- (+ 2 \times h _{water} - 3 \times c		lm/m
Soil in fron			·	ls - t _{base} - d _{cover} + d		
	urning moment			$+ M_{p o f} = 34.6 \text{ kl}$		
Restoring	-			F		
Wall stem	moments	Maari	- w	⊦ t _{wall} / 2) = 20.2 kl	Nm/m	
Wall base				• (waii / 2) = 20.2 Ki • / 2 = 9 kNm/m	NI11/111	
Wall down:	stand			_e / 2 = 3 kNm/m _{ds} / 2) = 0.7 kNm/r	n	
Soil in fron						
	ring moment		$= W_{p_f} \times I_{toe} / 2$	$= 4.0 \text{ KNM/III}$ $e_f + M_{ds_f} + M_{p_r_f}$	- 34 5 kNm/m	
		Ivirest_t	- IVIWall_f · IVIDas	e_t • lvids_t • lvip_r_t	- 34.3 KINIII/III	
	bearing pressure	м	- 14 14	- 0.4 (A) (ma		
	ent for bearing		= M _{rest_f} - M _{ot_f}			
Distance to	cal reaction		V _{total_f} = 42.7 kl = M _{total_f} / R _f = -2			
	y of reaction			_{bar_f}) = 677 mm		
Locenthold	yorreaction		DS((Dase / Z) - X)		G - Beyond sco	pe of calculati
Bearing pro	essure at toe	Dtop f	= R _f / (1.5 × x _{ba}	_{r_f}) = -11945.3 kN/		
	essure at heel		$= 0 \text{ kN/m}^2 = 0$			
	ange of base reaction	• -		r_f) = 1671716.13	kN/m²/m	
	essure at stem / toe			$_{f}$ - (rate × I_{toe}), 0 kl		
	essure at mid stem			$_{f}$ - (rate × (I_{toe} + I_{wa}		
Dearing pr	Sourc at min stem	Pstem_r	IIIIa_I – IIIav(Ptoe_	י - (ומוס × (ווספ ד wa	$(\mathcal{L}_{j}), \cup ((\mathcal{N}_{j})))$	
Booring r-	essure at stem / heel	n	-mov/n	_f - (rate \times (I _{toe} + t _w	$(1) 0 k N (m^2) =$	$0 k N l/m^2$

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Project: 3 ARNHILL ROAD, GRETTON					

Material properties	
Characteristic strength of concrete	f _{cu} = 35 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} = 40 mm
Calculate shear for toe design	
Shear from weight of base	$V_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times I_{toe} \times t_{base} = \textbf{10.9 kN/s}$
Shear from weight of downstand	$V_{toe_wt_ds} = \gamma_{f_d} \times \gamma_{base} \times d_{ds} \times t_{ds} = \textbf{4.5 kN/m}$
Total shear for toe design	$V_{toe} = V_{toe_wt_base} - V_{toe_wt_ds} = 6.4 \text{ kN/m}$
Calculate moment for toe design	

Moment from weight of base Moment from weight of downstand Total moment for toe design



l/m

 $M_{toe_wt_base} = (\gamma_{f_d} \times \gamma_{base} \times t_{base} \times (I_{toe} + t_{wall} / 2)^2 / 2) = 7.4 \text{ kNm/m}$ $M_{toe_wt_ds} = \gamma_{f_d} \times \gamma_{base} \times d_{ds} \times t_{ds} \times (I_{toe} - I_{ds} + (t_{wall} - t_{ds}) / 2) = 4.8 \text{ kNm/m}$ $M_{toe} = M_{toe_wt_base} - M_{toe_wt_ds} = 2.6 \text{ kNm/m}$



Width of toe Depth of reinforcement Constant

Lever arm

Area of tension reinforcement required Minimum area of tension reinforcement Area of tension reinforcement required Reinforcement provided Area of reinforcement provided

Check shear resistance at toe

Design shear stress Allowable shear stress

From BS8110:Part 1:1997 - Table 3.8

Design concrete shear stress

b = 1000 mm/m $d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2) = 255.0 \text{ mm}$ $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu}) = 0.001$ Compression reinforcement is not required $z_{\text{toe}} = \min(0.5 + \sqrt{(0.25 - (\min(K_{\text{toe}}, 0.225) / 0.9)), 0.95)} \times d_{\text{toe}}$ z_{toe} = **242** mm As toe des = M_{toe} / $(0.87 \times f_y \times z_{toe})$ = 25 mm²/m As toe min = $k \times b \times t_{base}$ = **390** mm²/m As_toe_req = Max(As_toe_des, As_toe_min) = 390 mm²/m A393 mesh As_toe_prov = 393 mm²/m PASS - Reinforcement provided at the retaining wall toe is adequate

 $v_{toe} = V_{toe} / (b \times d_{toe}) = 0.025 \text{ N/mm}^2$ $v_{adm} = min(0.8 \times \sqrt{(f_{cu} / 1 N/mm^2)}, 5) \times 1 N/mm^2 = 4.733 N/mm^2$ PASS - Design shear stress is less than maximum shear stress

vc toe = 0.424 N/mm²

v_{toe} < v_{c_toe} - No shear reinforcement required

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

Material properties	
Characteristic strength of concrete	f _{cu} = 35 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 downstand	c _{ds} = 40 mm
Calculate shear for downstand design	

