CampbellReith consulting engineers

38 Meadowbank

London

NW3 3AY

Basement Construction Methodology and Outline Sequence of Works

Project Number: 13065

November 2019

Campbell Reith Hill LLP Friars Bridge Court 41-45 Blackfriars Road London SE1 8NZ

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Document History and Status

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Structural • Civil • Environmental • Geotechnical • Transportation

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1.0 EXECUTIVE SUMMARY

- 1.1. The following report has been produced to show an indicative sequence of works for the construction of a new single storey basement at 38 Meadowbank, London, NW3 3AY. All sketches and information provided within this report are indicative and subject to change following detailed design.
- 1.2. The final Construction Sequence and Method Statements remain the responsibility of the Contractor. All temporary works design and stability of existing structures remain the responsibility of the Contractor during construction.
- 1.3. Although the party wall foundations were not fully exposed, probing suggests the party wall foundation between Nos. 37 and 38 Meadowbank extends to 50.28m AOD with the foundation between the site and No. 39 possibly extending to 48.40m AOD.
- Based on the ground investigation, the identified ground conditions and the existing formation level of No. 39, a reinforced concrete (RC) retaining wall is anticipated to be between Nos. 38 and 39 Meadowbank.
- 1.5. Once the site is set up for construction, it is advised that trial shafts are excavated to establish the existing foundation details as accurately as possible for the full site perimeter, including the rear garden masonry walls.
- 1.6. It is proposed that RC underpins are designed to support the footings of the existing building at basement level. The RC underpins are also designed to retain the soil behind the foundation. The underpins under the main house's footprint are designed to be propped top and bottom to prevent movement and also to provide an efficient and cost effective design in the permanent case. Similarly, the RC underpins in the rear garden between No. 37 & 38 and also the RC retaining wall supporting the main garden area/soil are designed as propped cantilevered walls in the permanent condition. The top of these RC walls are either directly connected to the ground floor slab or to a capping beam where sky lights are currently proposed, enabling them to transfer and distribute the horizontal force to the main RC box frame.
- 1.7. It is common during construction of underpinning that cosmetic damage will occur in the form of minor cracking of finishes in the building and its neighbours. As demonstrated in the Ground Movement Assessment (contained in the BIA), it would be expected that any damage observed during the construction underpinning would be no more than Category 1 as defined on the Burland Scale. It should be noted that the movement and damage predictions assume that the neighbouring properties are in good condition and that there is good control of workmanship throughout construction, with temporary and permanent propping.

2.0 OUTLINE SEQUENCE OF WORKS

- 2.1. Sketches to illustrate a suitable construction sequence below are included in Appendix 1. The proposed sequence is as follows:
 - Install temporary works to support floors and masonry walls above.
 - As part of the above temporary works, insure adequate horizontal bracings are installed to maintain the lateral stability of the building.
 - Demolish existing internal walls, ground to first.
 - Break out the existing RC slab at ground floor level and carefully cut back the existing footings as required.
 - Construct reinforced concrete underpinning of existing party walls to form basement wall. Carry out works in hit and miss, using a typical 1, 4, 2, 5, 3 underpinning sequence as per items below:
 - Underpinning to be carried out in maximum 1.0m sections in shaft excavations. It is anticipated that this is a single process.
 - Install trench sheeting, struts and walings as excavation proceeds for underpins in shafts.
 - Cast underpins in sections, dry pack on hardened concrete between new and existing foundations.
 - Continue the underpinning to the wall until all the underpinning is completed, underpins are to be back-propped with trench props and walings.
 - Allow for dewatering (by sump pumping) as necessary.
 - Carry out underpinning to party walls and to rear and front of the property as outlined above.
 - Construct RC wall/column thickening under steel column as part of underpinning outlined in the above items.
 - Lower the ground and install the upper row of temporary propping across the site.
 - Excavate the basement to near the bottom of the construction and install a second row of props.
 - Excavate to formation level and install drainage/sumps etc.
 - Pour central area of the basement slab incorporating drainage, sumps and chambers.
 - Remove bottom row of propping once the basement slab has gained sufficient strength.
 - Install new steel beams and columns of stability boxed between ground and 1st floor.
 - Cast the ground floor slab, incorporating concrete encased steel beams as part of ground floor slab construction.
 - Cast RC capping beam on top RC wall to rear garden where two large skylights proposed.

- Once the ground floor RC slab and capping beam has achieved sufficient strength, remove all temporary props.
- Re-support upper floor structure off new permanent works and remove temporary propping structure.
- Install waterproofing system as specified by Architect and the specialist subcontractor.
- Provide fire protection to steelworks to Architect's details and Building Control Officer's approval
- Construct non-load bearing walls/studs, insulation, stair, screeds and finishes.

3.0 WATER PROTECTION

3.1. All below ground water protection is to be to the Architect's details. The basement forms part of a dwelling and so it is anticipated this will be classed as Grade 3 in accordance with BS 8102:2009. The tanking system will be an internal drained cavity to the Architect's details.

4.0 LIMITATIONS ON MOVEMENT

- 4.1. Based on the available information and assumptions noted previously in this report, a ground movement assessment has been undertaken based on reasonably conservative assumptions. The ground movement assessment (reported separately) confirms that building damage can be limited to a maximum Burland Category 1 (very slight) damage for the neighbouring properties providing there is good control of workmanship.
- 4.2. Pre-condition surveys should be undertaken prior to any construction works taking place.

Appendix 1: Sketches







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C Campbell Reith Hill LLP 2012



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Notes :- 1. Only Status C drawings to be used for construction.

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1. Only Status C drawings to be used for construction. Notes :-2. Do not scale this drawing on print or electronically Remove escisting ground bearing slab Foundation (+ypical) 75 mm well vammed RC underpurnue as noted in Sequence of works m · construct wall column thickening under Steel columns as part of underfinner Install top temporary props as indicated Existing rear garden wall Top & bottom temporary props updated to architects revised 25. 11. 19 AP P2 Essued for BEA Submission 15.3.19 AP Pi Date By Status/Rev Descriptio cor MANCHESTER 0161 819 3060 LONDON 020 7340 1700 SURREY 01737 784 500 • BIRMINGHAM 01675 467 484 BRISTOL 0117 916 1066 . DUBAI 00 971 4345 7088 www.campbellreith.com Drg No. Status/Rev Job No. 13065 Info 13065/CS/01 © Campbell Reith Hill LLP 2012

Notes :- 1. Only Status C drawings to be used for construction. 2. Do not scale this drawing on print or electronically Dorain Cavity channel to be Formed once lower ground (12) with screed Floor reached XXXX 3 Install XX Sufficient Strength intermediate 3 Lower ground to prop Approx In above base level 1 construct lower ground Je . . . Floor including sunf & @ Remore intermediate 1AN champer. props once lower props are all installed. Existing) Whethere . RC way Arrangement as (10) Enstall cellcore. phase 6 peteril TBC Phase 3 Dowel shain on phase @ to manufacturer on site lower ground seperification Sheet 1 to Rc underpriving Enstall R.C ground Spech box Franc (15) Floor Install Steel 17 once ground Flour Frame box GeF (Beam & columns) Stab gained 1 UI XXX Not Shown Sufficient Strength Curefully break out here for clarity (13)vemore props and part of Grishing foundation all temporary works. ines so to allow 150 THK ANY N 14 upper part of NNNNN provide Re wall to provide KAX props support for RC to install updated to reflect Architects Phase (8) ground Floor. Phase 7 12 verised drawings 25.11.19 AP RC ground Essed for BEA Subuition 15.3.19 AP Fron Stab. PI Status/Rev Description Date By Job Title Note Cam 38 Meadowbank For vear garden RC wall, at phase 619 CO **Proposed Construction Sequence** once RC underpins gained sufficient LONDON 020 7340 1700 MANCHESTER 0161 819 3060 SURREY 01737 784 500 • BIRMINGHAM 01675 467 484 Sheet 2 DUBAI 00 971 4345 7088 BRISTOL 0117 916 1066 Strengthe remove all props. www.campbellreith.com C1 checked CAD filename drawn scale date Job No. totus/Rev Drg No. AP NTS 13065 15/03/2019 Info 13065/CS/02 A3 © Campbell Reith Hill LLP 2012

Appendix 2: Outline Calculations

Tekla Tedds	Project	Job no. 13065				
Campbell Reith Friars Bridge Court	Calcs for Front basement RC retaining wall				Start page no./Revision 1	
41-45 Blackfnars Road London SE1 8NZ	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved date

TEDDS calculation version 1.2.01.06

RETAINING WALL ANALYSIS (BS 8002:1994)



Wall details

Retaining wall type Height of retaining wall stem Thickness of wall stem Length of toe Length of heel Overall length of base Thickness of base Depth of downstand Position of downstand Thickness of downstand Height of retaining wall Depth of cover in front of wall Depth of unplanned excavation Height of ground water behind wall Height of saturated fill above base Density of wall construction Density of base construction Angle of rear face of wall Angle of soil surface behind wall Effective height at virtual back of wall **Retained material details**

Mobilisation factor Moist density of retained material

Itoe = 1000 mm $I_{heel} = 0 mm$ Ibase = Itoe + Iheel + twall = 1300 mm t_{base} = **400** mm $d_{ds} = \mathbf{0} mm$ Ids = 800 mm t_{ds} = **400** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3900 \text{ mm}$ $d_{cover} = 0 mm$ $d_{exc} = 0 mm$ hwater = 2750 mm hsat = max(hwater - tbase - dds, 0 mm) = 2350 mm γ wall = **23.6** kN/m³ $\gamma_{\text{base}} = 23.6 \text{ kN/m}^3$ α = **90.0** deg _β = **0.0** deg $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3900 \text{ mm}$

Cantilever propped at both

hstem = 3500 mm

twall = 300 mm

M = **1.5** _{γm} = **19.0** kN/m³

	Project				Job no.	
		13	065			
Campbell Reith	Calcs for			Start page no./Revision		
Friars Bridge Court		Front basement	RC retaining v	2		
41-45 Blackfriars Road	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	AP	14/03/2019				
				·		
Saturated density of retained m	aterial	_γ s = 21.5 ki	N/m ³			
Design shear strength		ϕ' = 25.8 de	eg			
Angle of wall friction		_δ = 19.9 de	g			
Base material details						
Firm clay						
Moist density		γ ^{mb} = 18.0	kN/m³			
Design shear strength		₀'ь = 22.6 d	leg			
Design base friction		δ ^b = 17.3 de	eg			
Allowable bearing pressure		Pbearing = 13	35 kN/m ²			
Using Coulomb theory						
Active pressure coefficient for re	etained material					
$K_a = \sin(\alpha)$	+ _φ ') ² / (sin(_α) ² ×	$sin(\alpha - \delta) \times [1 +$	· √(sin(ሐ' + გ) ×	sin(a' - B) / (sin(a))	$(\alpha + \delta) \times \sin(\alpha + \delta)$	_β)))] ²) = 0.347
Passive pressure coefficient for	base material		τι ψ υ Α	φp (u		p/// 1 /
	$K_{P} = sin(90)$) - _φ ' _b)² / (sin(90	- δ⊳) × [1 - √(s	$in(_{\phi}'_{b} + \delta_{b}) \times sin(_{\phi}$	'₅) / (sin(90 + გ	(jb)))] ²) = 3.690
At-rest pressure	•	φ, , , , , , , , , , , , , , , , , , ,		φ ο / φ		
At-rest pressure for retained ma	iterial	$K_0 = 1 - sir$	$h(x^{\prime}) = 0.565$			
	lional		(φ) = 0.000			
Loading details		Surabarga	$\mathbf{E} \mathbf{O} \mathbf{k} \mathbf{N} \mathbf{k}^2$			
Applied vertical dead lead on w			= 5.0 KIN/III			
Applied vertical live load on wa	an I	VV dead = 12.				
Position of applied vertical load	on wall	lugg - 1150	mm			
Applied horizontal dead load on	wall	$F_{dead} = 0.0$	kN/m			
Applied horizontal live load on v	vall	Flive = 0.0 k	N/m			
Height of applied horizontal load	d on wall	$h_{load} = 0 mr$	n			
o		17				
		Prop -				
				A		
	25.4		1.6 7.1 10.5	5 27.0		
	41.6	41.6	J			
				l oodo obcurr	in kN/m process	e chown in kN/m?
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Tekla	Project	Job no. 13065				
Campbell Reith Friars Bridge Court 41-45 Blackfriars Road London SE1 8NZ	Calcs for Since Si				Start page no./Revision 3	
	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved date

Vertical forces on wall	
Wall stem	Wwall = hstem \times twall $\times \gamma$ wall = 24.8 kN/m
Wall base	Wbase = Ibase \times tbase $\times \gamma$ base = 12.3 kN/m
Applied vertical load	$W_v = W_{dead} + W_{live} = 17 \text{ kN/m}$
Total vertical load	$W_{total} = W_{wall} + W_{base} + W_v = 54.1 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	F_{sur} = K _{a ×} cos(90 - $_{\alpha}$ + $_{\delta}$) × Surcharge × h _{eff} = 6.4 kN/m
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma^m \times (h_{eff} - h_{water})^2 = 4.1 \text{ kN/m}$
Moist backfill below water table	$F_{m_b} = K_a \times cos(90 - \alpha + \delta) \times \gamma^m \times (h_{eff} - h_{water}) \times h_{water} = 19.6 \text{ kN/m}$
Saturated backfill	$F_{s} = 0.5 \times K_{a} \times cos(90 - \alpha + \delta) \times (\gamma^{s-} \gamma^{water}) \times h_{water}^{2} = 14.4 \text{ kN/m}$
Water	$F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water} = 37.1 \text{ kN/m}$
Total horizontal load	$F_{total} = F_{sur} + F_{m_a} + F_{m_b} + F_s + F_{water} = 81.6 \text{ kN/m}$
Calculate total propping force	
Passive resistance of soil in front of wall	$F_{\text{P}} = 0.5 \times K_{\text{P}} \times \text{cos}(\delta^{\text{b}}) \times (\text{d}_{\text{cover}} + \text{t}_{\text{base}} + \text{d}_{\text{ds}} - \text{d}_{\text{exc}})^2 \times \gamma^{\text{mb}} = \textbf{5.1 kN/m}$
Propping force	$F_{prop} = max(F_{total} - F_{p} - (W_{total} - W_{live}) \times tan(_{\delta^{b}}), 0 \text{ kN/m})$
	F _{prop} = 61.3 kN/m
Overturning moments	
Surcharge	M_{sur} = $F_{sur \times}$ (heff - 2 $_{\times}$ dds) / 2 = 12.4 kNm/m
Moist backfill above water table	$M_{m_a} = F_{m_a \times} (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 12.9 \text{ kNm/m}$
Moist backfill below water table	$M_{m_b} = F_{m_b \times} (h_{water} - 2 \times d_{ds}) / 2 = 27 \text{ kNm/m}$
Saturated backfill	M_s = F _{s ×} (h _{water} - 3 × d _{ds}) / 3 = 13.2 kNm/m
Water	$M_{water} = F_{water \times} (h_{water} - 3 \times d_{ds}) / 3 = 34 \text{ kNm/m}$
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 99.5 \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{wall} = W_{wall} \times (I_{toe} + t_{wall} / 2) = 28.5 \text{ kNm/m}$
Wall base	$M_{\text{base}} = w_{\text{base}} \times I_{\text{base}} / 2 = 8 \text{ kNm/m}$
Design vertical dead load	$M_{dead} = W_{dead} \times I_{load} = 13.8 \text{ kNm/m}$
Total restoring moment	Mrest = Mwall + Mbase + Mdead = 50.3 kNm/m
Check bearing pressure	
Total vertical reaction	R = W _{total} = 54.1 kN/m
Distance to reaction	x _{bar} = I _{base} / 2 = 650 mm
Eccentricity of reaction	$e = abs((l_{base} / 2) - x_{bar}) = 0 mm$
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) = 41.6 \text{ kN/m}^2$
Bearing pressure at heel	Pheel = $(K \mid \text{lbase}) + (6 \times K \times e \mid \text{lbase}^2) = 41.6 \text{ kN/m}^2$
PASS	- waximum bearing pressure is less than allowable bearing pressure
Calculate propping forces to top and base of v	vall

Propping force to top of wall

 $F_{prop_top} = (M_{ot} - M_{rest} + R_{\times} |_{base} / 2 - F_{prop_{\times}} t_{base} / 2) / (h_{stem} + t_{base} / 2) = 19.483 \text{ kN/m}$ $II \qquad F_{prop_base} = F_{prop} - F_{prop_top} = 41.783 \text{ kN/m}$

