APPENDIX C

CALCULATIONS

	Project				Job no.		
	1 St. Marks Crescent					180507	
Conisbee	Calcs for					Start page no./Revision	
1-5 Offord Street		new bea	am at rear			1	
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date	



Support B

 $\text{Dead} \times 1.40$

	Project				Job no.		
	1 St. Marks Crescent					180507	
Conisbee 1-5 Offord Street	Calcs for	new bea	m at rear		Start page no./Re	evision 2	
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date	

Imposed imes 1.60

Maximum moment $M_{max} = 68.6 \text{ kNm}$ $M_{max} = 0 \text{ kNm}$ Maximum moment span 1 segment 1 $M_{max} = 63.5 \text{ kNm}$ $M_{max} = 0 \text{ kNm}$ Maximum shear span 1 segment 2 $M_{max} = 35.7 \text{ kN}$ $V_{max} = 2 \text{ max} = 63.6 \text{ kNm}$ $M_{max} = 0 \text{ kNm}$ Maximum shear span 1 segment 1 $V_{max} = 35.7 \text{ kN}$ $V_{max} = -71.9 \text{ kN}$ $V_{max} = 35.7 \text{ kN}$ $V_{max} = 0 \text{ cNm}$ Maximum shear span 1 segment 2 $V_{s1} = 0.8 \text{ kN}$ $V_{s1} = 0.0 \text{ kN}$ $V_{s1} = 0.0 \text{ kN}$ $V_{s1} = 0.0 \text{ kN}$ Maximum shear span 1 segment 2 $V_{s1} = 0.0 \text{ kN}$ Maximum shear span 1 segment 2 $V_{s1} = 0.0 \text{ kN}$ Maximum reaction at support A $R_{A} \text{ max} = 10 \text{ rm}$ $\delta_{max} = 10 \text{ rm}$ $\delta_{max} = 10 \text{ rm}$ Maximum reaction at support B $R_{A} \text{ max} = 71.9 \text{ kN}$ $R_{a,mn} = 71.9 \text{ kN}$ Unfactored imposed load reaction at support B $R_{B} \text{ max} = 71.9 \text{ kN}$ $R_{B} \text{ min} = 71.9 \text{ kN}$ Section dteiatisS355S55Form table 3: Design strength pr $max(T, t) = 11.0 \text{ rm}$ $p_{y} = 355 \text{ N/mn}^2$ Design strength $p_{y} = 355 \text{ N/mn}^2$ $= 205000 \text{ N/mm}^2$ Unductored imposed load reaction at support A $max(T, t) = 11.0 \text{ rm}$ Design strength $p_{y} = 355 \text{ N/mn}^2$ Unductored imposed load reaction at support b $max(T, t) = 11.0 \text{ rm}$ Unductored imposed load reaction $v = 0.0 \text{ sup}^2$ <th>Analysis results</th> <th></th> <th></th>	Analysis results		
Maximum noment span 1 segment 1 Maximum span 1 segment 2 Maximum spear Maximum shear Maximum shear span 1 segment 1 Maximum shear span 1 segment 1 Maximum shear span 1 segment 2 Maximum section at support A Maximum reaction at support A Maximum reaction at support B Maximum reaction at support B Section type Section type Modulus of elasticity Maximum ferment Maximum ferment Maximum reaction at support B Maximum reaction at Support B	Maximum moment	M _{max} = 68.6 kNm	M _{min} = 0 kNm
Maximum moment span 1 segment 2 Maximum shear Maximum shear span 1 segment 1 Maximum shear span 1 segment 2 Maximum shear span 1 segment 2 Maximum shear span 1 segment 2 Maximum shear span 1 segment 2 Vari_seg_max = 35.7 kN Vari_seg_max = 20.8 kN Vari_seg_max = 40.2 kN Maximum reaction at support A Maximum reaction at support B Ra_mesee = 4.5 kN Section details Section details Sectin details Section details	Maximum moment span 1 segment 1	M _{s1_seg1_max} = 63.5 kNm	$M_{s1_seg1_min} = 0 \text{ kNm}$
Maximum shear $V_{max} = 35.7 \text{ kN}$ $V_{min} = -71.9 \text{ kN}$ Maximum shear span 1 segment 1 $V_{11, seg1, max} = 35.7 \text{ kN}$ $V_{51, seg2, min} = -0 \text{ kN}$ Maximum shear span 1 segment 2 $V_{51, seg2, max} = 20.8 \text{ kN}$ $V_{51, seg2, min} = -71.9 \text{ kN}$ Deflection segment 3 $\partial_{max} = 10 \text{ mm}$ $\partial_{mm} = 0 \text{ mm}$ Maximum reaction at support A $R_{A, max} = 35.7 \text{ kN}$ $R_{A, min} = 35.7 \text{ kN}$ Unfactored imposed load reaction at support A $R_{A, max} = 20.3 \text{ kN}$ $H_{A, max} = 35.7 \text{ kN}$ Unfactored imposed load reaction at support B $R_{B, max} = 71.9 \text{ kN}$ $R_{B, min} = 71.9 \text{ kN}$ Maximum reaction at support B $R_{B, max} = 71.9 \text{ kN}$ $R_{B, min} = 71.9 \text{ kN}$ Unfactored imposed load reaction at support B $R_{B, max} = 71.9 \text{ kN}$ $R_{B, min} = 71.9 \text{ kN}$ Unfactored imposed load reaction at support B $R_{B, max} = 71.9 \text{ kN}$ $R_{B, min} = 71.9 \text{ kN}$ Section typeUC 203x203x46 (BS4-1)Steel gradeSteel gradeSection typeUC 203x203x46 (BS4-1)Steel gradeSteel gradeSection typeUC 203x200 N/mm² $V = 205000 \text{ N/mm²}$ Modulus of elasticity $E = 205000 \text{ N/mm²}$ $V = 203.666666666666666666666666666666666666$	Maximum moment span 1 segment 2	Ms1_seg2_max = 68.6 kNm	$M_{s1_seg2_min} = 0 \text{ kNm}$
Maximum shear span 1 segment 1 Maximum shear span 1 segment 2 Vst_segt_max = 35.7 kN Vst_segt_min = 0 mm Baximum reaction at support A Unfactored dead load reaction at support A Maximum reaction at support B Maximum reaction at support B Maximum reaction at support B Maximum reaction at support B Section details Section type Section type Section type Section type Design strength Design strength	Maximum shear	V _{max} = 35.7 kN	V _{min} = -71.9 kN
Maximum shear span 1 segment 2 Va1_sug2_max 20.8 kN Va1_sug2_min -71.9 kN Deflection segment 3 Joinx = 10 mm Joinx = 0 mm Joinx = 0 mm Maximum reaction at support A RA_max 35.7 kN RA_min = 35.7 kN Unfactored imposed load reaction at support A RA_Dead = 20.3 kN Unfactored imposed load reaction at support A Maximum reaction at support B Ra_max = 71.9 kN Ra_min = 71.9 kN Unfactored dead load reaction at support B Ra_Dead = 45.2 kN Unfactored imposed load reaction at support B Ra_mosed = 4.5 kN Section details Section type UC 203x203x46 (BS4-1) Stele grade S355 Formatble 9: Design strength py max(T, t) = 11.0 mm Thickness of element max(T, t) = 11.0 mm Design strength pr = 355 N/mm² Modulus of elasticity E = 205000 N/mm² Undectored to the support B To the support B Thickness of element max(T, t) = 11.0 mm Design strength pr = 355 N/ma² Undectored to the support B To the support B Undectored to the support B To the support B Undectored to the support B To th	Maximum shear span 1 segment 1	Vs1_seg1_max = 35.7 kN	$V_{s1_seg1_min} = 0 \ kN$
Deflection segment 3 max = 10 mm δ _{min} = 0 mm Maximum reaction at support A R _{A_mear} = 35.7 kN R _{A_min} = 35.7 kN Unfactored dead load reaction at support A R _{A_meare} = 20.3 kN Unfactored imposed load reaction at support B R _{B_max} = 71.9 kN R _{B_min} = 71.9 kN Maximum reaction at support B R _{B_max} = 4.5 kN Section details Section type UC 203x203x46 (BS4-1) Steel grade S355 From table 9: Design strength py Thickness of element max(T, t) = 11.0 mm Design strength py = 355 N/mm ² Modulus of elasticity E = 205000 N/mm ² Modulus of elasticity + 7.2 Lateral restraint External restraint at supports plus midspan	Maximum shear span 1 segment 2	V _{s1_seg2_max} = 20.8 kN	V _{s1_seg2_min} = -71.9 kN
Maximum reaction at support A RA_max = 35.7 kN RA_max = 35.7 kN Unfactored dead load reaction at support A RA_max = 35.7 kN RA_max = 35.7 kN Maximum reaction at support B RA_max = 71.9 kN RB_max = 71.9 kN Maximum reaction at support B RB_max = 71.9 kN RB_max = 71.9 kN Unfactored dead load reaction at support B RB_max = 71.9 kN RB_max = 71.9 kN Unfactored dead load reaction at support B RB_max = 45.7 kN RB_max = 71.9 kN Unfactored dead load reaction at support B RB_max = 71.9 kN RB_max = 71.9 kN Unfactored dead load reaction at support B RB_max = 45.7 kN RB_max = 71.9 kN Unfactored dead load reaction at support B RB_max = 71.9 kN RB_max = 71.9 kN Unfactored dead load reaction at support B UC 203x203x46 (BS4-1) Stell pace Stell grade S355 Stell grade S355 From table 9: Design strength py Thickness of element max(T, t) = 11.0 mm py = 355 N/mm² Modulus of elasticity E = 205000 N/mm² E = 205000 N/mm² E = 205000 N/m² Under the support B E = 203.00 km² E = 203.00 km² E = 203.00 km² Under the suport by the suport pace E = 203.00 km² <td>Deflection segment 3</td> <td>$\delta_{max} = 10 \text{ mm}$</td> <td>$\delta_{\text{min}} = \boldsymbol{0} \ mm$</td>	Deflection segment 3	$\delta_{max} = 10 \text{ mm}$	$\delta_{\text{min}} = \boldsymbol{0} \ mm$
Unfactored dead load reaction at support A $B_{A,Dead} = 20.3 \text{ kN}$ Unfactored imposed load reaction at support A $B_{A,Dead} = 40.3 \text{ kN}$ Maximum reaction at support B $B_{B,Dead} = 4.5 \text{ kN}$ Unfactored imposed load reaction at support B $B_{B,Dead} = 46.2 \text{ kN}$ Unfactored imposed load reaction at support B $B_{B,Dead} = 46.2 \text{ kN}$ Section details Section type UC 203x203x46 (BS4-1) Steel grade S355 From table 9: Design strength py Thickness of element max(T, t) = 11.0 mm Design strength $p_Y = 355 \text{ N/mm}^2$ Modulus of elasticity $E = 205000 \text{ N/mm}^2$ Modulus of elasticity $E = 205000 \text{ N/mm}^2$ Modulus of elasticity $E = 205000 \text{ N/mm}^2$	Maximum reaction at support A	R _{A_max} = 35.7 kN	R _{A_min} = 35.7 kN
Unfactored imposed load reaction at support A Maximum reaction at support B Unfactored dead load reaction at support B Unfactored imposed load reaction at support B Unfactored imposed load reaction at support B Cateral restraint Unfactored imposed load reaction at support B Re_Dead = 4.5 kN Re_Dead = 4.5 kN Settel grade Solution type UC 203x203x46 (BS4-1) Steel grade Solution type Trickness of element Design strength Design strength Desig	Unfactored dead load reaction at support A	R _{A_Dead} = 20.3 kN	
Maximum reaction at support B $R_{B_{L,mix}} = 71.9 \text{ kN}$ $R_{B_{L,min}} = 71.9 \text{ kN}$ Unfactored dead load reaction at support B $R_{B_{L,mix}} = 46.2 \text{ kN}$ Unfactored imposed load reaction at support B $R_{B_{L,mix}} = 46.2 \text{ kN}$ Section detailsUC 203x203x46 (BS4-1)Steel gradeS355From table 9: Design strength pyThickness of elementDesign strength $p_y = 355 \text{ N/mm^2}$ Modulus of elasticity $E = 205000 \text{ N/mm^2}$ Lateral restraint	Unfactored imposed load reaction at support A	RA_Imposed = 4.5 kN	
Unfactored dead load reaction at support B RB_Dead = 46.2 kN Unfactored imposed load reaction at support B RB_Dead = 45.2 kN Section details Section type UC 203x203x46 (BS4-1) Steel grade S355 From table 9: Design strength py Thickness of element max(T, t) = 11.0 mm Design strength py = 355 N/mm ² Modulus of elasticity E = 205000 N/mm ² $\int \frac{1}{T} \int 1$	Maximum reaction at support B	R _{B_max} = 71.9 kN	R _{B_min} = 71.9 kN
Unfactored imposed load reaction at support B $P_{B_mposed} = 4.5 \text{ kN}$ Section details Section type UC 203x203x46 (BS4-1) Steel grade S355 Front table 9: Design strength py Thickness of element max(T, t) = 11.0 mm Design strength py = 355 N/mm ² Modulus of elasticity E = 205000 N/mm ² $\int \frac{1}{T} \int 1$	Unfactored dead load reaction at support B	R _{B_Dead} = 46.2 kN	
Section details Section type UC 203x203x46 (BS4-1) Steel grade S355 From table 9: Design strength py max(T, t) = 11.0 mm Design strength py = 355 N/mm ² Modulus of elasticity E = 205000 N/mm ² Image: transform of the strength of the strengt of the strength of the strength of the strength of th	Unfactored imposed load reaction at support B	$R_{B_Imposed} = 4.5 \text{ kN}$	
Section type UC 203x203x46 (BS4-1) Steel grade S355 From table 9: Design strength py Thickness of element max(T, t) = 11.0 mm py = 355 N/mm ² Modulus of elasticity E = 205000 N/mm ² $\int \frac{1}{t} \int 1$	Section details		
Steel grade \$355 From table 9: Design strength py max(T, t) = 11.0 mm Design strength py = 355 N/mm² Modulus of elasticity E = 205000 N/mm² Image: transform of the strength of the strengt of the strength of the strength of the strengt of the strength	Section type	UC 203x203x46 (BS4-1)	
From table 9: Design strength py Thickness of element max(T, t) = 11.0 mm Design strength py = 355 N/mm ² Modulus of elasticity E = 205000 N/mm ² Image: transform the py = 100 mm Image: transform t	Steel grade	S355	
Thickness of element Design strength Modulus of elasticity $p_y = 355 \text{ N/mm}^2$ $E = 205000 \text{ N/mm}^2$ $f = \frac{1}{2}$ $f = \frac{1}{2}$ f =	From table 9: Design strength py		
Design strength Modulus of elasticity $p_y = 355 \text{ N/mm}^2$ $E = 205000 \text{ N/mm}^2$ f f f f f f f f	Thickness of element	max(T, t) = 11.0 mm	
Modulus of elasticity $E = 205000 \text{ N/mm}^2$ $f = \frac{1}{2}$ $f = \frac{1}{2}$ $f = \frac{1}{2}$ $f = \frac{1}{2}$ $f = \frac{1}{2}$ $f = \frac{1}{2}$ Lateral restraint at supports plus midspan	Design strength	p _y = 355 N/mm ²	
Lateral restraint at supports plus midspan	Modulus of elasticity	E = 205000 N/mm ²	
Lateral restraint Span 1 has lateral restraint at supports plus midspan	<u>_</u> <u>+</u>		
Lateral restraint Span 1 has lateral restraint at supports plus midspan	Ĩ <u>∓</u> └───		
Lateral restraint Span 1 has lateral restraint at supports plus midspan			
Lateral restraint Span 1 has lateral restraint at supports plus midspan			
Lateral restraint at supports plus midspan			
Lateral restraint at supports plus midspan			
Lateral restraint Span 1 has lateral restraint at supports plus midspan	503	→ -7.2	
Lateral restraint Span 1 has lateral restraint at supports plus midspan	Ì		
Lateral restraint Span 1 has lateral restraint at supports plus midspan			
Lateral restraint Span 1 has lateral restraint at supports plus midspan			
Lateral restraint Span 1 has lateral restraint at supports plus midspan			
Lateral restraint Span 1 has lateral restraint at supports plus midspan			
Lateral restraint Span 1 has lateral restraint at supports plus midspan	<u>↓</u> <u>↓</u>		
Lateral restraint Span 1 has lateral restraint at supports plus midspan	4	203.6	
Lateral restraint Span 1 has lateral restraint at supports plus midspan			
Span 1 has lateral restraint at supports plus midspan	Lateral restraint		
		Span 1 has lateral restraint at su	pports plus midspan
Effective length factors	Effective length factors	-	
Effective length factor in major axis $K_x = 1.00$	Effective length factor in maior axis	K _x = 1.00	

Effective length factor in major axis	K _x = 1.00
Effective length factor in minor axis	Ky = 1.00
Effective length factor for lateral-torsional buckling	K _{LT.A} = 1.00
	K _{LT.B} = 1.00

Classification of cross sections - Section 3.5

 $\boldsymbol{\epsilon} = \sqrt{[275 \text{ N/mm}^2 / p_y]} = \boldsymbol{0.88}$

	Project				Job no.	
		1 St. Mark	1 St. Marks Crescent			0507
Conisbee	Calcs for				Start page no./F	Revision
1-5 Offord Street		new bea	ım at rear			3
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date
	L	•		-		•
Internal compression parts	- Table 11					
Depth of section		d = 160.8 r	nm			
		d / t = 25.4	$3 \times 08 \Rightarrow 3 \times 08$	Class 1	plastic	
Outstand flanges - Table 11						
Width of section		b = B / 2 =	101.8 mm			
		b / T = 10.5	$\delta \times \epsilon <= 15 \times \epsilon$	Class 3	semi-compa	ot
				Sectio	n is class 3 s	semi-compact
Shear capacity - Section 4.2	2.3					
Design shear force		F _v = max(a	bs(V _{max}), abs(V _n	_{nin})) = 71.9 kN		
		d / t < 70 ×	ε			
			Web does n	ot need to be c	hecked for s	hear buckling
Shear area		$A_v = t \times D =$	• 1463 mm²			
Design shear resistance		$P_v = 0.6 \times p$	$D_{y} \times A_{v} = 311.6 \text{ k}$	N		
		PAS	S - Design she	ar resistance ex	ceeds desig	In shear force
Moment capacity at span 1	segment 2 - Sect	tion 4.2.5				
Design bending moment		M = max(al	os(M _{s1 seg2 max}), ;	abs(M _{s1 seg2 min}))	= 68.6 kNm	
Effective plastic modulus -	Section 3 5 6	, ,				
Limiting value for class 2 con	Dection 3.3.0	ß∝ – 10 × s	- 8 801			
Limiting value for class 2 con	ni-compact flange	$\beta_{21} = 10 \times c$	- 13 202			
Limiting value for class 2 con	n-compact hange	$\beta_{31} = 10 \times \epsilon$	= 13.202			
Limiting value for class 2 con	i compact wob	$\beta_{2w} = 100 \times$	c = 105.617			
Effective plastic modulus - cl	3562	$p_{3w} = 120 \times$	ε = 105.017			
$S_{-\#} = \min(Z_{-\#} + (S_{-\#} - Z_{-\#}))$	∑.5.5.2.2 ∑min/[/(ß₀/(d./t))2 - 1) / ((Bou / Bo	$(R_{0}^{2} - 1) [(R_{0} / (R_{0}))]$	n / T) - 1) / (Bos / (Soc. 1)]) S)	– 490411 mm ³
Moment capacity low shear -		$M_{\rm c} = \min(n)$	\sim S ₁ (12 \sim n)	$(p_{3}, p_{1}) = 17/11 k$	lm	- 430411 11111
			- Oeii, 1.2 ^ py /	$\sim 2xx) = 114.1$ KN		
Effective length for lateral-t		g - Section 4.3.5)			
Effective length for lateral tor	sional buckling	$L_E = 1.0 \times I$	_s1_seg2 = 2250 m	ım		
Slenderness ratio		$\lambda = L_E / r_{yy}$	= 43.823			
Equivalent slenderness - Se	ection 4.3.6.7					
Buckling parameter		u = 0.847				
Torsional index		x = 17.713				
Slenderness factor		v = 1 / [1 +	$0.05 \times (\lambda / x)^2]^{0.2}$	²⁵ = 0.935		
Ratio - cl.4.3.6.9		$\beta w = S_{eff} / S_{eff}$	S _{xx} = 0.986			
Equivalent slenderness - cl.4	.3.6.7	$\lambda_{\text{LT}} = u \times v$	$\times \lambda \times \sqrt{[\beta w]} = 34$.455		
Limiting slenderness - Annex	B.2.2	$\lambda_{L0}=0.4\times$	$(\pi^2 \times E / p_y)^{0.5} =$	30.198		
		$\lambda_{LT} > \lambda_{LO} - \lambda_{LO}$	Allowance sho	uld be made for	^r lateral-torsi	onal buckling
Bending strength - Section	4.3.6.5					
Robertson constant		$\alpha_{LT} = 7.0$				
Perry factor		η∟⊤ = max(e	$lpha_{ ext{LT}} imes (\lambda_{ ext{LT}} - \lambda_{ ext{L0}}) \; /$	1000, 0) = 0.030)	
Euler stress		$p_E = \pi^2 \times E$	/ λ _{LT} ² = 1704.3	N/mm²		
		φ _L τ = (p _y +)	(η _{LT} + 1) × p _E) / 2	2 = 1055 N/mm ²		
Bending strength - Annex B.2	2.1	$p_{b} = p_{E} \times p_{y}$, / (ф _{LT} + (ф _{LT} ² - р	_E × р _у) ^{0.5}) = 342.	2 N/mm ²	
Equivalent uniform momen	t factor - Section	4.3.6.6				
Moment at guarter point of se	egment	M ₂ = 67.7 k	Nm			
Moment at centre-line of seg	ment	M3 = 57.1 k	Nm			

	Project				Job no.	
		1 St. Mar	18	180507		
Conisbee	Calcs for		Start page no./	Revision		
1-5 Offord Street		new bea	am at rear			4
London	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
N1 1DH	НН	13/06/2018				
Moment at three quarter po	oint of segment	M ₄ = 34.5	kNm			
Maximum moment in segm	nent	M _{abs} = 68.6	i kNm			
Maximum moment governi	ng buckling resista	nce M _{LT} = M _{abs}	= 68.6 kNm			
Equivalent uniform momer	nt factor for lateral-t	orsional buckling				
		$m_{LT} = max($	$0.2 + (0.15 \times N)$	$M_2 + 0.5 \times M_3 + 0.5$	$15 imes M_4)$ / M_{abs}	s, 0.44) = 0.839
Buckling resistance mon	nent - Section 4.3.	6.4				
Buckling resistance mome	nt	$M_b = p_b \times S$	S _{eff} = 167.8 kN	m		
		$M_b / m_{LT} =$	200 kNm			
		PA	ASS - Moment	t capacity excee	ds design bei	nding moment
Check vertical deflection	- Section 2.5.2					
Consider deflection due to	dead and imposed	lloads				
Limiting deflection		$\delta_{\text{lim}} = L_{s1} / 2$	250 = 18 mm			
Maximum deflection span	1	$\delta = \max(ab)$	$bs(\delta_{max}), abs(\delta_{max})$	_{min})) = 10.016 mm	1	
		PAS	S - Maximum	deflection does	not exceed o	deflection limit





Imposed × 1.60

	Project	1 ST. MARK	Job no. 180507			
Conishee	Calcs for		Start page no./Revision			
1-5 Offord Street	NEW LOWER BOOM BOX FRAME REAR				2	
London N1 1DH	Calcs by	cs by Calcs date Checked by Checked		Checked date	Approved by	Approved date
	пп	12/06/2018				
		Support B		Dead imes	1.40	
				Impose	d imes 1.60	
Analysis results						
Maximum moment		M _{max} = 216	kNm	$M_{min} = 0$) kNm	
Maximum shear		$V_{max} = 154.$	9 kN	$V_{min} = -3$	384.6 kN	
Deflection		$\delta_{max} = 1.6$ n	nm	$\delta_{min} = \boldsymbol{0}$	mm	
Maximum reaction at support A		$R_{A_{max}} = 15$	4.9 kN	$R_{A_{min}} =$	154.9 kN	
Unfactored dead load reaction a	t support A	$R_{A_Dead} = 9^{-1}$	1.7 kN			
Unfactored imposed load reaction	n at support A	RA_Imposed =	16.6 KN	D	201 G LNI	
Infactored dead load reaction a	t sunnart R	$\square_{B_{max}} = 38$	99 3 kN	r∩ _{B_min} =	304.0 KIN	
Unfactored imposed load reaction	n at support B	R_{B} imposed =	39.8 kN			
Section details		D_iiiihosea —				
Section type		2 x UB 254	x146x43 (BS4	-1)		
Steel grade		S355		••		
From table 9: Design strength	р _у					
Thickness of element	-	max(T, t) =	12.7 mm			
Design strength		py = 355 N/	mm²			
Modulus of elasticity		E = 205000) N/mm²			
	-12.7					
T						
259.6	-	▶ ≪ 7.2				
	→ + 12.7	147.3				
l atoral restraint						
		Span 1 has	s lateral restrair	nt at supports only	y	
Effective length factors						
Effective length factor in major a	xis	K _x = 1.00				
Effective length factor in minor a	xis	K _y = 1.00				
Effective length factor for lateral-	torsional buckli	ng K _{LT.A} = 1.00)			
		К _{LТ.В} = 1.00				
Classification of cross section	s - Section 3.5	ε = √[275 Ν	$l/mm^2/p_v l = 0$	88		
Internal compression nerts. T	abla 11					
Depth of section	aule 11	d = 210 mm	n			
		d / t = 34.6	 × ε <= 80 × ғ	Class 1	plastic	
		G / I = 0 1 .0		01033 1	pidolio	

	Project				Job no.	
		1 ST. MARK	S CRESCENT		18	0507
Conisbee	Calcs for				Start page no./R	evision
1-5 Offord Street	NEV	V LOWER BOOM	I BOX FRAME I	REAR		3
London	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
N1 1DH	НН	12/06/2018				
Outstand flanges - Table 11						
Width of section		b = B / 2 =	73.7 mm			
		b / T = 6.6	3 × 9 => 3 ×	Class 1	plastic	
					Section is c	lass 1 plastic
					000000000000	
Shear capacity - Section 4.2.3		- (>> 		
Design shear force		$F_v = \max(a)$	bs(V _{max}), abs(V _m	hin)) = 384.6 KN		
		d / t < 70 ×	8			
			Web does n	ot need to be c	hecked for sl	hear buckling
Shear area		$A_v = t \times D =$	• 1869 mm²			
Design shear resistance		$P_v = 0.6 \times 10^{10}$	$\mathbf{V} \times \mathbf{p}_{\mathbf{y}} \times \mathbf{A}_{\mathbf{v}} = 796$	5.2 kN		
		PAS	S - Design shea	ar resistance ex	cceeds desig	n shear force
Moment capacity - Section 4.2	.5					
Desian bendina moment		M = max(al	os(Ms1 max), abs(Ms1 min)) = 216 k	Nm	
Moment capacity low shear - cl	1252	$M_c = N \times m$	$in(n_v \times S_{vv} + 1.2 \times 1.2)$	$(n_v \times Z_{vv}) = 402$	1 kNm	
Effective length for lateral-tors	sional buckling	g - Section 4.3.5				
Effective length for lateral torsion	hal buckling	$L_E = 1.0 \times I_c$	_{-s1} = 4200 mm			
Slenderness ratio		$\lambda = L_E / r_{yy}$:	= 119.431			
Equivalent slenderness - Sect	ion 4.3.6.7					
Buckling parameter		u = 0.891				
Torsional index		x = 21.162				
Slenderness factor		v = 1 / [1 +	$0.05 \times (\lambda / x)^2]^{0.2}$	²⁵ = 0.788		
Ratio - cl.4.3.6.9		βw = 1.000				
Equivalent slenderness - cl.4.3.6	5.7	$\lambda_{1T} = 11 \times V$	$\times \lambda \times \sqrt{[\beta_w]} = 83$.817		
Limiting slenderness - Annex B	22	$\lambda_{10} = 0.4 \times$	$(\pi^2 \times E / p_v)^{0.5} = 1$	30 198		
				uld bo mado foi	, lataral tarai	onal huokling
		$\lambda LT > \lambda LO = L$	Anowance sho		alerai-lui si	Shar buckning
Bending strength - Section 4.3	3.6.5					
Robertson constant		α _{LT} = 7.0				
Perry factor		η∟⊤ = max(o	xlt × (λlt - λlo) /	1000, 0) = 0.37 5	5	
Euler stress		$p_E = \pi^2 \times E$	$/ \lambda_{LT^2} = 288 \text{ N/m}$	1m²		
		$\phi_{LT} = (p_y + ($	η _{LT} + 1) × p _E) / 2	2 = 375.5 N/mm ²		
Bending strength - Annex B.2.1		$\mathbf{p}_{b} = \mathbf{p}_{E} \times \mathbf{p}_{v}$	/ (ф_т + (ф_т ² - р	$(E \times p_v)^{0.5}) = 178.0$	6 N/mm²	
	ator Contian	1066		1.77 7		
Equivalent uniform moment fa	ctor - Section	4.3.0.0	k Nino			
Moment at quarter point of segm		$101_2 = 132.1$				
Moment at three guarter point of	ll	$IVI_3 = 202.8$	KINITI			
Movimum moment in accordant	segment	1/14 = 212.3				
Maximum moment in segment	okling register	IVIabs = 2ID				
Faujvalent uniform moment fact	oning resisteril	reional buckling				
						0.44) 0.000
		mL⊺ = max(t	0.∠ + (0.15 × IVI2	$+ 0.5 \times 103 + 0.13$	$J \times IVI4) / IVIabs,$	0.44) = 0.909
Buckling resistance moment -	Section 4.3.6	.4				
Buckling resistance moment		$M_b = N \times p_b$	o × S _{xx} = 202.3 kl	Nm		
		$M_b / m_{LT} = 2$	222.6 kNm			
		PASS - Bucklin	ng resistance n	noment exceed	s design ben	ding moment