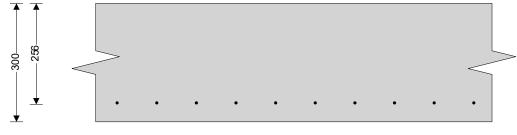
Total shear for downstand design

 $V_{down} = \gamma_{\underline{f}\underline{e}} \times K_p \times cos(\delta_b) \times \gamma_m \times d_{ds} \times (d_{cover} + t_{base} + d_{ds} / 2) = \textbf{37.1 kN/m}$

Calculate moment for downstand design

Total moment for downstand design

 $M_{down} = \gamma_{f_e} \times K_p \times cos(\delta_b) \times \gamma_m \times d_{ds} \times \left[(d_{cover} + t_{base}) \times (t_{base} + d_{ds}) + d_{ds} \times (t_{base} / 2 + 2 \times d_{ds} / 3) \right] / 2 = 14.7 \text{ kNm/m}$



↓100**→**

Check downstand in bending				
Width of downstand	b = 1000 mm/m			
Depth of reinforcement	$d_{down} = t_{ds} - c_{ds} - (\phi_{down} / 2) = 256.0 \text{ mm}$			
Constant	K_{down} = M_{down} / (b × d _{down} ² × f _{cu}) = 0.006			
	Compression reinforcement is not required			
Lever arm	z_{down} = Min(0.5 + $\sqrt{(0.25 - (min(K_{down}, 0.225) / 0.9)), 0.95)} \times d_{down}$			
	z _{down} = 243 mm			
Area of tension reinforcement required	$A_{s_down_des} = M_{down} / (0.87 \times f_y \times z_{down}) = 139 \text{ mm}^2/\text{m}$			
Minimum area of tension reinforcement	$A_{s_down_min} = k \times b \times t_{ds} = 390 \text{ mm}^2/\text{m}$			
Area of tension reinforcement required	As_down_req = Max(As_down_des, As_down_min) = 390 mm²/m			
Reinforcement provided	B503 mesh			
Area of reinforcement provided	A _{s_down_prov} = 503 mm ² /m			
PASS - F	Reinforcement provided at the retaining wall downstand is adequate			
Check shear resistance at downstand				
Design shear stress	$v_{down} = V_{down} / (b \times d_{down}) = 0.145 \text{ N/mm}^2$			
Allowable shear stress	v_{adm} = min(0.8 × $\sqrt{(f_{cu} / 1 N/mm^2)}$, 5) × 1 N/mm ² = 4.733 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_down} = 0.459 N/mm ²			
	<i>v</i> _{down} < <i>v</i> _{c_down} - No shear reinforcement required			
Design of reinforced concrete retaining wall stem (BS 8002:1994)				

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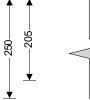
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Material properties	
Characteristic strength of concrete	f _{cu} = 35 N/mm ²
Characteristic strength of reinforcement	f _y = 500 N/mm ²
Wall details	
Minimum area of reinforcement	k = 0.13 %
Cover to reinforcement in stem	c _{stem} = 40 mm
Cover to reinforcement in wall	c _{wall} = 40 mm
Factored horizontal at-rest forces on stem	
Surcharge	$F_{s_sur_f} = \gamma_{f_l} \times K_0 \times Surcharge \times (h_{eff} - t_{base} - d_{ds})$
Moist backfill above water table	$F_{s_m_a_f} = 0.5 \times \gamma_{f_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{ds})$
Calculate shear for stem design	

Shear at base of stem

Calculate moment for stem design

Surcharge Moist backfill above water table Total moment for stem design



) = **4.2** kN/m h_{sat})² = 26.7 kN/m

 $V_{stem} = F_{s_sur_f} + F_{s_m_a_f} = 31 \text{ kN/m}$

 $M_{s_sur} = F_{s_sur_f} \times (h_{stem} + t_{base}) / 2 = 4.9 \text{ kNm/m}$ $M_{s_m_a} = F_{s_m_a_f} \times (2 \times h_{sat} + h_{eff} - d_{ds} + t_{base} / 2) / 3 = \textbf{21.8 kNm/m}$ $M_{stem} = M_{s_sur} + M_{s_m_a} = 26.7 \text{ kNm/m}$



_200____ -

Check wall stem in bending	
Width of wall stem	b = 1000 mm/m
Depth of reinforcement	$d_{stem} = t_{wall} - c_{stem} - (\phi_{stem} / 2) = 205.0 \text{ mm}$
Constant	$K_{stem} = M_{stem} / (b \times d_{stem}^2 \times f_{cu}) = 0.018$
	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} = 195 mm
Area of tension reinforcement required	$A_{s_stem_des} = M_{stem} / (0.87 \times f_y \times z_{stem}) = 315 \text{ mm}^2/\text{m}$
Minimum area of tension reinforcement	$A_{s_stem_min} = k \times b \times t_{wall} = 325 \text{ mm}^2/\text{m}$
Area of tension reinforcement required	A _{s_stem_req} = Max(A _{s_stem_des} , A _{s_stem_min}) = 325 mm ² /m
Reinforcement provided	A393 mesh
Area of reinforcement provided	A _{s_stem_prov} = 393 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 × d _{stem}) = 0.151 N/mm ²
Allowable shear stress	v_{adm} = min(0.8 × $\sqrt{(f_{cu} / 1 N/mm^2)}$, 5) × 1 N/mm ² = 4.733 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} = 0.482 N/mm ²