Propping force to base of wall

	Project	38 Mea	JOD NO.	3065			
Campbell Reith			Start page no./Revision				
Friars Bridge Court	Front basement RC retaining wall				4		
41-45 Blackfriars Road London SE1 8NZ	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved da	
RETAINING WALL DESIGN	I (BS 8002:1994)	<u></u>					
Ultimate limit state load fa	ctors				TEDDS calculatio	n version 1.2.01	
Dead load factor		wf d = 1.4					
Live load factor		γ⊑u = 1.4					
Earth and water pressure fac	ctor	γ <u>–</u> –e					
Eactored vertical forces or	wall	<i>Y</i>					
Wall stem	i wali		hatam turall	$-34.7 \mathrm{kN/r}$	m		
Wall base		Wwall_i = γ_{i} _u	\times instern \times twair \times	γ wall = 34.7 KN/7	l/m		
Applied vertical load		$vvbase_r = \gamma t_{-}$	$_{\times}$ W dead + $_{\times}$ for the set of the s	$W_{\text{live}} = 21 \text{ g kN/}$	m		
Total vertical load		$v v v_{-1} = \gamma t_{-1} d y$ W total f = Ww	_K vvueau ⊤γr_iX /all f + Wbase f + \	$W_{v f} = 76.7 \text{ kN/m}$	n		
Eastard harizantal active	forcos on well			····	•		
	TOICES ON Wall	E	K. 000(00	(a) Curata	rao h) kNI/~	
Surcharge	hla	$\Gamma \operatorname{sur}_{f} = \gamma f_{I}$	$\langle Na \times COS(90 - 0) \rangle$	$\alpha + \delta$ × Surchai	(h h h	2 E 7 LN1/	
Moist backfill below water ta	ble	$F_{m_a} = \gamma f_e \times 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times \gamma^m \times (heff - hwater)^2 = 5.7 \text{ kN/m}$					
kN/m	DIE	$Fm_b_f = \gamma f_e$	$_{\rm X}$ Ka $_{\rm X}$ COS(90	$-\alpha + \delta \times \gamma^m \times (r)$	Neff - Nwater) _X Nwa	ater = 27.5	
Saturated backfill		$F_{s_f} = \gamma_{f_e} \times$	$0.5 \times K_a \times cos$	$(90 - \alpha + \delta) \times (\gamma^{s})$	- γ water) \times hwater ²	= 20.2 kN/r	
Water		$F_{water_f} = \gamma_{f_e} \times 0.5 \times h_{water}^2 \times \gamma_{water} = 51.9 \text{ kN/m}$					
Total horizontal load		F _{total_f} = F _{su}	r_f + Fm_a_f + Fm	_b_f + Fs_f + Fwate	r_f = 115.5 kN/n	n	
Calculate total propping for	orce						
Passive resistance of soil in $\ensuremath{kN/m}$	front of wall	$F_{p_f} = \gamma_{f_e} \times$	$0.5 \times K_{P \times} \cos$	$(\delta^{b}) \times (d_{cover} + t_{ba})$	ase + dds - dexc) ²	$\times \gamma^{mb} = 7.1$	
Propping force		F _{prop_f} = ma	x(Ftotal_f - Fp_f -	(Wtotal_f - $\gamma f_l \times W$	/live) $_{ imes}$ tan($_{\delta^{\mathrm{b}}}$), C) kN/m)	
		Fprop_f = 87 .	0 kN/m	1			
Factored overturning mom	ents						
Surcharge		Msur f = Fsur	f_{\times} (heff - 2 $_{\times}$ C	d _{ds}) / 2 = 19.9 kN	lm/m		
Moist backfill above water ta	ble	Mm a f = Fm	af _x (heff + 2 _x	hwater - 3 × dds) /	/ 3 = 18 kNm/m		
Moist backfill below water ta	ble	 Mm b f = Fm	b f _× (hwater - 2	√ dds) / 2 = 37.8	kNm/m		
Saturated backfill		$M_{s f} = F_{s f}$	(hwater - 3 v dd	s) / 3 = 18.5 kNn	n/m		
Water		Mwater f = Fv	vater_f × (hwater - :	3 _× d _{ds}) / 3 = 47.	6 kNm/m		
Total overturning moment		$M_{ot_f} = M_{sur_f} + M_{m_a_f} + M_{m_b_f} + M_{s_f} + M_{water_f} = 141.8 \text{ kNm/m}$					
Restoring moments							
Wall stem		Mwall f = Wwa	all_f × (Itoe + twall /	/ 2) = 39.9 kNm/	'n		
Wall base		$M_{base f} = W_{f}$	$ase_f \times base / 2 =$	= 11.2 kNm/m			
Design vertical load	$M_{v_f} = W_{v_f} \times I_{load} = 28.5 \text{ kNm/m}$						
Total restoring moment		Mrest_f = Mw	all_f + Mbase_f + N	Mv_f = 79.6 kNm/	'n		
Factored bearing pressure	9						
Total vertical reaction		Rf = Wtotal f	= 76.7 kN/m				
Distance to reaction		Xbar_f = Ibase	/ 2 = 650 mm				
Eccentricity of reaction		$e_f = abs((I_b)$	ase / 2) - Xbar_f) =	= 0 mm			
				Reaction acts	s within middle	e third of ba	
Bearing pressure at toe		$p_{toe_f} = (R_f / $	Ibase) - (6 $_{\times}$ Rf	\times ef / Ibase ²) = 59	kN/m ²		
Bearing pressure at heel		pheel_f = (Rf	/ Ibase) + (6 $_{ imes}$ R	$f_{\rm X}$ ef / $f_{\rm base}^2$) = 59	9 kN/m²		
Rate of change of base read	tion	rate = (ptoe	_f - p heel_f) / Ibase	= 0.00 kN/m ² /m			

Tekla	Project	38 Mea	dowbank	Job no. 13065			
Campbell Reith	Calcs for	Fronthosomout		Start page no./Revision			
41-45 Blackfriars Road		Front basement RC retaining wall			5		
London SE1 8NZ	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved date	
Bearing pressure at stem / toe		Pstem_toe_f =	max(ptoe_f - (ra	te $_{\times}$ Itoe), 0 kN/m ²)	= 59 kN/m ²		
Bearing pressure at mid stem		Pstem_mid_f =	max(ptoe_f - (ra	$te \times (l_{toe} + t_{wall} / 2))$), 0 kN/m²) = 5	9 kN/m²	
Bearing pressure at stem / heel		Pstem_heel_f =	max(ptoe_f - (ra	ate $_{\times}$ (Itoe + twall)), 0	kN/m²) = 59 k	xN/m ²	
Calculate propping forces to t Propping force to top of wall	op and base o	of wall					
	Fprop_top_f =	(Mot_f - Mrest_f + Rf	$_{\rm X}$ Ibase / 2 - Fpr	$_{ m op_f} \times { m t}_{ m base}$ / 2) / (hs	tem + $t_{base} / 2) =$	25.568 kN/m	
Propping force to base of wall		Fprop_base_f =	Fprop_f - Fprop_t	_{op_f} = 61.479 kN/m	I		
Design of reinforced concrete	retaining wal	I toe (BS 8002:1	994)				
Material properties							
Characteristic strength of concre	ete	fcu = 30 N/n	nm²				
Characteristic strength of reinfo	rcement	$f_v = 500 \text{ N/r}$	mm²				
Base details							
Minimum area of reinforcement		k = 0.13 %					
Cover to reinforcement in toe		Ctoe = 50 mi	m				
Calculate shear for toe design	1						
Shear from bearing pressure		V _{toe} bear = (r	Dtoe f + Dstem toe	f) × Itoe / 2 = 59 kN	l/m		
Shear from weight of base		Vtoe wt base =	Vtoe wt base = $\sqrt{f} d = \sqrt{b}$ kbase v base = 13.2 kN/m				
Total shear for toe design		V _{toe} = V _{toe_b}	ear - Vtoe_wt_base	= 45.8 kN/m			
Calculate moment for toe des	ian						
Moment from bearing pressure	5	M _{toe_bear} = (2	2 × ptoe_f + pster	m_mid_f) \times (Itoe + twall	/ 2) ² / 6 = 39 k	Nm/m	
Moment from weight of base		Mtoe_wt_base =	= $(_{\gamma}f_d \times _{\gamma}base \times$	tbase × (Itoe + twall / 2	2) ² /2) = 8.7 k	Nm/m	
Total moment for toe design		Mtoe = Mtoe_	bear - Mtoe_wt_bas	e = 30.3 kNm/m			
▲ 4 00 3 42 ●	• •	•	•	• •	•		
	← 150 →						
Check toe in bending							
Width of toe		b = 1000 m	ım/m				
Depth of reinforcement		d _{toe} = t _{base} -	$- c_{toe} - (\phi_{toe} / 2)$	= 342.0 mm			
Constant		$K_{toe} = M_{toe} /$	$(b \times d_{toe}^2 \times f_{cu})$) = 0.009			
l over erm						not required	
		∠toe = MIN(0 7toe = 325 n	nm + √(0.25 - (111111(Ntoe, U.225) / (ງ.ອງງ,ບ.ອວ) _× dt	oe	
Area of tension reinforcement re	auired	$A_{s \text{ top des}} = 1$	 M _{toe} / (0.87 ∪ f.	$(\sim Z_{\text{toe}}) = 214 \text{ mm}^2$	²/m		
Minimum area of tension reinfor	cement	As toe min = I	$\mathbf{k} = \mathbf{b} - \mathbf{b}$	520 mm ² /m	,		
Area of tension reinforcement re	quired	As_toe_req = N	Max(As_toe_des, A	As_toe_min) = 520 mi	m²/m		
			, _ ,	,			

Teka	Project			Job no.			
Tedds		38 Mea	38 Meadowbank			13065	
Campbell Reith	Calcs for					Start page no./Revision	
Friars Bridge Court		Front basement	nt basement RC retaining wall			6	
41-45 Blacktriars Road	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date	
	AP	14/03/2019					
		40 mm dia	hara @ 450 m				
Area of reinforcement provided			.bars @ 150 m 1340 mm ² /m	in centres			
Area of remorcement provided		As_toe_prov =	forcement pro	wided at the ret	aining wall to	e is adequate	
		1 A00 - Nem	iorcement pro		anning wan to	e is adequate	
	9			A NI/			
Design snear stress		Vtoe = Vtoe /	$(D \times Ote) = 0.13$	34 N/mm ²	2 4 9 9 9 1		
Allowable shear stress		Vadm = MIN(0.8 _× √(tcu / 1 N Decian chocr	(mm^2) , 5) \times 1 N/i	mm² = 4.382 N	/mm²	
From BS9440, Dort 4,4007 T	ahla 2 0	PA55 -	Design snear	stress is less ti	nan maximum	snear stress	
Profil B36110:Part 1:1997 – 1	able 3.0	$V_{0} = 0.51$	1 N/mm ²				
Design concrete shear stress		Vc_toe - 0.3	Vto	< Va too - No sh	ear reinforcer	nent required	
						ione i oquii ou	
Design of reinforced concrete	e retaining wa	all stem (BS 8002	:1994 <u>)</u>				
Material properties							
Characteristic strength of conci	ete	f _{cu} = 30 N/n	nm²				
Characteristic strength of reinfo	orcement	f _y = 500 N/r	nm²				
Wall details							
Minimum area of reinforcement		k = 0.13 %					
Cover to reinforcement in stem		Cstem = 100	mm				
Cover to reinforcement in wall		Cwall = 50 M	m				
Factored horizontal active for	rces on stem						
Surcharge		$F_{s_sur_f} = \gamma^{f_}$	$_{\rm X}$ K _{a X} cos(90	- $_{\alpha}$ + $_{\delta}$) $_{\times}$ Surcha	rge_{\times} (heff - tbas	e - d _{ds}) = 9.1	
kN/m							
Moist backfill above water table		$F_{s_m_a_f} = 0$	$5 \times \gamma^{f_e} \times K_a \times K_a$	$\cos(90 - \alpha + \delta) \times$	$\gamma^{m} \times$ (heff - tbase	- dds - hsat) ² =	
5.7 kN/m							
Moist backfill below water table		$F_{s_m_b_f} = \gamma_f$	$_{e} \times K_{a} \times \cos(90)$	$(0 - \alpha + \delta) \times \gamma^m \times (0)$	heff - tbase - dds -	hsat) _× hsat =	
23.5 kN/m							
Saturated backfill		$F_{s_s_f} = 0.5$	$\times \gamma f_e \times Ka \times CO$	$s(90 - \alpha + \delta) \times (\gamma)$	s - γwater) _× hsat ² :	= 14.8 kN/m	
Water		$F_{s_water_f} = C$	$0.5 \times \gamma^{f_e} \times \gamma^{water}$	× h _{sat} ² = 37.9 kN	l/m		
Calculate shear for stem des	gn						
Surcharge		$V_{s_sur_f} = 5$	$_{\rm K} {\rm Fs}_{\rm sur_f} / 8 = 5.$. 7 kN/m			
Moist backfill above water table		$V_{s_m_a_f} = F$	$s_m_a_f \times b_1 \times ((5$	$_{\times}$ L²) - bı²) / (5 $_{\times}$	L ³) = 1.8 kN/m		
Moist backfill below water table		$V_{s_m_b_f} = F$	s_m_b_f × (8 - (n ²	× (4 - n))) / 8 = 1	1 8.9 kN/m		
Saturated backfill		$V_{s_s_f} = F_{s_s}$	$_{_{f} \times}$ (1 - (a $^{2} \times$ ((5 _× L) - aı) / (20 _{>}	< L³))) = 13.2 k	N/m	
Water		$V_{s_water_f} = F$	s_water_f _× (1 - (a	$u^2 \times ((5 \times L) - a))$	/ (20 _× L ³))) = 3	4 kN/m	
Total shear for stem design		V _{stem} = V _{s_s}	ur_f + Vs_m_a_f + '	Vs_m_b_f + Vs_s_f +	Vs_water_f = 73.6	6 kN/m	
Calculate moment for stem d	esign						
Surcharge		$Ms_sur = Fs_s$	sur_f × L / 8 = 4.2	2 kNm/m			
Moist backfill above water table		Ms_m_a = Fs	_m_a_f _× bi _× ((5 _{>}	_× L ²) - (3 _× bi ²)) /	$(15 \times L^2) = 2.1$	kNm/m	
Moist backfill below water table		$M_{s_m_b} = F_{s_b}$	_m_b_f _× al _× (2 -	n) ² / 8 = 12.9 kN	m/m		
Saturated backfill		Ms_s = Fs_s_	$_{\rm f}$ $_{\rm X}$ al $_{\rm X}$ ((3 $_{\rm X}$ al ²)-(1	$5_{\times}a_{\times}L)+(20_{\times}L^2)$	/(60 _× L²) = 7 kľ	Nm/m	
Water		Ms_water = Fs	s_water_f _× al _× ((3×	aı²)-(15 _× aı _× L)+(2	$0_{\times}L^{2}))/(60_{\times}L^{2})$	= 17.9	
kNm/m					/		
Total moment for stem design		Mstem = Ms_s	sur + Ms_m_a + M	s_m_b + Ms_s + Ms	_water = 44 kNm	/m	
Calculate moment for wall de	sign						
Surcharge	5	M _{w_sur} = 9 √	Fs_sur_f _× L / 12	28 = 2.4 kNm/m			
0			^ - · · -				



Teka	Project				Job no.	
Tedds		13065				
Campbell Reith Friars Bridge Court	Calcs for Front basement RC retaining wall			Start page no./Revision 8		
41-45 Blackfriars Road London SE1 8NZ	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved date

Lever arm		zwall = Min(0.5 + $\sqrt{(0.25 - (min(K_{wall}, 0.225) / 0.9)), 0.95)} \times d_{wall}$
		Zwall = 232 mm
Area of tension reinforcement	t required	$A_{s_wall_des} = M_{wall} / (0.87 \times f_y \times z_{wall}) = \textbf{200} \text{ mm}^2/\text{m}$
Minimum area of tension rein	forcement	$A_{s_wall_min} = k \times b \times t_{wall} = 390 \text{ mm}^2/\text{m}$
Area of tension reinforcement	t required	$A_{s_wall_req} = Max(A_{s_wall_des}, A_{s_wall_min}) = 390 \text{ mm}^2/\text{m}$
Reinforcement provided		12 mm dia.bars @ 150 mm centres
Area of reinforcement provide	ed	As_wall_prov = 754 mm ² /m
	PASS - Re	inforcement provided to the retaining wall at mid height is adequate
Check retaining wall deflect	tion	
Basic span/effective depth rate	tio	ratiObas = 20
Design service stress		$f_{s} = 2 \times f_{y} \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = 137.8 \text{ N/mm}^{2}$
Modification factor	factortens = min(0.5	5 + (477 N/mm ² - fs)/(120 $_{\times}$ (0.9 N/mm ² + (M _{stem} /(b $_{\times}$ d _{stem} ²)))),2) = 1.90

 $ratio_{max} = ratio_{bas} \times factor_{tens} = 38.01$

ratio_{act} = h_{stem} / d_{stem} = **18.23**

Maximum span/effective depth ratio

Actual span/effective depth ratio

PASS - Span to depth ratio is acceptable



Stem bars - 16 mm dia.@ 150 mm centres - (1340 mm²/m)

두 Tekla	Project	20 Maa	dev de en la		Job no.	b no. 13065 art page no./Revision 1 Provod by
Tedds		38 Mea	dowbank		1.	3065
Campbell Reith	Calcs for				Start page no./	Revision
Friars Bridge Court	RC	retaining wall for	party wall No.	37 & 38		1
41-45 Diackinars Road	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved date

TEDDS calculation version 1.2.01.06

RETAINING WALL ANALYSIS (BS 8002:1994)



Wall details

Retaining wall type Height of retaining wall stem Thickness of wall stem Length of toe Length of heel Overall length of base Thickness of base Depth of downstand Position of downstand Thickness of downstand Height of retaining wall Depth of cover in front of wall Depth of unplanned excavation Height of ground water behind wall Height of saturated fill above base Density of wall construction Density of base construction Angle of rear face of wall Angle of soil surface behind wall Effective height at virtual back of wall **Retained material details** Mobilisation factor

Moist density of retained material

Cantilever propped at both hstem = 3500 mm twall = 370 mm Itoe = 1030 mm $I_{heel} = 0 mm$ $I_{base} = I_{toe} + I_{heel} + I_{wall} = 1400 \text{ mm}$ t_{base} = **400** mm $d_{ds} = 0 mm$ Ids = 800 mm tds = **400** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3900 \text{ mm}$ $d_{cover} = 0 mm$ $d_{exc} = \mathbf{0} mm$ hwater = 2750 mm $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 2350 mm$ γ wall = 23.6 kN/m³ $\gamma base = 23.6 \text{ kN/m}^3$ α = **90.0** deg _β = **0.0** deg $h_{eff} = h_{wall} + l_{heel} \times tan(\beta) = 3900 \text{ mm}$ M = 1.5

 $\gamma^{m} = 19.0 \text{ kN/m}^{3}$

Tekla	Project	38 Mea	dowbank		Job no. 130	065
Campbell Reith	Calcs for				Start page no./Re	evision
Friars Bridge Court 41-45 Blackfriars Road	RC re	etaining wall for	party wall No. 3	37 & 38		2
London SE1 8NZ	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved date
				1		
Saturated density of retained m	aterial	γs = 21.5 ki	N/m ³			
Design shear strength		$_{ m \varphi}$ ' = 25.8 de	ġ			
Angle of wall friction		δ = 19.9 de	g			
Base material details						
Firm clay						
Moist density		γ ^{mb} = 18.0 k	⟨N/m³			
Design shear strength		_φ '₅ = 22.6 d	eg			
Design base friction		δ⊧ = 17.3 de	eg			
Allowable bearing pressure		Pbearing = 13	5 kN/m ²			
Using Coulomb theory						
Active pressure coefficient for re	etained material					
$K_a = sin(_{\alpha}$ Passive pressure coefficient for	+ $_{\phi}')^2$ / (sin($_{\Omega})^2$ × base material	$\sin(\alpha - \delta) \times [1 +$	$\sqrt{(\sin(\phi' + \delta))}$	$\sin(_{\phi}'{\beta}) / (\sin(_{\alpha}$	$(\alpha + \beta) \times \sin(\alpha + \beta)$	₃)))] ²) = 0.347
	$K_p = sin(90)$	- _{(b} 'b) ² / (sin(90	- $_{\delta^b}$) $_{\times}$ [1 - $_{\sqrt{si}}$	$n(_{\phi}'_{b} + \delta_{b}) \times sin(_{\phi}'$	b) / (sin(90 + $_{\delta}$	b)))] ²) = 3.690
At-rest pressure						
At-rest pressure for retained ma	aterial	$K_0 = 1 - sir$	n(_φ ') = 0.565			
Loading details						
Surcharge load on plan		Surcharge	= 2.5 kN/m ²			
Applied vertical dead load on wa	all	Wdead = 98.	0 kN/m			
Applied vertical live load on wal	I	Wlive = 30.0	kN/m			
Position of applied vertical load	on wall	lioad = 1200	mm			
Applied horizontal dead load on	wall	Fdead = 0.0	kN/m			
Applied horizontal live load on v	vall	Flive = 0.0 k	N/m			
Height of applied horizontal load	d on wall	Nload = 0 mr 128	n			
		Prop	3			
			÷	A		
	A					
	Prop-					
	25.4	12	0.8 7.1 10.	5 27.0		
				Loads shown	in kN/m, pressure	s shown in kN/m²