	Project 1 ST. MARKS CRESCENT				Job no. 180507	
Conisbee 1-5 Offord Street	Calcs for NEW	LOWER BOOM	I BOX FRAME I	REAR	Start page no./Re	evision 4
London N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved date

Check vertical deflection - Section 2.5.2

Consider deflection due to imposed loads

Limiting deflection

Maximum deflection span 1

 $\delta_{\text{lim}} = L_{s1} \ / \ 360 = \textbf{11.667} \ mm$

 $\delta = max(abs(\delta_{max}), \, abs(\delta_{min})) = \textbf{1.588} \ mm$

PASS - Maximum deflection does not exceed deflection limit





	Project	1 St Mark	Job no. 180507			
Conisbee	Calcs for			MENT	Start page no./I	Revision
1-5 Ottord Street London N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved da
Design moment resistance of	ectangular s	section (cl. 3.4.4)	- Positive mo	oment		
Design bending moment		$M = abs(M_s)$	₁_red) = 580 kN	lm		
Depth to tension reinforcement		$d = h - c_{nom}$	_b -	= 430 mm		
Redistribution ratio		$\beta_{b} = min(1 + 1)$	- m _{rs1} , 1) = 1.0	00		
		K = M / (b >	$\langle d^2 \times f_{cu} \rangle = 0.0$	42		
		K' = 0.156				
			K' > K -	No compressio	n reinforceme	ent is requi
Lever arm		$z = min(d \times$	(0.5 + (0.25 -	K / 0.9) ^{0.5}), 0.95	× d) = 408 mm	ı
Depth of neutral axis		x = (d - z) /	0.45 = 48 mm			
Area of tension reinforcement re-	quired	$A_{s,req} = M /$	$(0.87 \times f_y \times z) =$	= 3269 mm²		
Tension reinforcement provided		10 × 25¢ ba	ars			
Area of tension reinforcement pr	ovided	$A_{s,prov} = 490$)9 mm ²			
Minimum area of reinforcement		$A_{c,min} = 0.00$	$13 \times b \times h = 9$	75 mm ²		
Maximum area of reinforcement		Δ – 0.0	$4 \times b \times b = 30$	000 mm ²		
	PASS - Area	of reinforcement	nrovided is a	preater than area	a of reinforce	ment reau
						inent requ
Rectangular section in shear						
Shear reinforcement provided		3 × 8¢ legs	at 100 c/c			
Area of shear reinforcement prov	vided	$A_{sv,prov} = 15$	08 mm²/m		_	
Minimum area of shear reinforce	ment (Table 3	$A_{sv,min} = 0.4$	N/mm ² × b / (($0.87 \times f_{yv}) = 1379$	mm²/m	
	F	PASS - Area of sl	near reinforce	ement provided	exceeds mini	mum requ
Maximum longitudinal spacing (c	1. 3.4.5.5)	$S_{vl,max} = 0.7$	5 × d = 322 m	m		
	PASS - Long	gitudinal spacing	of shear reir	nforcement prov	rided is less t	han maxim
Design concrete shear stress		$v_c = 0.79 N/$	mm² × min(3,[$100 imes A_{s,prov} / (b >$	$(d)]^{1/3}) \times max($	1, (400mm
		/d) ^{1/4}) × (mi	n(f _{cu} , 40N/mm ²	²) / 25N/mm ²) ^{1/3} /	$\gamma_m = \textbf{0.675} \ N/r$	mm²
Design shear resistance provide	d	$v_{s,prov} = A_{sv,j}$	$_{ m prov} imes 0.87 imes f_{ m yv}$	/ b = 0.437 N/mr	m²	
Design shear stress provided		Vprov = Vs,prov	v + Vc = 1.112	N/mm²		
Design shear resistance		$V_{prov} = v_{prov}$	\times (b \times d) = 71	6.7 kN		
Shear links	provided va	lid between 0 mi	m and 4500 m	m with tension	reinforcemen	nt of 4909 n
Spacing of reinforcement (cl 3	12.11)					
Actual distance between bars in	tension	s = (b - 2 ×	$(C_{nom s} + \Phi_v + 0)$	(Npot - 1) -	• o _{bot} = 129 mn	า
Minimum distance between be	vo in tonoion		(,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	1	
Minimum distance between bas	in tension	(cl 3.12.11.1)	5 mm - 25 m	m		
Minimum distance between bars		Smin = Hagg 4	- 5 mm = 25 m DA	nn SS - Satisfias th	o minimum si	nacina crit
			r Av		ະ ແມ່ນແມ່ນ ອ	Jacing cin
Maximum distance between ba	ars in tensior	n (cl 3.12.11.2)				
Design service stress		$f_s = (2 \times f_y \times$	$< A_{s,req}) / (3 \times A_{s,req})$	$(s, prov \times \beta b) = 222.0$	0 N/mm²	
Maximum distance between bars	in tension	$S_{max} = min(4)$	47000 N/mm /	f _s , 300 mm) = 21	2 mm	
			PAS	SS - Satisfies the	e maximum s	pacing crit
Span to depth ratio (cl. 3.4.6)						
Basic span to depth ratio (Table	3.9)	span_to_de	epth _{basic} = 20.0	l.		
Design service stress in tension	reinforcemen	t $f_s = (2 \times f_y >$	$<$ A _{s,req})/ (3 \times A _s	$_{s,prov} \times \beta_b) =$ 222.0) N/mm ²	
Modification for tension reinforce	ment					
	f _{tens} =	min(2.0, 0.55 + (477N/mm² - fs)) / (120 × (0.9N/m	$1m^{2} + (M / (b \times$	(d ²))))) = 1 .
			,			
Modification for compression rein	ntorcement					

	Project				Job no.		
		1 St Marks Crescent				180507	
Conisbee	Calcs for				Start page no./I	Revision	
1-5 Offord Street	NE	W LOWER BOO	4				
London	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date	
N1 1DH	HH	12/06/2018					
Modification for span length		$f_{long} = 1.000$)				

Allowable span to depth ratio Actual span to depth ratio

 $span_to_depth_{allow} = span_to_depth_{basic} \times f_{tens} \times f_{comp} = \textbf{25.7}$ $span_to_depth_{actual} = L_{s1} \ / \ d = \textbf{10.5}$

PASS - Actual span to depth ratio is within the allowable limit



					-	
	Project	1 St Mark	e Crescent		Job no.	30507
	Conjubeo Cales for					50507
Conisbee	t lower around (SHORTER SI	PAN DESIGN)	Start page no./I	2	
1-5 Offord Street London			Chooked date	Approved by		
N1 1DH	HH	12/06/2018	Checked by	Checked date	Approved by	Approved date
Maximum moment span 1 at 22	50 mm	$M_{s1_max} = 3$	4 kNm	Ms1_red	= 34 kNm	
Maximum moment support B		$M_{B_{max}} = 0$	kNm	$M_{B_{red}} =$	₌ 0 kNm	
Maximum shear support A		V _{A_max} = 31	kN	VA_red =	31 kN	
Maximum shear support A span	1 at 200 mm	$V_{A_{s1}_{max}} =$	28 kN	V _{A_s1_re}	d = 28 kN	
Maximum shear support B	1 at 4000 mm	$V_{B_{max}} = -3$	1 KN	V _{B_red} =	-31 KN	
Maximum snear support B span	1 at 4300 mm	$V_{B_{s1}_{max}} =$	-28 KIN	VB_s1_re	d = -28 KIN	
Infactored dead load reaction a	at support A		8 KNI			
Infactored imposed load reaction	on at support A	BA Imposed =	3 kN			
Maximum reaction at support B		R _B = 31 kN				
Unfactored dead load reaction a	at support B	RB Dead = 1	8 kN			
Unfactored imposed load reaction	on at support B	R _{B_Imposed} =	3 kN			
Pactangular section details						
Section width		b – 1000 m	ım			
Section denth		b = 1000 m	n			
		1	000		>	
					-	
Concrete details						
Concrete strength class		C40/50				
Characteristic compressive cub	e strength	f _{cu} = 50 N/r	nm²			
Modulus of elasticity of concrete)	$E_c = 20 k N/r$	$mm^{2} + 200 \times f$	_{cu} = 30000 N/mm ²	2	
Maximum aggregate size		h _{agg} = 20 m	Im			
Reinforcement details						
Characteristic yield strength of r	einforcement	$f_y = 500 \text{ N/r}$	mm²			
Characteristic yield strength of s	hear reinforcen	nent f _{yv} = 500 N/	/mm²			
Nominal cover to reinforceme	nt					
Nominal cover to top reinforcem	ient	Cnom_t = 35	mm			
Nominal cover to bottom reinfor	cement	Cnom_b = 35	mm			
Nominal cover to side reinforcer	ment	Cnom_s = 35	mm			
Mid span 1						
				$2 \times 16_{\varphi}$ bars		
550-				2 x 8 $_{0}$ shear le	egs at 100 c/c	
	•	• •		$5 \times 20_{0}$ bars		
▼				r		
I						
	10	000	•			

	Project	1 St Mark	e Crescent	Job no.	Job no. 180507		
	O alea (an		SCIESCEII		010		
Conisbee 1-5 Offord Street	R.C slab a	t lower ground (SHORTER SP	AN DESIGN)	Start page no./F	3	
London N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved date	
Design moment resistance of	rectangular se	ection (cl. 3.4.4)	- Positive mo	ment			
Design bending moment		M = abs(Ms	1_red) = 34 kNm				
Depth to tension reinforcement		$d = h - C_{nom}$	_b -	= 197 mm			
Redistribution ratio	$\beta_{\rm b} = \min(1 \cdot $	· m _{rs1} , 1) = 1.00	00				
		$K = M / (b \times$	$(d^2 \times f_{cu}) = 0.0^{-1}$	18			
		K' = 0.156					
			K' > K - I	No compression	n reinforceme	nt is required	
Lever arm		$z = min(d \times$	(0.5 + (0.25 - 1	K / 0.9) ^{0.5}), 0.95 >	< d) = 187 mm		
Depth of neutral axis		x = (d - z) /	0.45 = 22 mm				
Area of tension reinforcement re	∍quired	$A_{s,req} = M / $	$(0.87 \times f_y \times z) =$	• 423 mm²			
Tension reinforcement provided]	5 × 20ø bar	S				
Area of tension reinforcement p	rovided	$A_{s,prov} = 157$	′1 mm²				
Minimum area of reinforcement		$A_{s,min} = 0.00$	$013 \times b \times h = 32$	25 mm²			
Maximum area of reinforcement	i	$A_{s,max} = 0.04$	$4 \times b \times h = 100$	00 mm²			
	PASS - Area or	f reinforcement	provided is g	reater than area	of reinforcer	nent required	
Rectangular section in shear							
Shear reinforcement provided		$2 \times 8\phi$ legs	at 100 c/c				
Area of shear reinforcement provided		$A_{sv,prov} = 10$	05 mm²/m				
Minimum area of shear reinforce	ement (Table 3.	7) $A_{sv,min} = 0.4$	N/mm ² × b / (0	.87 × f _{yv}) = 920 m	nm²/m		
	PA	ASS - Area of sh	near reinforce	ment provided e	exceeds minii	num requirec	
Maximum longitudinal spacing (cl. 3.4.5.5)	$S_{vl,max} = 0.75$	5 × d = 148 mn	n			
	PASS - Longi	tudinal spacing	of shear rein	forcement prov	ided is less tl	nan maximum	
Design concrete shear stress	-	$v_{c} = 0.79 N/r$	$mm^2 \times min(3,[1$	$00 \times A_{s,prov}$ / (b ×	$(d)^{1/3}) \times max(d)^{1/3}$	I, (400mm	
-		/d) ^{1/4}) × (mi	n(f _{cu} , 40N/mm ²) / 25N/mm ²) ^{1/3} /	γ _m = 0.818 N/r	nm²	
Design shear resistance provide	ed	$V_{s,prov} = A_{sv,t}$	$rov \times 0.87 \times f_{vv}$	/ b = 0.437 N/mn	• 1 ²		
Design shear stress provided		$V_{\text{prov}} = V_{\text{s prov}}$, + v _c = 1.256 ℕ	J/mm ²			
Design shear resistance		$V_{prov} = v_{prov} \times (b \times d) = 247.3 \text{ kN}$					
Shear link	s provided vali	d between 0 mr	m and 4500 m	m with tension i	reinforcemen	t of 1571 mm	
Encount of rainforcement (a)	2 10 11						
Actual distance between bare in	5.12.11)	a (h 2)	(0	· · /2)) //N· · · 1)			
Actual distance between bars in	lension	S = (D - 2 ×	$(Cnom_s + \psi_v + \psi_s)$	bot/∠)) / (INbot - I) -	φbot = 204 ΠΠΠ		
Minimum distance between b	ars in tension ((cl 3.12.11.1)					
Minimum distance between bars	s in tension	S _{min} = h _{agg} +	· 5 mm = 25 mi	m			
			PAS	S - Satisfies the	e minimum sp	acing criteria	
Maximum distance between b	ars in tension	(cl 3.12.11.2)					
Design service stress		$f_s = (2 \times f_y \times$	$(A_{s,req}) / (3 \times A_s)$	$_{s,prov} \times \beta_b) = 89.8$	N/mm ²		
Maximum distance between bars in tension		S _{max} = min(4	47000 N/mm / 1	f _s , 300 mm) = 30	0 mm		
			PAS	S - Satisfies the	maximum sp	acing criteria	
Span to depth ratio (cl. 3.4.6)							
Basic span to depth ratio (Table	; 3.9)	span_to_de	epth _{basic} = 20.0				
Design service stress in tension	reinforcement	$f_s = (2 \times f_y \times$	$(A_{s,req})/(3 \times A_{s,req})$	$(prov imes eta_b) = 89.8$ (N/mm ²		
Modification for tension reinforce	ement						
	$f_{tens} = r$	min(2.0, 0.55 + (4	477N/mm² - f _s)	/ (120 × (0.9N/m	m^2 + (M / (b ×	d²))))) = 2.000	
Modification for compression rel	inforcement						
Mounication for compression re-							
modification for compression re	f _{comp}	= min(1.5, 1 + (1	$00 imes A_{s2,prov}$ / (b×d)) / (3 + (100	$0 \times A_{s2,prov}$ / (b	× d)))) = 1.064	

	Project	1 St Mark	Job no. 180507			
Conisbee C 1-5 Offord Street London C N1 1DH	Calcs for Start page no./Revision R.C slab at lower ground (SHORTER SPAN DESIGN) 4					evision 4
	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved date

Allowable span to depth ratio Actual span to depth ratio $span_to_depth_{allow} = span_to_depth_{basic} \times f_{tens} \times f_{comp} = \textbf{42.5}$

 $span_to_depth_{actual} = L_{s1} \ / \ d = \textbf{22.8}$

PASS - Actual span to depth ratio is within the allowable limit



	Project 1 St Marks Crescent					Job no. 180507	
Conisbee	Calcs for				Start page no./I	Revision	
1-5 Offord Street		R.C cappin	g beam stair			2	
N1 1DH	HH	13/06/2018	Checked by	Checked date	Approved by	Approved date	
Maximum moment support B		M _{B_max} = 0	kNm	M _{B_red} :	= 0 kNm		
Maximum shear support A		$V_{A_{max}} = 11$	5 kN	V _{A_red} =	= 115 kN		
Maximum shear support A spar	n 1 at 300 mm	$V_{A_s1_max} =$	89 kN	VA_s1_re	ed = 89 kN		
Maximum shear support B		$V_{B_{max}} = -1$	15 kN	V _{B_red} =	= -115 kN		
Maximum shear support B spar	n 1 at 2400 mm	$V_{B_s1_max} =$	-89 kN	V _{B_s1_re}	ed = -89 kN		
Maximum reaction at support A		R _A = 115 k	N				
Unfactored dead load reaction	at support A	$R_{A_Dead} = 4$	kN				
Unfactored imposed load react	ion at support A	$R_{A_Imposed} =$	68 kN				
Maximum reaction at support B	_	R _B = 115 k	N				
Unfactored dead load reaction	at support B	$R_{B_{Dead}} = 4$	kN				
Unfactored imposed load react	ion at support B	$R_{B_{Imposed}} =$	68 kN				
Rectangular section details							
Section width		b = 350 mr	n				
Section depth		h = 350 mr	n				
	350						
		₹3	50►				
Concrete details							
Concrete strength class		C40/50	?				
Unaracteristic compressive cub	e strength	$T_{cu} = 50 \text{ N/r}$	nm² 000 (2		
iviodulus of elasticity of concret	e	$E_c = 20 \text{kN}/1$	$mm^{2} + 200 \times f_{c}$	_{cu} = 30000 N/mm ²	-		
iviaximum aggregate size		n _{agg} = 20 m	m				
Reinforcement details			0				
Characteristic yield strength of Characteristic yield strength of	reintorcement shear reinforcem	$t_y = 500 \text{ N/r}$ lent $f_{yy} = 500 \text{ N/r}$	mm² ′mm²				
Nominal cover to reinforceme	ent						
Nominal cover to top reinforcen	nent	Cnom_t = 50	mm				
Nominal cover to bottom reinfo	rcement	Cnom_b = 35	mm				
Nominal cover to side reinforce	ment	Cnom_s = 35	mm				

	Project	1 St Mark	s Crescent		Job no. 18	0507			
Caniahaa	Calcs for				Start page no /F	levision			
1-5 Offord Street		R.C cappin	R.C capping beam stair		otar page now	3			
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date			
Mid span 1									
	▲								
		J	$2 \times 8_{\varphi}$ bars						
			$2 \times 8_{\phi}$ shear	legs at 200 c/c					
		• • •	$3 \times 20_{\phi}$ bars						
	<u> </u>								
	4	350							
	1.								
Design moment resistan	ce of rectangular	section (cl. 3.4.4)) - Positive mo	oment					
Design bending moment		M = abs(M	s1_red) = 77 kNr	n 					
Depth to tension reinforce	ment	$d = h - C_{norr}$	n_b - ¢v - ¢bot / 2	= 297 mm					
Redistribution ratio		$\beta_{b} = min(1)$	$\beta_{b} = \min(1 - m_{rs1}, 1) = 1.000$						
		K = M / (b :	$\times d^2 \times f_{cu} = 0.0$)50					
		K = 0.156	K' - K -	No comprossio	n rainfaraama	nt is required			
Lover arm		$z = \min(d)$	Λ > Λ -	K / 0 0)0.5) 0 05	v d) - 270 mm	in is required			
Depth of neutral axis		$z = \min(u \times z) / z$	(0.5 + (0.25 - 0.45 - 30 mm	$(70.9)^{-1}, 0.95$	× u) = 219 mm				
Area of tension reinforcem	ent required	$\mathbf{A} = (\mathbf{u} - \mathbf{Z}) / \mathbf{A}_{\mathbf{a}} = \mathbf{M} / \mathbf{A}_{\mathbf{a}}$	(0.43 = 33 mm)	– 637 mm²					
Tension reinforcement pro	vided	3 × 20d bar	(0.07 × 19 × 2)						
Area of tension reinforcem	ent provided	$\Delta_{a} = 94$	2 mm ²						
Minimum area of reinforce	ment	$A_{s, min} = 0.0$	$013 \times b \times h = 1$	1 59 mm ²					
Maximum area of reinforce	ement	$A_{s,max} = 0.0$	$4 \times b \times h = 49$	00 mm ²					
	PASS - Area	of reinforcement	t provided is a	greater than area	a of reinforcer	nent required			
Bectangular section in s	hoar		, ,			•			
Shear reinforcement provid	ded	2 × 8¢ leas	at 200 c/c						
Area of shear reinforceme	nt provided	$A_{\text{sy proy}} = 50$	3 mm ² /m						
Minimum area of shear rei	nforcement (Table ;	$A_{sv,piov} = 0.4$	$A_{sv,min} = 0.4N/mm^2 \times b / (0.87 \times f_{vv}) = 322 \text{ mm}^2/m$						
		PASS - Area of s	hear reinforce	ement provided	exceeds minii	num required			
Maximum longitudinal spa	cing (cl. 3.4.5.5)	$S_{vl,max} = 0.7$	′5 × d = 223 m	m.					
	PASS - Long	gitudinal spacing	g of shear reii	nforcement prov	rided is less tl	nan maximum			
Design concrete shear stre	ess	$v_c = 0.79 N_c$	$/mm^2 \times min(3,[$	$100 imes A_{s,prov}$ / (b >	$(d)]^{1/3}) \times max(d)$	I, (400mm			
		$/d)^{1/4}) imes (mi)$	in(f _{cu} , 40N/mm	²) / 25N/mm ²) ^{1/3} /	γm = 0.771 N/r	nm²			
Design shear resistance p	rovided	$v_{s,prov} = A_{sv}$,prov $ imes$ 0.87 $ imes$ fy	/ b = 0.625 N/mr	m²				
Design shear stress provid	led	Vprov = Vs,pro	$v_v + V_c = 1.395$	N/mm²					
Design shear resistance		$V_{prov} = v_{prov}$	\times (b × d) = 14	5.1 kN					
She	ar links provided v	valid between 0 n	nm and 2700	mm with tensior	n reinforceme	nt of 942 mm ²			
Spacing of reinforcemen	it (cl 3.12.11)								
Actual distance between b	ars in tension	s = (b - 2 ×	$(C_{nom_s} + \phi_v + \phi_v)$	\$\phi_bot/2)) /(N_bot - 1) -	• \$\$bot = 102 mm	l			
Minimum distance betwe	en bars in tensior	ı (cl 3.12.11.1)							
Minimum distance betwee	n bars in tension	$s_{min} = h_{agg}$	+ 5 mm = 25 m	ım					
		39	PA	SS - Satisfies the	e minimum sp	acing criteria			

	Project	Project 1 St Marks Crescent					
Conishee	Calcs for	Calcs for R.C capping beam stair				Start page no./Revision	
1-5 Offord Street						4	
London	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date	
N1 1DH	НН	13/06/2018			PP,	PP	
Maximum diatanaa batura	on haro in tonoion	(0) 2 12 11 2)		•		•	
Design sonvise stress	en bars in tension	(CI 3.12.11.2)			\mathbf{O} N/mm ²		
Design service stress		$I_s = (2 \times I_y)$	\times A _{s,req}) / (3 \times P	$A_{s,prov} \times p_b) = 225.$	2 N/mm²		
Maximum distance between	s _{max} = min(47000 N/mm /	′ f _s , 300 mm) = 20)9 mm			
			PAS	SS - Satisfies the	e maximum sp	acing criteria	
Span to depth ratio (cl. 3.	4.6)						
Basic span to depth ratio (1	able 3.9)	span_to_d	epth _{basic} = 20.0)			
Design service stress in ter	sion reinforcement	$f_s = (2 \times f_y \times A_{s,req})/(3 \times A_{s,prov} \times \beta_b) = 225.2 \text{ N/mm}^2$					
Modification for tension reir	nforcement		. <i>"</i> .				
	f _{tens} = 1	min(2.0. 0.55 + (477N/mm ² - fs) / (120 × (0.9N/n	$nm^2 + (M / (b \times$	d ²))))) = 1.166	
Modification for compression	on reinforcement	(,		,, (1=0), (0101,00		- ,,,,,	
	f	$- \min(1.5.1 \pm ($	100 × A	$(b \times d)) / (3 + (10))$	$0 \times A_{20} \dots / (b)$	× d)))) – 1 031	
Modification for span length	rcomp	f 1 000		(0 × 0)) / (0 + (10	0 × 7 (s2,prov 7 (b	× a)))) = 1.001	
Allewable area to doubt ret	i 		, anth an ar	a ta alamata	4 6 6 .	0	
Allowable span to depth rai	10	span_to_d	eptn _{allow} = spar	1_to_depthbasic ×	$I_{tens} \times I_{comp} = 24$.0	
Actual span to depth ratio		span_to_d	epth _{actual} = L _{s1}	/ d = 9.1			

	Project 1 St Marks Crescent				Job no. 180507	
Conisbee 1-5 Offord Street	Calcs for Start page no./Revision Retaining wall No. 1/2 1				evision 1	
London N1 1DH	Calcs by HH	Calcs date 12/06/2018	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 h_{stem} = **3500** mm twall = 350 mm I_{toe} = **1000** mm $I_{heel} = 0 \text{ mm}$ $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 1350 \text{ mm}$ t_{base} = **350** mm $d_{ds} = 0 \text{ mm}$ l_{ds} = **900** mm t_{ds} = **350** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3850 \text{ mm}$ $d_{cover} = 0 mm$ $d_{exc} = 0 mm$ h_{water} = 2850 mm $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 2500 mm$ $\gamma_{wall} = 23.6 \text{ kN/m}^3$ γbase = 23.6 kN/m³ $\alpha = 90.0 \text{ deg}$ $\beta = 0.0 \text{ deg}$ $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3850 \text{ mm}$

$M = 1.5 \\ \gamma_m = 18.0 \text{ kN/m}^3$

	Project Job no.					
		1 St Mark	s Crescent	180507		
Conisbee	Calcs for	Dataining			Start page no./Revision	
1-5 Offord Street		Retaining	wall No. 1/2			2
N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved date
		12,00,2010				
Saturated density of retained n	naterial	γ _s = 21.0 kM	N/m ³			
Design shear strength		φ' = 24.2 de	eg			
Angle of wall friction		$\delta = 18.6 \text{ de}$	g			
Base material details						
Firm clay						
Moist density		γ _{mb} = 18.0 k	⟨N/m³			
Design shear strength		φ' _b = 24.2 d	eg			
Design base friction		$\delta_b = 18.6 det$	eg			
Allowable bearing pressure		P _{bearing} = 12	25 kN/m²			
Using Coulomb theory						
Active pressure coefficient for	retained material					
$K_a = sin(a)$	$(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \alpha)^2$	$\sin(\alpha - \delta) \times [1 + $	$\sqrt{(\sin(\phi' + \delta) \times s)}$	$\sin(\phi' - \beta) / (\sin(lpha))$	$-\delta$ × sin(α + (3)))] ²) = 0.369
Passive pressure coefficient for	r base material					
	$K_p = sin(9)$	0 - φ' _b)² / (sin(90) - δ_b) × [1 - $\sqrt{(sin)}$	$h(\phi'_{b} + \delta_{b}) \times \sin(\phi'_{b})$	b) / (sin(90 + δ	(b)))] ²) = 4.187
At-rest pressure						
At-rest pressure for retained m	aterial	$K_0 = 1 - sir$	n(φ') = 0.590			
Loading details						
Surcharge load on plan		Surcharge	= 10.0 kN/m²			
Applied vertical dead load on v	vall	W _{dead} = 80.	2 kN/m			
Applied vertical live load on wa	ll	W _{live} = 14.0	kN/m			
Position of applied vertical load	d on wall	I _{load} = 1175	mm			
Applied horizontal dead load o	n wall	$F_{dead} = 0.0$	kN/m			
Applied horizontal live load on	wall	F _{live} = 0.0 k	N/m			
Height of applied horizontal loa	ad on wall	$h_{load} = 0 mr$	n			
		_ i Ш	10			
	25.0 Prop	Prop	5	28.0		
				Loads shown	in kN/m. pressure	s shown in kN/m ²

	Project 1 St Marks Crescent				Job no. 180507		
Conisbee 1-5 Offord Street	Calcs for S Retaining wall No. 1/2					Start page no./Revision 3	
London N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved date	

Vertical forces on wall	
Wall stem	$w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall} = \textbf{28.9 kN/m}$
Wall base	$w_{\text{base}} = I_{\text{base}} \times t_{\text{base}} \times \gamma_{\text{base}} = \textbf{11.2} \ kN/m$
Applied vertical load	$W_v = W_{dead} + W_{live} = 94.2 \text{ kN/m}$
Total vertical load	$W_{total} = w_{wall} + w_{base} + W_v = 134.3 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	$\textbf{F}_{sur} = \textbf{K}_a \times cos(90 \text{ - } \alpha + \delta) \times Surcharge \times h_{eff} = \textbf{13.5 kN/m}$
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2 = \textbf{3.1 kN/m}$
Moist backfill below water table	$F_{m_b} = K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 17.9 \text{ kN/m}$
Saturated backfill	$F_{s} = 0.5 \times K_{a} \times cos(90 - \alpha + \delta) \times (\gamma_{s} - \gamma_{water}) \times h_{water}^{2} = \textbf{15.9 kN/m}$
Water	$F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water} = 39.8 \text{ kN/m}$
Total horizontal load	$F_{total} = F_{sur} + F_{m_a} + F_{m_b} + F_s + F_{water} = 90.3 \text{ kN/m}$
Calculate total propping force	
Passive resistance of soil in front of wall	$F_{p} = 0.5 \times K_{p} \times cos(\delta_{b}) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^{2} \times \gamma_{mb} = \textbf{4.4 kN}/m$
Propping force	$F_{prop} = max(F_{total} - F_{p} - (W_{total} - W_{live}) \times tan(\delta_{b}), 0 \; kN/m)$
	F _{prop} = 45.5 kN/m
Overturning moments	
Surcharge	$M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 25.9 \text{ kNm/m}$
Moist backfill above water table	$M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) \ / \ 3 = \textbf{10} \ kNm/m$
Moist backfill below water table	$M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = 25.6 \text{ kNm/m}$
Saturated backfill	$M_{s} = F_{s} \times (h_{water} - 3 \times d_{ds}) / 3 = 15.1 \text{ kNm/m}$
Water	$M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 37.8 \text{ kNm/m}$
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 114.5 \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = \textbf{34} \text{ kNm/m}$
Wall base	$M_{base} = w_{base} \times I_{base} / 2 = 7.5 \text{ kNm/m}$
Design vertical dead load	$M_{dead} = W_{dead} \times I_{load} = 94.2 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{dead} = \textbf{135.7} \text{ kNm/m}$
Check bearing pressure	
Total vertical reaction	R = W _{total} = 134.3 kN/m
Distance to reaction	x _{bar} = I _{base} / 2 = 675 mm
Eccentricity of reaction	$e = abs((I_{base} / 2) - x_{bar}) = 0 mm$
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 99.5 \text{ kN/m}^2$
Bearing pressure at heel	$p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 99.5 \text{ kN/m}^2$
PASS -	Maximum bearing pressure is less than allowable bearing pressure
Calculate propping forces to top and base of wa	all
Propping force to top of wall	