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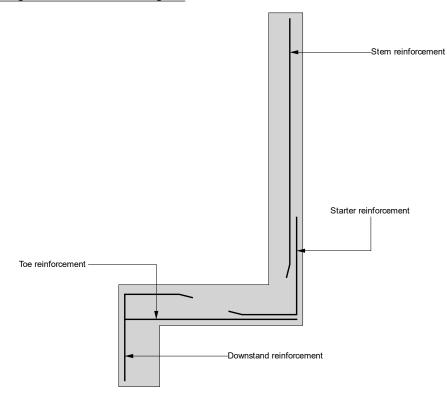
v_{stem} < v_{c_stem} - No shear reinforcement required

Check retaining wall defle	ection	
Basic span/effective depth	ratio	ratio _{bas} = 7
Design service stress		$f_s = 2 \times f_y \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = \textbf{275.9} \text{ N/mm}^2$
Modification factor	factor _{tens} = min(0.5	5 + (477 N/mm ² - f _s)/(120 × (0.9 N/mm ² + (M _{stem} /(b × d _{stem} ²)))),2) = 1.64
Maximum span/effective de	pth ratio	ratio _{max} = ratio _{bas} × factor _{tens} = 11.49
Actual span/effective depth	ratio	ratio _{act} = h _{stem} / d _{stem} = 9.76
		PASS - Span to depth ratio is acceptable

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Indicative retaining wall reinforcement diagram



Toe mesh - A393 - (393 mm²/m) Downstand mesh - B503 - (503 mm²/m) Stem mesh - A393 - (393 mm²/m)

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RETAINING WALL ANALYSIS (BS 8002:1994)

Wall details

Retaining wall type **Unpropped cantilever** Height of retaining wall stem h_{stem} = **2700** mm t_{wall} = **400** mm Thickness of wall stem I_{toe} = **300** mm Length of toe Length of heel I_{heel} = **1400** mm $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 2100 \text{ mm}$ Overall length of base t_{base} = **400** mm Thickness of base Depth of downstand $d_{ds} = 0 \text{ mm}$ Position of downstand I_{ds} = **0** mm t_{ds} = **400** mm Thickness of downstand $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3100 \text{ mm}$ Height of retaining wall d_{cover} = **300** mm Depth of cover in front of wall Depth of unplanned excavation d_{exc} = 300 mm $h_{water} = 0 mm$ Height of ground water behind wall Height of saturated fill above base $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 0 mm$ Density of wall construction ywall = 23.6 kN/m³ γ_{base} = 23.6 kN/m³ Density of base construction Angle of rear face of wall α = **90.0** deg Angle of soil surface behind wall $\beta = 0.0 \text{ deg}$ Effective height at virtual back of wall $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3100 \text{ mm}$

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TEDDS calculation version 1.2.01.06

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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	γs = 21.0 kN/m ³	
Design shear strength	∳' = 28.0 deg	
Angle of wall friction $\delta = 0.0$		
Base material details		
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 $P_{bearing} = 100 \text{ kN/m}^2$

Using Coulomb theory

Active pressure coefficient for retained material

 $\mathsf{K}_{\mathsf{a}} = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))}]^2) = \mathbf{0.361}$

Passive pressure coefficient for base material

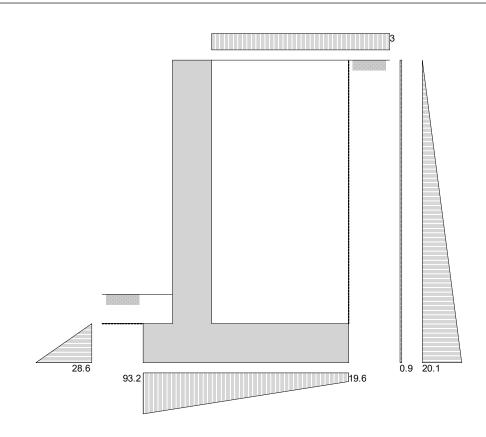
$$K_{p} = \sin(90 - \phi'_{b})^{2} / (\sin(90 - \delta_{b}) \times [1 - \sqrt{(\sin(\phi'_{b} + \delta_{b}) \times \sin(\phi'_{b})} / (\sin(90 + \delta_{b})))]^{2}) = 4.187$$

At-rest pressure

At-rest pressure for retained material	K₀ = 1 − sin(ϕ') = 0.531
Loading details	
Surcharge load on plan	Surcharge = 2.5 kN/m ²
Applied vertical dead load on wall	W _{dead} = 0.0 kN/m
Applied vertical live load on wall	W _{live} = 0.0 kN/m
Position of applied vertical load on wall	I _{load} = 0 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

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Loads shown in kN/m, pressures shown in kN/m 2