Tekla	Project				Job no.	
Tedds		38 Mead	dowbank		130)65
Campbell Reith	Calcs for				Start page no./Re	vision
Friars Bridge Court	RC re	taining wall for p	party wall No. 37	' & 38	:	3
London SE1 8NZ	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved date

Vertical forces on wall	
Wall stem	Wwall = hstem \times twall $\times \gamma$ wall = 30.6 kN/m
Wall base	Wbase = Ibase \times tbase $\times \gamma$ base = 13.2 kN/m
Applied vertical load	$W_v = W_{dead} + W_{live} = 128 \text{ kN/m}$
Total vertical load	$W_{total} = W_{wall} + W_{base} + W_v = 171.8 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	F_{sur} = K _{a ×} cos(90 - $_{\alpha}$ + $_{\delta}$) × Surcharge × h _{eff} = 3.2 kN/m
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma^m \times (h_{eff} - h_{water})^2 = 4.1 \text{ kN/m}$
Moist backfill below water table	$F_{m_{-}b} = K_{a} \times cos(90 - \alpha + \delta) \times \gamma^{m} \times (h_{eff} - h_{water}) \times h_{water} = 19.6 \text{ kN/m}$
Saturated backfill	$F_s = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times (\gamma^{s-} \gamma^{water}) \times h_{water}^2 = 14.4 \text{ kN/m}$
Water	F_{water} = 0.5 $_{\times}$ hwater ² $_{\times \gamma}$ water = 37.1 kN/m
Total horizontal load	$F_{total} = F_{sur} + F_{m_a} + F_{m_b} + F_s + F_{water} = 78.4 \text{ kN/m}$
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} = 5.1 kN/m
Propping force	$F_{prop} = max(F_{total} - F_p - (W_{total} - W_{live}) \times tan(\delta^b), 0 \text{ kN/m})$
	F _{prop} = 29.2 kN/m
Overturning moments	
Surcharge	$M_{sur} = F_{sur \times} (h_{eff} - 2 \times d_{ds}) / 2 = 6.2 \text{ kNm/m}$
Moist backfill above water table	M_{m_a} = $F_{m_a \times}$ (heff + 2 $_{\times}$ hwater - 3 $_{\times}$ dds) / 3 = 12.9 kNm/m
Moist backfill below water table	$M_{m_b} = F_{m_b \times} (h_{water} - 2 \times d_{ds}) / 2 = 27 \text{ kNm/m}$
Saturated backfill	M_s = F _{s ×} (h _{water} - 3 _× d _{ds}) / 3 = 13.2 kNm/m
Water	M_{water} = F _{water ×} (h _{water} - 3 × d _{ds}) / 3 = 34 kNm/m
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 93.3 \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{wall} = W_{wall} \times (I_{toe} + t_{wall} / 2) = 37.1 \text{ kNm/m}$
Wall base	Mbase = wbase × lbase / 2 = 9.3 kNm/m
Design vertical dead load	Mdead = Wdead × Iload = 117.6 kNm/m
Total restoring moment	Mrest = Mwall + Mbase + Mdead = 164 kNm/m
Check bearing pressure	
Total vertical reaction	R = W _{total} = 171.8 kN/m
Distance to reaction	x _{bar} = I _{base} / 2 = 700 mm
Eccentricity of reaction	$e = abs((I_{base} / 2) - x_{bar}) = 0 mm$
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 122.7 \text{ kN/m}^2$
Bearing pressure at heel	$p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 122.7 \text{ kN/m}^2$
PA	SS - Maximum bearing pressure is less than allowable bearing pressure
Calculate propping forces to top and base	of wall
Propping force to top of wall	

Propping force to base of wall

 $F_{prop_top} = (M_{ot} - M_{rest} + R_{\times} | base / 2 - F_{prop}_{\times} t_{base} / 2) / (h_{stem} + t_{base} / 2) = 11.809 \text{ kN/m}$ $F_{prop_base} = F_{prop} - F_{prop_top} = 17.393 \text{ kN/m}$

Tekla °	Project	20 Maa	dowbank		Job no.	3065
Tedds		38 IVIEA	NURGWOR		1	6006
Campbell Reith	Calcs for	rotaining wall for		27 8 20	Start page no./	Revision
41-45 Blackfriars Road						-+
London SE1 8NZ	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved date
	1		I			
RETAINING WALL DESIGN (B	S 8002:1994)				TEDDS calculatio	n version 1.2.01.06
Ultimate limit state load facto	rs					
Dead load factor		$\gamma^{f_d} = 1.4$				
Live load factor		γ ^{f_l} = 1.6				
Earth and water pressure factor		γ ^f _e = 1.4				
Factored vertical forces on wa	all					
Wall stem		Wwall_f = γf_d	$_{\times}$ hstem $_{\times}$ twall $_{\times}$)	wall = 42.8 kN/n	n	
Wall base		Wbase_f = γf_0	$_{1 \times}$ lbase $_{\times}$ tbase $_{\times}$	γ ^{base} = 18.5 kN	/m	
Applied vertical load		$W_{v_f} = \gamma f_d$	$_{\rm K}$ Wdead + $_{\gamma \rm f_{I}}$ $_{\rm X}$ V	Vlive = 185.2 kN	/m	
Total vertical load		$W_{total_f} = W_w$, all_f + Wbase_f + V	Vv_f = 246.5 kN/i	m	
Factored horizontal active for	ces on wall					
Surcharge		$F_{sur_f} = \gamma_{f_i}$	Ka _× cos(90 - 6	$(\alpha + \delta) \times Surchar$	ge _× h _{eff} = 5.1	kN/m
Moist backfill above water table		Fm_a_f = √fe	$_{\times}$ 0.5 $_{\times}$ Ka $_{\times}$ co	s(90 - _α + δ) _{× ν}	$_{\rm m}$ $_{\times}$ (heff - hwater) ² = 5.7 kN/m
Moist backfill below water table		$F_{m_b_f} = \sqrt{f} e$	× Ka × cos(90 -	$(\alpha + \delta) \times \gamma m \times (h)$	neff - hwater) _× hw	ater = 27.5
kN/m		1 -	, - ·			
Saturated backfill		$F_{s_f} = \gamma f_e \times$	$0.5 \times K_a \times cos($	90 - _α + _δ) _× (γs-	- $_{\gamma water}$) $_{\times}$ hwater ²	= 20.2 kN/m
Water		$F_{water_f} = v_{f_0}$	$ \times 0.5 \times h_{water}^2 $, _{×γwater} = 51.9 k	N/m	
Total horizontal load		F _{total_f} = F _{sur}	_f + Fm_a_f + Fm_	b_f + Fs_f + Fwater	_f = 110.4 kN/n	n
Calculate total propping force)					
Passive resistance of soil in from	nt of wall	$F_{p_f} = v_{f_e} \times$	$0.5 \times K_{P \times} \cos($	$_{\delta^{\mathrm{b}}})_{ imes}$ (dcover + tba	ase + dds - dexc) ²	$\times \gamma$ mb = 7.1
kN/m				- / ··· ·	,	· · 1
Propping force		F _{prop_f} = ma	x(F _{total_f} - F _{p_f} - (Wtotal_f - γ f_l \times W	$'$ live) $_{ imes}$ tan($_{\delta^{\mathrm{b}}}$), C) kN/m)
		$F_{prop_f} = 41.$	5 kN/m			
Factored overturning moment	ts					
Surcharge		Msur_f = Fsur	$_{f \times}$ (heff - 2 $_{\times}$ def	us) / 2 = 9.9 kNm	n/m	
Moist backfill above water table		Mm_a_f = Fm	_a_f × (heff + 2 ×	hwater - 3 $_{ imes}$ dds) /	3 = 18 kNm/m	
Moist backfill below water table		$M_{m_b_f} = F_{m_b}$	_b_f × (hwater - 2 >	< dds) / 2 = 37.8	kNm/m	
Saturated backfill		 Ms_f = Fs f √	(hwater - 3 × dds) / 3 = 18.5 kNm	n/m	
Water		Mwater f = Fw	vater_f _× (hwater - 3	× d⊲s) / 3 = 47.0	6 kNm/m	
Total overturning moment		Mot_f = Msur_	<u>f</u> + Mm_a_f + Mm_	_b_f + Ms_f + Mwate	er_f = 131.8 kNi	m/m
Restoring moments						
Wall stem		Mwall f = Wwa	$II_f \times (I_{toe} + t_{wall})$	2) = 52 kNm/m		
Wall base		$M_{base f} = W_{b}$	ase_f × Ibase / 2 =	13 kNm/m		
Design vertical load		$M_V f = W_V f$	$_{\times}$ load = 222.2 k	Nm/m		
Total restoring moment		Mrest_f = Mwa	all_f + Mbase_f + N	lv_f = 287.2 kNm	ı/m	
Factored bearing pressure						
Total vertical reaction		Rf = Wtotal f	= 246.5 kN/m			
Distance to reaction		Xbar_f = lbase	/ 2 = 700 mm			
Eccentricity of reaction		$e_f = abs((l_{ba}$	ase / 2) - Xbar_f) =	0 mm		
				Reaction acts	within middle	e third of base
Bearing pressure at toe		$p_{toe_f} = (R_f / $	lbase) - (6 $_{ imes}$ Rf $_{ imes}$	ef / Ibase ²) = 176	5.1 kN/m²	
Bearing pressure at heel		$p_{\text{heel}_f} = (R_f)$	/ Ibase) + (6 $_{ imes}$ Rf	$_{\times}$ er / Ibase ²) = 17	76.1 kN/m²	
Rate of change of base reaction	า	$rate = (p_{toe})$	f - pheel_f) / Ibase =	= 0.00 kN/m²/m		

					1	
Tekla	Project	38 Mea	dowbank		Job no.	065
ledds Campbell Reith	Calcs for	00 1104			Start page no /R	evision
Friars Bridge Court	RC re	etaining wall for	party wall No	. 37 & 38	olari pago no./re	5
41-45 Blackfriars Road	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
London SE1 8NZ	AP	14/03/2019				
						2
Bearing pressure at stem / toe		Pstem_toe_f =	max(p _{toe_f} - (ra	ate $_{\times}$ Itoe), 0 kN/m ²) = 176.1 kN/m	
Bearing pressure at mid stem		Pstem_mid_f =	max(ptoe_f - (r	ate $_{\times}$ (Itoe + twall / 2)), 0 kN/m²) = 1	76.1 kN/m ²
Bearing pressure at stem / heel		Pstem_heel_f =	max(ptoe_f - (I	rate $_{\times}$ (Itoe + twall)),	0 kN/m²) = 176	.1 kN/m²
Calculate propping forces to t Propping force to top of wall	op and base of	fwall				
	$F_{prop_top_f} =$	(Mot_f - Mrest_f + F	$R_{f \times} I_{base} / 2 - F$	$F_{prop_f \times} t_{base} / 2) / ($	hstem + t _{base} / 2)	= 2.402 kN/m
Propping force to base of wall		Fprop_base_f =	Fprop_f - Fprop_	_top_f = 39.118 kN/r	n	
Design of reinforced concrete	retaining wall	toe (BS 8002:1	994)			
Material properties		•				
Characteristic strength of concre	ete	fcu = 30 N/n	nm²			
Characteristic strength of reinfor	rcement	$f_y = 500 \text{ N/r}$	nm²			
Base details						
Minimum area of reinforcement		k = 0.13 %				
Cover to reinforcement in toe		Ctoe = 50 mi	m			
Calculate shear for toe design	l					
Shear from bearing pressure		Vtoe_bear = (p	Dtoe_f + Pstem_toe	$e_f) \times I_{toe} / 2 = 181.$	3 kN/m	
Shear from weight of base		Vtoe_wt_base =	$\gamma^{f_d} \times \gamma^{base} \times$	$I_{toe} \times t_{base} = 13.6 \text{ k}$	N/m	
Total shear for toe design		$V_{toe} = V_{toe_b}$	ear - Vtoe_wt_base	e = 167.7 kN/m		
Calculate moment for toe des	ign					
Moment from bearing pressure		Mtoe_bear = (2	$2 \times p_{toe_f} + p_{ste}$	em_mid_f) $_{ imes}$ (Itoe + twa	1 / 2) ² / 6 = 130	kNm/m
Moment from weight of base		Mtoe_wt_base =	= ($\gamma f_d \times \gamma base$)	$_{ imes}$ tbase $_{ imes}$ (Itoe + twall /	2) ² /2) = 9.8 k	Nm/m
Total moment for toe design		$M_{toe} = M_{toe}$	bear - M toe_wt_ba	ase = 120.2 kNm/m		
342	••	•	•	• •	•	
	← 150 →					
Check toe in bending						
Width of toe		b = 1000 m	m/m			
Depth of reinforcement		d _{toe} = t _{base} -	- Ctoe - (_{\$\phi} toe / 2	2) = 342.0 mm		
Constant		Ktoe = Mtoe /	$(b \times dtoe^2 \times fc)$	u) = 0.034		
				Compression rel	inforcement is	not required
Lever arm		Z _{toe} = min(C Z _{toe} = 325 n	0.5 + √(0.25 - nm	(min(K _{toe} , 0.225) /	0.9)),0.95) _× di	toe
Area of tension reinforcement re	equired	$A_{s_toe_des} = 1$	M _{toe} / (0.87 $_{ imes}$ f	f _{y ×} z _{toe}) = 850 mm	n²/m	
Minimum area of tension reinfor	cement	$A_{s_toe_min} = I$	$x \times b \times t_{base} =$	520 mm²/m		
Area of tension reinforcement re	equired	As_toe_req = I	Max(As_toe_des,	As_toe_min) = 850 m	nm²/m	

Tekla	Project				Job no.	
Tedds		38 Mea	dowbank		13	065
Campbell Reith	Calcs for				Start page no./R	evision
Friars Bridge Court	RC	retaining wall for	party wall No. 3	37 & 38		6
41-45 Blackfriars Road	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	AP	14/03/2019				
			hana @ 450 m			
Area of reinforcement provided			.Dars @ 150 m	im centres		
Area of remorcement provided		As_toe_prov =	forcement pro	wided at the ret	aining wall to	o is adoquato
		1 A00 - Neill	iorcement pro			e is adequate
Check shear resistance at to	Ð			2		
Design snear stress		Vtoe = Vtoe /	$(D \times Otoe) = 0.49$	90 N/mm²	2 4 9 9 9 1	
Allowable shear stress		Vadm = MIN(0.8 _× √(fcu / 1 N Deciser choos	I/mm²), 5) _× 1 N/i	mm² = 4.382 N	l/mm²
Erom BS9110-Part 1-1907 T	able 2.9	PA33 -	Design shear	stress is less ti	nan maximum	snear stress
Design concrete shear stress	able 5.0	Ve teo - 0.5	11 N/mm ²			
Design concrete shear stress		Vc_loe - 0.3	Vto	e < Vc toe - No sh	ear reinforcer	nent required
						none i oquin ou
Design of reinforced concret	e retaining wal	I stem (BS 8002	:1994)			
Material properties						
Characteristic strength of conc	rete	fcu = 30 N/r	nm²			
Characteristic strength of reinfo	prcement	fy = 500 N/i	mm²			
Wall details						
Minimum area of reinforcemen	t	k = 0.13 %				
Cover to reinforcement in stem		Cstem = 100	mm			
Cover to reinforcement in wall		Cwall = 50 m	m			
Factored horizontal active fo	rces on stem					
Surcharge		$F_{s_sur_f} = \gamma^{f_}$	$_{\rm I} \times {\rm Ka} \times \cos(90$	$(\alpha + \delta) \times Surcha$	rge_{\times} (heff - tbas	e - dds) = 4.6
kN/m						
Moist backfill above water table	9	$F_{s_m_a_f} = 0$	$.5 \times \gamma^{f_e} \times K_a \times f_e$	$\cos(90 - \alpha + \delta) \times$	γ m $_{ imes}$ (heff - tbase	- dds - hsat) ² =
5.7 kN/m		_				
Moist backfill below water table		$Fs_m_b_f = \gamma f$	$_{e \times} K_{a \times} COS(9)$	$(0 - \alpha + \delta) \times \gamma^{m} \times ($	heff - tbase - dds ·	• hsat) _× hsat =
23.5 KN/M		F 0.5	14	- (00) L 2	44.0 1.11/
Saturated backfill		$F_{s_s_f} = 0.5$	×γf_e × Ka × CO	$(90 - \alpha + \delta) \times (\gamma)$	s-γwater) _× Nsat ⁻	= 14.8 KN/M
Water		$Fs_water_f = 0$	$0.5 \times \gamma^{f_e} \times \gamma^{water}$	r _× Nsat ² = 37.9 KN	I/m	
Calculate shear for stem des	ign					
Surcharge		$V_{s_sur_f} = 5$	\times Fs_sur_f / 8 = 2	.9 kN/m		
Moist backfill above water table)	$V_{s_m_a_f} = F$	s_m_a_f _× bı _× ((5	$_{ imes}$ L ²) - bi ²) / (5 $_{ imes}$	L ³) = 1.8 kN/m	1
Moist backfill below water table		$V_{s_m_b_f} = F$	s_m_b_f _× (8 - (n ²	² _× (4 - n))) / 8 = 1	1 8.9 kN/m	
Saturated backfill		$V_{s_s_f} = F_{s_s}$	$_{-f} \times (1 - (a^2 \times (1 - a^2))))$	$(5 \times L) - a_1) / (20)$	_{<} L ³))) = 13.2 k	N/m
Water		$V_{s_water_f} = F$	s_water_f _× (1 - (a	$a^2 \times ((5 \times L) - a)$	$(20 \times L^3)) = 3$	34 kN/m
Total shear for stem design		Vstem = Vs_s	ur_f + Vs_m_a_f + '	Vs_m_b_f + Vs_s_f +	Vs_water_f = 70.8	3 kN/m
Calculate moment for stem d	esign					
Surcharge		$M_{s_sur} = F_{s_}$	$sur_{f \times} L / 8 = 2.7$	1 kNm/m		
Moist backfill above water table)	Ms_m_a = Fs	_m_a_f \times bl \times ((5	$_{ imes}$ L ²) - (3 $_{ imes}$ br ²)) /	(15 × L ²) = 2.1	kNm/m
Moist backfill below water table		$M_{s_m_b} = F_s$	_m_b_f $_{ imes}$ al $_{ imes}$ (2 -	n) ² / 8 = 12.9 kN	lm/m	
Saturated backfill		$M_{s_s} = F_{s_s}$	$f_{\times}al_{\times}((3_{\times}al^2)-(1_{\times}al^2))$	$5_{\times}a_{\times}L)+(20_{\times}L^2)$)/(60 _× L ²) = 7 kl	Nm/m
Water		Ms_water = F	s_water_f ×al×((3×	al²)-(15 _× al _× L)+(2	0 _× L ²))/(60 _× L ²)	= 17.9
kNm/m						
Total moment for stem design		$M_{stem} = M_{s_{-}}$	sur + Ms_m_a + N	ls_m_b + Ms_s + Ms	_water = 41.9 kN	m/m
Calculate moment for wall de	sign					
Surcharge		$M_{w_sur} = 9$		28 = 1.2 kNm/m		