Propping force to base of wall

$$\begin{split} F_{prop_top} = (M_{ot} - M_{rest} + R \times I_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = \textbf{16.713 kN/m} \\ F_{prop_base} = F_{prop} - F_{prop_top} = \textbf{28.746 kN/m} \end{split}$$

F	Project	Job no. 1 St Marks Crescent 18					
Conisbee	Calcs for				Start page no./F	Start page no./Revision	
1-5 Offord Street		Retaining	wall No. 1/2			4	
London C N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved d	
RETAINING WALL DESIGN (BS	8002:1994)						
		-			TEDDS calculatio	n version 1.2.0	
Deed load factor	i	∿ ⊣ – 1 4					
Live load factor		γi_a − 1. 4 γ _{4 +} − 1.6					
Earth and water pressure factor		}i_i = 1.6 ∿t ₀ = 1.4					
Eastered vertical forece on well		<u>1_e - 1.4</u>					
Factored vertical forces on wai	I		x h	40 E kN/m	-		
		$W_{wall_f} = \gamma f_d$	X listem X lwall X	$\gamma_{\text{wall}} = 40.5 \text{ Kin/II}$	1 /m		
Applied vertical load		Wbase_f = $\gamma_{f_{c}}$	X Ibase X Ibase X	γbase = 13.0 KIN	/111		
Applied vertical load		$VV_{v_f} = \gamma_{f_d}$	< VV dead + 'γf_I × '	W live = 134.7 KIN/	m		
		$\mathbf{v}\mathbf{v}_{\text{total}_f} = \mathbf{v}\mathbf{v}_w$	$vall_f + Wbase_f + V$	$v_{v_f} = 190.0 \text{ km/l}$			
Factored horizontal at-rest forc	es on wall	_	K 0 I				
Surcharge		$F_{sur_f} = \gamma_{f_l} > -$	K ₀ × Surcharg	$e \times n_{eff} = 36.3 \text{ K}$	N/M		
Moist backfill above water table		$F_{m_a_f} = \gamma_{f_e}$	$\times 0.5 \times K_0 \times \gamma_n$	$h \times (h_{eff} - h_{water})^2 =$	= 7.4 kN/m		
Moist backfill below water table		$F_{m_bf} = \gamma_{f_e} \times K_0 \times \gamma_m \times (\text{Neff} - \text{Nwater}) \times \text{Nwater} = 42.4 \text{ KN/m}$					
Saturated backfill $F_{s_f} = \gamma_{f_e} \times 0.5 \times K_0 \times (\gamma_{s_f} - \gamma_{water}) \times h_{water}^2 = 37$				37.5 kN/m			
Water		$F_{water_f} = \gamma_{f_e} \times 0.5 \times h_{water}^2 \times \gamma_{water} = 55.8 \text{ kN/m}$					
lotal horizontal load		Ftotal_f = Fsu	r_f +	$b_f + Fs_f + Fwater$	_f = 179.5 KIN/N	n	
Calculate total propping force							
Passive resistance of soil in front kN/m	of wall	$F_{p_f} = \gamma_{f_e} \times$	$0.5 \times K_p \times cos$	$(\delta_b) imes (d_{cover} + t_{ba})$	se + d _{ds} - d _{exc}) ²	× γ _{mb} = 6.1	
Propping force		$F_{prop_f} = ma$ $F_{prop_f} = 110$	x(F _{total_f} - F _{p_f} - 6.7 kN/m	(W _{total_f} - $\gamma_{f_l} \times W$	$_{live}) imes tan(\delta_b), 0$	kN/m)	
Factored overturning moments							
Surcharge		$M_{sur_f} = F_{sur}$	$_{f} \times (h_{eff} - 2 \times c)$	l _{ds}) / 2 = 70 kNm	/m		
Moist backfill above water table		$M_{m_a_f} = F_m$	$_{a_f} \times (h_{eff} + 2 \times$	h_{water} - 3 \times d _{ds}) /	3 = 23.7 kNm/	'n	
Moist backfill below water table		$M_{m_b_f} = F_m$	_b_f × (h _{water} - 2	× d _{ds}) / 2 = 60.4	kNm/m		
Saturated backfill		$M_{s_f} = F_{s_f}$	$<$ (h _{water} - 3 \times d _d	s) / 3 = 35.7 kNm	n/m		
Water		$M_{water_f} = F_w$	_{vater_f} × (h _{water} - 3	3 × d _{ds}) / 3 = 53 l	kNm/m		
Total overturning moment		$M_{ot_f} = M_{sur_f}$	$_f + M_{m_a_f} + M_{m}$	$h_b_f + M_{s_f} + M_{wat}$	_{er_f} = 242.7 kNi	m/m	
Restoring moments							
Wall stem		$M_{wall_f} = w_{wall_f}$	$_{all_f} \times (I_{toe} + t_{wall})$	(2) = 47.6 kNm/r	m		
Wall base		$M_{base_f} = w_b$	$_{ase_f} \times I_{base} / 2 =$	= 10.5 kNm/m			
Design vertical load		$M_{v_f} = W_{v_f}$	\times I _{load} = 158.2	⟨Nm/m			
Total restoring moment		$M_{rest_f} = M_{w}$	$all_f + M_{base_f} + N$	∕l _{v_f} = 216.3 kNm	ı/m		
Factored bearing pressure							
Total vertical reaction		$R_f = W_{total_f}$	= 190.8 kN/m				
Distance to reaction		$x_{\text{bar}_f} = I_{\text{base}}$	/ 2 = 675 mm				
Eccentricity of reaction		$e_f = abs((I_{ba}$	ase / 2) - Xbar_f) =	• 0 mm <i>Reaction acts</i>	within middle	e third of b	
Bearing pressure at toe		$p_{toe f} = (R_f)$	$(I_{base}) - (6 \times R_{f})$	$\times e_{\rm f} / l_{\rm base}^2) = 141$	1 .3 kN/m ²		
Bearing pressure at heel		$p_{\text{heel }f} = (R_f)$	$/ I_{base}$) + (6 × R	$_{\rm f} \times {\rm e_f} / {\rm l_{base}}^2$ = 14	11.3 kN/m ²		
Rate of change of base reaction		rate = (ptoe	f - Pheel f) / Ibase	= 0.00 kN/m ² /m			
Bearing pressure at stem / toe		Dstem toe f =	max(ptoe f - (rat	$e \times I_{toe}$). 0 kN/m ²	²) = 141.3 kN/n	1 ²	

	Project	1 St Mark	Job no.	0507				
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1-5 Offord Street	Cales Iol	Retaining	wall No. 1/2		Start page no./n	5		
London N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved date		
Bearing pressure at mid stem		p _{stem_mid_f} =	max(p _{toe_f} - (rate	$e \times (I_{toe} + t_{wall} / 2)$), 0 kN/m²) = 1	41.3 kN/m ²		
Bearing pressure at stem / heel		$p_{stem_heel_f} =$	max(p _{toe_f} - (rate	$e \times (I_{toe} + t_{wall})), 0$	0 kN/m²) = 141	.3 kN/m ²		
Calculate propping forces to Propping force to top of wall	top and base o	of wall						
	$F_{prop_top_f} =$	(M _{ot_f} - M _{rest_f} + R	$_{\rm f} imes {\sf I}_{\rm base}$ / 2 - ${\sf F}_{\rm prop}$	$_{f} \times t_{base}$ / 2) / (h	stem + t _{base} / 2) =	= 36.649 kN/m		
Propping force to base of wall		F _{prop_base_f} =	= F _{prop_f} - F _{prop_top}	_f = 80.049 kN/n	า			
Design of reinforced concrete	e retaining wal	I toe (BS 8002:1	<u>994)</u>					
Material properties								
Characteristic strength of concr	ete	$f_{cu} = 40 \text{ N/r}$	nm²					
Characteristic strength of reinfo	rcement	$f_y = 500 \text{ N/r}$	mm²					
Base details								
Minimum area of reinforcement		k = 0.13 %						
Cover to reinforcement in toe		c _{toe} = 50 m	m					
Calculate shear for toe design	า							
Shear from bearing pressure		$V_{toe_bear} = ($	Otoe_f + Pstem_toe_f)	\times I _{toe} / 2 = 141.3	3 kN/m			
Shear from weight of base		$V_{toe_wt_base} =$	$V_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times I_{toe} \times t_{base} = \textbf{11.6 kN/m}$					
Total shear for toe design		$V_{toe} = V_{toe_t}$	$p_{ear} - V_{toe_wt_base} =$	129.7 kN/m				
Calculate moment for toe des	ign							
Moment from bearing pressure		$M_{toe_bear} = ($	$2 \times p_{toe_f} + p_{stem_}$	$_{mid_f} \times (I_{toe} + t_{wall})$	/ 2) ² / 6 = 97.5	5 kNm/m		
Moment from weight of base		M _{toe_wt_base} :	= ($\gamma_{f_d} \times \gamma_{base} \times t_b)$	$ase imes (I_{toe} + t_{wall} / 1_{toe})$	2) ² / 2) = 8 kNr	m/m		
Total moment for toe design		$M_{toe} = M_{toe}$	bear - Mtoe_wt_base :	= 89.6 kNm/m				
	>							
32		•	• •	•	•			
▼								
	∢ — 150—►							
Check toe in bending								
Width of toe		b = 1000 m	ım/m					
Depth of reinforcement		$d_{toe} = t_{base}$ -	- c _{toe} - (\u00f6 _{toe} / 2) =	₌ 292.0 mm				
Constant		$K_{toe} = M_{toe}$	$(b \times d_{toe}^2 \times f_{cu}) =$	= 0.026				
			Ca	ompression rei	nforcement is	s not required		
Lever arm		z _{toe} = min(0 z _{toe} = 277 r).5 + √(0.25 - (m nm	in(K _{toe} , 0.225) /	0.9)),0.95) × d	toe		
Area of tension reinforcement re	equired	$A_{s_toe_des} =$	M_{toe} / (0.87 $ imes$ fy >	< z _{toe}) = 742 mm	²/m			
Minimum area of tension reinfor	rcement	$A_{s_toe_min} =$	$k \times b \times t_{base} = 45$	5 mm²/m				
Area of tension reinforcement re	equired	$A_{s_toe_req} = I$	Max(A _{s_toe_des} , A _s	s_toe_min) = 742 m	m²/m			
Reinforcement provided		16 mm dia	.bars @ 150 m	m centres				
Area of reinforcement provided		$A_{s_toe_prov} =$	1340 mm²/m					
		PASS - Rein	forcement prov	vided at the ret	aining wall to	e is adequate		

	Project	1 Ct Mark	o Crocopt		Job no.	07
		I St Mark	s Grescent		180	1507
Conisbee	Calcs for	Retaining	wall No. 1/2		Start page no./R	evision 6
London N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved date
		•		•		
Check shear resistance at to	9					
Design shear stress		$v_{toe} = V_{toe}$ /	$(b \times d_{toe}) = 0.4$	44 N/mm²		
Allowable shear stress		$v_{adm} = min($	0.8 × √(f _{cu} / 1 №	N/mm²), 5) × 1 N/i	mm² = 5.000 N	/mm²
		PASS -	Design shear	r stress is less ti	han maximum	shear stress
From BS8110:Part 1:1997 – T	able 3.8					
Design concrete shear stress		V _{c_toe} = 0.6 1	17 N/mm ²	AV No ob	oor roinforoor	oont required
			Vto	be < Vc_toe - INO SII	ear reiniorcen	ient required
Design of reinforced concret	e retaining wa	II stem (BS 8002	:1994)			
Material properties						
Characteristic strength of conc	rete	$f_{cu} = 40 \text{ N/r}$	nm²			
Characteristic strength of reinfo	prcement	$f_y = 500 \text{ N/r}$	nm²			
Wall details						
Minimum area of reinforcemen	t	k = 0.13 %				
Cover to reinforcement in stem		c _{stem} = 50 n	nm			
Cover to reinforcement in wall		$c_{wall} = 50 \text{ m}$	m			
Factored horizontal at-rest for	orces on stem					
Surcharge		$F_{s_sur_f} = \gamma_{f_i}$	$ imes K_0 imes$ Surcha	$hrge imes (h_{eff} - t_{base} - t_{base})$	d _{ds}) = 33 kN/m	I
Moist backfill above water table	9	$F_{s_m_a_f} = 0$	$.5 imes \gamma_{f_e} imes K_0 imes$	$\gamma_{ m m} imes$ (h _{eff} - t _{base} - c	l _{ds} - h _{sat}) ² = 7.4	kN/m
Moist backfill below water table		$F_{s_m_b_f} = \gamma_f$	$_{e} \times K_{0} \times \gamma_{m} \times ($	h _{eff} - t _{base} - d _{ds} - h _s	at) × h _{sat} = 37.2	kN/m
Saturated backfill		$F_{s_s_f} = 0.5$	$ imes \gamma_{f_e} imes K_0 imes (\gamma_{e})$	s- γ_{water}) $ imes$ h _{sat} ² = 2	8.9 kN/m	
Water		$F_{s_water_f} = 0$	$0.5 imes\gamma_{f_e} imes\gamma_{water}$	r × h _{sat} ² = 42.9 kN	/m	
Calculate shear for stem des	ian					
Surcharge	5	$V_{s sur f} = 5$:	× Fs sur f / 8 = 2	2 0.7 kN/m		
Moist backfill above water table)	V _{s m a f} = F	 s m a f × b 1 × ((5	$5 \times L^2$) - b ²) / (5 ×	L ³) = 2 kN/m	
Moist backfill below water table		V _{smbf} =F	s m b f × (8 - (n ⁴	$^{2} \times (4 - n))) / 8 = 2$	2 9.1 kN/m	
Saturated backfill		$V_{s s f} = F_{s s}$	$f \times (1 - (a)^2 \times (a)^2)$	(5 × L) - a _i) / (20 >	< L ³))) = 25.6 k	N/m
Water		Vs water f = F	= (((($a^2 \times ((5 \times L) - a)$	$(20 \times L^3)) = 3$	8.1 kN/m
Total shear for stem design		V _{stem} = V _{s_s}	ur_f + Vs_m_a_f +	$V_{s_m_b_f} + V_{s_s_f} +$	Vs_water_f = 115	.4 kN/m
Calculate moment for stem d	esian					
Surcharge	colgii	$M_{e,sur} = F_{e,sur}$	sur f × 1 / 8 = 1	5.2 kNm/m		
Moist backfill above water table	2	$M_{s,m,n} = F_{s}$		$\times ^{2}$) - (3 × b ²)) /	$(15 \times ^2) = 2.4$	kNm/m
Moist backfill below water table		$M_{s_mb} = F_{s_mb}$	a_i	- n) ² / 8 = 20.1 kN	() m/m	
Saturated backfill		$M_{s,a} = F_{s,a}$	_iii_o_i	15×a×l)+(20×l ²)	/(60×l ²) = 13 .7	kNm/m
Water		$M_{s_3} = \frac{1}{s_3}$	$\sum_{i=1}^{n} \sum_{i=1}^{n} \sum_{i$	(a ^{,2})-(15×a,×L)+(2	0×l ²))/(60×l ²)	= 20.4
kNm/m		water .				
Total moment for stem design		M _{stem} = M _s _	sur + Ms_m_a + N	/ls_m_b + Ms_s + Ms	_water = 71.8 kN	m/m
Calculate moment for wall de	sian					
Surcharge		$M_{w sur} = 9 \times$	$(F_{s,sur,f} \times L/1)$	28 = 8.5 kNm/m		
Moist backfill above water table	9	Mw m a = Fa	m a f × 0.577×	b _l ×[(b _l ³ +5×a _l ×L ²)/i	(5×L³)-0.577²/3] = 2.7
kNm/m		w_ni_a — 1 S	u_i · · • • • • • • • • •		,	
Moist backfill below water table		$M_{w_m_b} = F_s$	$_{m_b_f} \times a_l \times [((8)$	3-n²×(4-n))² /16)-4	+n×(4-n)]/8 = 1	I0.4 kNm/m
Saturated backfill		M _{w_s} = F _{s s}	$f \times [a^2 \times x \times ((5 \times l)^2)]$	L)-aı)/(20×L ³)-(x-b	$(3 \times a^2) = 5.$	2 kNm/m
Water		$M_{w_water} = F$	$s_{water_f} \times [a]^2 \times x$	×((5×L)-a)/(20×L3	/)-(x-b _l) ³ /(3×a _l ²)] = 7.8
kNm/m		_	- •			-



	Project	Job no.				
		1 St Marks	180507			
Conisbee 1-5 Offord Street	Calcs for Setaining wall No. 1/2				Start page no./Revision 8	
London N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved date

Check retaining wall deflection	on	
Basic span/effective depth ratio)	ratio _{bas} = 20
Design service stress		$f_{s} = 2 \times f_{y} \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = \textbf{261.4} \text{ N/mm}^{2}$
Modification factor	$factor_{tens} = min(0.55)$	+ (477 N/mm ² - f _s)/(120 × (0.9 N/mm ² + (M _{stem} /(b × d _{stem} ²)))),2) = 1.59
Maximum span/effective depth	ratio	$ratio_{max} = ratio_{bas} \times factor_{tens} = 31.76$
Actual span/effective depth rati	0	ratio _{act} = h _{stem} / d _{stem} = 11.90
		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 - 12 mm dia.@ 150 mm centres - $(754 \text{ mm}^2/\text{m})$

	Project 1 St Marks Crescent					Job no. 180507	
Conisbee 1-5 Offord Street London N1 1DH	Calcs for	Retaining	wall No. 1/2		Start page no./Re	evision 1	
	Calcs by HH	Calcs date 12/06/2018	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 h_{stem} = **3500** mm twall = 350 mm I_{toe} = **1000** mm $I_{heel} = 0 \text{ mm}$ $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 1350 \text{ mm}$ t_{base} = **350** mm $d_{ds} = 0 \text{ mm}$ l_{ds} = **900** mm t_{ds} = **350** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3850 \text{ mm}$ $d_{cover} = 0 mm$ $d_{exc} = 0 mm$ h_{water} = 2850 mm $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 2500 mm$ $\gamma_{wall} = 23.6 \text{ kN/m}^3$ γbase = 23.6 kN/m³ $\alpha = 90.0 \text{ deg}$ $\beta = 0.0 \text{ deg}$ $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3850 \text{ mm}$

M = **1.5** γ_m = **18.0** kN/m³

	Project Job no.					07
		I St Mark	s Crescent		180507	
Conisbee	Calcs for	Retaining	Start page no./Revision			
London	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
N1 1DH	HH	12/06/2018				
Saturated density of retained m	aterial	v. – 21 0 kľ	N/m ³			
Design shear strength	laterial	φ' = 24.2 de	D.			
Angle of wall friction		φ = 18.6 de	a			
Base material details			9			
Firm clay						
Moist density		γ _{mb} = 18.0 k	⟨N/m³			
Design shear strength		φ' _b = 24.2 d	ea			
Design base friction		$\delta_{\rm b} = 18.6 {\rm d}$	ea			
Allowable bearing pressure		$P_{\text{bearing}} = 12$	25 kN/m²			
Using Coulomb theory		g				
Active pressure coefficient for r	etained material					
K _a = sin(α	$(a + \phi')^2 / (\sin(\alpha)^2 \times$	$\sin(\alpha - \delta) \times [1 + \delta]$	$\sqrt{(\sin(\phi' + \delta) \times s)}$	sin(φ' - β) / (sin(α	$-\delta$) × sin(α +	3)))] ²) = 0.369
Passive pressure coefficient for	r base material					
	$K_p = sin(9)$	0 - φ' _b)² / (sin(90	$(1 - \delta_b) \times [1 - \sqrt{(sin)}]$	$n(\phi'_{b} + \delta_{b}) \times sin(\phi'_{b})$	_b) / (sin(90 + δ	(b)))] ²) = 4.187
At-rest pressure						
At-rest pressure for retained ma	aterial	$K_0 = 1 - sir$	n(φ') = 0.590			
Loading details						
Surcharge load on plan		Surcharge	= 10.0 kN/m ²			
Applied vertical dead load on w	vall	W _{dead} = 110).0 kN/m			
Applied vertical live load on wa	II	W _{live} = 13.1	kN/m			
Position of applied vertical load	l on wall	$I_{load} = 1175$	mm			
Applied horizontal dead load or	n wall	$F_{dead} = 0.0$	kN/m			
Applied horizontal live load on	wall	F _{live} = 0.0 k	N/m			
Height of applied horizontal loa	d on wall	$h_{load} = 0 mr$	n			
			10			
	25.0 Prop	Prop	.9	28.0		
				Loads shown	in kN/m, pressure	es shown in kN/m ²

	Project 1 St Marks Crescent				Job no. 180507	
Conisbee 1-5 Offord Street	Calcs for Start page no./Revision Retaining wall No. 1/2 3				evision 3	
London N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved date

Vertical forces on wall	
Wall stem	$w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall} = \textbf{28.9 kN/m}$
Wall base	$w_{base} = I_{base} \times t_{base} \times \gamma_{base} = \textbf{11.2 kN/m}$
Applied vertical load	$W_v = W_{dead} + W_{live} = 123.1 \text{ kN/m}$
Total vertical load	$W_{total} = w_{wall} + w_{base} + W_v = 163.2 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	$F_{sur} = K_a \times cos(90 - \alpha + \delta) \times Surcharge \times h_{eff} = \textbf{13.5 kN/m}$
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2 = \textbf{3.1 kN/m}$
Moist backfill below water table	$F_{m_b} = K_{a} \times \cos(90 - \alpha + \delta) \times \gamma_{m} \times (h_{eff} - h_{water}) \times h_{water} = \textbf{17.9} \ kN/m$
Saturated backfill	$\textbf{F}_{s} = 0.5 \times K_{a} \times cos(90 - \alpha + \delta) \times (\gamma_{s}\text{-} \gamma_{water}) \times h_{water}^{2} = \textbf{15.9} \text{ kN/m}$
Water	$F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water} = 39.8 \text{ kN/m}$
Total horizontal load	$F_{total} = F_{sur} + F_{m_a} + F_{m_b} + F_s + F_{water} = 90.3 \text{ kN/m}$
Calculate total propping force	
Passive resistance of soil in front of wall	$F_{p} = 0.5 \times K_{p} \times cos(\delta_{b}) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^{2} \times \gamma_{mb} = 4.4 \text{ kN/m}$
Propping force	$F_{prop} = max(F_{total} - F_{p} - (W_{total} - W_{live}) \times tan(\delta_{b}), 0 \text{ kN/m})$
	F _{prop} = 35.4 kN/m
Overturning moments	
Surcharge	$M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 25.9 \text{ kNm/m}$
Moist backfill above water table	$M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 10 \text{ kNm/m}$
Moist backfill below water table	$M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = 25.6 \text{ kNm/m}$
Saturated backfill	$M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 15.1 \text{ kNm/m}$
Water	$M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 37.8 \text{ kNm/m}$
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 114.5 \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 34 \text{ kNm/m}$
Wall base	$M_{base} = w_{base} \times I_{base} / 2 = 7.5 \text{ kNm/m}$
Design vertical dead load	$M_{dead} = W_{dead} \times I_{load} = 129.3 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{dead} = 170.7 \text{ kNm/m}$
Check bearing pressure	
Total vertical reaction	R = W _{total} = 163.2 kN/m
Distance to reaction	x _{bar} = I _{base} / 2 = 675 mm
Eccentricity of reaction	$e = abs((I_{base} / 2) - x_{bar}) = 0 mm$
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 120.9 \text{ kN/m}^2$
Bearing pressure at heel	$p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 120.9 \text{ kN/m}^2$
PASS -	Maximum bearing pressure is less than allowable bearing pressure
Calculate propping forces to top and base of w	all
Propping force to top of wall	

Propping force to base of wall

$$\label{eq:Fprop_top} \begin{split} F_{prop_top} &= (M_{ot} - M_{rest} + R \times I_{base} \ / \ 2 - F_{prop} \times t_{base} \ / \ 2) \ / \ (h_{stem} + t_{base} \ / \ 2) = \textbf{12.975} \ kN/m \\ F_{prop_base} &= F_{prop} - F_{prop_top} = \textbf{22.454} \ kN/m \end{split}$$

F	Project	t 1 St Marks Crescent				Job no. 180507		
Conisbee	alcs for	Retaining	wall No 1/2		Start page no./F	Revision 4		
London C N1 1DH	alcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved d		
	9002-1004					-		
RETAINING WALL DESIGN (BS	0002.1994	<u>l</u>			TEDDS calculatio	n version 1.2.0		
Ultimate limit state load factors								
Dead load factor		$\gamma_{f_d} = 1.4$						
Live load factor		γ _{f_l} = 1.6						
Earth and water pressure factor		$\gamma_{f_e} = 1.4$						
Factored vertical forces on wall								
Wall stem		$w_{wall_f} = \gamma_{f_d}$	imes h _{stem} $ imes$ t _{wall} $ imes$ '	$\gamma_{\text{wall}} = 40.5 \text{ kN/m}$	า			
Wall base		$W_{base_f} = \gamma_{f_c}$	$_{ m d} imes {\sf I}_{ m base} imes {\sf t}_{ m base} imes$	$\gamma_{\text{base}} = 15.6 \text{ kN}$	/m			
Applied vertical load		$W_{v_f} = \gamma_{f_d}$	$\times W_{dead} + \gamma_{f_l} \times V_{dead}$	<i>N</i> _{live} = 175 kN/m				
Total vertical load		$W_{total_f} = W_w$	$wall_f + W_{base_f} + V_{base_f}$	W _{v_f} = 231.1 kN/	m			
Factored horizontal at-rest force	es on wall							
Surcharge		$F_{sur_f} = \gamma_{f_l} \times$	$< K_0 \times Surchargenergy$	$je imes h_{eff} = 36.3 \; kl$	N/m			
Moist backfill above water table		$F_{m_a_f} = \gamma_{f_e}$	$ imes$ 0.5 $ imes$ K ₀ $ imes$ γ_{rr}	$h \times (h_{eff} - h_{water})^2 =$	= 7.4 kN/m			
Moist backfill below water table		$F_{m b} f = \gamma f e \times K_0 \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 42.4 \text{ kN/m}$						
Saturated backfill		$F_{s,f} = \gamma_{f,e} \times 0.5 \times K_{0} \times (\gamma_{s} - \gamma_{water}) \times h_{water}^{2} = 37.5 \text{ kN/m}$						
Water		$F_{water_{f}} = \gamma_{f_{e}} \times 0.5 \times h_{water}^{2} \times \gamma_{water} = 55.8 \text{ kN/m}$						
Total horizontal load		F _{total f} = F _{sur}	r f + Fm a f + Fm	b f + Fs f + Fwater	f = 179.5 kN/n	n		
Calculate total prophing force		_			_			
Passive resistance of soil in front	of wall	$F_{p_f} = \gamma_{f_e} \times$	$0.5 imes K_p imes cos$	$(\delta_b) imes (d_{ ext{cover}} + t_{ ext{ba}})$	se + d _{ds} - d _{exc}) ²	$\times \gamma_{mb} = 6.1$		
Propping force		F _{prop_f} = ma	ux(F _{total_f} - F _{p_f} -	(W _{total_f} - $\gamma_{f_l} imes W$	$_{ m live}) imes tan(\delta_{ m b}), 0$	kN/m)		
		$F_{prop_f} = 102$	2.7 kN/m					
Factored overturning moments								
Surcharge		$M_{sur_f} = F_{sur_f}$	$f_{f} \times (h_{eff} - 2 \times d)$	l _{ds}) / 2 = 70 kNm	/m			
Moist backfill above water table		$M_{m_a_f} = F_{m_a}$	$_a_f \times (h_{eff} + 2 \times$	h_{water} - 3 $ imes$ d _{ds}) /	3 = 23.7 kNm/	m		
Moist backfill below water table		$M_{m_b_f} = F_{m_b}$	$_b_f \times (h_{water} - 2$	× d _{ds}) / 2 = 60.4	kNm/m			
Saturated backfill		$M_{s_f} = F_{s_f} \times$	$<$ (h _{water} - 3 \times d _d	s) / 3 = 35.7 kNm	ı/m			
Water		$M_{water_f} = F_v$	$_{\rm water_f} imes (h_{\rm water} - 3)$	$3 \times d_{ds}) / 3 = 53$ l	kNm/m			
Total overturning moment		$M_{ot_f} = M_{sur_}$	$_{f} + M_{m_a_f} + M_{m}$	$b_f + M_{s_f} + M_{wat}$	_{er_f} = 242.7 kNr	m/m		
Restoring moments								
Wall stem		$M_{wall_f} = W_{wall_f}$	$_{all_f} imes (I_{toe} + t_{wall} /$	2) = 47.6 kNm/r	m			
Wall base		$M_{base_f} = w_b$	$_{base_f} \times I_{base} / 2 =$	10.5 kNm/m				
Design vertical load	$M_{v_{-}f} = W_{v_{-}f} \times I_{load} = \textbf{205.6} \text{ kNm/m}$							
Total restoring moment		$M_{rest_f} = M_{wa}$	$all_f + M_{base_f} + N$	∕l _{v_f} = 263.7 kNm	ı/m			
Factored bearing pressure								
Total vertical reaction		$R_f = W_{total_f}$	= 231.1 kN/m					
Distance to reaction		$x_{\text{bar}_f} = I_{\text{base}}$	/ 2 = 675 mm					
Eccentricity of reaction		$e_f = abs((I_{ba}$	_{ase} / 2) - x _{bar_f}) =	• 0 mm <i>Reaction acts</i>	within middle	e third of b		
Bearing pressure at toe		$D_{\text{toe}} = (R_f)$	$(I_{base}) - (6 \times R_{f})$	$\times e_{\rm f} / l_{\rm base}^2) = 171$.2 kN/m ²			
Bearing pressure at heel		$D_{\text{beel } f} = (R_f)$	$/ I_{\text{base}}$) + (6 × R	$f \times \mathbf{e}_{f} / _{\text{base}^2} = 17$	71.2 kN/m ²			
Rate of change of base reaction		rate = (D_{top})	f - Pheel f) / Ibase	= 0.00 kN/m ² /m				
Bearing pressure at stem / toe		Dstem top f =	max(ptoe f - (rat	$e \times I_{toe}$). 0 kN/m ²	²) = 171.2 kN/n	1 ²		