Vertical forces on wall	
Wall stem	$w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall} = 25.5 \text{ kN/m}$
Wall base	w_{base} = $I_{base} \times t_{base} \times \gamma_{base}$ = 19.8 kN/m
Surcharge	w _{sur} = Surcharge × I _{heel} = 3.5 kN/m
Moist backfill to top of wall	$w_{m_w} = I_{heel} \times (h_{stem} - h_{sat}) \times \gamma_m = 68 \text{ kN/m}$
Soil in front of wall	$w_p = I_{toe} \times d_{cover} \times \gamma_{mb} = 1.6 \text{ kN/m}$
Total vertical load	$W_{total} = W_{wall} + W_{base} + W_{sur} + W_{m_w} + W_p = 118.5 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	$F_{sur} = K_a \times Surcharge \times h_{eff} = 2.8 \text{ kN/m}$
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times \gamma_m \times (h_{eff} - h_{water})^2 = 31.2 \text{ kN/m}$
Total horizontal load	$F_{total} = F_{sur} + F_{m_a} = 34 \text{ kN/m}$
Calculate stability against sliding	
Passive resistance of soil in front of wall	$F_{p} = 0.5 \times K_{p} \times cos(\delta_{b}) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^{2} \times \gamma_{mb} = \textbf{5.7 kN/m}$
Resistance to sliding	$F_{res} = F_p + (W_{total} - w_{sur} - w_p) \times tan(\delta_b) = 43.9 \text{ kN/m}$
	PASS - Resistance force is greater than sliding force
Overturning moments	
Surcharge	M_{sur} = $F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 4.3 \text{ kNm/m}$
Moist backfill above water table	$M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 32.3 \text{ kNm/m}$
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} = 36.6 \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = \textbf{12.7 kNm/m}$
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Wall base	$M_{base} = w_{base} \times I_{base} / 2 = 20.8 \text{ kNm/m}$
Moist backfill	$M_{m_r} = (w_{m_w} \times (I_{base} - I_{heel} / 2) + w_{m_s} \times (I_{base} - I_{heel} / 3)) = 95.3 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{m_r} = 128.8 \text{ kNm/m}$
Check stability against overturning	
Total overturning moment	M _{ot} = 36.6 kNm/m
Total restoring moment	M _{rest} = 128.8 kNm/m
	PASS - Restoring moment is greater than overturning moment
Check bearing pressure	
Surcharge	$M_{sur_r} = w_{sur} \times (I_{base} - I_{heel} / 2) = 4.9 \text{ kNm/m}$
Soil in front of wall	$M_{p_r} = w_p \times I_{toe} / 2 = 0.2 \text{ kNm/m}$
Total moment for bearing	$M_{total} = M_{rest} - M_{ot} + M_{sur_r} + M_{p_r} = 97.4 \text{ kNm/m}$
Total vertical reaction	R = W _{total} = 118.5 kN/m
Distance to reaction	x _{bar} = M _{total} / R = 822 mm
Eccentricity of reaction	e = abs((I _{base} / 2) - x _{bar}) = 228 mm
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 93.2 \text{ kN/m}^2$
Bearing pressure at heel	p_{heel} = (R / I_{base}) - (6 × R × e / I_{base}^2) = 19.6 kN/m ²
PASS	- Maximum bearing pressure is less than allowable bearing pressure