Tekla Tedds	Project	38 Mea	Job no.	Job no. 13065		
Campbell Reith Friars Bridge Court	Calcs for RC	retaining wall for	party wall No.	37 & 38	Start page no./F	Revision 8
41-45 Blackfriars Road London SE1 8NZ	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved date
Lever arm		Zwall = Min(0.5 + √(0.25 - ((min(Kwall, 0.225)	/ 0.9)),0.95) _×	dwall
Area of tension reinforcement	t required	As_wall_des =	Mwall / (0.87 $_{\times}$	$f_{y \times} z_{wall}$ = 147 m	ım²/m	
Minimum area of tension reinf	forcement	$A_{s_wall_min} =$	$k \times b \times t_{wall} = 4$	l81 mm²/m		
Area of tension reinforcement	t required	As_wall_req =	Max(As_wall_des,	As_wall_min) = 481	mm²/m	
Reinforcement provided		12 mm dia	.bars @ 150 r	mm centres		
Area of reinforcement provide	ed	As_wall_prov =	754 mm²/m			
	PASS	S - Reinforcemen	t provided to	the retaining wa	all at mid heig	ht is adequate

Check retaining wall deflection	on	
Basic span/effective depth ratio	o ra	atio _{bas} = 20
Design service stress	fs	s = 2 $_{\times}$ fy $_{\times}$ As_stem_req / (3 $_{\times}$ As_stem_prov) = 119.6 N/mm ²
Modification factor	$factor_{tens} = min(0.55 +$	+ (477 N/mm ² - fs)/(120 \times (0.9 N/mm ² + (Mstem/(b \times dstem ²)))),2) = 2.00
Maximum span/effective depth	ratio ra	atio _{max} = ratio _{bas \times} factor _{tens} = 40.00
Actual span/effective depth rational	o ra	atiO _{act} = h _{stem} / d _{stem} = 13.36
		PASS - Span to depth ratio is acceptable



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

Calcs for Underpinning under RC wall between No. 38 & 39 Start page no./Revision Calcs by Calcs date Checked by Checked date Approved by Approved date AP 14/03/2019 Checked by Checked date Approved by Approved date	Tekla Tedds	Project	Job no. 13065				
Calcs by Calcs date Checked by Checked date Approved by Approved date AP 14/03/2019 Approved by Approved by Approved date		Calcs for Underpin	nning under RC	wall between No	o. 38 & 39	Start page no./Re	evision 1
		Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved date





	Project	Project 38 Meadowbank					
ieuus	Calcs for				Start page no./	Revision	
	Under	pinning under RC	wall between	No. 38 & 39		3	
	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved da	
		14/03/2019					
Applied vertical load		$W_v = W_{dead}$	+ Wlive = 65 k	N/m			
Total vertical load		W total = Wwa	II + Wbase + W_v	= 92.4 kN/m			
Horizontal forces on wall							
Surcharge		$F_{sur} = K_{a \times b}$	$\cos(90 - \alpha + \delta)$	$_{\times}$ Surcharge $_{\times}$ h	eff = 1.3 kN/m		
Moist backfill above water ta	able	$F_{m_a} = 0.5$	_× K _{a ×} cos(90 ·	$ \cdot \alpha + \delta) \times \gamma^{m} \times (h_{ef}) $	f - hwater) ² = 0 k	N/m	
Saturated backfill		$F_s = 0.5 \times P_s$	$x_{a \times} \cos(90 - \alpha)$	$(\gamma s - \gamma water) \times (\gamma s - \gamma water)$	\times hwater ² = 5.2 k	κN/m	
Water		$F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water} = 13.4 \text{ kN/m}$					
Total horizontal load		Ftotal = Fsur	+ Fm_a + Fs + F	water = 19.9 kN/m	1		
Calculate propping force							
Passive resistance of soil ir	front of wall	$F_{P} = 0.5 \times H$	$K_{p} \times cos(\delta^{b}) \times Cos(\delta^{b})$	dcover + tbase + dds	- $dexc)^2 \times \gamma mb =$	• 5.1 kN/m	
Propping force		$F_{prop} = max(F_{total} - F_p - (W_{total} - W_{live}) \times tan(\delta b), 0 \text{ kN/m})$					
	F _{prop} = 0.0 kN/m						
Overturning moments							
Surcharge		$M_{sur} = F_{sur}$	$_{\times}$ (heff - 2 $_{\times}$ dds) / 2 = 1 kNm/m			
Moist backfill above water ta	able	$M_{m_a} = F_{m_a}$	$_{\rm a}$ $_{\rm imes}$ (heff + 2 $_{\rm imes}$ h	water - 3 _× d _{ds}) / 3 :	= 0 kNm/m		
Saturated backfill		$M_s = F_s \times (H_s)$	Nwater - $3 \times d_{ds}$)	/ 3 = 2.9 kNm/m			
Water		Mwater = Fwa	ter _× (hwater - 3	_× d _{ds}) / 3 = 7.3 kN	lm/m		
Total overturning moment		Mot = Msur H	- Mm_a + Ms + 1	M _{water} = 11.3 kNm	ı/m		
Restoring moments							
Wall stem		Mwall = Wwall	$_{ imes}$ (Itoe + twall / 2	2) = 16.3 kNm/m			
Wall base		Mbase = Wba	se $_{\times}$ lbase / 2 = 9).3 kNm/m			
Design vertical dead load		$M_{dead} = W_{d}$	ead $_{\times}$ load = 55 l	kNm/m			
Total restoring moment		Mrest = Mwal	+ Mbase + Mde	ad = 80.5 kNm/m			
Check bearing pressure							
Design vertical live load		Mlive = Wlive	\times load = 16.5	«Nm/m			
Total moment for bearing		M _{total} = M _{res}	t - Mot + Mlive =	85.8 kNm/m			
Total vertical reaction		R = W _{total} =	9 2.4 kN/m				
Distance to reaction		$x_{bar} = M_{total}$	/ R = 929 mm				
Eccentricity of reaction		$e = abs((I_{ba})$	use / 2) - Xbar) =	229 mm			
				Reaction acts	within middle	e third of ba	
Bearing pressure at toe		p _{toe} = (R / I	base) - (6 $_{\times}$ R $_{\times}$	e / Ibase ²) = 1.4 kN	N/m²		
Bearing pressure at heel		pheel = (R /	I_{base} + (6 $_{\times}$ R $_{2}$	$_{\times} e / l_{base^2} = 130.$	6 kN/m ²		
	-	A O O M					

		38 Mea	dowbank		1	3065
leads	Calcs for				Start page no./F	Revision
	Under	rpinning under RC	wall between I	No. 38 & 39		4
	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved
RETAINING WALL DESIGI	N (BS 8002:1994	<u>)</u>				
Ultimate limit state load fa	ctors				TEDDS calculatio	n version 1.2
Dead load factor		$\gamma^{f_{d}} = 1.4$				
Live load factor		γ ^{f_l} = 1.6				
Earth and water pressure fa	ctor	γ ^f _e = 1.4				
Factored vertical forces o	n wall					
Wall stem		Wwall $f = \gamma f d$	$_{\times}$ h _{stem} $_{\times}$ t _{wall} $_{\times}$	vwall = 19.8 kN/n	า	
Wall base		Wbase $f = \sqrt{f}$	$d \times base \times tbase \times$	√ √ybase = 18.5 kN/	/m	
Applied vertical load		$W_{\rm v} f = \gamma f d$	\sqrt{W} dead + \sqrt{f}	Wlive = 94 kN/m		
Total vertical load		$W_{total_f} = W_v$	vall_f + Wbase_f + ¹	W _{v_f} = 132.3 kN/	m	
Factored horizontal active	forces on wall					
Surcharge		$F_{sur} f = a f b$. Ka cos(90 -	(x + s) = Surchar	ae., h _{e#} = 21 k	(N/m
Moist backfill above water ta	able	$F_{m,a,f} = \gamma_{i} f_{i}$		$(90 - \alpha + \beta)$	m v (heff - hwater)	$^{2} = 0 \text{ kN/r}$
Saturated backfill		$F_{n} = f_{n} = f_{n}$	$0.5 \dots K_{2} \dots cos$	(90 + s) ((100 here)	$-73 \mathrm{kN}/\mathrm{r}$
Water		$F_{\text{s}_{1}} = \gamma_{1} e_{X}$	$0.0 \times 10^{\circ} \times 100^{\circ}$	$(30 \alpha + \beta) \times (\gamma^{s})$	γwater) χ πwater N/m	- 7.5 KN/
Total horizontal load		Fixed to the first the first term of term o				
			i_i • • • • • <u>a_</u> i • • • s			
Calculate propping force	front of wall	F	0.5 1/ 000		. d. d.)2	. 7.
kN/m	front of wall	$\mathbf{F}\mathbf{p}_{t} = \gamma \mathbf{f}_{e} \times$	$0.5 \times k_{P} \times cos$	$(\delta b) \times (\mathbf{U} cover + \mathbf{l} bas)$	se + Ods - Oexc)	×γmb = / .
Propping force		Faraa (– ma	V(Etotal f - En f -	(Whatal f =f I W	$(h_0) \dots tan(s_h) \cap$	kN/m)
		$F_{\text{prop}_{i}} = 0.0$) kN/m		100) x tan(05), o	((1 ,11))
Eastarad avarturning man	onte	· ····				
Surcharge	lients	Mour (- Four		$(a_{1})/2 - 1.7$ kNm	u/m	
Moist backfill above water to	blo	Msu_i = i su	_! X (Hell - 2 X C	$\frac{1}{2} = \frac{1}{1} $	3 - 0 kNm/m	
Saturated backfill	able	$M_{m_a} = F_{m_b}$	(hunter - 3 da	(1) $(3 - 4 k)m/m$		
		$M_{a} = F_{a} + F_{a}$	$\langle (\text{IIwater} - 3 \times \text{Ud}) \rangle$	$s_{1} = \frac{1}{3} = \frac{1}{3} + \frac{1}{3} = \frac{1}{3}$	kNm/m	
Total overturning moment		$M_{ot} f = M_{our}$	$t + M_m \circ t + M_m$	$5 \times \text{uds} / 5 = 10.3$	kNm/m	
Postering memorie			_, , ,,,,,,,_a_1 + 1VIS	_, , ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
		KA		()) _) 0 0 Lbla-1	~	
		$VIwall_f = Wwa$	$\operatorname{au_t}_X$ (Itoe + Twall)	(2) = 22.0 KININ/I	11	
VVdII Dase		$IVIbase_f = Wb$	ase_t × Ibase / 2 =	= IS KINIII/M		
Design vertical load		$IVIv_f = VVv_f$	$\times \text{ lload} = 103.4$	KINITI/ITI	v/m	
		$ivirest_f = iViw$	an_i + ividase_t + i	viv_i - 133.1 KIN[]	V111	
Factored bearing pressure	9	N4	M			
Total moment for bearing		$IVItotal_f = IVIte$	est_f - IVlot_f = 12. - 133 3 kN/m	3.2 KINM/M		
Distance to reaction		$\mathbf{N} = \mathbf{V} \mathbf{V} \text{ total}_{f}$ $\mathbf{X}_{har} \mathbf{f} = \mathbf{M}_{total}$	-132.3 KIV/III at f / Rf = 931 m	m		
Eccentricity of reaction		$e_f = abs((I_b)$	ase / 2) - Xbar f) =	= 231 mm		
			,	Reaction acts	within middle	e third of
Bearing pressure at toe		$p_{toe_f} = (R_f / P_f)$	$^{\prime}$ Ibase) - (6 $_{ imes}$ Rf	$_{\times} \mathrm{e}_{\mathrm{f}} / \mathrm{l}_{\mathrm{base}^2}) = 1 \mathrm{kl}$	N/m ²	
Bearing pressure at heel		p _{heel_f} = (R _f	/ Ibase) + (6 _× R	$f_{\times} e_f / I_{base^2} = 18$	8 kN/m ²	
Rate of change of base read	ction	rate = (ptoe	_f - Pheel_f) / Ibase	= -133.59 kN/m	²/m	
Desiring pressure at store (4	00		$max(n_{bool} + (r$	ate (Ibool + twow))	$0 \text{ kN/m}^2) - 13$	01 2 kN/m

	-,	38 Mea	13065					
Ca	alcs for				Start page no./F	Revision		
	Underpir	nning under RC	wall between N	No. 38 & 39	Start page no./Revision Start page no./Revision 38 & 39 Checked date Approved by App $a \ge (lneel + twall / 2)), 0 \text{ kN/m}^2) = 154$ $e \ge lneel), 0 \text{ kN/m}^2) = 188 \text{ kN/m}^2$ $e \ge lneel), 0 \text{ kN/m}^2) = 188 \text{ kN/m}^2$ $a \ge 11.9 \text{ kN/m}$ $a \ge 10.9 \text{ km/m}$	5		
Ca	alcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved of		
Bearing pressure at mid stem		Pstem_mid_f =	max(pheel_f + (r	rate $_{\times}$ (Iheel + twall /	′ 2)), 0 kN/m²) :	= 154.6 kN		
Bearing pressure at stem / heel		Pstem_heel_f =	max(pheel_f + (rate $_{\times}$ Ineel), 0 kN/	/m²) = 188 kN/ı	m²		
Design of reinforced concrete re	etaining wall	toe (BS 8002:1	<u>994)</u>					
Material properties								
Characteristic strength of concrete)	f _{cu} = 30 N/r	nm²					
Characteristic strength of reinforce	ment	fy = 500 N/r	mm²					
Base details								
Minimum area of reinforcement		k = 0.13 %						
Cover to reinforcement in toe		Ctoe = 50 m	m					
Calculate shear for toe design								
Shear from bearing pressure		V _{toe_bear} = (t	Otoe_f + Dstem toe	_f) _× Itoe / 2 = 55 k	N/m			
Shear from weight of base		Vtoe wt base =	= vfd ∨ vbase ∨ ht	oe √ tbase = 11.9 k	N/m			
Total shear for toe design		Vtoe = Vtoe b	pear - Vtoe wt base	= 43.1 kN/m				
Calculate moment for too design	.							
Moment from bearing pressure		Missa haar - (2 Dreas f ± Datas	a mid f) (Itaa 🛨 tuur	"/2) ² /6 – 3 / 1	5 kNm/m		
Moment from weight of base		More we have $= (\sqrt{1 + 1})^2 / 2 = 8.7 \text{ kNm/m}$						
Total moment for too docign		Mice_wi_base	$-(\gamma^{1} \alpha \times \gamma^{\text{base}} \times$	-25.9 kNm/m	(2) / 2) - 0.7			
	•	•	•	•	•			
↓ —								
↓ —	 ⊲ 200	→						
Check toe in bending	∢200	→						
Check toe in bending Width of toe	200	→ b = 1000 m	ım/m					
Check toe in bending Width of toe Depth of reinforcement		→ b = 1000 m dtoe = tbase -	nm/m - Ctoe — (φtoe / 2)	= 342.0 mm				
Check toe in bending Width of toe Depth of reinforcement Constant	 ← 200	→ b = 1000 m dtoe = tbase - Ktoe = Mtoe /	nm/m - Ctoe – (_φ toe / 2) / (b _× dtoe ² _× fcu)	= 342.0 mm = 0.007				
Check toe in bending Width of toe Depth of reinforcement Constant	 4 —200—	b = 1000 m dtoe = tbase - Ktoe = Mtoe /	nm/m - Ctoe – (_ф toe / 2) / (b _× dtoe ² _× fcu) (= 342.0 mm = 0.007 Compression re	inforcement is	s not requ		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm	 ← 200	→ b = 1000 m dtoe = tbase - Ktoe = Mtoe / Ztoe = min(0	nm/m - c _{toe} - (_ф toe / 2) / (b _× dtoe ² _× fcu) (0.5 + √(0.25 - (r	= 342.0 mm = 0.007 Compression re min(K _{toe} , 0.225) /	<i>inforcement i</i> 0.9)),0.95) _× d	s <i>not requ</i>		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm	 4 —200—	b = 1000 m dtoe = tbase - Ktoe = Mtoe / Ztoe = min(0 Ztoe = 325 m	nm/m - c _{toe} – (_ф toe / 2) / (b _× dtoe ² _× fcu) (0.5 + √(0.25 - (r nm	= 342.0 mm = 0.007 Compression re min(K _{toe} , 0.225) /	<i>inforcement i</i> . 0.9)),0.95) _× d	s not requ		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement requ		b = 1000 m dtoe = tbase - Ktoe = Mtoe / Ztoe = min(0 Ztoe = 325 m As_toe_des = 1	nm/m - ctoe – (_ф toe / 2) / (b _× dtoe ² _× fcu) 0.5 + √(0.25 - (r nm Mtoe / (0.87 _× fy	= 342.0 mm = 0.007 <i>Compression re</i> min(Ktoe, 0.225) / 	<i>inforcement i</i> 0.9)),0.95) _× d 1 ² /m	s not requ toe		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement requ Minimum area of tension reinforce	ired ment	b = 1000 m dtoe = tbase - Ktoe = Mtoe / Ztoe = Mtoe / Ztoe = 325 m As_toe_des = As_toe_min =	$\frac{1}{1000} \frac{1}{1000} \frac{1}{10000} \frac{1}{10000} \frac{1}{10000000000000000000000000000000000$	= 342.0 mm = 0.007 <i>Compression re</i> min(K _{toe} , 0.225) / z _{toe}) = 182 mm 20 mm ² /m	<i>inforcement i</i> 0.9)),0.95) _× d 1 ² /m	s not requ toe		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement requ Minimum area of tension reinforce Area of tension reinforcement requ	lired ment µired	$b = 1000 \text{ m}$ $dtoe = tbase -$ $Ktoe = Mtoe /$ $Ztoe = min(C)$ $Ztoe = 325 \text{ m}$ $As_toe_des =$ $As_toe_min =$ $As_toe_req = 1$	$\frac{1}{2} \frac{1}{2} \frac{1}$	= 342.0 mm = 0.007 Compression re min(Ktoe, 0.225) / Ztoe) = 182 mm 20 mm ² /m As_toe_min) = 520 m	<i>inforcement i</i> (0.9)),0.95) _× d 1 ² /m nm²/m	s not requ _{ltoe}		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement requ Minimum area of tension reinforcer Area of tension reinforcement requ Reinforcement provided	uired ment uired	b = 1000 m dtoe = tbase - Ktoe = Mtoe / Ztoe = Mtoe / Ztoe = 325 m As_toe_des = 1 As_toe_min = 1 As_toe_req = 1 16 mm dia	$\frac{1}{1} \frac{1}{1} \frac{1}$	= 342.0 mm = 0.007 <i>Compression re</i> min(Ktoe, 0.225) / × Ztoe) = 182 mm 20 mm ² /m As_toe_min) = 520 m mm centres	<i>inforcement i</i> : 0.9)),0.95) _× d ² /m nm²/m	s not requ toe		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement requ Minimum area of tension reinforce Area of tension reinforcement requ Reinforcement provided Area of reinforcement provided	uired ment uired	b = 1000 m dtoe = tbase - Ktoe = Mtoe / Ztoe = Mtoe / Ztoe = 325 m As_toe_des = As_toe_min = As_toe_req = 1 16 mm dia As_toe_prov =	hm/m - Ctoe - (ϕ toe / 2) / (b × dtoe ² × fcu) (0.5 + $\sqrt{(0.25 - (r))}$ Mtoe / (0.87 × fy k × b × tbase = 5 Max(As_toe_des, / h.bars @ 200 n 1005 mm ² /m	= 342.0 mm = 0.007 <i>Compression re</i> min(Ktoe, 0.225) / × Ztoe) = 182 mm 20 mm ² /m As_toe_min) = 520 m nm centres	<i>inforcement i</i> 0.9)),0.95) _× d n²/m nm²/m	s not requ ltoe		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement requ Minimum area of tension reinforcer Area of tension reinforcement requ Reinforcement provided Area of reinforcement provided	uired ment uired	b = 1000 m dtoe = tbase - Ktoe = Mtoe / Ztoe = min(C Ztoe = 325 m As_toe_des = 1 As_toe_req = 1 16 mm dia As_toe_prov = PASS - Reim	$hm/m = Ctoe - (\phi toe / 2)$ $/ (b \times dtoe^2 \times fcu)$ $/ (b \times dtoe^2 \times fcu)$ $/ (0.25 - (r))$ $Mtoe / (0.87 \times fy)$ $Mtoe / (0.87 \times fy)$ $K \times b \times tbase = 5$ $Max(As_toe_des, A)$ $hbars @ 200 n$ $1005 mm^2/m$ $hor cement process$	= 342.0 mm = 0.007 <i>Compression re</i> min(Ktoe, 0.225) / × Ztoe) = 182 mm 20 mm ² /m As_toe_min) = 520 m nm centres	<i>inforcement i</i> 0.9)),0.95) _× d ² /m nm²/m taining wall to	s not requ toe be is adequ		
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement requ Minimum area of tension reinforcer Area of tension reinforcement requ Reinforcement provided Area of reinforcement provided	uired ment uired	b = 1000 m dtoe = tbase - Ktoe = Mtoe / Ztoe = Mtoe / Ztoe = 325 m As_toe_des = As_toe_min = As_toe_req = 1 16 mm dia As_toe_prov = PASS - Rein	hm/m - Ctoe - (ϕ toe / 2) / (b × dtoe ² × fcu) / (b × dtoe ² × fcu) / (0.25 - (r nm Mtoe / (0.87 × fy k × b × tbase = 5 Max(As_toe_des, / h.bars @ 200 n 1005 mm ² /m	= 342.0 mm = 0.007 Compression re min(Ktoe, 0.225) / $\times Ztoe$) = 182 mm 20 mm ² /m As_toe_min) = 520 m nm centres povided at the re	<i>inforcement i</i> 0.9)),0.95) _× d n²/m nm²/m <i>taining wall to</i>	s not requ ^{hoe}		