	Project				Job no.				
		1 St Mark	s Crescent		180507				
Conisbee 1-5 Offord Street	Calcs for	Retaining	wall No. 1/2		Start page no./Re	evision 5			
London N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved date			
Bearing pressure at mid stem		p _{stem_mid_f} =	max(p _{toe_f} - (rate	$e \times (I_{toe} + t_{wall} / 2))$), 0 kN/m²) = 1	71.2 kN/m ²			
Bearing pressure at stem / heel		p _{stem_heel_f} =	max(p _{toe_f} - (rate	$e \times (I_{toe} + t_{wall})), 0$	kN/m²) = 171	.2 kN/m ²			
Calculate propping forces to	top and base o	f wall							
Propping force to top of wall	F (01 000 kNI/m			
Propping force to base of wall	\vdash prop_top_f = ([Mot_f - Mrest_f + K Enron base f =	f × Ibase / 2 - Eprop = Eprop f - Eprop top	_f × lbase / 2) / (Nst _f = 70.825 kN/m	tem + Ibase / 2) =	= 31.832 KN/M			
Design of roinforced constate	votoining woll	. prop_base_i							
Design of reinforced concrete	e retaining wan	100 (05 0002:1	<u>994)</u>						
Material properties	oto	f – 40 N/r	nm²						
Characteristic strength of reinfo	rcement	$f_{v} = 500 \text{ N/I}$	mm ²						
Base detaile		.y — 300 i Wi							
Minimum area of reinforcement		k = 0.13 %							
Cover to reinforcement in toe		c _{toe} = 50 m	m						
Calculate shear for toe design	n								
Shear from bearing pressure		V _{toe_bear} = (Otoe_f + Pstem_toe_f)	\times I _{toe} / 2 = 171.2	kN/m				
Shear from weight of base		V _{toe_wt_base} =	$V_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times I_{toe} \times t_{base} = 11.6 \text{ kN/m}$						
Total shear for toe design		$V_{toe} = V_{toe_t}$	$V_{toe} = V_{toe_bear} - V_{toe_wt_base} = 159.6 \text{ kN/m}$						
Calculate moment for toe des	ign								
Moment from bearing pressure		$M_{toe_bear} = ($	$2 \times p_{toe_f} + p_{stem_}$	$_{\rm mid_f}) imes (I_{ m toe} + t_{ m wall})$	/ 2) ² / 6 = 118 .	.2 kNm/m			
Moment from weight of base		M _{toe_wt_base} :	= ($\gamma_{f_d} \times \gamma_{base} \times t_{base}$	$_{ m ase} imes (I_{ m toe} + t_{ m wall} / 2$	2)² / 2) = 8 kNr	n/m			
Total moment for toe design		$M_{toe} = M_{toe}$	bear - M _{toe_wt_base} :	= 110.2 kNm/m					
$\uparrow \uparrow$									
N N									
350-29	>								
<u> </u>	• •	•	• •	•	•				
▼									
	◄ —150—►								
Uneck toe in bending		h _ 1000 ~	um/m						
Depth of reinforcement		$d_{top} = t_{base} - t_{bas} - t_{base} - t_{base} - t_{base} - t_{base} - t_{base} - $	$- C_{\text{top}} - (\phi_{\text{top}} / 2) =$	= 292.0 mm					
Constant		$K_{toe} = M_{toe}$	$(b \times d_{toe}^2 \times f_{cu}) =$	= 0.032					
		-100 -1000 /	Cc	ompression reir	nforcement is	not required			
Lever arm		$z_{toe} = min(0)$).5 + √(0.25 - (m	in(K _{toe} , 0.225) / 0	$(0.9)), 0.95) imes d_t$	- 0e			
		z _{toe} = 277 r	nm						
Area of tension reinforcement r	equired	$A_{s_toe_des} =$	M_{toe} / (0.87 $ imes$ f _y $ imes$	< z _{toe}) = 913 mm ²	²/m				
Minimum area of tension reinfo	rcement	$A_{s_toe_min} =$	$k \times b \times t_{base} = 45$	5 mm²/m					
Area of tension reinforcement r	equired	$A_{s_toe_req} = I$	Max(A _{s_toe_des} , A _s	s_toe_min) = 913 mi	m²/m				
Keinforcement provided		16 mm dia	.bars @ 150 mr	n centres					
Area or reinforcement provided		As_toe_prov =	forcement nro	ided at the reta	ainina wall to	e is adequate			
		, AGG - Nelli				s is aucquale			