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	David Smith Associates Structural & Civil Engineering Design & De	-	Project No:	20 / 41512	Sheet No:	36
DSA Party Wall CDM Structural Surveys Expert Witness Flood Risk Assessments Temporary Works Desi		-	Made by:	OAM	Revision:	
s for: RETAINING WALL RW4		Date:	04/02/2021	Checked by:	TG	
ect: 3 ARNHIL	LL ROAD, GRETTON					
RETAINING	WALL DESIGN (BS 8002:1994)				TEDDS calcu	lation version 1.2.01
Ultimate lim	nit state load factors					
Dead load fa	actor	$\gamma_{f_d} =$	1.4			
Live load fac	ctor	γ _{f_l} = 1	1.6			
Earth and wa	ater pressure factor	γ _{f_e} =	1.4			
Factored ve	ertical forces on wall					
Wall stem		W wall f	= $\gamma_{f d} \times h_{stem} \times t$		۸/m	
Wall base		-	. –	base × γbase = 27.8		
Surcharge				$ge \times I_{heel} = 5.6 \text{ kN}$		
-	ll to top of wall		. –	h _{stem} - h _{sat}) × γ _m =		
Soil in front	•		. – 、	$r \times \gamma_{mb} = 2.3 \text{ kN/r}$		
Total vertica			. –	e f + Wsur f + Wm w		kN/m
		•• total_				
	prizontal at-rest forces on wall			aharra h - C		
Surcharge		-		charge × h _{eff} = 6.6		
	ll above water table	$F_{m_a_f} = \gamma_{f_e} \times 0.5 \times K_0 \times \gamma_m \times (h_{eff} - h_{water})^2 = 64.2 \text{ kN/m}$				
Total horizor			$= F_{sur_f} + F_{m_a_f}$		it id d)2 - 9 kN
Passive resi	stance of soil in front of wall	⊢p_f =	γf_e × 0.5 × K _p >	$(\cos(\delta_b) \times (d_{cover}))$	+ Ibase + Ods - Oex	$(c)^2 \times \gamma_{mb} = 8 KN$
Factored ov	verturning moments					
Surcharge		Msur_f	= $F_{sur_f} \times (h_{eff} -$	$2 \times d_{ds}) / 2 = 10.2$	2 kNm/m	
Moist backfil	ll above water table	$M_{m_a_f} = F_{m_a_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = \textbf{66.4 kNm/m}$				
Total overtur	rning moment	M _{ot_f} =	= M _{sur_f} + M _{m_a_f}	= 76.6 kNm/m		
Restoring n	noments					
Wall stem		M _{wall_f}	= $W_{wall_f} \times (I_{toe} +$	• t _{wall} / 2) = 17.8 kl	Nm/m	
Wall base		M _{base} _	$f = W_{base_f} \times I_{base}$, / 2 = 29.1 kNm/r	n	
Surcharge		Msur_r_	_f = W _{sur_f} × (I _{base}	- I _{heel} / 2) = 7.8 kl	Nm/m	
Moist backfil	I		- •	e - I _{heel} / 2) + w _{m_s}		3)) = 133.4
kNm/m			•			
Soil in front	of wall	M _{p_r_f}	= $w_{p_f} \times I_{toe} / 2 =$	= 0.3 kNm/m		
Total restori	ng moment	M _{rest_f}	= M _{wall_f} + M _{base}	e_f + Msur_r_f + Mm_r	_f + M _{p_r_f} = 188	.5 kNm/m
Factored be	earing pressure					
	nt for bearing	M _{total} f	= M _{rest f} - M _{ot f}	= 111.9 kNm/m		
Total vertica	-		V _{total_f} = 166.6 k			
Distance to I			= M _{total_f} / R _f = 6			
Eccentricity	of reaction		 bs((I _{base} / 2) - x _b			
				-,	ts outside mia	ldle third of ba
Bearing pres	ssure at toe	p _{toe_f} =	= $R_f / (1.5 \times x_{bar})$	_f) = 165.2 kN/m ²		
Bearing pres	ssure at heel	Pheel_f	= 0 kN/m² = 0 k	kN/m²		
Rate of char	nge of base reaction	rate =	$p_{toe_f} / (3 \times x_{bar})$	_f) = 81.94 kN/m ² /	′m	
Bearing pres	ssure at stem / toe	Pstem_t	_{oe_f} = max(p _{toe_f}	- (rate \times I _{toe}), 0 kl	N/m²) = 140.6 kl	N/m ²
Bearing pres	ssure at mid stem	p _{stem} r	nid_f = max(p _{toe f}	$r - (rate \times (I_{toe} + t_{water}))$	all / 2)), 0 kN/m²)	= 124.2 kN/m ²
	ssure at stem / heel	-		$_{\rm f}$ - (rate × ($I_{\rm toe}$ + $t_{\rm w}$		
		-		-		

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DSA	Party Wall CDM Structural Surveys Expert Witness Reports Flood Risk Assessments Temporary Works Design	Made by:	OAM	Revision:	
Calcs for: RETAINING WALL RW4		Date:	04/02/2021	Checked by:	TG
Project: 3 ARNHILL ROAD, GRETTON					

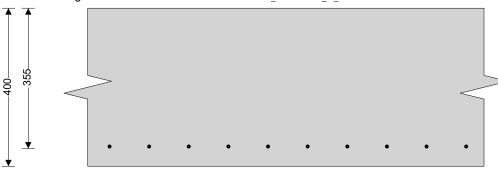
Material properties	
Characteristic strength of concrete	f _{cu} = 35 N/mm ²
Characteristic strength of reinforcement	f _y = 500 N/mm ²
Base details	
Minimum area of reinforcement	k = 0.13 %
Cover to reinforcement in toe	c _{toe} = 40 mm
Calculate shear for toe design	
Shear from bearing pressure	V_{toe_bear} = (p_{toe_f} + $p_{stem_toe_f}$) × I_{toe} / 2 =
Shear from weight of base	$V_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times I_{toe} \times t_{base} = \textbf{4}$
Total shear for toe design	$V_{toe} = V_{toe_bear} - V_{toe_wt_base} = 41.9 \text{ kN/m}$

Calculate moment for toe design

Moment from bearing pressure Moment from weight of base Total moment for toe design

= 45.9 kN/m **4** kN/m **41.9** kN/m V toe wt base

 $M_{toe_bear} = (2 \times p_{toe_f} + p_{stem_mid_f}) \times (I_{toe} + t_{wall} / 2)^2 / 6 = \textbf{18.9} \text{ kNm/m}$ $M_{toe_wt_base} = (\gamma_{f_d} \times \gamma_{base} \times t_{base} \times (I_{toe} + t_{wall} / 2)^2 / 2) = 1.7 \text{ kNm/m}$ $M_{toe} = M_{toe_bear} - M_{toe_wt_base} = 17.3 \text{ kNm/m}$



|--100-**--**

Check toe in bending	
Width of toe	b = 1000 mm/m
Depth of reinforcement	$d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2) = 355.0 \text{ mm}$
Constant	$K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu}) = 0.004$
	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} = 337 mm
Area of tension reinforcement required	$A_{s_toe_des}$ = M_{toe} / (0.87 × f _y × z _{toe}) = 118 mm ² /m
Minimum area of tension reinforcement	$A_{s_toe_min} = k \times b \times t_{base} = 520 \text{ mm}^2/\text{m}$
Area of tension reinforcement required	A _{s_toe_req} = Max(A _{s_toe_des} , A _{s_toe_min}) = 520 mm²/m
Reinforcement provided	B785 mesh
Area of reinforcement provided	A _{s_toe_prov} = 785 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 × d _{toe}) = 0.118 N/mm ²
Allowable shear stress	v_{adm} = min(0.8 × $\sqrt{(f_{cu} / 1 N/mm^2)}$, 5) × 1 N/mm ² = 4.733 N/mm ²
	PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