🐙 Tekla	Project	38 Mea	Job no. 38 Meadowbank 13065					
ledds	Calcs for			Start page no./Revision				
	Underpir	nning under RC	wall between I	No. 38 & 39		6		
	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Job no. 1 Start page no./I Approved by $\sqrt{mm^2} = 4.382 \text{ N}$ <i>s than maximum</i> <i>shear reinforce</i> <i>shear reinforce</i> <i>shear reinforce</i> $\chi \gamma m \times (heff - tbase)$ $\chi \gamma$	Approved date		
Allowable shear stress		Vadm = min(0.8 _{× √} (f _{cu} / 1 N	l/mm²), 5) _× 1 N/ı	mm ² = 4.382 N	l/mm ²		
From D60110.Dort 1.1007 T		PASS -	Design shear	r stress is less t	han maximun	n shear stress		
Design concrete shear stress	adle 3.8	$V_{c \text{ top}} = 0.46$	54 N/mm ²					
g			Vto	e < Vc_toe - No sh	ear reinforce	ment required		
Design of reinforced concrete	e retaining wall	stem (BS 8002	:1994)					
Material properties		•	ř					
Characteristic strength of concr	ete	fcu = 30 N/r	nm²					
Characteristic strength of reinfo	orcement	fy = 500 N/r	mm²					
Wall details								
Minimum area of reinforcement		k = 0.13 %						
Cover to reinforcement in stem		Cstem = 100	mm					
Cover to reinforcement in wall		Cwall = 50 m	IM					
Factored horizontal active for	rces on stem	_						
Surcharge		$Fs_sur_f = \gamma f_f$	$1 \times \text{Ka} \times \text{cos(90}$	$-\alpha + \delta$) × Surcha	rge_{\times} (heff - tbas	se - dds) = 1.6		
KIN/III Moist backfill above water table		E	5 (. K.	$\cos(90 - \pm s)$		$-d_{44} - b_{44})^2 -$		
		T s_m_a_1 — U	$.0 \times \gamma 1_e \times Ra \times$	$\cos(90 - \alpha + \delta) \times$	$\gamma^{m} \times (11e^{m} - coase)$	- uds - fisaty -		
Saturated backfill		Fs s f = 0.5	v vfev Kav CO	$s(90 - \alpha + \delta) \times (\gamma \delta)$	s- wwater) v hsat ²	= 4.2 kN/m		
Water		Fs_water_f = 0	$1.5 \times \gamma^{f}_{e} \times \gamma^{w}_{ate}$	$r_{x} h_{sat}^{2} = 10.7 \text{ kN}$	J/m			
Calculate shear for stem desi	an		~1- ~1	~				
Shear at base of stem	9	Vstem = Fs_s	ur_f + F s_m_a_f +	Fs_s_f + Fs_water_f =	= 16.5 kN/m			
Calculate moment for stem d	esian							
Surcharge		$M_{s_sur} = F_{s_s}$	sur_f _× (hstem + tt	_{base}) / 2 = 1.3 kNn	n/m			
Moist backfill above water table	•	Ms_m_a = Fs	_m_a_f _× (2 _× hsa	t + h eff - d ds + t base	a / 2) / 3 = 0 kN	m/m		
Saturated backfill		$M_{s_s} = F_{s_s}$	_{f ×} h _{sat} / 3 = 1.7	7 kNm/m				
Water		Ms_water = F	s_water_f _× hsat / 3	8 = 4.5 kNm/m				
Total moment for stem design		Mstem = Ms_	sur + Ms_m_a + N	/ls_s + Ms_water = 7 .	. 5 kNm/m			
	•	•	•	•	•			
	◄200							
Check wall stem in bending Width of wall stem		b = 1000 m	ım/m					

Tekla Tedds	Project	38 Mea	dowbank		Job no.	3065		
	Calcs for Under	pinning under RC	wall between I	No. 38 & 39	Start page no./ Approved by mm Approved by mm reinforcement in (0.225) / 0.9)),0.95) 46 mm2/m $retaining wall steens 1 N/mm2 = 4.382 for ess than maximum No shear reinforce$	Revision 7		
	Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved date		
Depth of reinforcement		d _{stem} = t _{wall} -	– Cstem – (_d stem /	(2) = 392.0 mm				
Constant		Kstem = Mste	m / (b $_{\times}$ d _{stem} ² $_{\times}$	(fcu) = 0.002				
			(Compression re	inforcement i	s not required		
Lever arm		Zstem = min((0.5 + √(0.25 -	(min(Kstem, 0.225) / 0.9)),0.95)	$_{\times}$ dstem		
		Zstem = 372	mm					
Area of tension reinforcement	nt required	As_stem_des =	Mstem / (0.87 >	$_{\times}$ fy $_{\times}$ zstem) = 46 n	nm²/m			
Minimum area of tension rein	nforcement	As_stem_min =	$A_{s_stem_min} = k \times b \times t_{wall} = 650 \text{ mm}^2/\text{m}$					
Area of tension reinforcement required		As_stem_req =	Max(As_stem_de	s, As_stem_min) = 65	50 mm²/m			
Reinforcement provided		16 mm dia	.bars @ 200 n	nm centres				
Area of reinforcement provid	led	As_stem_prov =	= 1005 mm²/m					
		PASS - Reinfo	prcement prov	vided at the reta	ining wall ste	m is adequate		
Check shear resistance at	wall stem							
Design shear stress		Vstem = Vsten	n / (b $_{\times}$ dstem) =	0.042 N/mm ²				
Allowable shear stress		$v_{adm} = min($	0.8 _× √(fcu / 1 №	N/mm²), 5) $_{ imes}$ 1 N/	mm ² = 4.382 N	J/mm²		
		PASS -	Design shear	r stress is less t	than maximun	n shear stress		
From BS8110:Part 1:1997 -	- Table 3.8		_					
Design concrete shear stres	S	Vc_stem = 0.4	129 N/mm ²					
			Vstem	< Vc_stem - NO St	near reinforce	ment required		
Check retaining wall defle	ction							
Basic span/effective depth ra	atio	ratio _{bas} = 7	ratio _{bas} = 7					
Design service stress		$f_s = 2 \times f_y \times$	As_stem_req / (3	$_{\times}$ As_stem_prov) = 21	1 5.5 N/mm ²			
Modification factor	factor _{tens} = mi	in(0.55 + (477 N/m	$m^{2} - f_{s})/(120 \times 10^{2})$	(0.9 N/mm ² + (N	$I_{stem}/(b \times d_{stem}^2)$))),2) = 2.00		
Maximum span/effective dep	oth ratio	ratio _{max} = ra	$atio_{bas} \times factor_{te}$	ens = 14.00				
Actual span/effective depth	atio	ratio _{act} = hs	tem / dstem = 3.0	6				
				PASS - Span	to depth ratio	is acceptable		

Project 38 Meadowbank				Job no. 13065	
Calcs for Underpinning under RC wall between No. 38 & 39				Start page no./Revision 8	
Calcs by AP	Calcs date 14/03/2019	Checked by	Checked date	Approved by	Approved date





Toe bars - 16 mm dia.@ 200 mm centres - (1005 mm²/m) Stem bars - 16 mm dia.@ 200 mm centres - (1005 mm²/m)

Tekla	Project				Job no.	
Tedds	38 Meadowbank				13065	
Campbell Reith	Calcs for				Start page no./Revision	
Friars Bridge Court	RC retaining wall for rear garden between No. 37 & 38				1	
41-45 Blackfinars Road London SE1 8NZ	Calcs by AP	Calcs date 26/11/2019	Checked by	Checked date	Approved by	Approved date

TEDDS calculation version 1.2.01.06

RETAINING WALL ANALYSIS (BS 8002:1994)



Wall details

Retaining wall type Height of retaining wall stem Thickness of wall stem Length of toe Length of heel Overall length of base Thickness of base Depth of downstand Position of downstand Thickness of downstand Height of retaining wall Depth of cover in front of wall Depth of unplanned excavation Height of ground water behind wall Height of saturated fill above base Density of wall construction Density of base construction Angle of rear face of wall Angle of soil surface behind wall Effective height at virtual back of wall **Retained material details** Mobilisation factor

Moist density of retained material

Cantilever propped at both hstem = 3500 mm twall = 370 mm Itoe = **1030** mm $I_{heel} = 0 mm$ $I_{base} = I_{toe} + I_{heel} + I_{wall} = 1400 \text{ mm}$ t_{base} = **400** mm $d_{ds} = 0 mm$ Ids = 800 mm tds = **400** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3900 \text{ mm}$ $d_{cover} = 0 mm$ $d_{exc} = \mathbf{0} mm$ hwater = 2750 mm $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 2350 mm$ γ wall = 23.6 kN/m³ $\gamma base = 23.6 \text{ kN/m}^3$ α = **90.0** deg _β = **0.0** deg $h_{eff} = h_{wall} + l_{heel} \times tan(\beta) = 3900 \text{ mm}$

M = **1.5** _{γ^m} = **19.0** kN/m³

Tekla	Project	38 Mea	dowbank		Job no. 13	065		
ledds Campbell Reith	Calcs for				Start page po /Re	avision		
Friars Bridge Court	RC retainir	ng wall for rear g	arden between	No. 37 & 38	otari page no./rte	2		
41-45 Blackfriars Road	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date		
London SE1 8NZ	AP	26/11/2019						
Saturated density of retained m	aterial	γs = 21.5 kľ	N/m³					
Design shear strength		_φ ' = 25.8 de	ġ					
Angle of wall friction		_δ = 19.9 de	g					
Base material details								
Firm clay								
Moist density		γmb = 18.0 k	۸/m³					
Design shear strength		_φ '₅ = 22.6 d	eg					
Design base friction		δ ^b = 17.3 de	eg					
Allowable bearing pressure		Pbearing = 13	5 kN/m²					
Using Coulomb theory								
Active pressure coefficient for re	etained material							
$K_a = sin(\alpha)$ Passive pressure coefficient for	+ $_{\phi}$ ') ² / (sin($_{\alpha}$) ² × base material	$\sin(\alpha - \delta) \times [1 + \beta]$	$\sqrt{(\sin(\phi' + \delta) \times \delta)}$	$\sin(\phi' - \beta) / (\sin(\alpha))$	$-\delta$ × sin(α +	_β)))]²) = 0.347		
	$K_p = sin(90)$	- _φ ' _b)² / (sin(90	- $_{\delta^b}$) $_{\times}$ [1 - $_{\sqrt{si}}$	$n(_{\phi}'_{b} + \delta_{b}) \times sin(_{\phi}'$	b) / (sin(90 + $_{\delta}$	b)))] ²) = 3.690		
At-rest pressure								
At-rest pressure for retained ma	terial	$K_0 = 1 - sin$	$h(\phi') = 0.565$					
Loading details								
Surcharge load on plan		Surcharge	= 2.5 kN/m ²					
Applied vertical dead load on wa	all	W _{dead} = 10.0 kN/m						
Applied vertical live load on wal	l	Wlive = 0.0	≺N/m					
Position of applied vertical load	on wall	load = 1200	mm					
Applied horizontal dead load on	wall	Fdead = 0.0	kN/m					
Applied horizontal live load on v	vall	Flive = 0.0 k	N/m					
Height of applied horizontal load	on wall	nioad = 0 mn	n					
		↓ []	3					
		=	<u>−</u>	A				
				<u> </u>				
	A							
	Prop-							
	25.4 38.4		0.8 7.1 10.4	5 27.0				
				Loads shown	in kN/m, pressure	s shown in kN/m²		

M Teka	Project				Job no.	
Tedds		38 Mead	13065			
Campbell Reith Friars Bridge Court	Calcs for RC retaining wall for rear garden between No. 37 & 38				Start page no./Revision 3	
41-45 Blackfriars Road London SE1 8NZ	Calcs by AP	Calcs date 26/11/2019	Checked by	Checked date	Approved by	Approved date

Vertical forces on wall	
Wall stem	wwall = hstem \times twall $\times \gamma$ wall = 30.6 kN/m
Wall base	Wbase = Ibase \times tbase $\times \gamma$ base = 13.2 kN/m
Applied vertical load	$W_v = W_{dead} + W_{live} = 10 \text{ kN/m}$
Total vertical load	$W_{total} = W_{wall} + W_{base} + W_v = 53.8 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	F_{sur} = Ka $_{\times}$ cos(90 - $_{\alpha}$ + $_{\delta}$) $_{\times}$ Surcharge $_{\times}$ h _{eff} = 3.2 kN/m
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma^m \times (h_{eff} - h_{water})^2 = 4.1 \text{ kN/m}$
Moist backfill below water table	$F_{m_b} = K_a \times cos(90 - \alpha + \delta) \times \gamma^m \times (h_{eff} - h_{water}) \times h_{water} = 19.6 \text{ kN/m}$
Saturated backfill	$F_s = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times (\gamma s^- \gamma water) \times hwater^2 = 14.4 \text{ kN/m}$
Water	Fwater = 0.5 \times hwater ² $\times \gamma$ water = 37.1 kN/m
Total horizontal load	$F_{total} = F_{sur} + F_{m_a} + F_{m_b} + F_s + F_{water} = 78.4 \text{ kN/m}$
Calculate total propping force	
Passive resistance of soil in front of wall	$F_{\text{P}} = 0.5 \times K_{\text{P}} \times \text{cos}(_{\delta^{\text{b}}}) \times (d_{\text{cover}} + t_{\text{base}} + d_{\text{ds}} - d_{\text{exc}})^2 \times \gamma^{\text{mb}} = \textbf{5.1 kN/m}$
Propping force	$F_{prop} = max(F_{total} - F_p - (W_{total}) \times tan(\delta^b), 0 \text{ kN/m})$
	F _{prop} = 56.6 kN/m
Overturning moments	
Surcharge	M_{sur} = $F_{sur \times}$ (heff - 2 \times dds) / 2 = 6.2 kNm/m
Moist backfill above water table	$M_{m_a} = F_{m_a \times} (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 12.9 \text{ kNm/m}$
Moist backfill below water table	$M_{m_b} = F_{m_b \times} (h_{water} - 2_{\times} d_{ds}) / 2 = 27 \text{ kNm/m}$
Saturated backfill	$M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 13.2 \text{ kNm/m}$
Water	$M_{water} = F_{water \times} (h_{water} - 3 \times d_{ds}) / 3 = 34 \text{ kNm/m}$
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 93.3 \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 37.1 \text{ kNm/m}$
Wall base	Mbase = Wbase × Ibase / 2 = 9.3 kNm/m
Design vertical dead load	$M_{dead} = W_{dead} \times I_{load} = 12 \text{ kNm/m}$
Total restoring moment	Mrest = Mwall + Mbase + Mdead = 58.4 kNm/m
Check bearing pressure	
Total vertical reaction	R = W _{total} = 53.8 kN/m
Distance to reaction	Xbar = Ibase / 2 = 700 mm
Eccentricity of reaction	$e = abs((I_{base} / 2) - x_{bar}) = 0 mm$
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 38.4 \text{ kN/m}^2$
Bearing pressure at heel	pheel = (R / Ibase) + (6 \times R \times e / Ibase ²) = 38.4 kN/m ²
PASS	 Maximum bearing pressure is less than allowable bearing pressure
Calculate propping forces to top and base of w	<i>v</i> all

Propping force to top of wall

 $\begin{aligned} F_{prop_top} &= (M_{ot} - M_{rest} + R_{\times} I_{base} / 2 - F_{prop}_{\times} t_{base} / 2) / (h_{stem} + t_{base} / 2) = 16.544 \text{ kN/m} \\ F_{prop_base} &= F_{prop} - F_{prop_top} = 40.067 \text{ kN/m} \end{aligned}$