$ \begin{array}{ c c c c } \hline P_{1} \ (a) \ (b) \ (b) \ (c) $		Project Job no.					0507		
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $			I St Mark	s Grescent		180	J507		
Check shear resistance at toe N1 10HCate sign HCate sign 12/06/2018Checked byChecked cate Approval byApproval by Approval cateCheck shear resistance at toe Design shear stressVace = Vsor / (b × das) = 0.547 Nmm² Vace = Vsor / (b × das) = 0.547 Nmm² PASS - Design shear stress is less than maximum shear stressFrom BS8110-Part 1:1997 - Table 3.8 Design concrete shear stressVace = Vsor / (b × das) = 0.547 Nmm² Vace = Vsor / vace = Vsor = Vsor / vace = Vsor / vac	Conisbee	Calcs for	Retaining	wall No. 1/2		Start page no./R	evision 6		
Check shear resistance at toe Design shear stress $v_{ee} = V_{ee} / (b \times d_{ee}) = 0.547 \text{ Nmm}^2$ Allowable shear stress $v_{ee} = V_{ee} / (b \times d_{ee}) + 0.747 \text{ Nmm}^2$, $5.1 \times 1 \text{ Nmm}^2 = 5.000 \text{ Nmm}^2$ PASS - Design shear stress is less than maximum shear stressPASS - Design shear stress is less than maximum shear stressFrom BS8110.Part 1:1997 - Table 3.8 Design concrete shear stress $v_{e,me} = 0.617 \text{ Nmm}^2$ Ver < $v_{e,me} = 0.617 \text{ Nmm}^2$ $v_{em} = 0.617 \text{ Nmm}^2$ Characteristic strength of concrete Characteristic strength of reinforcement $t_{er} = 40 \text{ Nmm}^2$ Characteristic strength of concrete 	London N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved date		
Check shear resistance at toeDesign shear stress $v_{um} = V_{um} / (b \times d_{um}) = 0.547 \text{ N/mm}^2$ Allowable shear stressVum = min(0.8 × \(f_{u,1} / 1 \text{ N/mm}^2), 5) × 1 \text{ N/mm}^2 = 5.000 \text{ N/mm}^2PASS - Design shear stress is less than maximum shear stressVum = 0.617 N/mm²Vum < Vu_use = 0.617 N/mm²Characteristic strength of concretef_u = 40 N/mm²Characteristic strength of concretef_u = 500 N/mm²Wall detailsMinimum area of reinforcementk = 0.13 %Cover to reinforcement in wallGau = 50 mmCover to reinforcement in wallGau = 50 mmGuerrer Full to the stand during wall steed (BL structure S									
$ \begin{array}{llllllllllllllllllllllllllllllllllll$	Check shear resistance at te	De			_				
Allowable shear stress $v_{adm} = min(0.8 \times V(l_m/1 \ Nmm^2), 5) \times 1 \ Nmm^2 = 20.00 \ Nmm^2$ PASS - Design shear stress is less than maximum shear stressPASS - Design shear stress is less than maximum shear stressVex < V_Live - No shear reinforcement requiredDesign concrete shear stressVex < V_Live - No shear reinforcement requiredDesign concrete retaining wall stem (BS 6002:1994)Material propertiesCharacteristic strength of concrete $f_{ay} = 40 \ N/mm^2$ Characteristic strength of concrete $f_{ay} = 500 \ Nmm^2$ Wail detailsK0.13 %Minimum area of reinforcementk = 0.13 %Cover to reinforcement in stem $G_{avet} = 50 \ mm$ Cactord horizontal al-rest forces on stemSurcharge $F_{a,m,2,1} = p_1 \times Ko \times Surcharge \times (hor - hase - dw, hang)^2 = 7.4 \ kN/m$ Moist backfill below water table $F_{a,m,2,2} = p_3 \times Ko \times y_m \times (hor - hase - dw, hang)^2 = 7.4 \ kN/m$ Moist backfill above water table $F_{a,m,2,2} = p_3 \times Ko \times y_m \times (hor - hase - dw, hang)^2 = 7.4 \ kN/m$ Moist backfill above water table $F_{a,m,2,2} = p_3 \times Ko \times y_m \times (hor - hase - dw, hang)^2 = 7.4 \ kN/m$ Moist backfill above water table $V_{a,m,2,2} = 5 \times T_{a,m,2,2} \times Nacw \times han^2 = 42.9 \ kN/m$ Surcharge $V_{a,w,2,2} = F_{a,w,2,4} \times (hor - hase - dw, hang)^2 = 7.4 \ kN/m$ Moist backfill above water table $V_{a,w,a,2} = F_{a,w,2,4} \times (hor - hase - dw, hang)^2 = 2.6 \ kN/m$ Moist backfill above water table $V_{a,w,a,2} = F_{a,w,2,4} \times (hor - hase - dw, hang)^2 = 2.6 \ kN/m$ <tr< td=""><td>Design shear stress</td><td></td><td>$v_{toe} = V_{toe} /$</td><td>$(b \times d_{toe}) = 0.5$</td><td>47 N/mm²</td><td>_</td><td>_</td></tr<>	Design shear stress		$v_{toe} = V_{toe} /$	$(b \times d_{toe}) = 0.5$	47 N/mm ²	_	_		
PASS - Design shear stress is less than maximum shear stressDesign concrete shear stress $v_{z,tex} = 0.617$ N/mm²Now < v_{z,tex} - No shear reinforcement required	Allowable shear stress		v _{adm} = min(0.8 × √(f _{cu} / 1 №	N/mm^{2}), 5) × 1 N/m	mm² = 5.000 N	/mm²		
From BS9110-Part 1:1997 - Table 3.8Vector BS9110-Part 1:1997 - Table 3.8Wall colspan="2">Vector BS9110-Part 1:1997 - Table 3.8Wall colspan="2">Vector BS9110-Part 1:1997 - Table 3.8Vector BS9110-Part 1:1997 - Table 3.8Wall colspan="2">Vector Part 1:1997 - Table 3.8Wall colspan="2">V			PASS -	Design shear	r stress is less ti	han maximum	shear stress		
Design concrete shear stress $V_{a,bell} = 0.517$ / Withintwo = Va_{a,bell} - No shear reinforcement requiredDesign of reinforced concrete retaining wall stem (BS 8002:1994)Material propertiesCharacteristic strength of concrete $(v_a = 40 \text{ N/mm}^2)$ Characteristic strength of reinforcement $k_a = 0.13$ %Cover to reinforcement in stemCaterian = 50 mmCover to reinforcement in wallCover to reinforcement in wallCover to reinforcement in wallCover to reinforcement in wallCover to reinforcement in wallSurcharge $F_{a,m,a,i} = 0.5 \times \gamma_{a,a} \times Ka \times Surcharge \times (her - base - das) = 33 kW/mMotist backfill above water tableF_{a,m,a,i} = 0.5 \times \gamma_{a,a} \times Ka \times \gamma_m \times (her - base - das) = 32 kW/mSurchargeF_{a,m,a,i} = 0.5 \times \gamma_{a,a} \times Ka \times \gamma_m \times (her - base - das) = 32 kW/mSurchargeV_{a,m,a,i} = 5 \times F_{a,m,a,i} + 0.5 \times \gamma_{a,a} \times Ka \times (her - base - das) = 32 kW/mSurchargeV_{a,m,a,i} = 5 \times \gamma_{a,a} \times Ka \times (her (her - base - das) = 32 kW/mSurchargeV_{a,m,a,i} = 5 \times \gamma_{a,a} \times Ka \times (her (her - base - das) - has) > has a = 37.2 kW/mSurchargeV_{a,m,a,i} = 5 \times \gamma_{a,a} \times (her (her - base - das) - has) > has a = 37.2 kW/mSurchargeV_{a,m,a,i} = 5 \times \gamma_{a,m,a,i} / 8 = 20.7 kW/mMaterV_{a,m,a,i} = 5 \times \gamma_{a,m,a,i} / 8 = 20.7 kW/mSurchargeV_{a,m,a,i} = F_{a,m,a,i} / 8 = 20.7 kW/mMaterV_{a,m,a,i} = F_{a,m,a,i} / 4 = 20.7 kW/mSurchargeM_{a,m,a} = F_{a,m,a,i} \times Ka $	From BS8110:Part 1:1997 –	Table 3.8							
Design of reinforced concrete retaining wall stem (BS 8002:1994)Material propertiesCharacteristic strength of concretefor acteristic strength of reinforcement $I_y = 500 \text{ N/mm}^2$ Wall detailsMinimum area of reinforcement $I_y = 500 \text{ N/mm}^2$ Wall detailsCover to reinforcement in stemCourse = 50 mmPactored horizontal at-rest forces on stemSurcharge $F_{x_m,x_1} = y_{x_1} \times K_a \times \text{Surcharge} \times (her - base - des) = 33 kM/mPactored horizontal at-rest forces on stemF_{x_m,x_1} = y_{x_1} \times K_a \times Surcharge \times (her - base - des) = 33 kM/mMoist backfill above water tableF_{x_m,x_1} = y_{x_1} \times K_a \times y_m \times (her - base - des) = 32 kM/mSurchargeF_{x_m,x_1} = y_{x_1} \times K_a \times y_m \times (her - base - des) = 32 kM/mSaturated backfillF_{x_m,x_1} = y_{x_1} \times K_a \times y_m \times (her - base - des) = 32 kM/mSaturated backfill above water tableF_{x_m,x_1} = y_{x_1} \times K_a \times y_m \times (her - base - des) = 32 kM/mWaterF_{x_m,x_1} = y_{x_1} \times K_a \times y_m \times (her - base - des) = 32 kM/mSurchargeV_{x_m,x_1} = f_{x_m,x_1} \times (h_x + y_m \times (her - base - des) = 32 kM/mWaterF_{x_m,x_1} = y_{x_1} \times K_a \times y_{max} + y_{max} = 42.9 kM/mMoist backfill above water tableV_{x_m,x_2} = F_{x_m,x_1} \times (h_1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3)))) = 25.6 kM/mWaterV_{x_m,x_2} = F_{x_m,x_1} \times (h_1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 23.1 kM/mMoist backfill above water tableM_{x_m,x_2} = F_{x_m,x_1} \times (h_1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 23.1 kM/mMoist backfill above water tableM_{x_m,x_2} = F_{x_m,x_1} \times (h_1 - (a^2 \times ((5 \times L) - a) / (20 $	Design concrete shear stress		Vc_toe = U.6 1	I / N/mm²	V No sh	ear reinforcer	nent required		
Design of reinforced concrete retaining wall stem (BS 8002:1994)Material propertiesCharacteristic strength of concrete $f_{sy} = 40 \text{ N/mm}^2$ Characteristic strength of concrete $f_y = 500 \text{ N/mm}^2$ Wall detailsKMinimum area of reinforcement $k = 0.13 \text{ %}$ Cover to reinforcement in stem $G_{stem} = 50 \text{ mm}$ Cover to reinforcement in wall $G_{stem} = 50 \text{ mm}$ Surcharge $F_{x,w,t} = \gamma_{1,x} \times K_0 \times Surcharge \times (har - hame - dw) = 33 kV/mMoist backfill above water tableF_{x,w,t} = 0.5 \times \gamma_{1,x} \times K_0 \times \gamma_m \times (har - hame - dw) = 32 kV/mMoist backfill bolow water tableF_{x,m,t} = 0.5 \times \gamma_{1,x} \times K_0 \times \gamma_m \times (har - hame - dw) = 32 kV/mSurchargeF_{x,w,t} = 0.5 \times \gamma_{1,x} \times K_0 \times \gamma_m \times (har - hame - dw) = 32 kV/mWaterF_{x,w,t} = 0.5 \times \gamma_{1,x} \times k_0 \times (\gamma_t, \gamma_{unwn}) \times h_{xt} = 232.8 kV/mSurchargeV_{x,w,t} = 5 \times \gamma_{x,x} \times \gamma_{unw} \times ham^2 = 42.9 kV/mWaterF_{x,w,t} = 0.5 \times \gamma_{1,x} \times (h \approx (\gamma_t, \gamma_{unwn}) \times h_{xt} = 23.8 kV/mSurchargeV_{x,w,t} = F_{x,w,t} / 8 = 20.7 kk/mMoist backfill above water tableV_{x,w,t} = F_{x,w,t} / 8 = 20.7 kk/mMoist backfill above water tableV_{x,w,t} = F_{x,w,t} / 1 (a^2 \times ((5 \times L) - a)) / (20 \times L^3))) = 25.6 kk/mWaterV_{x,w,w,t} = F_{x,w,t} / 4 = 40.2 kk/mMoist backfill below water tableV_{x,w,t} = F_{x,w,t} / 1 (a^2 \times ((5 \times L) - a)) / (20 \times L^3))) = 33.1 kk/mVaturate backfillV_{x,w,w,t} = F_{x,w,t} / 4 = 45.2 kkm/mMoist backfill below water tableM_{x,m,t} = F_{x,w,t} / 2 (-2)^2 / (3 \times h^2) / (15 \times L^3) = 2.$				V IC	6e < Vc_toe - NO SIT	earrennorcen	ient required		
Material propertiesCharacteristic strength of concrete $f_{cu} = 40 \text{ N/mm}^2$ Characteristic strength of reinforcement $f_{v} = 500 \text{ N/mm}^2$ Wall detailsKaracteristic strength of reinforcementMinimum area of reinforcement in stemCasen = 50 mmCover to reinforcement in wallCasen = 50 mmSurcharge $F_{u,m,l} = \eta_{1,1} \times K_0 \times \text{Surcharge} \times (heri - here - dae) = 33 kN/mMoist backfill above water tableF_{u,m,l} = \eta_{1,1} \times K_0 \times \text{Surcharge} \times (heri - here - dae) = 33 kN/mMoist backfill below water tableF_{u,m,l} = \eta_{1,2} \times K_0 \times Y_{10} \times (heri - here - dae) + hear)^2 = 7.4 kN/mMoist backfill below water tableF_{u,m,l} = \eta_{1,2} \times K_0 \times Y_{10} \times (heri - here - dae) + hear)^2 = 7.4 kN/mSaturated backfillF_{u,m,l} = 0.5 \times \gamma_{1,2} \times X_0 \times (\gamma_{10} \times \gamma_{10} \times hear)^2 = 7.4 kN/mWaterF_{u,m,l} = 0.5 \times \gamma_{1,2} \times X_0 \times (\gamma_{10} \times \gamma_{10} \times hear)^2 = 2.4 kN/mSaturated backfill below water tableV_{u,m,l} = 5 \times F_{u,m,l} / 8 = 20.7 kN/mMoist backfill above water tableV_{u,m,l} = F_{u,m,l} \times b \times ((5 \times L^2) - b^2) / (5 \times L^2) = 2 kN/mMoist backfill below water tableV_{u,m,l} = F_{u,m,l} \times b \times ((5 \times L^2) - b^2) / (5 \times L^2) = 2 kN/mMoist backfill below water tableV_{u,m,l} = F_{u,m,l} \times b \times ((5 \times L^2) - b^2) / (5 \times L^2) = 2.4 kN/mMoist backfill below water tableV_{u,m,l} = F_{u,m,l} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 kN/mMoist backfill below water tableM_{u,m,l} = F_{u,m,l} \times b \times ((5 \times L^2) - (3 \times b^2)) / ((5 \times L^2) = 2.4 kN/mMoist backfill below water tableM_{u,m,l} = F_{u,m,l} \times b \times ((5 \times L^2) - (3 \times b^2)) / ((5$	Design of reinforced concre	ete retaining wa	III stem (BS 8002	:1994 <u>)</u>					
Characteristic strength of concrete $f_{w} = 40 \text{ N/mn}^2$ Characteristic strength of reinforcement $f_y = 500 \text{ N/mn}^2$ Wall detailsMinimum area of reinforcement in stemCover to reinforcement in stem $C_{astm} = 50 \text{ mm}$ Cover to reinforcement in stem $C_{astm} = 50 \text{ mm}$ Surcharge $F_{a.not,1} = p_{1,1} \times K_0 \times \text{Surcharge} \times (herr - house - das) = 33 kN/mMoist backfill above water tableF_{a.not,2} = p_{1,2} \times K_0 \times y_m \times (herr - house - das - houly \times hour = 37.2 kN/mMoist backfill above water tableF_{a.not,2} = p_{1,2} \times K_0 \times y_m \times (herr - house - das - houly \times hour = 37.2 kN/mSaturated backfill below water tableF_{a.not,2} = p_{a.2} \times K_0 \times y_m \times (horr - house - das - houly \times hour = 37.2 kN/mWaterF_{a.not,2} = b_{a.2} \times y_{a.2} \times K_0 \times y_{mort} \times hour > house - das - houly \times hour = 37.2 kN/mSurchargeV_{a.moto,1} = 5 \times y_{a.2} \times K_0 \times y_{mort} \times hour? = 28.9 kN/mWaterF_{a.not,1} = 5 \times y_{a.2} \times y_{outrx} \times hour? = 28.9 kN/mSurchargeV_{a.moto,1} = 5 \times F_{a.mot,1} / 8 = 20.7 kN/mMoist backfill above water tableV_{a.moto,1} = F_{a.mot,1} \times b \times ((5 \times L^2) - b^2) / (5 \times L^2) = 2 kN/mSaturated backfillV_{a.a.b.t} = F_{a.moto,1} + V_{a.moto,1} + V_{a.moto,1} = 1/2.4 kN/mSaturated backfillV_{a.moto,1} = F_{a.moto,1} + V_{a.moto,1} + V_{a.moto,1} = 1/2.4 kN/mSaturated backfillV_{a.moto,1} = F_{a.moto,1} \times (1 - (a^2 \times ((5 \times L^2) - a) / (20 \times L^2)))) = 38.1 kN/mMaterV_{a.moto,1} = F_{a.moto,1} \times (1 - (a^2 \times ((5 \times L^2) - (3 \times b^2))) / (15 \times L^2) = 2.4 kN/mSurchargeM_{a.moto,1} = F_{a.moto,1} \times (1 - (a^2 \times $	Material properties								
Characteristic strength of reinforcement $f_y = 500 \text{ N/mm}^2$ Wall detailsK = 0.13 %Minimum area of reinforcement in stemCauen = 50 mmCover to reinforcement in wallCauen = 50 mmFactored horizontal at-rest forces on stemSurcharge $F_{x,m,1} = p_1 \times K_0 \times \text{Surcharge} \times (her - base - das) = 33 \text{ kN/m}$ Moist backfill above water table $F_{x,m,1} = p_1 \times K_0 \times \text{Surcharge} \times (her - base - das) = 33 \text{ kN/m}$ Moist backfill below water table $F_{x,m,1} = p_1 \times K_0 \times y_m \times K_0 \times y_m \times (her - base - das - has) > has = 37.2 \text{ kN/m}$ Maist backfill below water table $F_{x,m,1} = 0.5 \times y_{1,n} \times K_0 \times (y_m - y_mann) > has ^2 = 22.9 \text{ kN/m}$ Vater $F_{x,m,0,1} = 5 \times Y_{1,n} \times Y_0 \times K_0 \times (y_m - y_mann) > has ^2 = 22.9 \text{ kN/m}$ Calculate shear for stem design $V_{x,m,1} = F_{x,m,n,1} \times b \times ((5 \times L^2) - b^2) / (5 \times L^2) = 2 \text{ kN/m}$ Sutrated backfill above water table $V_{x,m,1} = F_{x,m,n,1} \times b \times ((5 \times L^2) - b^2) / (5 \times L^2) = 2 \text{ kN/m}$ Moist backfill above water table $V_{x,m,1} = F_{x,m,n,1} \times b \times ((5 \times L) - a) / (20 \times L^3))) = 25.6 \text{ kN/m}$ Water $V_{x,m,1} = F_{x,m,n,1} \times b \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 \text{ kN/m}$ Calculate moment for stem design $M_{x,m,n} = F_{x,m,n,1} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kN/m}$ Surcharge $M_{x,m,n} = F_{x,m,n,1} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kN/m}$ Moist backfill above water table $M_{x,m,n} = F_{x,m,n,1} \times b \times ((5 \times L^2) - (2 \times b^2)) / (5 \times L^2) = 2.4 \text{ kN/m}$ Surcharge $M_{x,m,n} = F_{x,m,n,1} \times a \times ((3 \times a^2) - (15 \times a^2)) / ((5 \times a^2) - 1.5 \text{ kN/m}/m}$ Moist backf	Characteristic strength of con	crete	$f_{cu} = 40 \text{ N/r}$	nm²					
Wall detailsMinimum area of reinforcement in stemk = 0.13 %.Cover to reinforcement in stem $C_{stem} = 50 \text{ mm}$ Cover to reinforcement in wall $C_{stem} = 50 \text{ mm}$ Factored horizontal at-rest forces on stemSurchargeSurcharge $F_{a,m,a,l} = 0.5 \times y_{a,o} \times K_0 \times y_m \times (har + house - das - hasp)^2 = 7.4 kN/m$ Moist backfill above water table $F_{a,m,a,l} = 0.5 \times y_{a,o} \times K_0 \times y_m \times (har + house - das - hasp)^2 = 7.4 kN/m$ Saturated backfill $F_{a,m,a,l} = 0.5 \times y_{a,o} \times K_0 \times y_m \times (har + house - das - hasp)^2 = 7.4 kN/m$ Saturated backfill below water table $F_{a,m,a,l} = 0.5 \times y_{a,o} \times K_0 \times (y_m + (har + house - das - hasp)^2 = 7.4 kN/m$ Water $F_{a,m,a,l} = 0.5 \times y_{a,o} \times K_0 \times y_m \times (har + house - das - hasp)^2 = 7.4 kN/m$ Water $F_{a,m,a,l} = 0.5 \times y_{a,o} \times K_0 \times y_m \times (har + house - das - hasp)^2 = 7.4 kN/m$ Water $F_{a,m,a,l} = 0.5 \times y_{a,o} \times y_m \times K_0 \times (y_m + (har + house - das - hasp)^2 = 7.4 kN/m$ Water $F_{a,m,a,l} = 0.5 \times y_{a,o} \times y_m \times K_0 \times (y_m + (har + house - das - hasp)^2 = 7.4 kN/m$ Moist backfill above water table $V_{a,m,a,l} = F_{a,m,a,l} \times K_0 \times (y_m + (har + house - das - hasp)^2 = 7.4 kN/m$ Moist backfill above water table $V_{a,m,a,l} = F_{a,m,a,l} \times b_{a,m}(15 \times l^2) - b^2/ / (5 \times l^2) = 2 kN/m$ Moist backfill above water table $V_{a,m,a,l} = F_{a,m,a,l} \times (1 - (a^2 \times ((5 \times L) - a)) / (20 \times l^3))) = 35.4 kN/m$ Total shear for stem design $V_{a,m,a,l} = F_{a,m,a,l} \times V_{a,m,b,l} + V_{a,m,b,l} + V_{a,m,b,l} = 115.4 kN/m$ Moist backfill above water table $M_{a,m,n} = F_{a,m,a,l} \times h_{a,m,b,l} + K_{a,m,a,l} + K_{a,m,a,l} + K_{a,m,b,l} + K$	Characteristic strength of rein	forcement	$f_y = 500 \text{ N/r}$	mm²					
Minimum area of reinforcementk = 0.13 %Cover to reinforcement in stemCauen = 50 mmCover to reinforcement in wallCauen = 50 mmSurcharge $F_{x,m,t} = \gamma_{t,1} \times K_0 \times Surcharge \times (h_{eff} - t_{base} - d_{os}) = 33 kN/mMoist backfill above water tableF_{x,m,t,1} = 0.5 \times \gamma_{t,0} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{os} - h_{as})^2 = 7.4 kN/mMoist backfill below water tableF_{x,m,t,1} = \gamma_{t,0} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{os} - h_{as})^2 = 7.4 kN/mSaturated backfillF_{x,m,t,1} = 0.5 \times \gamma_{t,0} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{os} - h_{as})^2 = 7.2 kN/mSaturated backfillF_{x,m,t,1} = \gamma_{t,0} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{os} - h_{as})^2 = 7.2 kN/mWaterF_{x,m,t,1} = (h_{t,0} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{os} - h_{as})^2 = 7.2 kN/mWaterF_{x,m,t,1} = (h_{t,0} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{os} - h_{as})^2 = 7.2 kN/mWaterF_{x,m,t,1} = (h_{t,0} \times K_0 \times \gamma_m \times K_0 \times (\gamma_m - \gamma_{uniter}) \times h_{as})^2 = 2.8 kN/mSurchargeV_{x,m,t,1} = 5 \times F_{x,m,t,1} \times (h \times (15 \times L^2) - 10^2) / (15 \times L^2) = 2.4 kN/mMoist backfill below water tableV_{x,m,t,1} = F_{x,m,t,1} \times (h \cdot (1 - a^2 \times ((5 \times L) - a)) / (20 \times L^3))) = 25.6 kN/mWaterV_{x,m,t,1} = F_{x,m,t,1} \times (h \cdot (a^2 \times ((5 \times L) - a)) / (20 \times L^3))) = 25.4 kN/mSurchargeM_{x,m,t} = F_{x,m,t,1} \times h \times ((5 \times L^2) - (3 \times h^2)) / (15 \times L^2) = 2.4 kN/mMoist backfill below water tableM_{x,m,t} = F_{x,m,t,1} \times h \times ((5 \times L^2) - (3 \times h^2)) / (15 \times L^2) = 2.4 kN/mMoist backfill below water tableM_{x,m,t} = F_{x,m,t,1} \times h \times ((5 \times L^2) - (3 \times h^2)) / (15 \times L^2) = 2.4 kN/m/mMoist backfill bolew w$	Wall details								
Cover to reinforcement in stem Cover to reinforcement in wallCetem = 50 mm Cover to reinforcement in wallCetem = 50 mmFactored horizontal at-rest forces on stemFer. Swr.J = $\psi_L \times K_0 \times Surcharge \times (herr - base - das) = 33 kN/m$ SurchargeFer. Swr.J = $\psi_L \times K_0 \times Syn \times (herr - base - das) = 33 kN/m$ Moist backfill below water tableFer. Swr.J = $\psi_L \times K_0 \times Syn \times (herr - base - das) = 33 kN/m$ Moist backfill below water tableFer. St. S $\psi_R \times K_0 \times \psi_m \times (herr - base - das) = heal)^2 = 7.4 kN/m$ Saturated backfillFer. St. S $\psi_R \times K_0 \times \psi_m \times (herr - base - das) - heal) \times heart = 37.2 kN/m$ Saturated backfillFer. St. S $\psi_R \times K_0 \times \psi_m \times (herr - base - das) - heal) \times heart = 37.2 kN/m$ VaterFer. St. S $\psi_R \times K_0 \times \psi_m \times (herr - base - das) + heart = 37.2 kN/m$ Saturated backfillFer. St. S $\psi_R \times K_0 \times \psi_m \times (herr - base - das) + heart = 37.2 kN/m$ Moist backfill below water tableVar. St. S $\psi_R \times K_0 \times \psi_m \times (herr - base - das) + heart = 37.2 kN/m$ Moist backfill below water tableVar. St. S $\psi_R \times W_{RW} \times \psi_{RW} \times heart = 42.9 kN/m$ Moist backfill below water tableVar. St. S $\psi_{RW} \times \psi_{RW} \times (1 + (a^2 \times (5 \times L) - a)) / (5 \times L^3) = 2 kN/m$ Moist backfill below water tableVar. St. S $\psi_{RW} \times (1 - (a^2 \times (5 \times L) - a)) / (20 \times 1^3)) = 38.1 kN/m$ VaterVar. St. S $\psi_{RW} \times (1 - (a^2 \times (5 \times L) - a)) / (20 \times 1^3)) = 38.1 kN/m$ SurchargeMar. St. S $\psi_{RW} \times (3 \times a^2) - (15 \times a^2) / (15 \times a^2) = 2.4 kNm/m$ Moist backfill above water tableMar. St. S $\psi_{RW} \times (3 \times a^2) - (15 \times a^2) / (15 \times a^2) = 2.4 kNm/m$ Moist backfill above water tableMar. S $\psi_{RW} = F_{R,RM} \times a$	Minimum area of reinforceme	nt	k = 0.13 %						
Cover to reinforcement in wall $C_{well} = 50 \text{ mm}$ Factored horizontal at-rest forces on stem $F_{n,wr,l} = \eta_{l,l} \times K_0 \times Surcharge \times (h_{0}\pi - base - d_{sb}) = 33 \text{ kN/m}$ Moist backfill above water table $F_{n,wr,l,l} = 0.5 \times \gamma_{n,s} \times K_0 \times \gamma_m \times (h_{0}\pi - base - d_{sb} - h_{scl}) \ge 7.4 \text{ kN/m}$ Moist backfill below water table $F_{n,m,l,l} = \eta_{v} \propto K_0 \times \gamma_m \times (h_{0}\pi - base - d_{sb} - h_{scl}) \times h_{scl} = 37.2 \text{ kN/m}$ Saturated backfill $F_{n,m,l,l} = \eta_{v} \propto K_0 \times \gamma_m \times (h_{0}\pi - base - d_{sb} - h_{scl}) \times h_{scl} = 37.2 \text{ kN/m}$ Water $F_{n,m,l,l} = f_{n,m,k,l} \times K_0 \times (\gamma_{tr} \gamma_{water}) \times h_{scl}^2 = 42.9 \text{ kN/m}$ Calculate shear for stem designSurcharge $V_{n,m,n,l} = F_{n,m,n,k} \times b \times ((5 \times L^2) - b^2) / (5 \times L^3) = 2 \text{ kN/m}$ Moist backfill below water table $V_{n,m,n,l} = F_{n,m,n,k} \times b \times ((5 \times L^2) - a) / (20 \times L^3)) = 25.6 \text{ kN/m}$ Water $V_{n,m,n,l} = F_{n,m,n,k} \times (1 - (a^2 \times ((5 \times L) - a)) / (20 \times L^3))) = 38.1 \text{ kN/m}$ Saturated backfill $V_{n,m,n,l} = F_{n,m,n,k} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kN/m}$ Water $V_{n,m,n,l} = F_{n,m,n,k} \to b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kN/m}$ Moist backfill below water table $M_{n,m,n} = F_{n,m,n,k} \to b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kN/m}$ Moist backfill below water table $M_{n,m,n} = F_{n,m,n,k} \to b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kN/m}$ Moist backfill below water table $M_{n,m,n} = F_{n,m,n,k} \to b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kN/m}$ Moist backfill below water table $M_{n,m,n} = F_{n,m,n,k} \to ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kN/m}$ Moist backfill be	Cover to reinforcement in ster	n	C _{stem} = 50 n	nm					
Factored horizontal at-rest forces on stemSurcharge $F_{x_m,x_n} = \gamma_{L,1} \times K_0 \times Surcharge \times (herr - base - das) = 33 kN/mMoist backfill above water tableF_{x_m,x_n} = 0.5 \times \gamma_{n,s} \times K_0 \times \gamma_m \times (herr - base - das) - han)^2 = 7.4 kN/mMoist backfill below water tableF_{x_m,x_n} = 0.5 \times \gamma_{n,s} \times K_0 \times \gamma_m \times (herr - base - das) - han)^2 = 7.4 kN/mSaturated backfillF_{x_n,x_n} = \gamma_n \times K_0 \times \gamma_m \times (herr - base - das) - han) \times han = 37.2 kN/mWaterF_{x_n,x_n} = 0.5 \times \gamma_{n,s} \times K_0 \times \gamma_m \times (y_{water}) \times h_{and}^2 = 28.9 kN/mCalculate shear for stem designSurchargeSurchargeV_{x_n,x_n,t} = 5 \times F_{x_n,x_n,t} / 8 = 20.7 kN/mMoist backfill above water tableV_{x_n,x_n,t} = F_{x_n,x_n,t} \times b \times ((5 \times L^2) - br^2) / (5 \times L^3) = 2 kN/mMoist backfill below water tableV_{x_n,x_n,t} = F_{x_n,x_n,t} \times b \times ((5 \times L^2) - br^2) / (5 \times L^3) = 2 kN/mSaturated backfillV_{x_n,x_n,t} = F_{x_n,x_n,t} \times b \times ((5 \times L) - a) / (20 \times L^3))) = 25.6 kN/mWaterV_{x_n,x_n,t} = F_{x_n,x_n,t} \times V_{x_n,x_n,t} + V$	Cover to reinforcement in wal	l	c _{wall} = 50 m	m					
Surcharge $F_{a,m,j} = \gamma_{i,j} \times K_0 \times Surcharge \times (hart - base - das) = 33 kN/mMoist backfill above water tableF_{a,m,b,j} = 0.5 \times \gamma_{a,s} \times K_0 \times \gamma_m \times (hart - base - das) - han)^2 = 7.4 kN/mMoist backfill below water tableF_{a,m,b,j} = \gamma_{i,s} \times K_0 \times \gamma_m \times (hart - base - das - han) \times hant = 37.2 kN/mSaturated backfillF_{a,m,b,j} = \gamma_{i,s} \times K_0 \times \gamma_m \times (hart - base - das - han) \times hant = 37.2 kN/mWaterF_{a,m,b,j} = (h, s \times K_0 \times \gamma_m \times (hart - base) - das - hant) \times hant = 37.2 kN/mWaterF_{a,m,d,i} = 0.5 \times \gamma_{b,s} \times K_0 \times (\gamma_{b,r} \vee water) \times hant^2 = 28.9 kN/mWaterF_{a,m,d,i} = 5 \times F_{a,m,d,i} \times K_0 \times (\gamma_{b,r} \vee water) \times hant^2 = 42.9 kN/mSurchargeV_{a,m,d,i} = 5 \times F_{a,m,d,i} \times K_0 \times (15 \times L^2) - b^2) / (5 \times L^2) = 2 kN/mMoist backfill below water tableV_{a,m,d,i} = F_{a,m,b,i} \times (1 - (a)^2 \times (15 \times L^2) - b^2) / (5 \times L^2) = 2 kN/mMoist backfill below water tableV_{a,m,d,i} = F_{a,m,b,i} \times (1 - (a)^2 \times (15 \times L) - a) / (20 \times L^3))) = 38.1 kN/mSaturated backfillV_{a,m,d,i} = F_{a,m,d,i} \times (1 - (a)^2 \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 kN/mWaterV_{a,m,d,i} = F_{a,m,d,i} \times b_{i,m,d,i} + V_{a,m,d,i} + V_{a,m,d$	Factored horizontal at-rest	orces on stem							
Moist backfill above water table $F_{n,m,n,l} = 0.5 \times \gamma_{n,s} \times K_0 \times \gamma_m \times (heir \cdot base - das - heal)^2 = 7.4 kN/m$ Moist backfill below water table $F_{n,m,b,l} = \gamma_{n,s} \times K_0 \times \gamma_m \times (heir \cdot base - das - heal)^2 = 7.4 kN/m$ Saturated backfill $F_{n,s,l} = 0.5 \times \gamma_{n,s} \times K_0 \times (\gamma_m \gamma_{water}) \times hear^2 = 28.9 kN/m$ Water $F_{n,m,k,l} = 0.5 \times \gamma_{l,s} \times K_0 \times (\gamma_m \gamma_{water}) \times hear^2 = 28.9 kN/m$ Calculate shear for stem design $Surcharge$ Surcharge $V_{n,m,k,l} = 5 \times F_{n,s,w,l} / 8 = 20.7 kN/m$ Moist backfill above water table $V_{n,m,k,l} = 5 \times F_{n,s,w,l} / 8 = 20.7 kN/m$ Moist backfill below water table $V_{n,m,k,l} = F_{n,m,k,l} \times b_l \times ((5 \times L^2) - b^2) / (5 \times L^2) = 2 kN/m$ Moist backfill below water table $V_{n,m,k,l} = F_{n,m,k,l} \times b_l \times ((5 \times L) - a) / (20 \times L^3))) = 25.6 kN/m$ Water $V_{n,m,k,l} = F_{n,m,k,l} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3)))) = 38.1 kN/m$ Vater $V_{n,m,k,l} = F_{n,m,k,l} \times b_{n,m,k,l} + V_{n,m,k,l} + V_{n,m,k,l} = 115.4 kN/m$ Calculate moment for stem design $M_{n,m,n} = F_{n,m,k,l} \times b_{n,k} ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 kNm/m$ Moist backfill above water table $M_{n,m,k} = F_{n,m,k,l} \times b_{n,k} ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 kNm/m$ Moist backfill below water table $M_{n,m,k} = F_{n,m,k,l} \times b_{n,k} ((5 \times a^2 - (1 \times a^2 + (1 \times a^2 + (1 \times a^2 + (1 \times a^2 + a$	Surcharge		$F_{s_sur_f} = \gamma_{f_}$	$ imes K_0 imes$ Surcha	$trge imes (h_{eff} - t_{base} - t_{base})$	$d_{ds}) = \textbf{33} \text{ kN/m}$	l		
Moist backfill below water table $F_{n,m,b,f} = \gamma_{f,v} \times K_0 \times \gamma_m \times (h_{eff} \cdot h_{base} \cdot d_{ab} - h_{ast}) \times h_{ast} = 37.2 kN/m$ Saturated backfill $F_{n,m,b,f} = \gamma_{f,v} \times K_0 \times (\gamma_{e^-} \gamma_{water}) \times h_{ast}^2 = 28.9 kN/m$ Water $F_{n,m,b,f} = 0.5 \times \gamma_{f,v} \times \gamma_{water} \times h_{ast}^2 = 42.9 kN/m$ Calculate shear for stem design $Surcharge$ Surcharge $V_{n,m,f} = 5 \times F_{n,m,f} / 8 = 20.7 kN/m$ Moist backfill above water table $V_{n,m,d,f} = F_{n,m,d,f} \times bi \times ((5 \times L^2) - b^2) / (5 \times L^3) = 2 kN/m$ Moist backfill below water table $V_{n,m,f} = F_{n,m,d,f} \times bi \times ((5 \times L) - a) / (20 \times L^3))) = 25.6 kN/m$ Water $V_{n,m,f} = F_{n,m,d,f} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 33.1 kN/m$ Vater $V_{n,m,d,f} = F_{n,m,d,f} \times b \times ((5 \times L^2) - (3) / (15 \times L^2) = 2.4 kN/m$ Moist backfill below water table $M_{n,m,n} = F_{n,m,d,f} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 kN/m$ Surcharge $M_{n,m,n} = F_{n,m,d,f} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 kN/m$ Moist backfill below water table $M_{n,m,n} = F_{n,m,d,f} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 kN/m$ Moist backfill below water table $M_{n,m,h} = F_{n,m,h,f} \times a \times (2 - n)^2 / 8 = 20.1 kN/m$ Moist backfill below water table $M_{n,m,h} = F_{n,m,h,f} \times a \times (2 - n)^2 / 8 = 20.1 kN/m$ Water $M_{n,m,k} = F_{n,m,h,f} \times a \times (2 - n)^2 / 8 = 20.1 kN/m$ Moist backfill below water table $M_{n,m,h} \times M_{n,m,h} \times M_{n,m,h} + M_{n,m$	Moist backfill above water tab	le	$F_{s_m_a_f} = 0$	$.5 imes \gamma_{f_e} imes K_0 imes$	$\gamma_{ m m} imes$ (h _{eff} - t _{base} - c	l _{ds} - h _{sat}) ² = 7.4	kN/m		
Saturated backfill $F_{a,b} = 0.5 \times \gamma_{L,a} \times K_0 \times (\gamma_c \gamma_{water}) \times h_{sal}^2 = 28.9 kN/m$ Water $F_{a,water,l} = 0.5 \times \gamma_{L,a} \times \gamma_{water} \times h_{sal}^2 = 42.9 kN/m$ Calculate shear for stem designSurcharge $V_{a,sur,a,l} = 5 \times F_{a,sur,l} \times 8 = 20.7 kN/m$ Moist backfill above water table $V_{a,m,a,l} = F_{a,m,a,l} \times b \times ((5 \times L^2) - b^2) / (5 \times L^3) = 2 kN/m$ Moist backfill below water table $V_{a,m,a,l} = F_{a,m,b,l} \times (8 - (n^2 \times (4 - n))) / 8 = 29.1 kN/m$ Saturated backfill $V_{a,s,l} = F_{a,s,l} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 25.6 kN/m$ Water $V_{a,water,l} = F_{a,water,l} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 kN/m$ Vater $V_{a,water,l} = F_{a,water,l} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 kN/m$ Calculate moment for stem design $V_{a,s,arr} = F_{a,wat,l} \times L / 8 = 15.2 kNm/m$ Moist backfill above water table $M_{a,g,ar} = F_{a,g,h,l} \times L / 8 = 15.2 kNm/m$ Moist backfill above water table $M_{a,g,ar} = F_{a,g,h,l} \times h \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 kNm/m$ Moist backfill below water table $M_{a,g,ar} = F_{a,g,h,l} \times h \times ((3 \times a^2) - (15 \times a) \times 1) / (20 \times L^2)) / (60 \times L^2) = 2.4 kNm/m$ Water $M_{a,g,arr} = F_{a,g,h,l} \times h \times ((3 \times a^2) - (15 \times a) \times 1) / ((0 \times L^2)) / (60 \times L^2) = 20.4 kNm/m$ Water $M_{a,g,arr} = F_{a,g,h,l} \times h \times ((3 \times a^2) - (15 \times a) \times 1) / ((60 \times L^2) = 13.7 kNm/m$ Water $M_{a,g,arr} = 9 \times F_{a,g,nr,l} \times L / 128 = 8.5 kNm/m$ Water $M_{a,g,arr} = 9 \times F_{a,g,nr,l} \times L / 128 = 8.5 kNm/m$ Moist backfill above water table $M_{w,g,arr} = 9 \times F_{a,g,nr,l} \times L / 128 = 8.5 kNm/m$ Moist backfill a	Moist backfill below water tab	le	$F_{s_m_b_f} = \gamma_{f}$	$_{e} \times K_{0} \times \gamma_{m} \times ($	h _{eff} - t _{base} - d _{ds} - h _s	_{sat}) × h _{sat} = 37.2	kN/m		
Water $F_{s_water_1} = 0.5 \times \gamma_{u_0e} \times \gamma_{water} \times h_{sal}^2 = 42.9 \text{ kN/m}$ Calculate shear for stem designSurcharge $V_{s_swr,1} = 5 \times F_{s_swr,1} / 8 = 20.7 \text{ kN/m}$ Moist backfill above water table $V_{s_w,m,0,1} = F_{s_w,m,0,1} \times b_1 \times ((5 \times L^2) \cdot b^2) / (5 \times L^3) = 2 \text{ kN/m}$ Moist backfill below water table $V_{s_w,m,0,1} = F_{s_w,m,0,1} \times (8 - (n^2 \times (4 - n))) / 8 = 29.1 \text{ kN/m}$ Saturated backfill $V_{s_w,m,0,1} = F_{s_w,m,0,1} \times (8 - (n^2 \times ((5 \times L) - a) / (20 \times L^3))) = 25.6 \text{ kN/m}$ Water $V_{s_water,1} = F_{s_water,1} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3)))) = 38.1 \text{ kN/m}$ Total shear for stem design $V_{s_water,1} + V_{s_w,m,0,1} + V_{s_w,n,0,1} + V_{s_w,water,1} = 115.4 \text{ kN/m}$ Calculate moment for stem design $V_{storm} = V_{s_water,1} \times L / 8 = 15.2 \text{ kN/m}$ Moist backfill above water table $M_{s_water} = F_{s_water,1} \times L / 8 = 15.2 \text{ kN/m}$ Moist backfill above water table $M_{s_water} = F_{s_water,1} \times (1 - (a^2 \times ((2 - n)^2 / (3 \times b^2))) / (15 \times L^2) = 2.4 \text{ kN/m}/m$ Moist backfill above water table $M_{s_water} = F_{s_water,1} \times a_x ((2 \cdot n)^2 / (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kN/m}/m$ Water $M_{s_water} = F_{s_water,1} \times a_x ((3 \times a^2) - (15 \times a_x L) + (20 \times L^2)) / (60 \times L^2) = 20.4 \text{ kN/m}/m$ Water $M_{s_water} = F_{s_water,1} \times a_x ((3 \times a^2) - (15 \times a_x L) + (20 \times L^2)) / (60 \times L^2) = 20.4 \text{ kN/m}/m$ Moist backfill above water table $M_{s_water} = 9 \times F_{s_water,1} \times L / 128 = 8.5 \text{ kN/m}/m$ Moist backfill above water table $M_{w_water} = 9 \times F_{s_water,1} \times L / 128 = 8.5 \text{ kN/m}/m$ Moist backfill above water table $M_{w_water} = 9 \times F_{s_water,1} \times (1 $	Saturated backfill		$F_{s_s_f} = 0.5 \times \gamma_{f_e} \times K_0 \times (\gamma_{s^-} \gamma_{water}) \times h_{sat}^2 = \textbf{28.9 kN/m}$						
Calculate shear for stem designSurcharge $V_{s,sur_1} = 5 \times F_{s,sur_1} / 8 = 20.7 \text{ kN/m}$ Moist backfill above water table $V_{s,m,a,f} = F_{s,m,a,f} \times b_1 \times ((5 \times L^2) - b^2) / (5 \times L^3) = 2 \text{ kN/m}$ Moist backfill below water table $V_{s,m,b,f} = F_{s,m,b,f} \times (8 - (n^2 \times (4 - n))) / 8 = 29.1 \text{ kN/m}$ Saturated backfill $V_{s,s,f} = F_{s,s,s,f} \times (1 - (a)^2 \times ((5 \times L) - a) / (20 \times L^3))) = 25.6 \text{ kN/m}$ Water $V_{s,water,f} = F_{s,s,s,r} \times (1 - (a)^2 \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 \text{ kN/m}$ Total shear for stem design $V_{s,sur_f} = F_{s,sur_f} + V_{s,m,a,f} + V_{s,m,b,f} + V_{s,m,s,f} + V_{s,water,f} = 115.4 \text{ kN/m}$ Calculate moment for stem design $V_{s,sur_f} = F_{s,sur_f} \times L / 8 = 15.2 \text{ kNm/m}$ Moist backfill above water table $M_{s,sur_f} = F_{s,m,s,f} \times b_1 \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kNm/m}$ Moist backfill above water table $M_{s,m,a} = F_{s,m,a,f} \times b_1 \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kNm/m}$ Moist backfill below water table $M_{s,m,a} = F_{s,m,b,1} \times a_1 \times (2 - n)^2 / 8 = 20.1 \text{ kNm/m}$ Water $M_{s,m,a} = F_{s,sur_f,1} \times a_1 \times (2 - n)^2 / 8 = 20.1 \text{ kNm/m}$ Water $M_{s,water} = F_{s,water,1} \times a_{xi} ((3 \times a^2) - (15 \times a_1 \times L) + (20 \times L^2))/(60 \times L^2) = 13.7 \text{ kNm/m}$ Water $M_{s,water} = F_{s,water,1} \times a_{xi} ((3 \times a^2) - (15 \times a_1 \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 \text{ kNm/m}$ Moist backfill above water table $M_{w,g,ur} = 9 \times F_{s,sur_f} \times L / 128 = 8.5 \text{ kNm/m}$ Motist backfill above water table $M_{w,g,ur} = 9 \times F_{s,sur_f} \times L / 128 = 8.5 \text{ kNm/m}$ Moist backfill above water table $M_{w,g,ur} = F_{s,m,h,d} \times 0.577 \times b_{Xi} $	Water		$F_{s_water_f} = 0$	$0.5 imes\gamma_{f_e} imes\gamma_{water}$	r × h _{sat} ² = 42.9 kN	/m			
Surcharge $V_{s,sur,t} = 5 \times F_{s,sur,t} / 8 = 20.7 \text{ kN/m}$ Moist backfill above water table $V_{s,m,a,l} = F_{s,m,a,l} \times b \times ((5 \times L^2) - b^2) / (5 \times L^3) = 2 \text{ kN/m}$ Moist backfill below water table $V_{s,m,b,l} = F_{s,m,b,l} \times (8 - (n^2 \times (4 - n))) / 8 = 29.1 \text{ kN/m}$ Saturated backfill $V_{s,s,l} = F_{s,s,l} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 25.6 \text{ kN/m}$ Water $V_{s,water,l} = F_{s,s,water,l} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 \text{ kN/m}$ Total shear for stem design $V_{s,s,ur} = F_{s,s,ur,l} + V_{s,m,a,l} + V_{s,s,u} + V_{s,water,l} = 115.4 \text{ kN/m}$ Calculate moment for stem design $V_{s,s,ur} = F_{s,s,ur,l} \times L / 8 = 15.2 \text{ kNm/m}$ Surcharge $M_{s,s,ur} = F_{s,s,ur,l} \times L / 8 = 15.2 \text{ kNm/m}$ Moist backfill above water table $M_{s,m,a} = F_{s,m,b,l} \times a_k (2 - n)^2 / 8 = 20.1 \text{ kNm/m}$ Moist backfill below water table $M_{s,s,ur} = F_{s,s,r} \times a_k ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2))/(60 \times L^2) = 2.4 \text{ kNm/m}$ Water $M_{s,uster} = F_{s,uster,l} \times a_k (2 - n)^2 / 8 = 20.1 \text{ kNm/m}$ Water $M_{s,uster} = F_{s,uster,l} \times a_k ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 \text{ kNm/m}$ Water $M_{s,uster} = F_{s,uster,l} \times a_k ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 \text{ kNm/m}$ Water $M_{s,uster} = M_{s,ur,l} + M_{s,m,k} + M_{s,m,k} + M_{s,k} + M_{s,k$	Calculate shear for stem de	sign							
Moist backfill above water table $V_{s.m.a.f} = F_{s.m.a.f} \times b \times ((5 \times L^2) - b^2) / (5 \times L^3) = 2 kN/m$ Moist backfill below water table $V_{s.m.b.f} = F_{s.m.b.f} \times (8 - (n^2 \times (4 - n))) / 8 = 29.1 kN/m$ Saturated backfill $V_{s.s.f} = F_{s.s.f} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 kN/m$ Water $V_{s.water_f} = F_{s.water_f} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 kN/m$ Total shear for stem design $V_{stem} = V_{s.water_f} + V_{s.m.a.f} + V_{s.m.b.f} + V_{s.s.f} + V_{s.water_f} = 115.4 kN/m$ Calculate moment for stem design $V_{stem} = V_{s.watr_f} \times L / 8 = 15.2 kNm/m$ Surcharge $M_{s.m.a.f} = F_{s.m.a.f.1} \times b \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 kNm/m$ Moist backfill above water table $M_{s.m.a.f} = F_{s.m.a.f.1} \times b \times ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2)) / (60 \times L^2) = 20.4 kNm/m$ Mater $M_{s.s.s.f} = F_{s.s.f.1} \times a \times (2 - n)^2 / 8 = 20.1 kNm/m$ Water $M_{s.s.s.f} = F_{s.s.f.2} \times a \times ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2)) / (60 \times L^2) = 20.4 kNm/m$ Water $M_{s.s.s.f} = F_{s.s.f.1} \times a \times ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2)) / (60 \times L^2) = 20.4 kNm/m$ Water $M_{s.s.sur} = F_{s.water_f} \times a \times ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2)) / (60 \times L^2) = 20.4 kNm/m$ Water $M_{w.s.sur} = 9 \times F_{s.s.s.f.1} \times L / 128 = 8.5 kNm/m$ Moist backfill above water table $M_{w.s.sur} = 9 \times F_{s.s.s.f.1} \times L / 128 = 8.5 kNm/m$ Moist backfill above water table $M_{w.s.sur} = 9 \times F_{s.s.s.f.1} \times L / 128 = 8.5 kNm/m$ Moist backfill above water table $M_{w.s.s.f.s.f.1} \times a \times [((8 - a^2 \times (-1))^2 / (16) - 4 + n \times (4 - n))/8 = 10.4 kNm/m$ Moist backfill below water table $M_{w.m.$	Surcharge	0	$V_{s_sur_f} = 5$	$\times F_{s_{sur_f}} / 8 = 2$	2 0.7 kN/m				
Moist backfill below water table $V_{s.m.b.f} = F_{s.m.b.f} \times (8 - (n^2 \times (4 - n)))/8 = 29.1 kN/m$ Saturated backfill $V_{s.s.f} = F_{s.m.b.f} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 25.6 kN/m$ Water $V_{s.s.f} = F_{s.s.f} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 kN/m$ Total shear for stem design $V_{s.mater.f} = F_{s.m.a.f} + V_{s.m.b.f} + V_{s.s.f} + V_{s.water.f} = 115.4 kN/m$ Calculate moment for stem design $V_{s.mater.f} + V_{s.m.a.f} + V_{s.m.b.f} + V_{s.s.f} + V_{s.water.f} = 115.4 kN/m$ Surcharge $M_{s.sur} = F_{s.m.a.f} \times L / 8 = 15.2 kNm/m$ Moist backfill above water table $M_{s.m.a} = F_{s.m.b.f} \times a \times (2 - n)^2 / 8 = 20.1 kNm/m$ Moist backfill below water table $M_{s.m.b} = F_{s.m.b.f} \times a \times (2 - n)^2 / 8 = 20.1 kNm/m$ Water $M_{s.sur} = F_{s.water.f} \times a \times (3 \times a^2) - (15 \times a \times L) + (20 \times L^2)) / (60 \times L^2) = 13.7 kNm/m$ Water $M_{s.water} = F_{s.water.f} \times a \times ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2)) / (60 \times L^2) = 20.4 kNm/m$ Water $M_{s.sur} = F_{s.water.f} \times a \times ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2)) / (60 \times L^2) = 20.4 kNm/m$ Water $M_{s.sur} = F_{s.water.f} \times a \times ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2)) / (60 \times L^2) = 20.4 kNm/m$ Moist backfill above water table $M_{w.sur} = F_{s.water.f} \times a \times ((3 \times a^2) - (15 \times a \times L) + (20 \times L^2)) / (60 \times L^2) = 20.4 kNm/m$ Moist backfill above water table $M_{w.sur} = 9 \times F_{s.sur.f} \times L / 128 = 8.5 kNm/m$ Moist backfill above water table $M_{w.sur} = F_{s.s.sur.f} \times (1 - (a^2 \times ((5 \times L) - a)) / (20 \times L^3) - 0.577^2/3) = 2.7 kNm/m$ Moist backfill below water table $M_{w.s.sur} = F_{s.s.s.t} \times (a^2 \times ((5 \times L) - a)) / (20 \times L^3) - (5 \times L^3)^3 / (3 \times a$	Moist backfill above water tab	le	$V_{s_m_a_f} = F$	$s_m_a_f \times b_I \times ((5))$	$5 \times L^2$) - bi ²) / (5 ×	L ³) = 2 kN/m			
Saturated backfill $V_{s_ss_1} = F_{s_ss_1} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 25.6 kN/m$ Water $V_{s_swater_f} = F_{s_swater_j} \times (1 - (a^2 \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 kN/m$ Total shear for stem design $V_{s_swater_f} = F_{s_swater_j} + V_{s_sm_b,j} + V_{s_s,s_1} + V_{s_swater_f} = 115.4 kN/m$ Calculate moment for stem design $V_{s_swater_f} = F_{s_swr_f} \times L / 8 = 15.2 kNm/m$ Surcharge $M_{s_sm_s} = F_{s_swr_f} \times L / 8 = 15.2 kNm/m$ Moist backfill above water table $M_{s_sm_s} = F_{s_swr_f} \times a \times (2 - n)^2 / 8 = 20.1 kNm/m$ Moist backfill below water table $M_{s_ss} = F_{s_s,s_1} \times a \times ((3 \times a^2) - (15 \times a_1 \times L) + (20 \times L^2))/(60 \times L^2) = 13.7 kNm/m$ Water $M_{s_swater} = F_{s_swater_f} \times a \times ((3 \times a^2) - (15 \times a_1 \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 kNm/m$ Water $M_{s_swater} = F_{s_swater_f} \times a_{k} \times ((3 \times a^2) - (15 \times a_1 \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 kNm/m$ Water $M_{s_swater} = F_{s_swater_f} \times a_{k} \times ((3 \times a^2) - (15 \times a_1 \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 kNm/m$ Moist backfill below water table $M_{w_swater} = F_{s_swater_f} \times a_{k} \times ((3 \times a^2) - (15 \times a_1 \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 kNm/m$ Moist backfill below water table $M_{w_swater} = 9 \times F_{s_swatr_f} \times L / 128 = 8.5 kNm/m$ Moist backfill below water table $M_{w_swatr} = 9 \times F_{s_swatr_f} \times a_{k} \times ((3 \times a^2) - (3 \times a^2)) - 0.577^2/3] = 2.7 kNm/m$ Moist backfill below water table $M_{w_smatr} = F_{s_sm_s} + a_{k} \times (((s \times L) - a))/(20 \times L^3) - 0.577^2/3] = 2.7 kNm/m$ Moist backfill below water table $M_{w_sm_s} = F_{s_sm_s} + a_{k} \times (((s \times L) - a))/(20 \times L^3) - 0.577^2/3] = 2.7 kNm/m$ Moist backfill below water table </td <td>Moist backfill below water tab</td> <td>le</td> <td colspan="6">$V_{s_m,b_f} = F_{s_m,b_f} \times (8 - (n^2 \times (4 - n))) / 8 = 29.1 \text{ kN/m}$</td>	Moist backfill below water tab	le	$V_{s_m,b_f} = F_{s_m,b_f} \times (8 - (n^2 \times (4 - n))) / 8 = 29.1 \text{ kN/m}$						
Water $V_{s_water_f} = F_{s_water_j} \times (1 - (a_i^2 \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 kN/m$ Total shear for stem design $V_{s_water_f} = F_{s_water_j} \times (1 - (a_i^2 \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 kN/m$ Calculate moment for stem design $V_{stem} = V_{s_water_j} \times (1 - (a_i^2 \times ((5 \times L) - a) / (20 \times L^3))) = 38.1 kN/m$ Surcharge $M_{s_water} = F_{s_water_j} \times L / 8 = 15.2 kNm/m$ Moist backfill above water table $M_{s_w_n_a} = F_{s_w_n_b_f} \times b_i \times ((5 \times L^2) - (3 \times b_i^2)) / (15 \times L^2) = 2.4 kNm/m$ Moist backfill below water table $M_{s_w_b_b} = F_{s_w_b_f} \times a_i \times (2 - n)^2 / 8 = 20.1 kNm/m$ Saturated backfill $M_{s_w_b_b} = F_{s_w_b_f} \times a_i \times (2 - n)^2 / 8 = 20.1 kNm/m$ Water $M_{s_water} = F_{s_water_f} \times a_i \times ((3 \times a_i^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 13.7 kNm/m$ Water $M_{s_water} = F_{s_water_f} \times a_i \times ((3 \times a_i^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 kNm/m$ Mummin $M_{s_water} = F_{s_water_f} \times a_i \times ((3 \times a_i^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 kNm/m$ Moist backfill bove water table $M_{w_water} = F_{s_water_f} \times a_i \times ((3 \times a_i^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 kNm/m$ Moist backfill above water table $M_{w_water} = 9 \times F_{s_water_f} \times a_i \times ((3 \times a_i^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 kNm/m$ Moist backfill below water table $M_{w_water} = 9 \times F_{s_water_f} \times a_i \times ((3 \times a_i^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 kNm/m$ Moist backfill below water table $M_{w_water} = 9 \times F_{s_water_f} \times 1 - 128 = 8.5 kNm/m$ Moist backfill below water table $M_{w_water} = 9 \times F_{s_water_f} \times 1 - 128 = 8.5 kNm/m$ Moist backfill below wate	Saturated backfill		$V_{s_s_f} = F_{s_s_f} \times (1 - (a_1^2 \times ((5 \times L) - a_1) / (20 \times L^3))) = 25.6 \text{ kN/m}$						
Total shear for stem design $V_{stem} = V_{s_sur_f} + V_{s_m_a_f} + V_{s_m_b_f} + V_{s_s_f} + V_{s_water_f} = 115.4 kN/m$ Calculate moment for stem design $W_{stem} = V_{s_sur_f} \times L / 8 = 15.2 kNm/m$ Surcharge $M_{s_sur} = F_{s_sur_f} \times L / 8 = 15.2 kNm/m$ Moist backfill above water table $M_{s_m_a} = F_{s_m_a_f} \times b_l \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 kNm/m$ Moist backfill below water table $M_{s_m_a} = F_{s_m_a_f} \times a_l \times (2 - n)^2 / 8 = 20.1 kNm/m$ Saturated backfill $M_{s_s=F_{s_s_f}} \times a_l \times ((3 \times a^2) - (15 \times a_l \times L) + (20 \times L^2))/(60 \times L^2) = 13.7 kNm/m$ Water $M_{s_water} = F_{s_water_f} \times a_l \times ((3 \times a^2) - (15 \times a_l \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 kNm/m$ KNm/mMoist backfill above water table $M_{s_water} = F_{s_water_f} \times a_l \times ((3 \times a^2) - (15 \times a_l \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 kNm/m$ Surcharge $M_{s_water} = F_{s_water_f} \times a_l \times ((3 \times a^2) - (15 \times a_l \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 kNm/m$ Moist backfill above water table $M_{s_water} = 9 \times F_{s_sur_f} \times L / 128 = 8.5 kNm/m$ Moist backfill above water table $M_{w_sur_a} = F_{s_m_a_t} \times 0.577 \times b_l ((b^1 + 5 \times a_l \times L)/(5 \times L^3) - 0.577^2/3] = 2.7 kNm/m$ Moist backfill below water table $M_{w_m_a} = F_{s_m_a_t} \times a_l \times (((8 - n^2 \times (4 - n)))^2 / 16) - 4 + n \times (4 - n)]/8 = 10.4 kNm/m$ Moist backfill below water table $M_{w_m_b} = F_{s_m_b_t} \times a_l \times ([(8 - n^2 \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b)^3 / ((3 \times a^2)] = 5.2 kNm/m$ MummMoist backfill below water table $M_{w_m_a} = F_{s_m_a_t} \times [a^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b)^3 / ((3 \times a^2)] = 7.8 kNm/m$ MeaterMater $M_w_water = F_{s_water_t} \times [a^2 \times x \times ((5 \times L) $	Water		$V_{s \text{ water } f} = F_{s \text{ water } f} \times (1 - (a_1^2 \times ((5 \times L) - a_1) / (20 \times L^3))) = 38.1 \text{ kN/m}$						
Calculate moment for stem designSurcharge $M_{s_sur} = F_{s_sur_f} \times L / 8 = 15.2 \text{ kNm/m}$ Moist backfill above water table $M_{s_m_a} = F_{s_m_a_f} \times b_i \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kNm/m}$ Moist backfill below water table $M_{s_m_b} = F_{s_m_b_f} \times a_i \times (2 - n)^2 / 8 = 20.1 \text{ kNm/m}$ Saturated backfill $M_{s_m_b} = F_{s_m_b_f} \times a_i \times (2 - n)^2 / 8 = 20.1 \text{ kNm/m}$ Water $M_{s_water} = F_{s_m_b_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 13.7 \text{ kNm/m}$ Water $M_{s_water} = F_{s_water_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 \text{ kNm/m}$ Total moment for stem design $M_{s_water} = M_{s_sur_f} \times L / 128 = 8.5 \text{ kNm/m}$ Surcharge $M_{w_sur_g} = 9 \times F_{s_sur_f} \times 0.577 \times b_i \times [(b^3 + 5 \times a_i \times L^2)/(5 \times L^3) - 0.577^2/3] = 2.7 \text{ kNm/m}$ Moist backfill above water table $M_{w_m_a} = F_{s_m_a_f} \times a_i \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 10.4 \text{ kNm/m}$ Moist backfill below water table $M_{w_m_b} = F_{s_m_b_f} \times a_i \times [((5 \times L) - a_i)/(20 \times L^3) - (x - b)^3 / ((3 \times a^2)] = 7.8 \text{ kNm/m}$ Moist backfill below water table $M_{w_m_b=} = F_{s_m_b_f} \times a_i \times [((6 \times L) - a_i)/(20 \times L^3) - (x - b)^3 / ((3 \times a^2)] = 7.8 \text{ kNm/m}$ MaterMater $M_{w_water} = F_{s_water_f} \times [a^2 \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b)^3 / ((3 \times a^2)] = 7.8 \text{ kNm/m}$ WaterMater $M_{w_water} = F_{s_water_f} \times [a^2 \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b)^3 / ((3 \times a^2)] = 7.8 \text{ kNm/m}$	Total shear for stem design		$V_{stem} = V_{s_sur_f} + V_{s_m_a_f} + V_{s_m_b_f} + V_{s_s_f} + V_{s_water_f} = 115.4 \text{ kN/m}$						
Surcharge $M_{s_sur} = F_{s_sur_f} \times L / 8 = 15.2 \text{ kNm/m}$ Moist backfill above water table $M_{s_m_a} = F_{s_m_a_f} \times b_i \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kNm/m}$ Moist backfill below water table $M_{s_m_b} = F_{s_m_b_f} \times a_i \times (2 - n)^2 / 8 = 20.1 \text{ kNm/m}$ Saturated backfill $M_{s_s} = F_{s_s_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 13.7 \text{ kNm/m}$ Water $M_{s_water} = F_{s_water_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 \text{ kNm/m}$ Total moment for stem design $M_{s_sur} = M_{s_sur} + M_{s_m_b} + M_{s_s} + M_{s_water} = 71.8 \text{ kNm/m}$ Calculate moment for wall design $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 8.5 \text{ kNm/m}$ Surcharge $M_{w_sur} = 9 \times F_{s_sur_f} \times 0.577 \times b_i \times [(b_i^3 + 5 \times a_i \times 2)/(5 \times L^3) - 0.577^2/3] = 2.7 \text{ kNm/m}$ Moist backfill above water table $M_{w_m_a} = F_{s_m_a_f} \times a_i \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 10.4 \text{ kNm/m}$ Moist backfill below water table $M_{w_m_b} = F_{s_m_a_f} \times [a_i^2 \times \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / ((3 \times a_i^2)] = 7.8 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_i^2 \times \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / ((3 \times a_i^2)] = 7.8 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_i^2 \times \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / ((3 \times a_i^2)] = 7.8 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_i^2 \times \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / ((3 \times a_i^2)] = 7.8 \text{ kNm/m}$	Calculate moment for stem	desian							
Noist backfill above water table $M_{s_ma} = F_{s_ma}f \times b_l \times ((5 \times L^2) - (3 \times b^2)) / (15 \times L^2) = 2.4 \text{ kNm/m}$ Moist backfill below water table $M_{s_mb} = F_{s_mb}f \times a_l \times (2 - n)^2 / 8 = 20.1 \text{ kNm/m}$ Saturated backfill $M_{s_s} = F_{s_ss}f \times a_l \times (2 - n)^2 / 8 = 20.1 \text{ kNm/m}$ Water $M_{s_s} = F_{s_ss}f \times a_l \times ((3 \times a^2) - (15 \times a_l \times L) + (20 \times L^2))/(60 \times L^2) = 13.7 \text{ kNm/m}$ Water $M_{s_water} = F_{s_water_f} \times a_l \times ((3 \times a^2) - (15 \times a_l \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 \text{ kNm/m}$ Total moment for stem design $M_{stem} = M_{s_ssur} + M_{s_mb} + M_{s_s} + M_{s_water} = 71.8 \text{ kNm/m}$ Calculate moment for wall design $M_{w_wsur} = 9 \times F_{s_ssur_f} \times L / 128 = 8.5 \text{ kNm/m}$ Surcharge $M_{w_wsur} = 9 \times F_{s_ssur_f} \times 0.577 \times b_l \times [(b^3 + 5 \times a_l \times L^2)/(5 \times L^3) - 0.577^2/3] = 2.7 \text{ kNm/m}$ Moist backfill below water table $M_{w_wm_b} = F_{s_wm_b} \times a_l \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 10.4 \text{ kNm/m}$ Moist backfill below water table $M_{w_wsur} = F_{s_wter_f} \times a_l \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 10.4 \text{ kNm/m}$ Water $M_{w_wwater} = F_{s_wter_f} \times [a^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b)^3 / ((3 \times a_l^2)] = 7.8 \text{ kNm/m}$ Water $M_{w_water} = F_{s_wter_f} \times [a^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b)^3 / ((3 \times a_l^2)] = 7.8 \text{ kNm/m}$	Surcharge	5	$M_{s,sur} = F_{s,sur}$	sur f×L/8 = 1	5.2 kNm/m				
Moist backfill below water table $M_{s_mb} = F_{s_mb_f} \times a_i \times (2 - n)^2 / 8 = 20.1 \text{ kNm/m}$ Saturated backfill $M_{s_mb} = F_{s_mb_f} \times a_i \times (2 - n)^2 / 8 = 20.1 \text{ kNm/m}$ Water $M_{s_s} = F_{s_s f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 13.7 \text{ kNm/m}$ Water $M_{s_water} = F_{s_water_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 \text{ kNm/m}$ Total moment for stem design $M_{stem} = M_{s_water} = F_{s_water_f} \times a_i \times ((3 \times a^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 20.4 \text{ kNm/m}$ Calculate moment for wall design $M_{stem} = M_{s_water} + M_{s_ma} + M_{s_mb} + M_{s_s} + M_{s_water} = 71.8 \text{ kNm/m}$ Surcharge $M_{w_wsur} = 9 \times F_{s_water_f} \times L / 128 = 8.5 \text{ kNm/m}$ Moist backfill above water table $M_{w_ma} = F_{s_ma_f} \times 0.577 \times b_i \times [(b_i^3 + 5 \times a_i \times L^2)/(5 \times L^3) - 0.577^2/3] = 2.7 \text{ kNm/m}$ Moist backfill below water table $M_{w_mb} = F_{s_mb_f} \times a_i \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 10.4 \text{ kNm/m}$ Mater $M_{w_water} = F_{s_water_f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a_i^2)] = 5.2 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a_i^2)] = 7.8 \text{ kNm/m}$	Moist backfill above water tab	le	M _{sma} = F _s	$m_{a f} \times b_{l} \times ((5))$	\times L ²) - (3 \times b ₁ ²)) /	$(15 \times L^2) = 2.4$	kNm/m		
Saturated backfill $M_{s_s} = F_{s_s_f} \times a_i \times ((3 \times a_i^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 13.7 \text{ kNm/m}$ Water $M_{s_s} = F_{s_s_f} \times a_i \times ((3 \times a_i^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 20.4$ kNm/mTotal moment for stem design $M_{s_sur} = F_{s_water_f} \times a_i \times ((3 \times a_i^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 20.4$ Calculate moment for wall design $M_{s_sur} = M_{s_sur} + M_{s_m_b} + M_{s_s} + M_{s_water} = 71.8 \text{ kNm/m}$ Surcharge $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 8.5 \text{ kNm/m}$ Moist backfill above water table $M_{w_m_a} = F_{s_m_a_f} \times 0.577 \times b_i \times [(b_i^3 + 5 \times a_i \times L^2)/(5 \times L^3) - 0.577^2/3] = 2.7$ kNm/mMoist backfill below water table $M_{w_m_b} = F_{s_m_b_f} \times a_i \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 10.4 \text{ kNm/m}$ Mater $M_{w_water} = F_{s_water_f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / ((3 \times a_i^2)] = 5.2 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / ((3 \times a_i^2)] = 7.8 \text{ kNm/m}$	Moist backfill below water tab	le	$M_{s,m,b} = F_{s}$	 	- n)² / 8 = 20.1 kN	lm/m			
Water $M_{s_water} = F_{s_water_f} \times a_i \times ((3 \times a_i^2) - (15 \times a_i \times L) + (20 \times L^2))/(60 \times L^2) = 20.4$ kNm/mTotal moment for stem design $M_{stem} = M_{s_sur} + M_{s_m_a} + M_{s_m_b} + M_{s_s} + M_{s_water} = 71.8$ kNm/mCalculate moment for wall design $M_{stem} = M_{s_sur} + M_{s_m_a} + M_{s_m_b} + M_{s_s} + M_{s_water} = 71.8$ kNm/mSurcharge $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 8.5$ kNm/mMoist backfill above water table $M_{w_m_a} = F_{s_m_a_f} \times 0.577 \times b_i \times [(b_i^3 + 5 \times a_i \times L^2)/(5 \times L^3) - 0.577^2/3] = 2.7$ kNm/mMoist backfill below water table $M_{w_m_b} = F_{s_m_b_f} \times a_i \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 10.4$ kNm/mSaturated backfill $M_{w_s} = F_{s_s_f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x-b_i)^3 / (3 \times a_i^2)] = 5.2$ kNm/mWater $M_{w_water} = F_{s_water_f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x-b_i)^3 / (3 \times a_i^2)] = 7.8$ kNm/m $M_w_m_a$	Saturated backfill		$M_{s,s} = F_{s,s}$	$_{f} \times a_{1} \times ((3 \times a_{1}^{2})) - (1)^{2}$, 15×a×L)+(20×L²)))/(60×L²) = 13. 7	7 kNm/m		
kNm/mModel and the control of the first or t	Water		Ms_water = F	s water f ×ai×((3×	(a ²)-(15×a×L)+(2	0×L²))/(60×L²)	= 20.4		
Total moment for stem design $M_{stem} = M_{s_sur} + M_{s_m_a} + M_{s_m_b} + M_{s_s} + M_{s_water} = 71.8 \text{ kNm/m}$ Calculate moment for wall design $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 8.5 \text{ kNm/m}$ Surcharge $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 8.5 \text{ kNm/m}$ Moist backfill above water table $M_{w_m_a} = F_{s_m_a_f} \times 0.577 \times b_i \times [(b^3 + 5 \times a_i \times L^2)/(5 \times L^3) - 0.577^2/3] = 2.7 \text{ kNm/m}$ Moist backfill below water table $M_{w_m_b} = F_{s_m_b_f} \times a_i \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 10.4 \text{ kNm/m}$ Saturated backfill $M_{w_s} = F_{s_s_f} \times [a^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a_i^2)] = 5.2 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a_i^2)] = 7.8 \text{ kNm/m}$	kNm/m		<u> </u>	5_inatoi_i ((- /// (/	-		
Calculate moment for wall designSurcharge $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 8.5 \text{ kNm/m}$ Moist backfill above water table $M_{w_m_a} = F_{s_m_a_f} \times 0.577 \times b_i \times [(b_i^3 + 5 \times a_i \times L^2)/(5 \times L^3) - 0.577^2/3] = 2.7 \text{ kNm/m}$ Moist backfill below water table $M_{w_m_b} = F_{s_m_b_f} \times a_i \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 10.4 \text{ kNm/m}$ Saturated backfill $M_{w_s} = F_{s_s_f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a_i^2)] = 5.2 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a_i^2)] = 7.8 \text{ kNm/m}$	Total moment for stem desigr	1	M _{stem} = M _s	sur + Ms_m_a + N	/ls_m_b + Ms_s + Ms	_water = 71.8 kN	m/m		
Surcharge $M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128 = 8.5 \text{ kNm/m}$ Moist backfill above water table $M_{w_m_a} = F_{s_m_a_f} \times 0.577 \times b_i \times [(b_i^3 + 5 \times a_i \times L^2)/(5 \times L^3) - 0.577^2/3] = 2.7$ kNm/m Moist backfill below water table $M_{w_m_b} = F_{s_m_b_f} \times a_i \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 10.4 \text{ kNm/m}$ Saturated backfill $M_{w_s} = F_{s_s_f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a_i^2)] = 5.2 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a_i^2)] = 7.8$ kNm/m Max	Calculate moment for wall o	lesign							
Moist backfill above water table $M_{w_ma} = F_{s_ma_f} \times 0.577 \times b_i \times [(b_i^3 + 5 \times a_i \times L^2)/(5 \times L^3) - 0.577^2/3] = 2.7$ kNm/m Moist backfill below water table $M_{w_mb} = F_{s_mb_f} \times a_i \times [((8 - n^2 \times (4 - n))^2 / 16) - 4 + n \times (4 - n)]/8 = 10.4 \text{ kNm/m}$ Saturated backfill $M_{w_s} = F_{s_s f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a_i^2)] = 5.2 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_i^2 \times x \times ((5 \times L) - a_i)/(20 \times L^3) - (x - b_i)^3 / (3 \times a_i^2)] = 7.8$ kNm/m KNm/m	Surcharge	C	$M_{w sur} = 9 \times$	$(F_{s_{sur_f}} \times L / 1)$	28 = 8.5 kNm/m				
kNm/m Moist backfill below water table $M_{w_mb} = F_{s_mb_f} \times a_i \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 10.4 \text{ kNm/m}$ Saturated backfill $M_{w_s} = F_{s_s} \times [a_1^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / (3 \times a_1^2)] = 5.2 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_1^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / (3 \times a_1^2)] = 7.8$ kNm/m $M_{w_water} = F_{s_water_f} \times [a_1^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / (3 \times a_1^2)] = 7.8$	Moist backfill above water tab	le	$M_{w_m} = F_s$	 f × 0.577×	b _l ×[(b _l ³ +5×a _l ×L ²)/	(5×L ³)-0.577 ² /3] = 2.7		
Moist backfill below water table $M_{w_mb} = F_{s_mb_f} \times a_l \times [((8-n^2 \times (4-n))^2 / 16) - 4 + n \times (4-n)]/8 = 10.4 \text{ kNm/m}$ Saturated backfill $M_{w_s} = F_{s_sf} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = 5.2 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = 7.8$ kNm/m $M_{w_s} = F_{s_water_f} \times [a_l^2 \times x \times ((5 \times L) - a_l)/(20 \times L^3) - (x - b_l)^3 / (3 \times a_l^2)] = 7.8$	kNm/m		~		/		-		
Saturated backfill $M_{w_s} = F_{s_s} + [a_1^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / (3 \times a_1^2)] = 5.2 \text{ kNm/m}$ Water $M_{w_water} = F_{s_water_f} \times [a_1^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / (3 \times a_1^2)] = 7.8$ kNm/m $M_{w_water} = F_{s_water_f} \times [a_1^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / (3 \times a_1^2)] = 7.8$	Moist backfill below water tab	le	$M_{w_m_b} = F_s$	$\underline{b}_{m_b_f} \times a_I \times [((8)$	B-n²×(4-n))² /16)-4	I+n×(4-n)]/8 = [−]	10.4 kNm/m		
Water $M_{w_water} = F_{s_water_f} \times [a_1^2 \times x \times ((5 \times L) - a_1)/(20 \times L^3) - (x - b_1)^3 / (3 \times a_1^2)] = 7.8$ kNm/m	Saturated backfill		$M_{w_s} = F_{s_s}$	$f \times [a^2 \times x \times ((5 \times l)^2)]$	L)-aı)/(20×L ³)-(x-b	$(3 \times a^2) = 5.$	2 kNm/m		
kNm/m	Water		$M_{w_water} = F$	s_water_f \times [al ² \times x	×((5×L)-a)/(20×L3	³)-(x-b _i) ³ /(3×a _i ²)] = 7.8		
	kNm/m								