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		Made by:	OAM	Revision:	
Ics for: RETAINING WALL RW4		Date:	04/02/2021	Checked by:	TG
oject: 3 ARNHILL ROAD, GRETTON					
Design concrete shear stress	Vo. too	= 0.441 N/mm [:]	2		
	VC_loe	- 0.441 10/1111		o shear reinfor	cement require
Design of reinforced concrete retaining wall	heel (BS	3002:1994)			
Material properties		<u>,</u>			
Characteristic strength of concrete	f _{cu} = 3	5 N/mm ²			
Characteristic strength of reinforcement	f _y = 5	00 N/mm ²			
Base details					
Minimum area of reinforcement	k = 0 .	13 %			
Cover to reinforcement in heel	Cheel =	30 mm			
Calculate shear for heel design					
Shear from bearing pressure	Vheel_b	ear = p _{stem_heel_f}	\times ((3 \times x _{bar_f}) - I _{toe} \cdot	- t _{wall}) / 2 = 71 kl	N/m
Shear from weight of base	Vheel_v	νt_base = γf_d × γt	$_{\text{base}} \times \mathbf{I}_{\text{heel}} \times \mathbf{t}_{\text{base}} = 1$	8.5 kN/m	
Shear from weight of moist backfill	V _{heel_v}	_{vt_m} = w _{m_w_f} = 9	95.3 kN/m		
Shear from surcharge	Vheel_s	ur = W _{sur_f} = 5.6	kN/m		
Total shear for heel design	V _{heel} = - V _{heel_bear} + V _{heel_wt_base} + V _{heel_wt_m} + V _{heel_sur} = 48.4 kN/m				
Calculate moment for heel design					
Moment from bearing pressure	M _{heel_}	_{pear} = p _{stem_mid_f}	\times ((3 \times X _{bar_f}) - I _{toe} ·	$- t_{wall} / 2)^2 / 6 = 4$	7.6 kNm/m
Moment from weight of base			$\gamma_{ ext{base}} imes ext{t}_{ ext{base}} imes ext{(I_{ ext{heel}} + ext{})}$		
Moment from weight of moist backfill			(I _{heel} + t _{wall}) / 2 = 85		
Moment from surcharge $M_{heel_sur} = w_{sur_f} \times (I_{heel} + t_{wall}) / 2 = 5 kNm/m$					
5	-	= (

 $M_{heel} = -M_{heel_bear} + M_{heel_wt_base} + M_{heel_wt_m} + M_{heel_sur} = \textbf{60.1 kNm/m}$