Propping force to base of wall

Tekla	Project	38 Mea	dowbank		Job no.	3065	
Campbell Reith	Calcs for				Start page no./F	Revision	
Friars Bridge Court	RC retai	ning wall for rear g	arden betweer	n No. 37 & 38		4	
41-45 Blackfriars Road London SE1 8NZ	Calcs by AP	Calcs date 26/11/2019	Checked by	Checked date	Approved by	Approved date	
RETAINING WALL DESIGN (BS	8002:1994)		-		TEDDS calculatio	n version 1 2 01 06	
Ultimate limit state load factors	6					1 10131011 1.2.01.00	
Dead load factor		γf_d = 1.4					
Live load factor		ν _{f_l} = 1.6					
Earth and water pressure factor		$\gamma_{f_e} = 1.4$					
Factored vertical forces on wa	1	,					
Wall stem	-	Wwall f = √f d	✓ hstem ✓ twall ✓	√wall = 42.8 kN/r	n		
Wall base		Wbase $f = \sqrt{f}$	$ \downarrow _{\text{base}} \downarrow t_{\text{base}} \downarrow$	vbase = 18.5 kN	/m		
Applied vertical load		$W_{\rm v} f = v_{\rm f} d$	W dead + \sqrt{f} $$	$W_{live} = 14 \text{ kN/m}$			
Total vertical load		$V_{\text{total}_f} = W_{\text{w}}$	all_f + Wbase_f + \	Nv_f = 75.3 kN/m	1		
Factored horizontal active force	es on wall						
Surcharge		$F_{surf} = \sqrt{f}$	Ka v cos(90 -	$\alpha + \beta$) \sim Surchar	ae v h _{eff} = 5.1	kN/m	
Moist backfill above water table		$F_{m a f = \sqrt{f}}$	√ 0.5 √ Ka √ co	$(90 - \alpha + \beta) \times \alpha$	m √ (heff - hwater)	² = 5.7 kN/m	
Moist backfill below water table kN/m		$F_{m_b_f} = \gamma_{f_e}$	$_{\times}$ K _{a \times} cos(90	$-\alpha + \delta$) $\times \gamma^m \times (h)$	neff - hwater) _× hwa	ater = 27.5	
Saturated backfill		$F_{sf} = \sqrt{f} e \sqrt{f}$	0.5 v Ka v cos	(90 - a + b) × (vs	- water) v hwater ²	= 20.2 kN/m	
Water		Fwater $f = \sqrt{f}$	$\sim 0.5 \times h_{water}^2$	$\sim \sqrt{water} = 51.9 \text{ k}$	N/m		
Total horizontal load		$F_{total_f} = F_{sur}$	_f + Fm_a_f + Fm	_b_f + Fs_f + Fwater	_f = 110.4 kN/n	ı	
Calculate total propping force							
Passive resistance of soil in front	of wall	$F_{p_f} = \gamma_{f_e} \times$	$0.5 \times K_{P} \times cos$	$(\delta^{b}) imes$ (dcover + tba	ise + dds - dexc) ²	$\times \gamma^{mb} = 7.1$	
Propping force		$F_{prop_f} = ma$	X(Ftotal_f - Fp_f -	(Wtotal_f) $_{ imes}$ tan($_{\delta^b}$), 0 kN/m)		
		$\Gamma prop_t = 19.$	9 KIN/III				
Factored overturning moments	5	M =	"		,		
Surcharge		Msur_f = Fsur	$_{f \times}$ (heff - 2 $_{\times}$ 0	lds) / 2 = 9.9 kNm	1/m 0. 40 kbkm/m		
Moist backfill above water table		$IVIm_a_f = Fm_b$	$a_f \times (\text{Neff} + 2 \times $	Nwater - $3 \times \text{Ods}$ /	3 = 18 KNM/M		
Noist backill below water table			_b_f _X (Nwater - 2	\times Ods) / 2 = 37.8	KINITI/ITI		
Saturated backfill		$IVIs_f = Fs_f \times$	(Nwater - 3×0 ds	(3 = 18.3 KINIT)	1/[[] C. {N mo/mo		
Total overturning moment		$\frac{1}{M_{ot} f - M_{out}}$	$a_{ter_t \times} (Iwater - C_{t+1} M_m \circ f + M_m)$	$D \times uds / J = 47.0$	$r_{\rm f} = 1.31 \ \text{g kNir}$	n/m	
		$iviot_i = ivisur_i$, c wum_a_r∓ WIm	i_u_i + ivis_i + iviwat		17/111	
Wall stem		M	uz (h +)	2) - 52 kNm/m			
Wall base		$V_{\text{Wall}} = W_{\text{Wall}}$	$m_r \times (\text{itoe} + \text{twall})$	$z_j = \mathbf{J}\mathbf{Z} \operatorname{KIN(1)}/(1)$			
Nesion vertical load		$M_{i,i} = M_{i,i}$		v i ji kivili/ill vlm/m			
Total restoring moment		$M_{\text{rest } f} = M_{\text{wz}}$	\times illiau – 10.0 Kl all f + Mbase f + N	/lv f = 81.7 kNm/l	m		
Factored bearing pressure							
Total vertical reaction		Rf = Wtotal f	= 75.3 kN/m				
Distance to reaction		Xbar_f = Ibase	/ 2 = 700 mm				
Eccentricity of reaction		$e_f = abs((lba))$	ase / 2) - Xbar_f) =	• 0 mm			
				Reaction acts	within middle	third of base	
Bearing pressure at toe		$p_{toe_f} = (R_f / $	Ibase) - (6 $_{ imes}$ Rf $_{ imes}$	$_{\rm K}$ ef / Ibase ²) = 53.	8 kN/m²		
Bearing pressure at heel		Pheel_f = (Rf	/ Ibase) + (6 $_{ imes}$ Ri	$f_{\times} e_f / I_{base}^2) = 53$	3.8 kN/m ²		
Rate of change of base reaction		$rate = (p_{toe})$	f - Pheel_f) / Ibase	= 0.00 kN/m ² /m			

	1					
Tekla	Project	38 Mea	dowbank		Job no.	3065
Tedds Campbell Reith	Calcs for				Start page no./F	Revision
Friars Bridge Court	RC retainin	ng wall for rear g	arden betwee	en No. 37 & 38		5
41-45 Blackfriars Road	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	AP	26/11/2019				
Bearing pressure at stem / toe		Detem too f =	max(n _{toe f} - (ra	nte v Itae) 0 kN/m²	$f) = 53.8 \text{kN/m}^2$	2
Bearing pressure at stem? toe		Dstem mid f =	max(ploe_r (re	ate \sim (Itoe + twall / 2)). 0 kN/m ²) = $\frac{1}{2}$	53.8 kN/m²
Bearing pressure at stem / heel	l	Pstem_heel_f =	max(ptoe_f - (r	ate \times (Itoe + twall)),	0 kN/m²) = 53 .	8 kN/m ²
Calculate propping forces to Propping force to top of wall	top and base of	wall				
	Fprop_top_f = (I	Mot_f - Mrest_f + Rt	$_{\times}$ Ibase / 2 - Fp	$_{ m rop_f} \times t_{ m base}$ / 2) / (h	stem + t _{base} / 2)	= 23.463 kN/m
Propping force to base of wall		Fprop_base_f =	Fprop_f - Fprop_	top_f = 56.430 kN/r	n	
Design of reinforced concrete	e retaining wall	toe (BS 8002:1	994)			
Material properties						
Characteristic strength of concr	ete	fcu = 30 N/n	nm²			
Characteristic strength of reinfo	orcement	fy = 500 N/r	nm²			
Base details						
Minimum area of reinforcement		k = 0.13 %				
Cover to reinforcement in toe		Ctoe = 50 mi	n			
Calculate shear for toe design	n				1-11/	
Shear from weight of base		V toe_bear = (\mathbf{F}	Dtoe_f + Pstem_toe	$_{\rm f}$ _f) $_{\times}$ Itoe / 2 = 33.4	KIN/m	
Total shear for toe design		V toe_wt_base = V toe = V toe h	$\dot{\gamma}^{T_{d}} \times \gamma^{\text{base}} \times \dot{\gamma}^{\text{base}}$	noe _× ubase = 13.0 k e = 41.8 kN/m	JN/111	
Calculate moment for toe des	sian	•				
Moment from bearing pressure	, gii	Mtoe bear = ()	2 _∨ Dtoe f + Dste	m mid f) √ (Itoe + twa	$(/2)^2/6 = 39.$	7 kNm/m
Moment from weight of base		Mtoe_wt_base =	= $(\gamma f_d \times \gamma base \times$	tbase \times (Itoe + twall /	$(2)^2 / 2) = 9.8$	kNm/m
Total moment for toe design		Mtoe = Mtoe_	bear - Mtoe_wt_bas	_{se} = 29.9 kNm/m		
342	> • •	•	•	• •	•	
	∢ —150 — ►					
Check toe in bending						
Check toe in bending Width of toe		b = 1000 m	m/m			
Check toe in bending Width of toe Depth of reinforcement		b = 1000 m d _{toe} = t _{base} -	m/m - Ctoe — (_ф toe / 2)) = 342.0 mm		
Check toe in bending Width of toe Depth of reinforcement Constant		b = 1000 m d _{toe} = t _{base} - K _{toe} = M _{toe} /	m/m - $C_{toe} - (\phi_{toe} / 2)$ (b $\times d_{toe}^2 \times f_{cu}$) = 342.0 mm) = 0.009	inforcement i	s not required
Check toe in bending Width of toe Depth of reinforcement Constant		b = 1000 m dtoe = tbase - Ktoe = Mtoe / ztoe = min/0	$m/m = c_{toe} - (\phi_{toe} / 2)$ $(b_{\times} d_{toe}^2 \times f_{cu})$) = 342.0 mm h) = 0.009 Compression re fmin(King 0.225)/	inforcement i	s not required
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm		b = 1000 m dtoe = tbase - Ktoe = Mtoe / ztoe = min(0 ztoe = 325 n	m/m $- c_{toe} - (\phi_{toe} / 2)$ $(b \times d_{toe}^2 \times f_{cu}$ $0.5 + \sqrt{0.25} - (0.25)$) = 342.0 mm h) = 0.009 Compression re fmin(K _{toe} , 0.225) /	<i>inforcement i</i> 0.9)),0.95) _× c	s not required
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement r	equired	b = 1000 m dtoe = tbase - Ktoe = Mtoe / Ztoe = Mtoe / Ztoe = 325 m As_toe_des = 1	m/m $- c_{toe} - (\phi_{toe} / 2)$ $(b \times d_{toe}^2 \times f_{cu})$ $0.5 + \sqrt{0.25 - (0.5)}$ m Mtoe / (0.87 × f_{cu})) = 342.0 mm i) = 0.009 <i>Compression re</i> (min(K _{toe} , 0.225) / y _× z _{toe}) = 212 mm	<i>inforcement i</i> 0.9)),0.95) _× c n²/m	s not required
Check toe in bending Width of toe Depth of reinforcement Constant Lever arm Area of tension reinforcement r Minimum area of tension reinfor	equired rcement	b = 1000 m dtoe = tbase - Ktoe = Mtoe / Ztoe = Mtoe / Ztoe = 325 m As_toe_des = 1 As_toe_min = 1	$\frac{dm}{m} = \frac{c_{\text{toe}} - (\phi_{\text{toe}} / 2)}{(b_{\times} d_{\text{toe}}^2 \times f_{\text{cu}})}$ $\frac{dc_{\times} + \sqrt{(0.25 - (c_{\times} - c_{\times}))}}{(c_{\times} + c_{\times} + c_{\times})}$) = 342.0 mm h) = 0.009 Compression re (min(K _{toe} , 0.225) / y _× z _{toe}) = 212 mm 520 mm ² /m	<i>inforcement i</i> . 0.9)),0.95) _× c n²/m	s not required I _{toe}

Tekla °	Project	Job no.					
Tedds		38 Mea	dowbank		13	3065	
Campbell Reith	Calcs for PC retain	ving wall for rear o	lardan batwaan	No 37 & 38	Start page no./R	evision	
41-45 Blackfriars Road						0	
London SE1 8NZ	AP	26/11/2019	Checked by	Checked date	Approved by	Approved date	
Poinforcomont provided		16 mm dia	bars @ 150 m	moontros	•		
Area of reinforcement provided			1340 mm ² /m	in centres			
Alea of reinforcement provided		PASS - Rein	forcement pro	vided at the ret	aining wall to	e is adequate	
Check shear resistance at too			· · · · ·		J	1	
Design shear stress		$\gamma = \sqrt{1}$	(hd.a) - 0 13	2 N/mm ²			
Allowable shear stress		Vode - vice /	$(0 \times 0.00) = 0.12$	(mm^2) 5) 1 N/	mm ² – 4 382 N	l/mm ²	
Allowable shear stress		PASS -	Desian shear	stress is less t	han maximum	shear stress	
From BS8110:Part 1:1997 – Ta	able 3.8		g				
Design concrete shear stress		Vc_toe = 0.5 1	1 1 N/mm ²				
			Vtoe	e < Vc_toe - No sh	ear reinforcer	ment required	
Design of reinforced concrete	retaining wa	II stem (BS 8002	:1994 <u>)</u>				
Material properties							
Characteristic strength of concre	ete	fcu = 30 N/n	nm²				
Characteristic strength of reinfo	rcement	fy = 500 N/r	mm²				
Wall details							
Minimum area of reinforcement		k = 0.13 %					
Cover to reinforcement in stem		Cstem = 100	mm				
Cover to reinforcement in wall		Cwall = 50 m	m				
Factored horizontal active for	ces on stem						
Surcharge		$F_{s_sur_f} = \gamma_{f_}$	I_{\times} Ka $_{\times}$ cos(90	- $_{\alpha}$ + $_{\delta}$) $_{\times}$ Surcha	rge_{\times} (heff - tbas	se - dds) = 4.6	
kN/m							
Moist backfill above water table		$F_{s_m_a_f} = 0.$	$5 \times \gamma^{f_e} \times K_a \times K_a$	$\cos(90 - \alpha + \delta) \times$	$\gamma^{m} imes$ (heff - tbase	- dds - hsat) ² =	
5.7 kN/m							
Moist backfill below water table		$F_{s_m_b_f} = \gamma_f$	$_{e} \times K_{a} \times \cos(90)$	$(0 - \alpha + \delta) \times \gamma^m \times (0)$	heff - tbase - dds	- h _{sat}) _× h _{sat} =	
23.5 kN/m		F 0 F		(22)	× 1 2	44.01.01/	
Saturated backfill		$F_{s_s_f} = 0.5$	×γf_e × Κa × CO	$s(90 - \alpha + \delta) \times (\gamma)$	s-γwater) _× Nsat ⁻	= 14.8 KN/M	
vvater		$Fs_water_f = C$	$0.5 \times \gamma^{f}e \times \gamma^{water}$	\times Nsat ² = 37.9 KN	v/m		
Calculate shear for stem desig	gn						
Surcharge		$V_{s_sur_f} = 5$	$_{\times}$ Fs_sur_f / 8 = 2.	. 9 kN/m			
Moist backfill above water table		$V_{s_m_a_f} = F$	s_m_a_f _× bi _× ((5	$_{\times}$ L ²) - bi ²) / (5 $_{\times}$	L ³) = 1.8 kN/m)	
Moist backfill below water table		$V_{s_m_b_f} = F$	s_m_b_f _× (8 - (n ²	\times (4 - n))) / 8 = 1	1 8.9 kN/m		
Saturated backfill		$V_{s_s_f} = F_{s_s}$	_f _× (1 - (a [,] _× ((5 _× L) - aı) / (20 ₃	_≺ L³))) = 13.2 k	N/m	
Water		$V_{s_water_f} = F$	-s_water_f _× (1 - (8	u² _× ((5 _× L) - aı)	$/(20 \times L^3))) = 3$	34 kN/m	
Total shear for stem design		Vstem = Vs_s	ur_f + Vs_m_a_f + `	Vs_m_b_f + Vs_s_f +	$Vs_water_f = 10.0$	5 KIN/M	
Calculate moment for stem de	esign						
Surcharge		Ms_sur = Fs_s	$sur_{f \times} L / 8 = 2.1$	I kNm/m			
Moist backfill above water table		Ms_m_a = Fs_	_m_a_f _× bl _× ((5 ;	K L ²) - (3 × bl ²)) /	(15 _× L ²) = 2.1	KNM/M	
Moist backfill below water table		$M_{s_m_b} = F_{s_b}$	$_m_b_f \times a_1 \times (2 -$	n) ² / 8 = 12.9 kN	Im/m		
Saturated backfill		$M_{s_s} = F_{s_s}$	f _× al _× ((3 _× al [∠])-(1	$5_{\times}a_{\times}L)+(20_{\times}L^{2})$)/(60 _× L²) = 7 kl	NM/M	
vvater kNm/m		IVIs_water = Fs	s_water_f _X al _X ((3 _X a	a⊧)-(15 _× ai _× L)+(2	U _X L ⁻))/(6U _X L ²)	= 17.9	
Total moment for stem design		Meter - Ma	sur + M∝ m ~ + M	s m h + Ma a + Ma	water = 41 9 k N	m/m	
Coloulate memort for well de-	lan		ουι ι ινις_Π_α τ ΙVΙ	JULU TIVISS TIVIS	_walei — 71.3 NN		
Calculate moment for wall des Surcharge	sign	$M_{w_sur} = 9 \times$	_ Fs_sur_f _× L / 12	8 = 1.2 kNm/m			



Tekla Tedds	Project	38 Mea	Job no.	Job no. 13065				
Campbell Reith Friars Bridge Court 41-45 Blackfriars Road	Calcs for RC retai	ning wall for rear g	garden betwee	en No. 37 & 38	Start page no./F	Revision 8		
41-45 Blackfriars Road London SE1 8NZ	Calcs by AP	Calcs date 26/11/2019	Checked by	Checked date	Approved by	Approved date		
Lever arm Area of tension reinforcemer	it required	zwall = Min(4 zwall = 298 As_wall_des =	0.5 + √(0.25 - mm M _{wall} / (0.87 _×	(min(K _{wall} , 0.225) f _{y ×} z _{wall}) = 147 m	/ 0.9)),0.95) $_{\times}$ mm²/m	dwall		
Minimum area of tension reir Area of tension reinforcemer	forcement t required	As_wall_min = $k \times b \times t$ wall = 481 mm ² /m As wall reg = Max(As wall des, As wall min) = 481 mm ² /m						
Reinforcement provided Area of reinforcement provid	Reinforcement provided		12 mm dia.bars @ 150 mm centres As_wall_prov = 754 mm ² /m					
	PASS	S - Reinforcemen	t provided to	the retaining wa	all at mid heig	ht is adequate		
Check retaining wall deflect Basic span/effective depth ra	tion	rationes - 2	n					