	Project				Job no.	
		1 St Marks	s Crescent		180	507
Conisbee 1-5 Offord Street	Calcs for	Retaining v	wall No. 1/2		Start page no./Re	evision 8
London N1 1DH	Calcs by HH	Calcs date 12/06/2018	Checked by	Checked date	Approved by	Approved date

Check retaining wall deflection	on	
Basic span/effective depth ratio)	ratio _{bas} = 20
Design service stress		$f_{s} = 2 \times f_{y} \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = \textbf{261.4} \text{ N/mm}^{2}$
Modification factor	$factor_{tens} = min(0.55)$	+ (477 N/mm ² - f _s)/(120 × (0.9 N/mm ² + (M _{stem} /(b × d _{stem} ²)))),2) = 1.59
Maximum span/effective depth	ratio	$ratio_{max} = ratio_{bas} \times factor_{tens} = 31.76$
Actual span/effective depth rati	0	ratio _{act} = h _{stem} / d _{stem} = 11.90
		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 - 12 mm dia.@ 150 mm centres - $(754 \text{ mm}^2/\text{m})$

	Project				Job no.	
		1 St Mark	s Crescent		180	507
Conisbee 1-5 Offord Street	Calcs for	Retaining wa	ll No. 1/2 Rear		Start page no./Re	evision 1
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	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 h_{stem} = **3500** mm twall = 350 mm I_{toe} = **1000** mm $I_{heel} = 0 \text{ mm}$ $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 1350 \text{ mm}$ t_{base} = **350** mm $d_{ds} = 0 \text{ mm}$ l_{ds} = **900** mm t_{ds} = **350** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3850 \text{ mm}$ $d_{cover} = 0 mm$ $d_{exc} = 0 mm$ h_{water} = 2850 mm $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 2500 mm$ $\gamma_{wall} = 23.6 \text{ kN/m}^3$ γbase = 23.6 kN/m³ $\alpha = 90.0 \text{ deg}$ $\beta = 0.0 \text{ deg}$ $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3850 \text{ mm}$

M = **1.5** γ_m = **18.0** kN/m³

	Project				Job no.	
		1 St Mark	s Crescent		180)507
Conisbee	Calcs for	Deteining			Start page no./Re	evision
1-5 Offord Street		Retaining wa	II No. 1/2 Rear			2
N1 1DH	Calcs by	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date
		10/00/2010				
Saturated density of retained n	naterial	γ _s = 21.0 kM	N/m ³			
Design shear strength		φ' = 24.2 d€	eg			
Angle of wall friction		δ = 18.6 de	g			
Base material details						
Firm clay						
Moist density		$\gamma_{mb} = 18.0$ k	⟨N/m³			
Design shear strength		φ' _b = 24.2 d	eg			
Design base friction		$\delta_{b} = 18.6 \text{ det}$	eg			
Allowable bearing pressure		P _{bearing} = 12	2 5 kN/m²			
Using Coulomb theory						
Active pressure coefficient for	retained material					
$K_a = sin(a)$	$(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \alpha)^2$	$\sin(\alpha - \delta) \times [1 + $	$\sqrt{(\sin(\phi' + \delta) \times s)}$	$\sin(\phi' - \beta) / (\sin(lpha))$	- δ) × sin(α +	3)))] ²) = 0.369
Passive pressure coefficient fo	r base material					
	$K_p = sin(9)$	0 - φ' _b)² / (sin(90	$(-\delta_b) imes [1 - \sqrt{(sin)}]$	$h(\phi'_{b} + \delta_{b}) \times \sin(\phi'_{b})$	_b) / (sin(90 + δ	(b)))] ²) = 4.187
At-rest pressure						
At-rest pressure for retained m	aterial	$K_0 = 1 - sir$	n(φ') = 0.590			
Loading details						
Surcharge load on plan		Surcharge	= 10.0 kN/m²			
Applied vertical dead load on v	vall	W _{dead} = 47 .	6 kN/m			
Applied vertical live load on wa	all	Wlive = 4.2	κN/m			
Position of applied vertical load	d on wall	l _{load} = 1175	mm			
Applied horizontal dead load o	n wall	F _{dead} = 0.0	kN/m			
Applied horizontal live load on	wall	F _{live} = 0.0 k	N/m			
Height of applied horizontal loa	ad on wall	$h_{load} = 0 mr$	n			
		_ ¥ Ш	10			
	25.0 Prop +			28.0		
				Loads shown	in kN/m, pressure	s shown in kN/m ²