Total moment for heel design

Check heel in bending				
Width of heel	b = 1000 mm/m			
Depth of reinforcement	$d_{\text{heel}} = t_{\text{base}} - c_{\text{heel}} - (\phi_{\text{heel}} / 2) = 365.0 \text{ mm}$			
Constant	$K_{heel} = M_{heel} / (b \times d_{heel}^2 \times f_{cu}) = 0.013$			
	Compression reinforcement is not required			
Lever arm	z_{heel} = min(0.5 + $\sqrt{(0.25 - (\text{min}(K_{\text{heel}}, 0.225) / 0.9)), 0.95) \times d_{\text{heel}}}$			
	z _{heel} = 347 mm			
Area of tension reinforcement required	$A_{s_heel_des}$ = M_{heel} / (0.87 × f_y × z_{heel}) = 398 mm ² /m			
Minimum area of tension reinforcement	$A_{s_heel_min}$ = k × b × t _{base} = 520 mm ² /m			
Area of tension reinforcement required	A _{s_heel_req} = Max(A _{s_heel_des} , A _{s_heel_min}) = 520 mm ² /m			
Reinforcement provided	B785 mesh			
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D S A	Structural & Civil Engineering Design & Detailing Party Wall CDM Structural Surveys Expert Witness Reports Flood Risk Assessments Temporary Works Design		Made by:	OAM	Revision:	
Ics for: RETAINING WALL RW4		Date:	04/02/2021	Checked by:	TG	
ect: 3 ARNH	ILL ROAD, GRETTON		1			
Area of rei	nforcement provided	A	_{1 prov} = 785 mm	² /m		
	norocinent provided	_		t provided at the	retaining wall	heel is adequa
Check she	ear resistance at heel					
Design she	ear stress	v _{heel} =	V_{heel} / (b × d _{he}	_{el}) = 0.133 N/mm ²		
Allowable	shear stress	v _{adm} =	min($0.8 \times \sqrt{f_c}$	u / 1 N/mm²), 5) ×	1 N/mm ² = 4.7 3	33 N/mm ²
		PA	ASS - Design a	shear stress is le	ss than maxin	num shear stre
From BS8	110:Part 1:1997 – Table 3.8					
Docian cor	ncrete shear stress	V _{c_heel}	= 0.433 N/mm	1 ²		
Design cor		v _{heel} < v _{c_heel} - No shear reinforcement require				
Design cor				Vheel < Vc_heel - N		cement requi
-	reinforced concrete retaining wa	ll stem (BS	8002:1994)	Vheel < Vc_heel - N	o shear reinior	cement requi
Design of	reinforced concrete retaining wa	ll stem (BS	<u>8002:1994)</u>	Vheel < Vc_heel - N	o shear rennor	cement requir
Design of Material p	roperties		8002:1994) 35 N/mm²	Vheel < Vc_heel - N	o snear rennor	cement requir
Design of Material pr Characteris		f _{cu} = 3		Vheel < Vc_heel - N	o shear rennor	cement requir
Design of Material pr Characteris	roperties stic strength of concrete stic strength of reinforcement	f _{cu} = 3	85 N/mm ²	Vheel < Vc_heel - N	o shear rennor	cement requir
Design of Material p Characteris Characteris Wall detail	roperties stic strength of concrete stic strength of reinforcement	f _{cu} = 3	85 N/mm² 00 N/mm²	Vheel < Vc_heel - N	o shear rennor	cement requir
Design of Material p Characteris Characteris Wall detail Minimum a	roperties stic strength of concrete stic strength of reinforcement Is	f _{cu} = 3 f _y = 50 k = 0.	85 N/mm² 00 N/mm²	Vheel < Vc_heel - N	o shear rennor	cement requir
Design of Material p Characteris Characteris Wall detail Minimum a Cover to re	roperties stic strength of concrete stic strength of reinforcement Is Irea of reinforcement	f _{cu} = 3 f _y = 50 k = 0. _{Cstem} =	35 N/mm² 00 N/mm² 13 %	Vheel < Vc_heel - N	o shear rennor	cement requir
Design of Material p Characteris Characteris Wall detail Minimum a Cover to re Cover to re	roperties stic strength of concrete stic strength of reinforcement Is urea of reinforcement sinforcement in stem	f _{cu} = 3 f _y = 50 k = 0. _{Cstem} =	85 N/mm² 00 N/mm² 13 % = 40 mm	Vheel < Vc_heel - N	o shear rennor	cement requir
Design of Material p Characteris Characteris Wall detail Minimum a Cover to re Cover to re	roperties stic strength of concrete stic strength of reinforcement Is urea of reinforcement einforcement in stem einforcement in wall	f _{cu} = 3 f _y = 50 k = 0. _{Cstem} = _{Cwall} =	85 N/mm ² 00 N/mm ² 13 % = 40 mm 40 mm	vheel < vc_heel - N		
Design of Material pu Characteris Characteris Wall detail Minimum a Cover to re Cover to re Cover to re Factored H Surcharge	roperties stic strength of concrete stic strength of reinforcement Is urea of reinforcement einforcement in stem einforcement in wall	f _{cu} = 3 f _y = 5(k = 0. _{Cstem} = _{Cwall} =	55 N/mm ² 00 N/mm ² 13 % = 40 mm 40 mm		_{base} - d _{ds}) = 5.7	kN/m
Design of Material p Characteris Characteris Wall detail Minimum a Cover to re Cover to re Factored h Surcharge Moist back	roperties stic strength of concrete stic strength of reinforcement Is urea of reinforcement einforcement in stem einforcement in wall norizontal at-rest forces on stem	f _{cu} = 3 f _y = 5(k = 0. _{Cstem} = _{Cwall} =	55 N/mm ² 00 N/mm ² 13 % = 40 mm 40 mm	_ urcharge × (h₅ff - t	_{base} - d _{ds}) = 5.7	kN/m
Design of Material p Characteris Characteris Wall detail Minimum a Cover to re Cover to re Factored I Surcharge Moist back Calculate	roperties stic strength of concrete stic strength of reinforcement Is urea of reinforcement sinforcement in stem sinforcement in wall norizontal at-rest forces on stem fill above water table	f _{cu} = 3 f _y = 50 k = 0. C _{stem} = C _{wall} = F _{s_sur_} a	35 N/mm ² 00 N/mm ² 13 % 40 mm 40 mm f = γ _{f_1} × K ₀ × S f = 0.5 × γ _{f_e} ×	_ urcharge × (h₅ff - t	_{base} - d _{ds}) = 5.7	kN/m
Design of Material p Characteris Characteris Wall detail Minimum a Cover to re Cover to re Factored H Surcharge Moist back Calculate Shear at ba	roperties stic strength of concrete stic strength of reinforcement Is urea of reinforcement sinforcement in stem sinforcement in wall norizontal at-rest forces on stem fill above water table shear for stem design	f _{cu} = 3 f _y = 50 k = 0. C _{stem} = C _{wall} = F _{s_sur_} a	35 N/mm ² 00 N/mm ² 13 % 40 mm 40 mm f = γ _{f_1} × K ₀ × S f = 0.5 × γ _{f_e} ×	urcharge × (h _{eff} - t _{ba} K ₀ × γ m × (h _{eff} - t _{ba}	_{base} - d _{ds}) = 5.7	kN/m
Design of Material p Characteris Characteris Wall detail Minimum a Cover to re Cover to re Factored H Surcharge Moist back Calculate Shear at ba	roperties stic strength of concrete stic strength of reinforcement Is urea of reinforcement sinforcement in stem sinforcement in wall norizontal at-rest forces on stem fill above water table shear for stem design ase of stem	f _{cu} = 3 f _y = 50 k = 0. C _{stem} = C _{wall} = F _{s_sur_} F _{s_m_a}	35 N/mm ² 10 N/mm ² 13 % = 40 mm 40 mm f = γ _{f_1} × K ₀ × S f = 0.5 × γ _{f_e} × = F _{s_sur_f} + F _{s_m}	urcharge × (h _{eff} - t _{ba} K ₀ × γ m × (h _{eff} - t _{ba}	_{base} - d _{ds}) = 5.7 _{ise} - d _{ds} - h _{sat}) ² =	kN/m
Design of Material p Characteris Characteris Wall detail Minimum a Cover to re Cover to re Factored H Surcharge Moist back Calculate Shear at ba Calculate Surcharge	roperties stic strength of concrete stic strength of reinforcement Is urea of reinforcement sinforcement in stem sinforcement in wall norizontal at-rest forces on stem fill above water table shear for stem design ase of stem	f _{cu} = 3 f _y = 5(k = 0. C _{stem} = C _{wall} = F _{s_sur_} F _{s_m_a} V _{stem} =	35 N/mm ² 13 % = 40 mm 40 mm f = γ _{f_1} × K ₀ × S f = 0.5 × γ _{f_e} × = F _{s_sur_f} + F _{s_m} = F _{s_sur_f} × (h _{st}	urcharge × (h _{eff} - t K ₀ × γ _m × (h _{eff} - t _{ba} a_f = 54.5 kN/m	_{base} - d _{ds}) = 5.7 _{ise} - d _{ds} - h _{sat}) ² = kNm/m	kN/m 48.7 kN/m