Design service stress		f_{s} = 2 $_{\times}$ fy $_{\times}$ As_stem_req / (3 $_{\times}$ As_stem_prov) = 119.6 N/mm^{2}
Modification factor	$factor_{tens} = min(0.55)$	+ (477 N/mm ² - fs)/(120 \times (0.9 N/mm ² + (M _{stem} /(b \times d _{stem} ²)))),2) = 2.00
Maximum span/effective depth	ratio	$ratio_{max} = ratio_{bas} \times factor_{tens} = 40.00$
Actual span/effective depth ratio	D	ratio _{act} = h _{stem} / d _{stem} = 13.36

PASS - Span to depth ratio is acceptable

Tekla Tedds Campbell Reith Friars Bridge Court	Project	38 Mea	Job no. 1:	Job no. 13065		
	Calcs for RC retain	ning wall for rear g	garden betwee	en No. 37 & 38	Start page no./F	Revision 9
41-45 Blackfriars Road London SE1 8NZ	Calcs by AP	Calcs date 26/11/2019	Checked date	Approved by	Approved date	
Indicative retaining wall re	einforcement dia	gram				



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

Tekla	Project				Job no.		
Tedds	38 Meadowbank					13065	
Campbell Reith	Calcs for					Start page no./Revision	
Friars Bridge Court		Rear garden R	C retaining wal	I		1	
41-45 Blackfriars Road London SE1 8NZ	Calcs by AP	Calcs date 26/11/2019	Checked by	Checked date	Approved by	Approved date	



Angle of soil surface behind wall Effective height at virtual back of wall

Retained material details Mobilisation factor Moist density of retained material

M = 1.5 $\gamma m = 19.0 \text{ kN/m}^3$

 $h_{eff} = h_{wall} + l_{heel} \times tan(\beta) = 3700 \text{ mm}$

	1					1			
🖊 Tekla	Project	29 Maa	Job no.						
Tedds		30 Mea	dowbank		13	600			
Friars Bridge Court	Calcs for	Rear garden R	C retaining wa	all		Start page no./R	evision 2		
41-45 Blackfriars Road	Calcs by	Calcs date		Check	atch hay	Approved by			
London SE1 8NZ	AP	26/11/2019	Checked by	Check		Approved by	Approved date		
Saturated density of retained m	aterial	_γ s = 21.5 kl	N/m ³						
Design shear strength		, ط' = 25.8 de	eg						
Angle of wall friction		_δ = 19.9 de	g						
Base material details		0	0						
Firm clay									
Moist density		vmb = 18.0	kN/m ³						
Design shear strength		, , , , , , , , , , , , , , , , , , ,	lea						
Design base friction		φ ² <u>17.3</u> de	ea						
Allowable bearing pressure		$P_{\text{bearing}} = 13$	35 kN/m ²						
Using Coulomb theory		,	-						
Active pressure coefficient for r	etained materia	1							
$K_{a} = \sin(\alpha)$	+ $\frac{1}{2}/(\sin(\omega)^2)$		$\sqrt{(\sin(x' + s))}$	sin(+' -	a) / (sin($-s) \cup sin(a +$	$(0)))(1^2) = 0.347$		
Passive pressure coefficient for	base material	× 3π(α - 0) × [1 -	γ(3 π(φ + 6) ×	σιι(φ	ρ) / (3π(α	0) × 3π(α τ	p///] / – 0.04 7		
· ·····	K _p = sin(9	0'b) ² / (sin(90	- sb) √ [1 - √(s	sin("'ь +	ջթ) որ sin(պ	.'b) / (sin(90 + s	$(x_b)))]^2) = 3.690$		
At root processo		φ., . (0-7 × 1 · · · · · · · · · · · · · · · · · ·	ψ	0-7 ×φ		,-,,,],		
At-rest pressure for retained ma	atorial	$K_0 = 1 - sir$	o('') - 0 565						
	aterial	$R_0 = 1 - SI$	$I(\phi) = 0.303$						
Loading details			501 11/ 2						
Surcharge load on plan	- 11	Surcharge	= 5.0 kN/m ²						
Applied vertical dead load on w	all I	VV dead = 0.0	/ KIN/M kNl/m						
Position of applied vertical load	on wall	$l_{load} = 0 \text{ mm}$	אוא/ווו ו						
Applied horizontal dead load or	n wall	Fdead = 0.0	kN/m						
Applied horizontal live load on	wall	Flive = 0.0 k	N/m						
Height of applied horizontal load	d on wall	$h_{load} = 0 mr$	n						
		[μιμιμ						
25.	Prop				23.5				
					Loads show	n in kN/m, pressure	es shown in kN/m ²		

M Teka	Project				Job no.	
Tedds		13065				
Campbell Reith	Calcs for				Start page no./Revision	
Friars Bridge Court		Rear garden R	C retaining wall			3
41-45 Blackfriars Road London SE1 8NZ	Calcs by AP	Calcs date 26/11/2019	Checked by	Checked date	Approved by	Approved date

Vertical forces on wall	
Wall stem	Wwall = hstem \times twall $\times \gamma$ wall = 19.5 kN/m
Wall base	Wbase = Ibase \times tbase $\times \gamma$ base = 17.9 kN/m
Surcharge	w _{sur} = Surcharge × I _{heel} = 1.3 kN/m
Moist backfill to top of wall	$w_{m_w} = I_{heel \times} (h_{stem} - h_{sat}) \times \gamma^m = 6.2 \text{ kN/m}$
Saturated backfill	$W_s = I_{heel \times} h_{sat \times \gamma^s} = 10.8 \text{ kN/m}$
Total vertical load	$W_{total} = W_{wall} + W_{base} + W_{sur} + W_{m_w} + W_s = 55.6 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	$F_{sur} = K_a \times cos(90 - \alpha + \delta) \times Surcharge \times h_{eff} = 6 \text{ kN/m}$
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma^m \times (h_{eff} - h_{water})^2 = 5.2 \text{ kN/m}$
Moist backfill below water table	$F_{m_b} = K_a \times cos(90 - \alpha + \delta) \times \gamma^m \times (h_{eff} - h_{water}) \times h_{water} = 19.4 \text{ kN/m}$
Saturated backfill	$F_s = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times (\gamma^{s-} \gamma^{water}) \times h_{water}^2 = 11 \text{ kN/m}$
Water	Fwater = $0.5 \times h_{water}^2 \times \gamma_{water}$ = 28.3 kN/m
Total horizontal load	$F_{total} = F_{sur} + F_{m_a} + F_{m_b} + F_s + F_{water} = 69.9 \text{ kN/m}$
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 $_{\times \gamma mb}$ = 5.1 kN/m
Propping force	$F_{prop} = max(F_{total} - F_p - (W_{total} - w_{sur}) \times tan(\delta b), 0 \text{ kN/m})$
	F _{prop} = 47.9 kN/m
Overturning moments	
Surcharge	Msur = Fsur $_{\times}$ (heff - 2 $_{\times}$ dds) / 2 = 11.2 kNm/m
Moist backfill above water table	$M_{m_a} = F_{m_a \times} (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 14.9 \text{ kNm/m}$
Moist backfill below water table	$M_{m_b} = F_{m_b \times} (h_{water} - 2_{\times} d_{ds}) / 2 = 23.2 kNm/m$
Saturated backfill	$M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 8.8 \text{ kNm/m}$
Water	Mwater = Fwater $_{\times}$ (hwater - 3 $_{\times}$ dds) / 3 = 22.6 kNm/m
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 80.7 \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{wall} = W_{wall} \times (I_{toe} + t_{wall} / 2) = 29.7 \text{ kNm/m}$
Wall base	$M_{\text{base}} = w_{\text{base}} \times I_{\text{base}} / 2 = 17 \text{ kNm/m}$
Moist backfill	$M_{m_r} = (w_{m_w} \times (l_{\text{base}} - l_{\text{heel}} / 2) + w_{m_s} \times (l_{\text{base}} - l_{\text{heel}} / 3)) = 11 \text{ kNm/m}$
Saturated backfill	$M_{s_r} = w_s \times (l_{base} - l_{heel} / 2) = 19.1 \text{ kNm/m}$
Total restoring moment	$M_{\text{rest}} = M_{\text{wall}} + M_{\text{base}} + M_{\text{m}_{r}} + M_{\text{s}_{r}} = 76.8 \text{ kNm/m}$
Check bearing pressure	
Total vertical reaction	R = W _{total} = 55.6 kN/m
Distance to reaction	x _{bar} = I _{base} / 2 = 950 mm
Eccentricity of reaction	$e = abs((l_{base} / 2) - x_{bar}) = 0 mm$
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 29.3 \text{ kN/m}^2$
Bearing pressure at heel	pheel = (R / Ibase) + (6 \times R \times e / Ibase ²) = 29.3 kN/m ²
PASS -	waximum bearing pressure is less than allowable bearing pressure
Calculate propping forces to top and base of w	all
Propping force to top of wall	
Fprop_top =	(Mot - Mrest + R_{\times} lbase / 2 - $F_{prop \times}$ tbase / 2) / (hstem + tbase / 2) = 13.458 kN/m

Propping force to base of wall

Fprop_base = Fprop - Fprop_top = **34.432** kN/m

Tekla	Project	Project Job no. 38 Meadowbank 13065					
ledds Campbell Reith	Calco for	Cales for					
Friars Bridge Court	Calcs for	Rear garden R	C retaining wa	all	Start page no./r	4	
41-45 Blackfriars Road	Calco by	Cales data	Chackad by	Approved by	Approved date		
London SE1 8NZ	AP	26/11/2019	Checked by	Checked date	Approved by	Approved date	
				-			
RETAINING WALL DESIGN	N (BS 8002:1994)	<u>)</u>			TEDDS calculatio	n version 1.2.01.0	
Ultimate limit state load fa	ctors						
Dead load factor		$\gamma^{f_d} = 1.4$					
Live load factor		γ ^{f_l} = 1.6					
Earth and water pressure fa	ctor	γ ^f _e = 1.4					
Factored vertical forces or	n wall						
Wall stem		W wall_f = γ f_d	$_{ imes}$ hstem $_{ imes}$ twall $_{ imes}$	γ wall = 27.3 kN/r	m		
Wall base		Wbase_f = γf_{-}	d $_{\times}$ lbase $_{\times}$ tbase $_{>}$	_{<γbase} = 25.1 kN	l/m		
Surcharge		Wsur_f = γf_1	$_{\times}$ Surcharge $_{\times}$	I _{heel} = 2 kN/m			
Moist backfill to top of wall		$W_{m_w_f} = \gamma f_{\phi}$	d $_{\times}$ Iheel $_{\times}$ (hstem	- hsat) _{× γ} m = 8.6	s kN/m		
Saturated backfill		$Ws_f = \gamma f_d \times$	Iheel × hsat × vs	= 15.1 kN/m			
Total vertical load		W total_f = Wv	vall_f + Wbase_f + V	Wsur_f + Wm_w_f + V	Ns_f = 78.1 kN/n	n	
Factored horizontal active	forces on wall						
Surcharge		$F_{sur} f = \sqrt{f}$	∠ Ka ∨ cos(90 -	$(\alpha + s) \sim Surchar$	rae v heff = 9.7	kN/m	
Moist backfill above water ta	ble	$F_{m,a,f} = \sqrt{f}$,	$0s(90 - \alpha + \delta) \times \delta$	/m v (heff - hwater) ² = 7.3 kN/m	
Moist backfill below water ta	ble	$F_{m,b,f} = v_{f,c}$		+ s)	h_{X} (new inwater)		
kN/m	bie	τ m_b_i — γι_e	× 11a × 003(30	- α + ο) × γ ^m × (ι	Ten - Tiwater) X Tiwa	aler — 21.1	
Saturated backfill		$F_{s_f} = \gamma f_e \times$	$0.5 \times K_a \times cos$	$(90 - \alpha + \delta) \times (\gamma^{s})$	- γ water) \times hwater ²	= 15.4 kN/m	
Water		$F_{water_f} = \gamma f_{-}$	$_{e}$ $_{\times}$ 0.5 $_{\times}$ hwater ²	$\times \gamma^{water} = 39.6 \text{ k}$	kN/m		
Total horizontal load		F _{total_f} = F _{su}	r_f + Fm_a_f + Fm	n_b_f + Fs_f + Fwater	_{r_f} = 99 kN/m		
Calculate total propping for	orce						
Passive resistance of soil in	front of wall	$F_{p_f} = \gamma_{f_e} \times$	$0.5 \times K_{P} \times cos$	$(\delta^{b}) \times (d_{cover} + t_{ba})$	ase + dds - dexc) ²	$\times \gamma^{mb} = 7.1$	
kN/m							
Propping force		Fprop_f = ma	ax(F total_f - Fp_f -	(Wtotal_f - Wsur_f) >	$_{<}$ tan($_{\delta^{b}}$), 0 kN/i	m)	
		$F_{prop_f} = 68$.3 kN/m				
Factored overturning mon	nents						
Surcharge		$M_{sur_f} = F_{sur}$	$r_f \times (h_{eff} - 2 \times c)$	dds) / 2 = 17.9 kN	lm/m		
Moist backfill above water ta	ble	$M_{m_a_f} = F_m$	$_{a_f \times}$ (heff + 2 $_{\times}$	$_{\rm c}$ hwater - 3 $_{ imes}$ dds) /	′ 3 = 20.8 kNm/	m	
Moist backfill below water ta	ble	$M_{m_b_f} = F_{m}$	$h_b_f \times (h_{water} - 2)$	$_{\times}$ d _{ds}) / 2 = 32.5	kNm/m		
Saturated backfill		$M_{s_f} = F_{s_f}$	$_{\rm <}$ (h _{water} - 3 $_{ imes}$ dd	s) / 3 = 12.3 kNn	n/m		
Water		$M_{water_f} = F_{v}$	water_f $_{\times}$ (hwater - 3	$3 \times d_{ds}) / 3 = 31.0$	6 kNm/m		
Total overturning moment		Mot_f = Msur	_f + Mm_a_f + Mn	n_b_f + Ms_f + Mwat	ter_f = 115.2 kNi	m/m	
Restoring moments							
Wall stem		$M_{wall_f} = W_{wall_f}$	all_f $_{ imes}$ (Itoe + twall ,	/ 2) = 41.6 kNm/	m		
Wall base		Mbase_f = Wb	$_{ m base_f \times lbase}$ / 2 =	= 23.9 kNm/m			
Surcharge		Msur_r_f = Ws	sur_f _× (Ibase - Ihee	a / 2) = 3.6 kNm/	m		
Moist backfill		$M_{m_r_f} = (W_r)$	n_w_f _× (Ibase - Ihe	eel / 2) + Wm_s_f _× !	(Ibase - Iheel / 3))	= 15.3 kNm/m	
Saturated backfill $M_{s r f} = W_{s f} (I_{base} - I_{heel} / 2) = 26.7 \text{ kNm/m}$							
Total restoring moment		Mrest_f = Mw	all_f + Mbase_f + N	Nsur_r_f + Mm_r_f +	Ms_r_f = 111 kN	lm/m	
Factored bearing pressure	2						
Total vertical reaction	-	Rf = Wtotal f	= 78.1 kN/m				
Distance to reaction		Xbar_f = Ibase	/ 2 = 950 mm				

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Campbell Reith	Calcs for	Deer verden D	C ratainin a w	- 11	Start page no./R	Revision				
41-45 Blackfriars Road					_	5				
London SE1 8NZ	Calcs by AP	Calcs date 26/11/2019	Checked by	Checked date	Approved by	Approved date				
Eccentricity of reaction		ef = abs((Iba	ase / 2) - Xbar_f) :	= 0 mm <i>Reaction acts</i>	within middle	third of base				
Bearing pressure at toe		Dtoe $f = (Rf)$	lbase) - (6 v Rf	$\sim e_{\rm f} / l_{\rm base}^2 = 41.1$	l kN/m ²					
Bearing pressure at beel		$p_{\text{hose}} = (\mathbf{R})$	/ lbase) + (6 F	$R_{f} = \Theta_{f} / (h_{0} c_{0}^{2}) - 41$	1 kN/m ²					
Bate of change of base reaction	,	rate - (no	$f = D_{\text{bool}} f / boost$	$x = 0.00 \text{ kN/m}^2/\text{m}$						
Bearing pressure at stem / toe	•	$\mathbf{D}_{\text{storm too}} = (\mathbf{p}_{100})$	$max(n_{too} + - (rate))$	$(1 + 1) = 0.00 \text{ km}/\text{m}^2$) – 41 1 kN/m ²					
Boaring pressure at mid stom			$max(p_{100}) (red)$	$\frac{1}{2} = \frac{1}{2} $	(1 - 4 - 1) = (1 - 4)	11 1 kN/m^2				
Bearing pressure at this stem		pstem_mid_t =		ate \times (lite $+$ twai / 2)	$(), 0 \text{ kN/m}^2)$	+ 1.1 KIN/III				
Bearing pressure at stem / neer		$p_{stem_heel_f} =$	max(ptoe_f - (fa	ate \times (Itoe + twall)),	$0 \text{ kin/m}^{-} = 41.$	T KIN/m ⁻				
Calculate propping forces to t Propping force to top of wall	op and base	of wall								
	Enrop top f =	(Mot f - Mrest f + Rt	Ibase / 2 - F n	ron f., thase / 2) / (h	stem + thase / 2) :	= 18 465 kN/m				
Propping force to base of wall	1 piop_iop_i =	Fprop_base_f =	Fprop_f - Fprop_t	top_f = 49.790 kN/r	n	10.400 14 011				
Design of reinforced concrete	retaining wa	III toe (BS 8002:1	994 <u>)</u>							
Material properties										
Characteristic strength of concre	ete	f _{cu} = 30 N/n	nm²							
Characteristic strength of reinfo	rcement	fy = 500 N/r	fy = 500 N/mm ²							
Base details										
Minimum area of reinforcement		k – 0 13 %								
Cover to reinforcement in toe		Ctoe = 50 mi	$C_{\text{the}} = 50 \text{ mm}$							
Calculate shear for toe design	1	,		· · · ·						
Shear from bearing pressure		$V_{toe_{bear}} = (p_{bear})$	Dtoe_f + Pstem_toe	_f) \times Itoe / 2 = 57.5	kN/m					
Shear from weight of base		V _{toe_wt_base} =	$V_{toe_wt_base} = \gamma f_d \times \gamma pase \times I_{toe} \times t_{base} = 18.5 \text{ kN/m}$							
Total shear for toe design		$V_{toe} = V_{toe_b}$	ear - Vtoe_wt_base	e = 39 kN/m						
Calculate moment for toe des	ign									
Moment from bearing pressure		Mtoe_bear = (2	$2 \times p_{toe_f} + p_{ste}$	m_mid_f) $_{ imes}$ (Itoe + twal	$(/2)^2/6 = 47.8$	3 kNm/m				
Moment from weight of base		Mtoe_wt_base =	= ($\gamma f_d \times \gamma base \times$	$t_{ m base}$ $ imes$ (Itoe + t _{wall} /	$(2)^2 / (2) = 15.4$	kNm/m				
Total moment for toe design		Mtoe = Mtoe_	Mtoe = Mtoe_bear - Mtoe_w_base = 32.4 kNm/m							
	-	•	•	• •	•					
	◀── 150──▶									
Chack too in handing										
Width of toe		h - 1000 ~	m/m							
		ט = וו 1000 ווו	···/·) _ 242 0						
		Utoe = Ibase -	- Utoe – (ϕ toe / 2)	y = 342.0 (1)(1)						
Constant	nt $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu}) = 0.009$									