	Project	1 St Mark	s Crescent		Job no. 180	507
Conisbee 1-5 Offord Street	Calcs for	Retaining wa	ll No. 1/2 Rear		Start page no./Re	evision 3
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date

Vertical forces on wall	
Wall stem	$w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall} = \textbf{28.9 kN/m}$
Wall base	$w_{\text{base}} = I_{\text{base}} \times t_{\text{base}} \times \gamma_{\text{base}} = \textbf{11.2 kN/m}$
Applied vertical load	$W_v = W_{dead} + W_{live} = 51.8 \text{ kN/m}$
Total vertical load	$W_{total} = w_{wall} + w_{base} + W_v = 91.9 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	$F_{sur} = K_a \times cos(90 - \alpha + \delta) \times Surcharge \times h_{eff} = \textbf{13.5} \text{ kN/m}$
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2 = \textbf{3.1 kN/m}$
Moist backfill below water table	$F_{m_b} = K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 17.9 \text{ kN/m}$
Saturated backfill	$\textbf{F}_{s} = 0.5 \times \textbf{K}_{a} \times cos(90 \text{ - } \alpha + \delta) \times (\gamma_{s}\text{- } \gamma_{water}) \times h_{water}^{2} = \textbf{15.9 kN/m}$
Water	$F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water} = 39.8 \text{ kN/m}$
Total horizontal load	$F_{total} = F_{sur} + F_{m_a} + F_{m_b} + F_s + F_{water} = 90.3 \text{ kN/m}$
Calculate total propping force	
Passive resistance of soil in front of wall	$F_{p} = 0.5 \times K_{p} \times cos(\delta_{b}) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^{2} \times \gamma_{mb} = \textbf{4.4 kN}/m$
Propping force	$F_{prop} = max(F_{total} - F_{p} - (W_{total} - W_{iive}) \times tan(\delta_{b}), 0 \text{ kN/m})$
	F _{prop} = 56.4 kN/m
Overturning moments	
Surcharge	$M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 25.9 \text{ kNm/m}$
Moist backfill above water table	$M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 10 \text{ kNm/m}$
Moist backfill below water table	$M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = 25.6 \text{ kNm/m}$
Saturated backfill	$M_{s} = F_{s} \times (h_{water} - 3 \times d_{ds}) / 3 = 15.1 \text{ kNm/m}$
Water	$M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 37.8 \text{ kNm/m}$
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 114.5 \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = \textbf{34} \text{ kNm/m}$
Wall base	$M_{base} = w_{base} \times I_{base} / 2 = 7.5 \text{ kNm/m}$
Design vertical dead load	$M_{dead} = W_{dead} \times I_{load} = 55.9 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{dead} = 97.4 \ kNm/m$
Check bearing pressure	
Total vertical reaction	R = W _{total} = 91.9 kN/m
Distance to reaction	x _{bar} = I _{base} / 2 = 675 mm
Eccentricity of reaction	$e = abs((I_{base} / 2) - x_{bar}) = 0 mm$
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 68.1 \text{ kN/m}^2$
Bearing pressure at heel	$p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 68.1 \text{ kN/m}^2$
PASS -	Maximum bearing pressure is less than allowable bearing pressure
Calculate propping forces to top and base of w	all
Propping force to top of wall	

Propping force to base of wall

$$\label{eq:Fprop_top} \begin{split} F_{prop_top} &= (M_{ot} - M_{rest} + R \times I_{base} \ / \ 2 - F_{prop} \times t_{base} \ / \ 2) \ / \ (h_{stem} + t_{base} \ / \ 2) = \textbf{18.829 kN/m} \\ F_{prop_base} &= F_{prop} - F_{prop_top} = \textbf{37.600 kN/m} \end{split}$$

	Project	1 St Mark	s Crescent		Job no. 18	0507
Conisbee	Calcs for				Start page no./F	levision
1-5 Offord Street		Retaining wa	ll No. 1/2 Rear			4
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date
		·			·	
RETAINING WALL DESIGN (BS 8002:1994)				TEDDS calculation	n version 1.2.01.
Ultimate limit state load fact	ors					
Dead load factor		$\gamma_{f_d} = 1.4$				
Live load factor		$\gamma_{f_l} = 1.6$				
Earth and water pressure factor	or	$\gamma_{f_e} = 1.4$				
Factored vertical forces on v	vall					
Wall stem		$W_{wall_f} = \gamma_{f_d}$	$ imes$ h _{stem} $ imes$ t _{wall} $ imes$ γ_w	all = 40.5 kN/m		
Wall base		$W_{base_f} = \gamma_{f_c}$	$1 imes I_{base} imes t_{base} imes \gamma$	base = 15.6 kN/	m	
Applied vertical load		$W_{v_f} = \gamma_{f_d}$	$\times W_{dead} + \gamma_{f_l} \times W$	live = 73.4 kN/m	l	
Total vertical load		$W_{total_f} = w_w$	all_f + Wbase_f + W	_{v_f} = 129.5 kN/n	n	
Factored horizontal at-rest f	orces on wall					
Surcharge		$F_{sur} = \gamma_{f} \times$	K₀ × Surcharge	× h _{eff} = 36.3 kN	J/m	
Moist backfill above water tabl	e	$F_{m,a,f} = \gamma_{f,a}$	$\times 0.5 \times K_0 \times v_m$	$(h_{\text{eff}} - h_{\text{water}})^2 =$	7.4 kN/m	
Moist backfill below water table	-	$F_{m,b,f} = \gamma_{f,c}$	$\times K_0 \times v_m \times (h_{off})$	- hwater) × hwater =	= 42 4 kN/m	
Saturated backfill	5	F % . ×	$0.5 \times K_0 \times (v_{\rm err})^{\rm v}$	(1) (1)	75 kNl/m	
Water		$F_{s_1} = f_{1_0} + f_{s_1}$	$\times 0.5 \times h_{\rm m} \times c/s^2 \times$	$\frac{1}{2} = 558 \text{ km}$	J/m	
Total horizontal load		Fixed $f = F_{equation}$		$f \pm F_{0} f \pm F_{water}$	₄ – 179 5 kN/m	n
					<u> </u>	
Calculate total propping ford	e				, d. d.)2	61
	Shi u wali	$\Gamma p_t = \gamma_t e X$	$0.5 \times R_p \times COS(0)$	b) × (Ucover + lbas	e + Uds - Uexc)	× γmb = Ο. Ι
Propping force		$F_{prop_f} = ma$	x(F _{total_f} - F _{p_f} - (V	$V_{total_{f}}$ - $\gamma_{f_{f}} imes W_{h}$	$_{ m ive}) imes tan(\delta_{ m b}), 0$	kN/m)
	_	$I \text{ prop}_f = I 3 2$	 KIN/111			
Factored overturning mome	nts		"			
Surcharge		$M_{sur_f} = F_{sur_f}$	$_{f} \times (h_{eff} - 2 \times d_{ds})$	2 = 70 kNm/	m • • • • • • •	
Moist backfill above water tabl	e	$M_{m_a_f} = F_{m_a}$	$a_f \times (h_{eff} + 2 \times h)$	$l_{water} - 3 \times d_{ds}) / 3$	3 = 23.7 kNm/	m
Moist backfill below water table	Э	$M_{m_b_f} = F_{m_f}$	$_{b_f} \times (h_{water} - 2 \times$	d _{ds}) / 2 = 60.4	<nm m<="" td=""><td></td></nm>	
Saturated backfill		$M_{s_f} = F_{s_f} \times$	$(h_{water} - 3 \times d_{ds})$	/ 3 = 35.7 kNm	/m	
Water		$M_{water_f} = F_w$	$_{\rm vater_f} \times (h_{\rm water} - 3)$	× d _{ds}) / 3 = 53 k	Nm/m	
Total overturning moment		$M_{ot_f} = M_{sur_f}$	$f + M_{m_a_f} + M_{m_b}$	_f + M _{s_f} + M _{wate}	_{r_f} = 242.7 kNr	n/m
Restoring moments						
Wall stem		$M_{wall_f} = W_{wall_f}$	$II_f \times (I_{toe} + t_{wall} / 2)$	2) = 47.6 kNm/n	n	
Wall base		$M_{base_f} = w_b$	$ase_f \times I_{base} / 2 = 1$	l 0.5 kNm/m		
Design vertical load		$M_{v_f} = W_{v_f}$	× I _{load} = 86.2 kNr	m/m		
Total restoring moment		$M_{rest_f} = M_{was}$	$AII_f + M_{base_f} + M_v$	_f = 144.3 kNm/	/m	
Factored bearing pressure						
Total vertical reaction		$R_{\rm f} = W_{\rm total_f}$	= 129.5 kN/m			
Distance to reaction		$x_{bar_f} = I_{base}$	/ 2 = 675 mm			
Eccentricity of reaction		$e_f = abs((I_{ba}$	$x_{se} / 2) - x_{bar_f} = 0$) mm		
				Reaction acts	within middle	third of ba
Bearing pressure at toe		$p_{toe_f} = (R_f / $	I_{base}) - (6 × R_f ×	$e_f / I_{base^2} = 95.9$	J KN/m²	
Bearing pressure at heel		$p_{heel_f} = (R_f)$	$/ I_{base}$) + (6 × R _f >	$\langle e_f / I_{base}^2 \rangle = 95$.9 kN/m²	
Rate of change of base reaction	on	$rate = (p_{toe})$	$f - p_{heel_f} / I_{base} =$	U.00 kN/m ² /m		
Bearing pressure at stem / toe		p _{stem_toe_f} =	max(p _{toe_f} - (rate	\times I _{toe}), 0 kN/m ²) = 95.9 kN/m ²	

	Project	1 St Mark	s Crescent		Job no. 18	0507
Conishoo	Calcs for				Start page no./F	Revision
1-5 Offord Street		Retaining wa	ll No. 1/2 Rear			5
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date
Bearing pressure at mid stem		p _{stem_mid_f} =	max(p _{toe_f} - (rat	$e \times (I_{toe} + t_{wall} / 2)$)), 0 kN/m²) = 9	95.9 kN/m²
Bearing pressure at stem / hee		p _{stem_heel_f} =	max(p _{toe_f} - (rat	$e \times (I_{toe} + t_{wall})), 0$	0 kN/m²) = 95.	9 kN/m²
Calculate propping forces to Propping force to top of wall	top and base	of wall				
	F _{prop_top_f} =	= (M _{ot_f} - M _{rest_f} + R _f	imes I _{base} / 2 - F _{pro}	$_{\rm p_f} imes t_{\rm base}$ / 2) / (h	stem + t _{base} / 2) :	= 44.256 kN/m
Propping force to base of wall		F _{prop_base_f} =	Fprop_f - Fprop_top	_f = 87.801 kN/n	n	
Design of reinforced concret	e retaining wa	III toe (BS 8002:1	994 <u>)</u>			
Material properties						
Characteristic strength of conci	rete	f _{cu} = 40 N/n	nm²			
Characteristic strength of reinfo	orcement	f _y = 500 N/r	mm²			
Base details						
Minimum area of reinforcement	t	k = 0.13 %				
Cover to reinforcement in toe		c _{toe} = 50 m	m			
Calculate shear for toe desig	n					
Shear from bearing pressure		V _{toe} bear = (Dtoe f + Dstem toe f	$\times _{\text{toe}} / 2 = 95.9$	kN/m	
Shear from weight of base		Vtoe wt base =	= $\gamma_f d \times \gamma_{base} \times I_{top}$	\times t _{base} = 11.6 k	N/m	
Total shear for toe design		$V_{\text{toe}} = V_{\text{toe}}$ b	ear - Vtoe wt base =	= 84.3 kN/m		
Calculate moment for toe dev	eian					
Moment from bearing pressure	Sigii	M_{tes} here $-(1)$	2 × Dtop (+ Datam	$mid f \times (ltop \pm turol)$	$(/2)^2/6 - 66$	2 kNm/m
Moment from weight of base		M_{too} with boost	= (<u>)</u> * d X <u>Maaaa</u> X tu	$_1$ $(100 + 1)$	$(2)^2 / (2) - 8 kN$	m/m
Total moment for toe design		Miss – Miss	= (yf_d ~ ybase ~ u	- 58.2 kNm/m	z = 0 KN	
350	-	•	•	•	•	
	∢ —150—►					
Check toe in bending						
Width of toe		b = 1000 m	m/m	004.0		
Depth of reinforcement		$d_{toe} = t_{base} -$	$- C_{\text{toe}} - (\phi_{\text{toe}} / 2)$	= 294.0 mm		
Constant		$K_{toe} = M_{toe} /$	$(D \times O_{toe^2} \times f_{cu})$	= 0.017 ompression rei	inforcement is	s not required
						,
Lever arm		z _{toe} = min(0	.5 + √(0.25 - (n	nin(K _{toe} . 0.225) /	(0.9) . $(0.95) \times d$	toe
Lever arm		z _{toe} = min(0 z _{toe} = 279 n	.5 + √(0.25 - (n nm	nin(K _{toe} , 0.225) /	0.9)),0.95) × d	ltoe
Lever arm Area of tension reinforcement r	required	z _{toe} = min(0 z _{toe} = 279 n A _{s toe des} = 1	0.5 + √(0.25 - (n nm M _{toe} / (0.87 × f _v	nin(K _{toe} , 0.225) / × z _{toe}) = 479 mm	0.9)),0.95) × d ^{,2} /m	toe
Lever arm Area of tension reinforcement r Minimum area of tension reinfo	required	$z_{toe} = min(0)$ $z_{toe} = 279 m$ $A_{s_toe_des} = 1$ $A_{s_toe_min} = 1$	$0.5 + \sqrt{(0.25 - (n - f_y))}$ Mtoe / (0.87 × f_y) $0.87 \times b_{base} = 44$	nin(K _{toe} , 0.225) / × z _{toe}) = 479 mm 5 5 mm²/m	0.9)),0.95) × d ^{²/} m	toe
Lever arm Area of tension reinforcement r Minimum area of tension reinfo Area of tension reinforcement r	required prcement required	$z_{toe} = min(0)$ $z_{toe} = 279 m$ $A_{s_toe_des} = 1$ $A_{s_toe_min} = 1$ $A_{s_toe_req} = 1$	$0.5 + \sqrt{(0.25 - (n - 1))}$ $M_{toe} / (0.87 \times f_y)$ $4 \times b \times t_{base} = 44$ $Max(A_{s_toe_des}, A - 1)$	hin(K _{toe} , 0.225) / × z _{toe}) = 479 mm 55 mm²/m s_toe_min) = 479 m	0.9)),0.95) × d ^{,2} /m 1m ² /m	ltoe
Lever arm Area of tension reinforcement r Minimum area of tension reinfo Area of tension reinforcement r Reinforcement provided	required prcement required	$z_{toe} = min(0)$ $z_{toe} = 279 m$ $A_{s_toe_des} = 1$ $A_{s_toe_min} = 1$ $A_{s_toe_req} = 1$ 12 mm dia	$0.5 + \sqrt{(0.25 - (n - 1))^2}$ $M_{toe} / (0.87 \times f_y)$ $4 \times b \times t_{base} = 48$ $Max(A_{s_toe_des}, A - 1)^2$ $Max(B_s (D - 1))^2$	hin(K _{toe} , 0.225) / × z _{toe}) = 479 mm 55 mm²/m s_toe_min) = 479 m m centres	0.9)),0.95) × d ^{²/} m 1m²/m	Itoe
Lever arm Area of tension reinforcement r Minimum area of tension reinfo Area of tension reinforcement r Reinforcement provided Area of reinforcement provided	required prcement required	$z_{toe} = min(0)$ $z_{toe} = 279 n$ $A_{s_toe_des} = 1$ $A_{s_toe_req} = 1$ 12 mm dia $A_{s_toe_prov} = 1$	0.5 + $(0.25 - (n m m m m m m m m m m m m m m m m m m $	hin(K _{toe} , 0.225) / × z _{toe}) = 479 mm 55 mm²/m s_toe_min) = 479 m m centres	0.9)),0.95) × d /²/m ım²/m	ltoe

	Project	1 St Mark	s Crescent		Job no.	0507
O a niak a a	Calcs for				Start page no /B	evision
CONISDEE		Retaining wa	I No. 1/2 Rear		Start page 10./h	6
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date
	-		•	1		+
Check shear resistance at to	be					
Design shear stress		$v_{toe} = V_{toe}$ /	$(b \times d_{toe}) = 0.23$	87 N/mm²		
Allowable shear stress		$v_{adm} = min(0)$	0.8 × √(f _{cu} / 1 N	l/mm²), 5) × 1 N/ı	mm² = 5.000 N	/mm²
		PASS -	Design shear	stress is less tl	han maximum	shear stress
From BS8110:Part 1:1997 –	Table 3.8		2 11/20.002			
Design concrete snear stress		Vc_toe = 0.50	07 N/mm∸ Vto	e < Vc toe - No sh	ear reinforcen	nent reauired
Design of reinforced concre	to rotaining wall	stom /BS 8002	-1004)			
	te retaining wai	Stelli (BS 6002	.1994)			
Material properties		f 40 N//-				
Characteristic strength of cond	crete	$T_{cu} = 40 \text{ IN/m}$	1m²			
Characteristic strength of reini	orcement	$I_y = 500 IN/f$	1111-			
Wall details						
Minimum area of reinforcemen	nt -	k = 0.13 %				
Cover to reinforcement in sten	n	C _{stem} = 50 m	im m			
Cover to reinforcement in wai		$C_{wall} = 50$ m				
Factored norizontal at-rest f	orces on stem		v Ka v Suroba	raox (h "t	d.) – 22 kN/m	
Moint bookfill above water tabl		$\Gamma s_sur_t = \gamma t_t$		rge × (neff - lbase -	$(U_{ds}) = 33 \text{ km/m}$	kN/m
Moist backfill bolow water tabl	e	$Fs_m_a_f = 0.$	$\mathbf{J} \times \mathbf{\gamma}_{\text{f}} \times \mathbf{K}_0 \times \mathbf{V}_0$	γm × (Πeff - Lbase - O	$ds - Hsat)^{-} = 7.4$	
	e	$\Gamma_{s_m_b_f} = \gamma_{f_s}$	_e × Νο × Ύm × (Γ	leff - lbase - Uds - Hs	at) \times [Isat = 31.2	KIN/III
Saturated backfill		$F_{s_s_f} = 0.5$	$\times \gamma_{f_e} \times \kappa_0 \times (\gamma_s)$	- γ_{water} × Π_{sat^2} = 2	8.9 KIN/M	
Waler		Γ s_water_f = 0	$.5 \times \gamma_{f_e} \times \gamma_{water}$	× IIsat ⁻ = 42.9 KIN	/111	
Calculate shear for stem des	sign					
Surcharge		$V_{s_sur_f} = 5 >$	< Fs_sur_f / 8 = 2	0.7 kN/m		
Moist backfill above water tabl	е	$V_{s_m_a_f} = F_s$	$s_m_a_f \times b_I \times ((5))$	$1 \times L^2$) - bi ²) / (5 ×	L^{3}) = 2 kN/m	
Moist backfill below water tabl	e	$V_{s_m_b_f} = F_s$	s_m_b_f × (8 - (n²	(4 - n)) / 8 = 2	29.1 kN/m	
Saturated backfill		$V_{s_s_f} = F_{s_s_f}$	$_{f} \times (1 - (a)^{2} \times (1 - a)^{2})$	(5 × L) - aı) / (20 >	< L ³))) = 25.6 k	N/m
Water		$V_{s_water_f} = F$	$s_{water_f} \times (1 - (a))$	$a^2 \times ((5 \times L) - a)$	$(20 \times L^3)) = 3$	8.1 kN/m
lotal shear for stem design		V _{stem} = V _{s_s}	ur_f + Vs_m_a_f +	$V_{s_m_b_f} + V_{s_s_f} +$	Vs_water_f = 115	.4 kN/m
Calculate moment for stem	design					
Surcharge		$M_{s_sur} = F_{s_s}$	_{sur_f} × L / 8 = 15	5.2 kNm/m	_	
Moist backfill above water tabl	е	$M_{s_m_a} = F_{s_m_a}$	$m_a_f \times b_i \times ((5))$	\times L ²) - (3 × b ₁ ²)) /	$(15 \times L^2) = 2.4$	kNm/m
Moist backfill below water tabl	e	$M_{s_m_b} = F_{s_}$	$_{m_b_f} \times a_{l} \times (2 -$	n) ² / 8 = 20.1 kN	m/m	
Saturated backfill		$M_{s_s} = F_{s_s_s_s_s_s_s_s$	$\times a_{l} \times ((3 \times a_{l}^{2}) - (1$	$5 \times a_1 \times L$)+(20×L ²))	/(60×L²) = 13. 7	7 kNm/m
Water		$M_{s_water} = F_s$	s_water_f ×al×((3×	a_{12})-(15× a_{1} ×L)+(2)	0×L²))/(60×L²)	= 20.4
kNm/m		N4 N4	N4 N		74.0	
I otal moment for stem design		Mstem = Ms_s	sur + Ms_m_a + N	$ls_m_b + Ms_s + Ms_s$	_water = /1.8 KN	m/m
Calculate moment for wall d	esign		-			
	-	$M_{w_{sur}} = 9 \times$	$F_{s_sur_f} \times L / 12$	28 = 8.5 kNm/m		1 0 7
Moist backfill above water tabl kNm/m	e	$M_{w_m_a} = F_s$	$_{m_a_f} \times 0.577 \times 1000$	bi×[(bi³+5×ai×L²)/(5×L³)-0.577²/3] = 2.7
Moist backfill below water tabl	e	$M_{w_m_b} = F_s$	$_{m_b_f} \times a_l \times [((8)$	8-n²×(4-n))² /16)-4	+n×(4-n)]/8 = -	10.4 kNm/m
Saturated backfill		$M_{w_s} = F_{s_s}$	$f \times [a]^2 \times x \times ((5 \times L)^2)$	_)-aı)/(20×L³)-(x-b	$(3 \times a^2) = 5.$	2 kNm/m
Water		$M_{w_water} = F_{e}$	$s_water_f \times [a]^2 \times x$	<((5×L)-aı)/(20×L ³)-(x-bi) ³ /(3×ai ²)] = 7.8



	Project				Job no.	
		1 St Marks	s Crescent		180	507
Conisbee 1-5 Offord Street	Calcs for	Retaining wal	l No. 1/2 Rear		Start page no./Re	vision 8
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date

Check retaining wall deflection	on	
Basic span/effective depth ratio)	ratio _{bas} = 20
Design service stress		$f_s = 2 \times f_y \times A_{s_stem_req} \ / \ (3 \times A_{s_stem_prov}) = \textbf{261.4} \ N/mm^2$
Modification factor	factor _{tens} = min(0.55	+ $(477 \text{ N/mm}^2 - f_s)/(120 \times (0.9 \text{ N/mm}^2 + (M_{\text{stem}}/(b \times d_{\text{stem}}^2)))),2) = 1.59$
Maximum span/effective depth	ratio	$ratio_{max} = ratio_{bas} \times factor_{tens} = 31.76$
Actual span/effective depth rati	0	ratio _{act} = h _{stem} / d _{stem} = 11.90
		PASS - Span to depth ratio is acceptable

Conisbee 1-5 Offord Street London N1 1DH dicative retaining wall re	Calcs for Calcs by HH	Retaining wa Calcs date 13/06/2018 agram	all No. 1/2 Rea	r Checked date	Approved by	Approved date
Conisbee 1-5 Offord Street London N1 1DH dicative retaining wall re	Calcs for Calcs by HH reinforcement dia	Retaining wa Calcs date 13/06/2018 agram	all No. 1/2 Rea	r Checked date	Start page no./F	Revision 9 Approved date
1-5 Offord Street London N1 1DH dicative retaining wall re	Calcs by HH reinforcement dia	Retaining wa Calcs date 13/06/2018	Checked by	r Checked date	Approved by	9 Approved date
London N1 1DH dicative retaining wall re	Calcs by HH reinforcement dia Wai	Calcs date 13/06/2018 agram	Checked by	Checked date	Approved by	Approved date
N1 1DH	reinforcement dia	agram				
licative retaining wall re	reinforcement dia	agram				
				Stem reinforcement		

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

Toe reinforcement -

	Project				Job no.	
	1 St Marks Crescent				180507	
Conisbee 1-5 Offord Street	Calcs for Retaining wall No. 1/2 Rear with no 2 loading				Start page no./Revision 1	
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	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 h_{stem} = **3500** mm twall = 350 mm I_{toe} = **1000** mm $I_{heel} = 0 \text{ mm}$ $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 1350 \text{ mm}$ t_{base} = **350** mm $d_{ds} = 0 \text{ mm}$ l_{ds} = **900** mm t_{ds} = **350** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3850 \text{ mm}$ $d_{cover} = 0 mm$ $d_{exc} = 0 mm$ h_{water} = 2850 mm $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 2500 mm$ $\gamma_{wall} = 23.6 \text{ kN/m}^3$ γbase = 23.6 kN/m³ $\alpha = 90.0 \text{ deg}$ $\beta = 0.0 \text{ deg}$ $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3850 \text{ mm}$

$M = 1.5 \\ \gamma_{m} = 18.0 \text{ kN/m}^{3}$

	Project				Job no.	
		1 St Marks	s Crescent		180)507
Conisbee	Calcs for			I	Start page no./Re	evision
1-5 Offord Street	Retain	ing wall No. 1/2	Rear with no 21	oading		2
N1 1DH	Calcs by	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date
		13/00/2018				
Saturated density of retained m	aterial	γ _s = 21.0 kN	J/m³			
Design shear strength		φ' = 24.2 de	g			
Angle of wall friction		$\delta =$ 18.6 de	g			
Base material details						
Firm clay						
Moist density		$\gamma_{mb} = 18.0 \text{ k}$	⟨N/m³			
Design shear strength		φ' _b = 24.2 d	eg			
Design base friction		δ _b = 18.6 de	eg			
Allowable bearing pressure		P _{bearing} = 12	5 kN/m ²			
Using Coulomb theory		-				
Active pressure coefficient for r	etained material					
$K_a = sin(\alpha)$	+ ϕ') ² / (sin(α) ² ×	$\sin(\alpha - \delta) \times [1 +$	$\sqrt{(\sin(\phi' + \delta) \times s)}$	in(φ' - β) / (sin(α	$-\delta$ × sin(α + (3)))] ²) = 0.369
Passive pressure coefficient for	base material	() L			, , ,	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
	$K_p = sin(9)$	0 - φ' _b)² / (sin(90	- δ_b) × [1 - $\sqrt{(sin)}$	$(\phi'_{b} + \delta_{b}) \times \sin(\phi')$	_b) / (sin(90 + δ	(b)))] ²) = 4.187
At-rest pressure						
At-rest pressure for retained ma	aterial	$K_0 = 1 - \sin \theta$	$(\phi') = 0.590$			
			(+)			
Loading details		Suraharaa	$-100 k M/m^2$			
Applied vertical dead load on w	all	W _{dood} – 79	2 kN/m			
Applied vertical live load on wal		$W_{live} = 5.4 k$	N/m			
Position of applied vertical load	on wall	$I_{load} = 1175$	mm			
Applied horizontal dead load or	wall	F _{dead} = 0.0	≺N/m			
Applied horizontal live load on v	vall	F _{live} = 0.0 k	N/m			
Height of applied horizontal load	d on wall	$h_{load} = 0 mn$	n			
		85 ↓ ∏	10			
	25.0 92.4	Prop		28.0		
				Loads shown	in kN/m, pressure	s shown in kN/m ²

	Project J				Job no.	
	1 St Marks Crescent				180	0507
Conisbee 1-5 Offord Street	Calcs for Retaining wall No. 1/2 Rear with no 2 loading				Start page no./Revision 3	
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date