↓100**→**

Check wall stem in bending Width of wall stem

400-

Depth of reinforcement Constant
$$\label{eq:b} \begin{split} b &= \textbf{1000} \text{ mm/m} \\ d_{stem} &= t_{wall} - c_{stem} - (\varphi_{stem} / 2) = \textbf{355.0} \text{ mm} \\ K_{stem} &= M_{stem} / (b \times d_{stem}^2 \times f_{cu}) = \textbf{0.014} \end{split}$$

Compression reinforcement is not required

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DSA Party Wall CDM Structural Surveys Expert \	Structural & Civil Engineering Design & Detailing Party Wall CDM Structural Surveys Expert Witness Reports Flood Risk Assessments Temporary Works Design		OAM	Revision:		
alcs for: RETAINING WALL RW4		Date:	04/02/2021	Checked by:	TG	
roject: 3 ARNHILL ROAD, GRETTON		1				
Lever arm			.25 - (min(K _{stem} , 0	.225) / 0.9)),0.9	5) × d _{stem}	
	Zstem =	= 337 mm				
Area of tension reinforcement required		$A_{s_stem_des}$ = M_{stem} / (0.87 × f_y × z_{stem}) = 426 mm ² /m				
Minimum area of tension reinforcement As_ste		$A_{s_stem_min} = k \times b \times t_{wall} = 520 \text{ mm}^2/\text{m}$				
Area of tension reinforcement required	_{s_stem_req} = Max(A _{s_stem_des} , A _{s_stem_min}) = 520 mm²/m					
Reinforcement provided	B785	mesh				
Area of reinforcement provided	As_sten	1_prov = 785 mm	1 ² /m			
	PASS - R	einforcement	provided at the	retaining wall s	stem is adequat	
Check shear resistance at wall stem						
Design shear stress	Vstem =	= V _{stem} / (b × d _{st}	_{tem}) = 0.153 N/mm	2		
Allowable shear stress				33 N/mm ²		
			shear stress is le			
From BS8110:Part 1:1997 – Table 3.8						
Design concrete shear stress	Vc_stem	= 0.441 N/mm	1 ²			
-	_		Vstem < Vc_stem - No	o shear reinfor	rcement require	

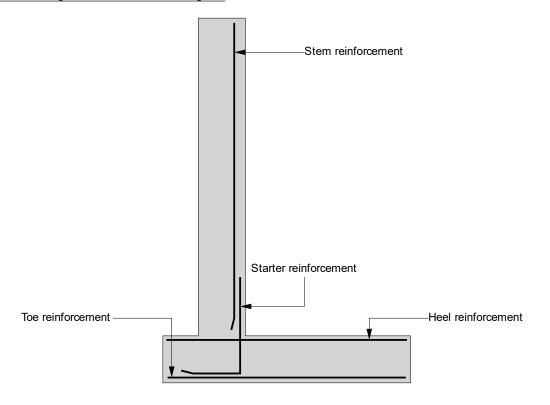
Basic span/effective depth ratioratio_bas = 7Design service stress $f_s = 2 \times f_y \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = 220.7 \text{ N/mm}^2$ Modification factorfactor_tens = min(0.55 + (477 N/mm^2 - f_s)/(120 \times (0.9 N/mm^2 + (M_{stem}/(b \times d_{stem}^2)))),2) = 2.00Maximum span/effective depth ratioratio_max = ratio_bas × factor_tens = 14.00Actual span/effective depth ratioratio_act = h_{stem} / d_{stem} = 7.61

Check retaining wall deflection

PASS - Span to depth ratio is acceptable

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Project: 3 ARNHILL ROAD, GRETTON					

Indicative retaining wall reinforcement diagram



Toe mesh - B785 - (785 mm²/m) Heel mesh - B785 - (785 mm²/m) Stem mesh - B785 - (785 mm²/m)

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