Compression reinforcement is not required

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Campbell Reith Friars Bridge Court	Calcs for	Rear garden R	C retaining wa	II	Start page no./F	Start page no./Revision 6			
41-45 Blackfriars Road London SE1 8NZ	Calcs by AP	Calcs date 26/11/2019	Checked by	Checked date	Approved by	Approved date			
Lever arm		$z_{\text{toe}} = \min(0.5 + \sqrt{(0.25 - (\min(K_{\text{toe}}, 0.225) / 0.9)), 0.95)} \times d_{\text{toe}}$ $z_{\text{toe}} = 325 \text{ mm}$							
Area of tension reinforcement	t required	As toe des =	Mtoe / (0.87 _v fv	✓ Ztoe) = 229 mm	n²/m				
Minimum area of tension rein	forcement	As toe min =	$k \ge b \ge t_{base} = 5$	20 mm²/m					
Area of tension reinforcement	t required	As_toe_req = I	Max(As_toe_des, A	(s_toe_min) = 520 m	nm²/m				
Reinforcement provided	·	16 mm dia	.bars @ 150 m	im centres					
Area of reinforcement provide	ed	As_toe_prov =	1340 mm²/m						
		PASS - Rein	forcement pro	vided at the rea	taining wall to	e is adequate			
Check shear resistance at t	oe								
Design shear stress		Vtoe = Vtoe /	(b _∨ d _{toe}) = 0.1 1	14 N/mm ²					
Allowable shear stress		Vadm = min(0.8 × √(f _{cu} / 1.N	$/mm^2$) 5) $\sim 1 N/$	mm ² = 4.382 M	J/mm ²			
		$vaam = 1111(0.0 \times \sqrt{(100 / 1.10/11111 /), 3) \times 1.10/11111^{-}} = 4.302 10/11111^{-}$							
From BS8110:Part 1:1997 –	Table 3.8	i Add - Design shear su ess is iess than maximum shear su ess							
Design concrete shear stress		Vc_toe = 0.5 ²	1 N/mm ²						
-			Vtoe	e < Vc_toe - No sh	ear reinforce	ment required			
Design of reinforced concre	ete retaining wa	all heel (BS 8002:	1994)						
Motorial properties	<u></u>		<u></u>						
Characteristic strength of con	crete	fau – 30 N/r	nm ²						
Characteristic strength of rein		$f_{\rm M} = 500 {\rm N/r}$	mm ²						
Base details	nt	k - 0 13 %							
Cover to reinforcement in bee	11L SI	K = 0.13%	m						
	•								
Calculate shear for heel des	sign								
Shear from bearing pressure		Vheel_bear = (Pheel_f + Pstem_he	$el_f) \times lheel / 2 = 10$	0.3 kN/m				
Shear from weight of base		Vheel_wt_base	$= \gamma^{f_d} \times \gamma^{base} \times I$	heel \times tbase = 3.3 k	kN/m				
Shear from weight of moist ba	ackfill	Vheel_wt_m =	Wm_w_f = 8.6 kN	/m					
Shear from weight of saturate	ed backfill	$V_{heel_wt_s} = V_{heel_wt_s}$	Ws_f = 15.1 KN/n	n					
Shear from surcharge		$V_{heel_{sur}} = W_{sur_{f}} = 2 \text{ kN/m}$							
lotal snear for neel design		Vheel = - Vheel_bear + Vheel_wt_base + Vheel_wt_m + Vheel_wt_s + Vheel_sur = 18.7							
Calculate moment for heel	design			N U		- · · · ·			
Moment from bearing pressu	re	Mheel_bear =	$(2 \times p_{\text{heel}_f} + p_{\text{ster}})$	$m_{mid_f} \times (lheel + 1)$	$(vall / 2)^2 / 6 = 2$.9 kNm/m			
Moment from weight of base		Mheel_wt_base	= $(\gamma f_d \times \gamma pase \times$	$t_{base} \times (I_{heel} + t_{wal})$	$(2)^2/2 = 0.9$) kNm/m			
Moment from weight of moist backfill $M_{heel_wt_m} = W_{m_w_f}$				$m = W_{m_w_f} \times (I_{heel} + t_{wall}) / 2 = 2.2 \text{ kNm/m}$					
Moment from weight of satura	ated backfill	Mheel_wt_s =	Ws_f $_{\times}$ (Iheel + twa	u) / 2 = 3.8 kNm/	m				
Moment from surcharge		$M_{heel_sur} = v$	/sur_f $_{\times}$ (Iheel + twa	all) / 2 = 0.5 kNm/	/m				
Total moment for heel designMneel = - Mheel_bear + Mheel_wt_base + Mheel_wt_m +kNm/m					+ Mheel_wt_s + N	Mheel_sur = 4.5			

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Campbell Reith Friars Bridge Court	Calcs for	Rear garden F	C retaining wal	I	Start page no./F	Revision 7	
41-45 Blackfriars Road London SE1 8NZ	Calcs by AP	Calcs date 26/11/2019	Checked by	Checked date	Approved by	Approved date	
	 ← 150 → 	•	•	•	•		
400							
Check heel in bending							
Width of heel		b = 1000 n	nm/m				
Depth of reinforcement		dheel = tbase	$- Cheel - (_{\phi}heel / 2)$	2) = 364.0 mm			
Constant		Kheel = Mhee	er / (b $_{\times}$ dheer ² $_{\times}$ fc	u) = 0.001	dereement i	o not required	
Lever arm		$Z_{\text{heel}} = \min($	0.5 + √(0.25 - (r	$\min(K_{heel}, 0.225) /$	(0.9)),0.95) _×	dheel	
Area of tension reinforcement rec	quired		Mhool / (0.87 f	v zhool) – 30 mm	² /m		
Minimum area of tension reinforc	rement	As heat min =	$\mathbf{k} = \mathbf{b} = \mathbf{b}$	20 mm ² /m	. ,		
Area of tension reinforcement rec	auired	As_heel_rnin =	$Max(A_s heel des$	As beel min) = 520	mm²/m		
Reinforcement provided	401100	12 mm dia	l.bars @ 150 m	m centres			
Area of reinforcement provided		As heel prov =	= 754 mm²/m				
		PASS - Reinf	orcement prov	ided at the retai	ning wall he	el is adequate	
Check shear resistance at heel	I						
Design shear stress		Vheel = Vheel	/ (b $_{\times}$ dheel) = 0.	051 N/mm²			
Allowable shear stress		Vadm = min($0.8 \times \sqrt{f_{cu} / 1 N}$	/mm²), 5) $_{ imes}$ 1 N/m	1m ² = 4.382 N	√/mm²	
		PASS -	Design shear	stress is less th	an maximun	n shear stress	
From BS8110:Part 1:1997 – Tal	ble 3.8						
Design concrete shear stress		Vc_heel = 0.4	07 N/mm ²				
			Vheel	< V _{c_heel} - NO SNE	ear reinforcei	ment required	
Design of reinforced concrete	retaining wall	stem (BS 8002	::1994)				
Material properties							
Characteristic strength of concre	te	fcu = 30 N/r	nm²				
Characteristic strength of reinford	cement	fy = 500 N/	mm ²				
Wall details							
Minimum area of reinforcement		k = 0.13 %					
Cover to reinforcement in stem		Cstem = 100	mm				
Cover to reinforcement in wall		Cwall = 50 m	ım				
Factored horizontal active forc	es on stem						
Surcharge		$F_{s_sur_f} = \gamma f_{_}$	$_{I \times} K_{a \times} \cos(90 \cdot$	$(\alpha + \delta) \times Surchar$	$ge \times (h_{eff} - t_{ba})$	se - dds) = 8.6	
kN/m		- -	_	(00 ·	<i>"</i>		
vioist backfill above water table 7.3 kN/m		⊢s_m_a_f = 0	.5 $_{ imes}$ γ^{f}_{-} e $_{ imes}$ Ka $_{ imes}$ C	:os(90 - _α + δ) _{× γ}	m _X (Neff - t base	→ - Øds - Nsat) ² =	

Tekla Tedds	Project	38 Mea	dowbank	Job no. 13065				
Campbell Reith Friars Bridge Court	Calcs for	Rear garden R	C retaining wa	all	Start page no./R	Start page no./Revision 8		
41-45 Blackfriars Road London SE1 8NZ	Calcs by AP	Calcs date 26/11/2019	Checked by	Checked date	Approved by	Approved date		
Moist backfill below water table		$F_{s_m_b_f} = \gamma f_{-}$	₋e _× Ka _× cos(9	$0 - \alpha + \delta) \times \gamma^m \times (h)$	Neff - tbase - dds -	hsat) _× hsat =		
22.6 KN/m								
Saturated backfill		$F_{s_s_f} = 0.5$	$_{\times \gamma^{f}_{e} \times} K_{a} \times CC$	$(90 - \alpha + \delta) \times (\gamma^{s})$	· - γwater) _X hsat ⁻ : ,	= 10.7 kN/m		
Water		$Fs_water_f = 0$	$.5 \times \gamma^{f_e} \times \gamma^{wate}$	r _× hsat ² = 27.5 kN	/m			
Calculate shear for stem desi	gn							
Surcharge		$V_{s_sur_f} = 5$	< Fs_sur_f / 8 = 5	5 .4 kN/m				
Moist backfill above water table		$V_{s_m_a_f} = F_s$	s_m_a_f _× bı _× ((5	$5_{ imes}$ L ²) - bi ²) / (5 $_{ imes}$	L ³) = 2.7 kN/m			
Moist backfill below water table		$V_{s_m_b_f} = F_s$	s_m_b_f _× (8 - (n ²	² _× (4 - n))) / 8 = 1	8.8 kN/m			
Saturated backfill		$V_{s_s_f} = F_{s_s}$	$_{1}^{f} \times (1 - (a^{2} \times ($	(5 $_{ imes}$ L) - aı) / (20 $_{ imes}$	(L ³))) = 9.8 kN	/m		
Water		$V_{s_water_f} = F_{s_water_f \times} (1 - (a_{12}^2 \times ((5 \times L) - a_{12}) / (20 \times L^3))) = 25.1 \text{ kN/m}$						
Total shear for stem design		Vstem = Vs_su	ır_f + Vs_m_a_f +	$V_{s_m_b_f} + V_{s_s_f} +$	Vs_water_f = 61.7	′ kN/m		
Calculate moment for stem d	esign							
Surcharge		$M_{s_sur} = F_{s_s}$	$ur_f \times L / 8 = 3.$	8 kNm/m				
Moist backfill above water table		Ms_m_a = Fs_	$m_a_f \times b_1 \times ((5$	$_{ imes}$ L ²) - (3 $_{ imes}$ bl ²)) /	(15 _× L ²) = 2.9	kNm/m		
Moist backfill below water table		$M_{s_m_b} = F_{s_b}$.m_b_f $_{\times}$ al $_{\times}$ (2 -	• n) ² / 8 = 11.7 kN	m/m			
Saturated backfill		$M_{s_s} = F_{s_s_f}$	\times al \times ((3 \times al ²)-(1	$15_{\times}a_{\times}L)+(20_{\times}L^2))$	/(60 _× L ²) = 4.6	kNm/m		
Water		Ms_water = Fs	_water_f ×al×((3×	a^{2})-(15 $_{\times}a_{1\times}L$)+(20)	0 _× L ²))/(60 _× L ²) =	= 11.8		
kNm/m								
Total moment for stem design		Mstem = Ms_s	sur + Ms_m_a + N	1s_m_b + Ms_s + Ms_	water = 34.8 kN	m/m		
Calculate moment for wall de	sign							
Surcharge		$M_{w_sur} = 9 \times$	$F_{s_sur_f \times} L / 12$	28 = 2.1 kNm/m				
Moist backfill above water table kNm/m		$M_{w_m_a} = F_{s_a}$	_m_a_f $_{\times}$ 0.577 $_{\times}$	$b_{1\times}[(b_{1}^{3}+5_{\times}a_{1\times}L^{2})/($	5 _× L ³)-0.577 ² /3] = 2.9		
Moist backfill below water table		$M_{w_m_b} = F_{s_m_b_f \times a_l \times} [((8-n^2_{(4-n))^2 / 16})-4+n_{(4-n)}]/8 = 5.6 \text{ kNm/m}$						
Saturated backfill		$M_{w_{-}s} = F_{s_{-}s_{-}f_{\times}} \left[a_{+}^{2}x_{\times}((5_{\times}L)-a_{+})/(20_{\times}L^{3})-(x-b_{+})^{3}/(3_{\times}a_{+}^{2})\right] = 1.6 \text{ kNm/m}$						
Water		$M_{w_water} = F_s$	s_water_f × [al ² ×x	\times ((5 \times L)-a)/(20 \times L ³))-(x-bi) ³ /(3 _× ai ²)] = 4.1		
kNm/m	m							
Total moment for wall design		$M_{wall} = M_{w_s}$	ur + Mw_m_a + N	1w_m_b + Mw_s + Mw	_water = 16.3 kN	lm/m		
	← 100 →							



Tekla Tedds	Project 38 Meadowbank Calcs for Rear garden RC retaining wall			Job no. 13065 Start page no./Revision 9			
Campbell Reith Friars Bridge Court 41-45 Blackfriars Road London SE1 8NZ							
	Calcs by AP	Calcs date 26/11/2019	Checked by	Checked date	Approved by	Approved date	
Depth of reinforcement		dstem = twall	– Cstem – (_d stem /	2) = 142.0 mm			
Constant		Kstem = Mste	Kstem = Mstem / (b \times dstem ² \times fcu) = 0.058				
			C	compression rel	inforcement i	s not required	
Lever arm		Zstem = min Zstem = 132	$z_{stem} = min(0.5 + \sqrt{(0.25 - (min(K_{stem}, 0.225) / 0.9)), 0.95)} \times d_{stem}$ $z_{stem} = 132 \text{ mm}$				
Area of tension reinforcement required		As_stem_des =	As_stem_des = Mstem / (0.87 $_{\times}$ fy $_{\times}$ Zstem) = 605 mm ² /m				
Minimum area of tension reinforcement		As_stem_min =	$A_{s_stem_min} = k_{\times} b_{\times} t_{wall} = 325 \text{ mm}^2/\text{m}^2$				
Area of tension reinforcement required		As_stem_req =	As_stem_req = Max(As_stem_des, As_stem_min) = 605 mm²/m				
Reinforcement provided		16 mm dia	16 mm dia.bars @ 150 mm centres				
Area of reinforcement provided		As_stem_prov :	As_stem_prov = 1340 mm ² /m				
		PASS - Reinfo	orcement provi	ided at the retai	ining wall ste	m is adequate	
Check shear resistance at w	all stem						
Design shear stress		Vstem = Vster	Vstem = Vstem / (b $_{\times}$ dstem) = 0.435 N/mm ²				
Allowable shear stress		Vadm = min($v_{adm} = min(0.8 \times \sqrt{(f_{cu} / 1 \text{ N/mm}^2)}, 5) \times 1 \text{ N/mm}^2 = 4.382 \text{ N/mm}^2$				
		PASS -	PASS - Design shear stress is less than maximum shear stress				
From BS8110:Part 1:1997 -	Table 3.8		U				
Design concrete shear stress		Vc_stem = 0.8	354 N/mm ²				
			Vstem	< Vc_stem - No sh	ear reinforce	ment required	
Check mid height of wall in	bending						
Depth of reinforcement		d _{wall} = t _{wall} -	$d_{wall} = t_{wall} - c_{wall} - (d_{wall}/2) = 192.0 \text{ mm}$				
Constant		Kwall = Mwall	$K_{\text{wall}} = M_{\text{wall}} / (b_{\text{v}} d_{\text{wall}}^2 \times f_{\text{cu}}) = 0.015$				
			C	ompression rei	inforcement i	s not required	
Lever arm		$z_{wall} = Min($	zwall = Min(0.5 + √(0.25 - (min(Kwall, 0.225) / 0.9)).0.95) √ dwall				
		Zwall = 182	z _{wall} = 182 mm				
Area of tension reinforcement required		As_wall_des =	As_wall_des = Mwall / (0.87 $_{\times}$ fy $_{\times}$ zwall) = 206 mm ² /m				
Minimum area of tension reinforcement		As wall min =	As wall min = $k \times b \times t$ wall = 325 mm ² /m				
Area of tension reinforcement required		As wall reg =	As_wall_req = $Max(As_wall_des, As_wall_min) = 325 \text{ mm}^2/\text{m}$				
Reinforcement provided		16 mm dia	16 mm dia.bars @ 100 mm centres				
Area of reinforcement provide	d	As_wall_prov =	$A_{s_wall_prov} = 2011 \text{ mm}^2/\text{m}$				
	PASS	S - Reinforcemen	provided to t	he retaining wa	ll at mid heig	ht is adequate	
	ion						
Check retaining wall deflect			n				
Check retaining wall deflect Basic span/effective depth rat	io	ratiObas = 2					
Check retaining wall deflect Basic span/effective depth rat Design service stress	io	$ratiO_{bas} = 2$ $f_s = 2 \times f_y \times f_y$	As_stem_req / (3 _×	$(As_stem_prov) = 15$	0.5 N/mm ²		
Check retaining wall deflect Basic span/effective depth rat Design service stress Modification factor	io factor _{tens} = mi	ratio _{bas} = 2 $f_s = 2 \times f_y \times n(0.55 + (477 N/m))$	As_stem_req / (3 $_{\times}$ m ² - fs)/(120 $_{\sim}$	$(0.9 \text{ N/mm}^2 + (\text{M}))$	50.5 N/mm ² stem/(b × dstem ²)))),2) = 1.59	
Check retaining wall deflect Basic span/effective depth rat Design service stress Modification factor Maximum span/effective depth	io factor _{tens} = mi n ratio	ratiObas = 2 $f_s = 2 \times f_y \times n(0.55 + (477 N/m))$ ratiOmax = ratio	As_stem_req / (3 $_{\times}$ m ² - fs)/(120 $_{\times}$ atiobas $_{\times}$ factorte	<pre>(As_stem_prov) = 15 (0.9 N/mm² + (M ns = 31.72</pre>	stem/(b _× dstem ²)))),2) = 1.59	
Check retaining wall deflect Basic span/effective depth rat Design service stress Modification factor Maximum span/effective depth Actual span/effective depth ra	io factor _{tens} = mi n ratio tio	$ratiObas = 2$ $f_s = 2 \times f_y \times n(0.55 + (477 \text{ N/m}) + (477 $	As_stem_req / (3 _× lm ² - fs)/(120 _× atiobas _× factorte tem / dstem = 23.2	<pre></pre>	i0.5 N/mm ² stem/(b _× dstem ²)))),2) = 1.59	



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