Vertical forces on wall	
Wall stem	$w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall} = 28.9 \text{ kN/m}$
Wall base	$w_{\text{base}} = I_{\text{base}} \times t_{\text{base}} \times \gamma_{\text{base}} = 11.2 \text{ kN/m}$
Applied vertical load	$W_v = W_{dead} + W_{live} = 84.6 \text{ kN/m}$
Total vertical load	$W_{total} = W_{wall} + W_{base} + W_v = 124.7 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	$F_{sur} = K_a \times cos(90 - \alpha + \delta) \times Surcharge \times h_{eff} = \textbf{13.5 kN/m}$
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2 = \textbf{3.1 kN}/m$
Moist backfill below water table	$F_{m_b} = K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = \textbf{17.9} \text{ kN/m}$
Saturated backfill	$F_{s} = 0.5 \times K_{a} \times cos(90 - \alpha + \delta) \times (\gamma_{s} - \gamma_{water}) \times h_{water}^{2} = \textbf{15.9 kN/m}$
Water	$F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water} = 39.8 \text{ kN/m}$
Total horizontal load	$F_{total} = F_{sur} + F_{m_a} + F_{m_b} + F_s + F_{water} = 90.3 \text{ kN/m}$
Calculate total propping force	
Passive resistance of soil in front of wall	$F_{p} = 0.5 \times K_{p} \times cos(\delta_{b}) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^{2} \times \gamma_{mb} = \textbf{4.4 kN}/m$
Propping force	$F_{prop} = max(F_{total} - F_p - (W_{total} - W_{live}) \times tan(\delta_b), 0 \text{ kN/m})$
	F _{prop} = 45.8 kN/m
Overturning moments	
Surcharge	$M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = \textbf{25.9} \text{ kNm/m}$
Moist backfill above water table	$M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) \ / \ 3 = \textbf{10} \ kNm/m$
Moist backfill below water table	$M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) / 2 = \textbf{25.6} \text{ kNm/m}$
Saturated backfill	$M_s = F_s \times (h_{water} - 3 \times d_{ds}) \ / \ 3 = \textbf{15.1} \ kNm/m$
Water	$M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = \textbf{37.8} \text{ kNm/m}$
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 114.5 \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{\text{wall}} = w_{\text{wall}} \times (I_{\text{toe}} + t_{\text{wall}} / 2) = \textbf{34} \text{ kNm/m}$
Wall base	$M_{\text{base}} = w_{\text{base}} \times I_{\text{base}} \ / \ 2 = \textbf{7.5} \ kNm/m$
Design vertical dead load	$M_{dead} = W_{dead} \times I_{load} = 93.1 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{dead} = 134.6 \text{ kNm/m}$
Check bearing pressure	
Total vertical reaction	R = W _{total} = 124.7 kN/m
Distance to reaction	x _{bar} = I _{base} / 2 = 675 mm
Eccentricity of reaction	$e = abs((I_{base} / 2) - x_{bar}) = 0 mm$
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{\text{toe}} = (\text{R} / \text{I}_{\text{base}}) - (6 \times \text{R} \times \text{e} / \text{I}_{\text{base}^2}) = 92.4 \text{ kN/m}^2$
Bearing pressure at heel	$p_{\text{heel}} = (\text{H} / \text{I}_{\text{base}}) + (6 \times \text{H} \times \text{e} / \text{I}_{\text{base}^2}) = 92.4 \text{ kN/m}^2$
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	

Propping force to base of wall

$$\begin{split} F_{prop_top} = (M_{ot} - M_{rest} + R \times I_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = \textbf{15.260} \text{ kN/m} \\ F_{prop_base} = F_{prop} - F_{prop_top} = \textbf{30.534} \text{ kN/m} \end{split}$$

	Project				Job no.	
		1 St Mark	s Crescent		18	80507
Conisbee	Calcs for			la a dina:	Start page no./	Revision
1-5 Offord Street						4
N1 1DH	Calcs by HH	Calcs date 13/06/2018	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 fact	ors					
Dead load factor		$\gamma_{f_d} = 1.4$				
Live load factor		$\gamma_{f_l} = 1.6$				
Earth and water pressure fact	or	$\gamma_{f_e} = 1.4$				
Factored vertical forces on	wall					
Wall stem		$w_{wall_f} = \gamma_{f_d}$	$ imes$ h _{stem} $ imes$ t _{wall} $ imes$ γ	wall = 40.5 kN/m	ı	
Wall base		$W_{base_f} = \gamma_{f_c}$	$1 \times I_{base} \times t_{base} \times \gamma$	ybase = 15.6 kN/	m	
Applied vertical load		$W_{v_f} = \gamma_{f_d} \times$	$\times W_{dead} + \gamma_{f_l} \times W_{dead}$	/live = 119.6 kN/	m	
Total vertical load		$W_{total_f} = w_w$	$_{all_f} + W_{base_f} + W$	/ _{v_f} = 175.7 kN/r	n	
Factored horizontal at-rest f	orces on wall					
Surcharge		$F_{sur_f} = \gamma_{f_l} \times$	$K_0 \times Surcharge$	e × h _{eff} = 36.3 kN	N/m	
Moist backfill above water tab	e	$F_{m_a_f} = \gamma_{f_e}$	$ imes$ 0.5 $ imes$ K ₀ $ imes$ γ_m :	$\times (h_{eff} - h_{water})^2 =$	7.4 kN/m	
Moist backfill below water tabl	e	$F_{m_b_f} = \gamma_{f_e}$	$\times K_0 \times \gamma_m \times (h_{\text{eff}}$	- h_{water}) × h_{water} :	= 42.4 kN/m	
Saturated backfill		$F_{s_f} = \gamma_{f_e} \times$	$0.5 imes K_0 imes$ ($\gamma_{ extsf{s}}$ - $\gamma_{ extsf{s}}$	water) \times hwater ² = 3	37.5 kN/m	
Water		$F_{water_f} = \gamma_{f_e}$	$h_{e} imes 0.5 imes h_{water}^2 imes$	γ _{water} = 55.8 kl	N/m	
Total horizontal load		$F_{total_f} = F_{sur}$	$_f + F_{m_a_f} + F_{m_k}$	o_f + Fs_f + Fwater_	_f = 179.5 kN/n	n
Calculate total propping for	ce					
Passive resistance of soil in fr	ont of wall	$F_{p_f} = \gamma_{f_e} \times$	$0.5 imes K_p imes \cos(\delta)$	$\delta_{b}) imes (d_{cover} + t_{bas})$	$se + d_{ds} - d_{exc})^2$	$\times \gamma_{mb} = 6.1$
kN/m						
Propping force		$F_{prop_f} = ma$	x(F _{total_f} - F _{p_f} - ($W_{total_f} - \gamma_{f_l} \times W_l$	$_{\rm live}) imes tan(\delta_{\rm b}), 0$	kN/m)
		F _{prop_f} = 117	7.2 kN/m			
Factored overturning mome	nts					
Surcharge		$M_{sur_f} = F_{sur_f}$	$_{f} \times (h_{eff} - 2 \times d_{d})$	s) / 2 = 70 kNm/	/m	
Moist backfill above water tab	e	$M_{m_a_f} = F_{m_a}$	$a_f \times (h_{eff} + 2 \times h)$	$n_{water} - 3 \times d_{ds}) /$	3 = 23.7 kNm/	'n
Moist backfill below water tabl	е	$M_{m_b_f} = F_{m_f}$	$_{b_f} \times (h_{water} - 2 \times$	(d _{ds}) / 2 = 60.4	kNm/m	
Saturated backfill		$M_{s_f} = F_{s_f} \times$	$(h_{water} - 3 \times d_{ds})$	/ 3 = 35.7 kNm	ı/m	
water		$M_{water_f} = F_w$	$_{\text{ater}_{f}} \times (\text{N}_{\text{water}} - 3)$	$\times d_{ds}$) / 3 = 53 k	(Nm/m	/
		IVIot_f = IVIsur_	$t + IVIm_a_f + IVIm_$	b_t + IVIs_f + IVIwate	er_t = 242.7 KINI	11/111
Restoring moments		NA			~	
Wall stem		IVIwall_f = Wwa	$\lim_{f \to 0} f \times (\text{toe} + \text{twall} / 2)$	2) = 47.6 KINM/r 10 5 kN/m	n	
Wall base		$IVI_{base_f} = W_b$	ase_f × Ibase / $2 =$	10.5 KINIII/III		
Total restoring moment		$V_{V_f} = V_{V_f}$	$\times \text{ Iload} = 140.3 \text{ KI}$	NIII/III 108 6 kNm	/m	
		$ivirest_t = iviwa$	an_1 + IVIDase_1 + IVI	v_i - 130.0 MINIII	/111	
Total vortical reaction		$\mathbf{D}_{\ell} = \mathbf{W}_{\ell}$	– 175 7 kN/m			
Distance to reaction		$T t = VV tota_f$ Xbar f = base	/ 2 = 675 mm			
Eccentricity of reaction		$e_f = abs((I_{base}))$	$x_{se} / 2) - x_{bar} f = 1$	0 mm		
			· ···=/	Reaction acts	within middle	e third of base
Bearing pressure at toe		$p_{toe_f} = (R_f / $	$I_{\text{base}})$ - (6 $\timesR_{\text{f}}\times$	$e_{f} / I_{base}^{2}) = 130$. 1 kN/m²	
Bearing pressure at heel		$p_{heel_f} = (R_f)$	/ I _{base}) + (6 × R _f :	$\times e_{f} / I_{base}^{2}) = 13$	0.1 kN/m ²	
Rate of change of base reacti	on	$rate = (p_{toe})$	$f - p_{heel_f}) / I_{base} =$	• 0.00 kN/m²/m		
Bearing pressure at stem / toe)	$p_{stem_toe_f} = 1$	max(p _{toe_f} - (rate	$\times I_{toe}$), 0 kN/m ²) = 130.1 kN/n	1 ²

	Project	1 St Mark	s Crescent		Job no. 18	0507
Conishee	Calcs for				Start page no./F	Revision
1-5 Offord Street	Reta	ining wall No. 1/2	Rear with no 2	loading		5
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date
Bearing pressure at mid stem		p _{stem_mid_f} =	max(p _{toe_f} - (rat	$e \times (I_{toe} + t_{wall} / 2)$)), 0 kN/m²) = ⁻	1 30.1 kN/m ²
Bearing pressure at stem / hee		$p_{stem_heel_f} =$	max(p _{toe_f} - (ra	$te \times (I_{toe} + t_{wall})),$	0 kN/m²) = 130).1 kN/m²
Calculate propping forces to Propping force to top of wall	top and base	of wall				
Propping force to base of wall	$F_{prop_top_f} =$	$(M_{ot_f} - M_{rest_f} + R_{f})$ $F_{prop_base_f} =$	f × I _{base} / 2 - F _{pro} F _{prop_f} - F _{prop_top}	p_f × t _{base} / 2) / (h _{b_f} = 78.488 kN/r	_{stem} + t _{base} / 2) : n	= 38.680 kN/m
Design of reinforced concret	e retaining wa	ll toe (BS 8002:1	994)			
Matarial propartias			<u>554)</u>			
Characteristic strength of conc	rete	f _{ou} = 40 N/n	nm²			
Characteristic strength of reinfo	prcement	$f_{v} = 500 \text{ N/r}$	mm ²			
Base details						
Minimum area of reinforcement	t	k = 0 13 %				
Cover to reinforcement in toe	•	$C_{toe} = 50 \text{ m}$	m			
Calculate chear for too desig	n					
Shear from bearing pressure		Vtee beer - (r)taa (⊥ Natam taa () × Itee / 2 - 130	1 kN/m	
Shear from weight of base		Vice_bear - ()	$- \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2}$	$3 \times 1007 = 130$	N/m	
Total shear for toe design		Vtoe_wt_base =	$-\gamma_{1}$ $\rightarrow\gamma_{1}$ $\rightarrow\gamma_{1}$	= 118.6 kN/m	N/111	
Colouloto moment for too do	alan					
Moment from bearing pressure	sign	M		$(1, 1, 2) \times (1, 2, 1, 1, 2)$	" / 2) ² / 6 - 80 9	8 kNm/m
Moment from weight of bace		$N_{\rm toe_bear} = 0$	$2 \times \text{Ptoe}_f + \text{Pstem}$	$_{\rm mid_f} \times ({\rm Itoe} + {\rm Iwal})$	$(2)^{2} / 2 = 0$	o KINIII/III m/m
Total moment for toe design		Mice_wt_base =	= (yf_d × ybase × u	- 81.8 kNm/m	(2) / (2) = 0 KIN	111/111
350	-	•	•	• •	•	
	┫150►					
Check toe in bending		h 1000 m	m/m			
Depth of reinforcement		$d_{test} = t_{test} - t_{test}$	- Ctop - (mer / 2)	= 294.0 mm		
Constant		$K_{toe} = M_{toe} /$	$(b \times d_{toe}^2 \times f_{cu})$	= 0.024		
				ompression re	inforcement is	s not reauired
Lever arm		z _{toe} = min(0 z _{toe} = 279 n	0.5 + √(0.25 - (n nm	nin(K _{toe} , 0.225) /	0.9)),0.95) × d	toe
Area of tension reinforcement r	required	$A_{s_toe_des} = 1$	M_{toe} / (0.87 $ imes$ f _y	× z _{toe}) = 674 mm	1²/m	
Minimum area of tension reinfo	orcement	A _{s_toe_min} = I	$\mathbf{k} \times \mathbf{b} \times \mathbf{t}_{base} = 4$	55 mm²/m		
				.) 674 ~	m^{2}/m	
Area of tension reinforcement r	required	$A_{s_toe_req} = I$	Max(A _{s_toe_des} , A	s_toe_min) = 074 11	1111 /111	
Area of tension reinforcement r Reinforcement provided	required	A _{s_toe_req} = I 12 mm dia	Max(A _{s_toe_des} , A .bars @ 150 m	im centres		
Area of tension reinforcement r Reinforcement provided Area of reinforcement provided	required	A _{s_toe_req} = 1 12 mm dia A _{s_toe_prov} =	Max(A _{s_toe_des} , A .bars @ 150 m 754 mm²/m	us_toe_min) = 674 II	1111 /111	

		Project				Job no.	
			1 St Mark	s Crescent		18	0507
	Conisbee	Calcs for				Start page no./R	evision
	1-5 Offord Street	Reta	Ining wall No. 1/2	Rear with no 2	2 loading		6
	N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date
	Check shear resistance at toe	•					
	Design shear stress		$v_{toe} = V_{toe} /$	$(b \times d_{toe}) = 0.4$	03 N/mm ²		
	Allowable shear stress		V _{adm} = min(0.8 × √(f _{cu} / 1 №	N/mm²), 5) × 1 N/i	mm² = 5.000 N	l/mm ²
	From D00110-Doub 1:1007		PASS -	Design shear	r stress is less ti	han maximum	shear stress
	From BS8110:Part 1:1997 – 1a	adie 3.8	v · - 0 50	17 N/mm ²			
	Design concrete shear sitess		$v_{c_{toe}} = 0.50$	V IN/IIIII	ne < Vc toe - No sh	ear reinforcer	nent reauired
				1004)			
	Design of reinforced concrete	e retaining wai	I stem (BS 8002	<u>:1994)</u>			
	Material properties			2			
	Characteristic strength of concr	ete	f _{cu} = 40 N/n	nm²			
	Characteristic strength of reinfo	rcement	$t_y = 500 \text{ N/r}$	mm²			
	Wall details						
	Minimum area of reinforcement		k = 0.13 %				
	Cover to reinforcement in stem		C _{stem} = 50 n	nm			
	Cover to reinforcement in wall		$C_{wall} = 50 \text{ m}$	IM			
	Factored horizontal at-rest for	rces on stem	_				
	Surcharge		$F_{s_sur_f} = \gamma_{f_i}$	$\times K_0 \times Surcha$	$rge \times (h_{eff} - t_{base} - t_{base})$	d _{ds}) = 33 kN/m	ו
	Moist backfill above water table		$F_{s_m_a_f} = 0$	$.5 imes \gamma_{f_e} imes K_0 imes f$	$\gamma_{m} imes$ (h _{eff} - t _{base} - C	l _{ds} - h _{sat}) ² = 7.4	kN/m
	Moist backfill below water table		$F_{s_m_b_f} = \gamma_{f}$	$_{e} \times K_{0} \times \gamma_{m} \times (l$	h _{eff} - t _{base} - d _{ds} - h _s	_{sat}) × h _{sat} = 37.2	2 kN/m
	Saturated backfill		$F_{s_s_f} = 0.5$	$ imes \gamma_{f_e} imes K_0 imes (\gamma_{e}$	s- γ_{water}) × h_{sat}^2 = 2	2 8.9 kN/m	
	Water		$F_{s_water_f} = C$	$0.5 imes\gamma_{f_e} imes\gamma_{water}$	r × h _{sat} ² = 42.9 kN	/m	
	Calculate shear for stem desi	gn					
	Surcharge		$V_{s_sur_f} = 5$ 2	$\times F_{s_sur_f} / 8 = 2$	2 0.7 kN/m		
	Moist backfill above water table		$V_{s_m_a_f} = F$	$s_m_a_f \times b_I \times ((5))$	5 imesL ²) - bl ²) / (5 $ imes$	L ³) = 2 kN/m	
	Moist backfill below water table		$V_{s_m_b_f} = F$	s_m_b_f × (8 - (n ²	² × (4 - n))) / 8 = 2	2 9.1 kN/m	
	Saturated backfill		$V_{s_s_f} = F_{s_s}$	$a_f \times (1 - (a)^2 \times (a)^2)$	(5 × L) - a _l) / (20 >	× L³))) = 25.6 k	N/m
	Water		$V_{s_water_f} = F$	$s_{water_f} \times (1 - (a))$	$a_1^2 \times ((5 \times L) - a_1)$	/ (20 × L ³))) = 3	38.1 kN/m
	Total shear for stem design		$V_{stem} = V_{s_s}$	$ur_f + Vs_m_a_f +$	$V_{s_m_b_f} + V_{s_s_f} +$	$V_{s_water_f} = 115$.4 kN/m
	Calculate moment for stem de	esign					
	Surcharge		$M_{s_sur} = F_{s_s}$	_{sur_f} × L / 8 = 1	5.2 kNm/m		
	Moist backfill above water table		$M_{s_m_a} = F_{s_a}$	$_{m_a_f} \times b_l \times ((5$	imes L ²) - (3 $ imes$ b ₁ ²)) /	(15 × L ²) = 2.4	kNm/m
	Moist backfill below water table		$M_{s_m_b} = F_{s_b}$	$_{m_b_f} \times a_l \times (2 -$	- n)² / 8 = 20.1 kN	lm/m	
	Saturated backfill		$M_{s_s} = F_{s_s_}$	$f \times a_1 \times ((3 \times a_1^2) - (1$	15×a¦×L)+(20×L²))	/(60×L ²) = 13.	7 kNm/m
	Water		$M_{s_water} = F_s$	s_water_f ×aI×((3×	<a₁²)-(15×a₁×l)+(2< td=""><td>0×L²))/(60×L²)</td><td>= 20.4</td></a₁²)-(15×a₁×l)+(2<>	0×L ²))/(60×L ²)	= 20.4
	kNm/m						
	Total moment for stem design		$M_{stem} = M_{s_s}$	sur + Ms_m_a + N	$M_{s_m_b} + M_{s_s} + M_{s_s}$	_water = 71.8 kN	m/m
	Calculate moment for wall de	sign					
	Surcharge		$M_{w_sur} = 9 \times$	$F_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_{s_$	28 = 8.5 kNm/m		
	Moist backfill above water table		$M_{w_m_a} = F_s$	_m_a_f × 0.577×	b _l ×[(b _l ³ +5×a _l ×L ²)/	(5×L³)-0.577²/3	B] = 2.7
	kNm/m						
	Moist backfill below water table		$M_{w_m_b} = F_s$	$s_m_b_f \times a_I \times [((8)$	B-n²×(4-n))² /16)-4	I+n×(4-n)]/8 = [−]	10.4 kNm/m
	Saturated backfill		$M_{w_s} = F_{s_s_}$	$_{f} \times [a_{l}^{2} \times x \times ((5 \times l)^{2})]$	_)-aı)/(20×L³)-(x-b	$(3 \times a^2) = 5.$	2 kNm/m
	Water		$M_{w_water} = F$	$s_{water_f} \times [a_{l}^2 \times x_{l}^2]$	×((5×L)-a)/(20×L ³	³)-(x-b ₁) ³ /(3×a ₁ ²))] = 7.8
	kNm/m						
1							



	Project	1 St Mark	s Crescent		Job no. 180)507
Conisbee 1-5 Offord Street	Calcs for Retain	ing wall No. 1/2	Rear with no 2	2 loading	Start page no./Re	evision 8
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date

Check retaining wall deflection	on	
Basic span/effective depth ratio)	ratio _{bas} = 20
Design service stress		$f_{s} = 2 \times f_{y} \times A_{s_stem_req} / (3 \times A_{s_stem_prov}) = \textbf{261.4} \text{ N/mm}^{2}$
Modification factor	$factor_{tens} = min(0.55)$	+ (477 N/mm ² - f _s)/(120 × (0.9 N/mm ² + (M _{stem} /(b × d _{stem} ²)))),2) = 1.59
Maximum span/effective depth	ratio	$ratio_{max} = ratio_{bas} \times factor_{tens} = 31.76$
Actual span/effective depth rati	0	$ratio_{act} = h_{stem} / d_{stem} = 11.90$
		PASS - Span to depth ratio is acceptable



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



	Project	1 St Mark	s Crescent		Job no. 18	80507
Conisbee 1-5 Offord Street	Calcs for	R.C capping	beam lightwel	I	Start page no./I	Revision 2
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date
Maximum moment support B Maximum shear support A Maximum shear support A spar Maximum shear support B Maximum shear support B spar Maximum reaction at support A Unfactored dead load reaction Unfactored imposed load reaction Unfactored dead load reaction Unfactored dead load reaction Unfactored imposed load reaction Unfactored imposed load reaction Section width Section depth	n 1 at 300 mm n 1 at 3200 mm at support A on at support A at support B on at support B	MB_max = 0 VA_max = 15 VA_s1_max = VB_max = -1! VB_s1_max = RA = 156 k RA_Dead = 5 RA_Imposed = RB = 156 k RB_Dead = 5 RB_Imposed = b = 350 mr h = 350 mr	kNm 6 kN 129 kN 56 kN -129 kN N kN 93 kN 93 kN n n	MB_red = VA_red = VA_s1_re VB_red = VB_s1_re	= 0 kNm = 156 kN d = 129 kN = -156 kN d = -129 kN	
Concrete details Concrete strength class Characteristic compressive cub Modulus of elasticity of concret Maximum aggregate size Reinforcement details Characteristic yield strength of Characteristic yield strength of	e strength e reinforcement shear reinforcem	C40/50 $f_{cu} = 50 \text{ N/r}$ $E_c = 20 \text{ kN/r}$ $h_{agg} = 20 \text{ m}$ $f_y = 500 \text{ N/r}$ tent $f_{yy} = 500 \text{ N/r}$	nm² mm² + 200 × fa ım mm² ′mm²	cu = 30000 N/mm ²	2	
Nominal cover to reinforceme Nominal cover to top reinforceme Nominal cover to bottom reinfor Nominal cover to side reinforce	e nt nent rcement ment	Cnom_t = 50 Cnom_b = 35 Cnom_s = 35	mm mm			

	Project				Job no.	
		1 St Mark	s Crescent		18	0507
Conisbee 1-5 Offord Street	Calcs for	R.C capping	apping beam lightwell Start page no./Rev			
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date
Mid span 1						
			$2 \times 8_{\varphi}$ bars			
	-350-		$2 \times 8_{\varphi}$ shear	legs at 200 c/c		
			$4 \times 20_{\varphi}$ bars			
	◀	-350				
	·					
Design moment resistan	ce of rectangular se	ection (cl. 3.4.4)) - Positive mo	ment		
Design bending moment	mont	M = abs(M	s1_red) = 136 KIN	m 207 mm		
Bedistribution ratio	ment	$G_{\rm h} = min(1)$	- m ₁ 1) - 1 0	= 297 mm		
Redistribution ratio		$p_{\rm b} = \min(1$	$-11r_{s1}, 1) = 1.00$ $\times d^2 \times f_{m}) = 0.0$	88		
		K' = 0.156		00		
			K' > K -	No compressio	n reinforceme	ent is required
Lever arm		z = min(d >	< (0.5 + (0.25 -	K / 0.9) ^{0.5}), 0.95	× d) = 264 mm	• I
Depth of neutral axis		x = (d - z) /	0.45 = 73 mm			
Area of tension reinforcem	nent required	$A_{s,req} = M /$	$(0.87 \times f_y \times z) =$	= 1184 mm²		
Tension reinforcement pro	ovided	$4 imes 20\phi$ ba	rs			
Area of tension reinforcem	nent provided	A _{s,prov} = 12	57 mm²			
Minimum area of reinforce	ement	$A_{s,\text{min}}=0.0$	013 × b × h = 1	59 mm²		
Maximum area of reinforce	ement	$A_{s,max} = 0.0$	04 × b × h = 490)0 mm²		
	PASS - Area o	f reinforcemen	t provided is g	reater than area	a of reinforce	ment required
Rectangular section in s	hear					
Shear reinforcement provi	ded	$2 \times 8\phi$ legs	at 200 c/c			
Area of shear reinforceme	ent provided	$A_{sv,prov} = 50$)3 mm²/m			
Minimum area of shear rei	inforcement (Table 3	.7) $A_{sv,min} = 0.4$	1N/mm ² × b / (0	0.87 × f _{yv}) = 322 r	nm²/m	
		ASS - Area of s	hear reinforce	ment provided	exceeds mini	mum required
Maximum longitudinal spa	cing (cl. 3.4.5.5)	$S_{vl,max} = 0.7$	′5 × d = 223 mr	n		
.	PASS - Long	itudinal spacing	g of shear rein	forcement prov		han maximum
Design concrete shear stre	ess	$v_{c} = 0.79N$	$mm^2 \times min(3,[^2$	$100 \times A_{s,prov} / (b > 2) 1/3 / (b > 2) 1$	(d) (d) $(1)^{1/3}$ (d) $\times \max(1)^{1/3}$	1, (400mm
		/d) ^{1/4}) × (m	In(f _{cu} , 40N/mm ²	²) / 25N/mm ²) ^{1/3} /	$\gamma_{\rm m} = 0.848 {\rm N/r}$	nm²
Design shear resistance p	orovided	$V_{s,prov} = A_{sv}$	$prov \times 0.87 \times fyv$	/ b = 0.625 N/mr	n²	
Design shear stress provid	bed	Vprov = Vs,pro	$v + V_c = 1.473$			
Consign shear resistance	inks provided valid	v prov = Vprov between 100 m	m and 3400 m	m with tonsion	reinforcemen	t of 1957 mm^2
			and 5400 m			
Actual distance between b	ot (CI 3.12.11) Dars in tension	s = (b - 2 ×	: (Cnom_s + φv + ¢	0 _{bot} /2)) /(N _{bot} - 1) -	φ _{bot} = 61 mm	
Minimum distance betwe	een bars in tension	(cl 3.12.11.1)				
Minimum distance betwee	n bars in tension	$s_{min} = h_{agg}$	+ 5 mm = 25 m	m		
		50	PAS	SS - Satisfies the	e minimum sp	oacing criteria

	Project	1 St Mark	s Crescent		Job no. 18()507
Conishee	Calcs for				Start page no./R	evision
1-5 Offord Street		R.C capping	beam lightwel	l	Job no. 18 Start page no./F Approved by 4.2 N/mm ² 150 mm <i>he maximum sp</i> 4.2 N/mm ² 100 × A _{s2,prov} / (b × 100 × A _{s2,prov} / (b	4
London	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
N1 1DH	НН	13/06/2018			PP 7	
Maximum distance botwo	on hars in tonsion	(0) 2 12 11 2)				
Design service stress		$f_{c} = (2 \times f_{v})$	$\times A_{a reg}) / (3 \times A_{b reg})$	$(a prov \times \beta_b) = 314$	2 N/mm ²	
Maximum diatanaa batwaa	a hara in tanaian	$s = (2 \times iy)$		$f_{1} = 200 \text{ mm}$ 15	0 mm	
Maximum distance between	i bars in tension	$S_{max} = \Pi \Pi \Pi$	47000 N/mm/	$I_s, 300 \Pi \Pi I = 13$	••••••••••••••••••••••••••••••••••••••	!!!!
			PAS	5 - Satisties the	e maximum sp	acing criteria
Span to depth ratio (cl. 3.	4.6)					
Basic span to depth ratio (1	able 3.9)	span_to_d	epth _{basic} = 20.0)		
Design service stress in ter	sion reinforcement	$f_s = (2 \times f_y)$	$\times A_{s,req})/(3 \times A)$	$_{s,prov} \times \beta_b) = 314.2$	N/mm ²	
Modification for tension reir	nforcement					
	ftene = I	min(2.0, 0.55 + (477N/mm ² - f) / (120 × (0 9N/m	$m^{2} + (M / (b \times))$	d ²))))) = 0 806
Modification for comprossic	nens – i	1111(2:0, 0:00 1 (// (120 × (0.014/11		
mounication for compression	in remorcement	· / . – . /		(1 1)) ((2 (1 0		
	Tcomp	$= \min(1.5, 1 + ($	$100 \times A_{s2,prov}$ /	(b×d)) / (3 + (10	$0 \times A_{s2,prov} / (b >$	< d)))) = 1.031
Modification for span length	1	$f_{long} = 1.000$)			
	io	span_to_d	epth _{allow} = spar	$to_depth_{basic} \times f$	$t_{tens} \times f_{comp} = 16.$.6
Allowable span to depth rat						
Allowable span to depth rat Actual span to depth ratio		span_to_d	$epth_{actual} = L_{s1}$	′ d = 11.8		

	Project				Job no.	
	1 St Marks Crescent				180507	
Conisbee 1-5 Offord Street	Calcs for	Retaining wall No. 1/31 Rear			Start page no./Revision 1	
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	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 h_{stem} = **3500** mm twall = 350 mm I_{toe} = **1000** mm $I_{heel} = 0 \text{ mm}$ $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 1350 \text{ mm}$ t_{base} = **350** mm $d_{ds} = 0 \text{ mm}$ l_{ds} = **900** mm t_{ds} = **350** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3850 \text{ mm}$ $d_{cover} = 0 mm$ $d_{exc} = 0 mm$ h_{water} = 2850 mm $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 2500 mm$ $\gamma_{wall} = 23.6 \text{ kN/m}^3$ γbase = 23.6 kN/m³ $\alpha = 90.0 \text{ deg}$ $\beta = 0.0 \text{ deg}$ $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3850 \text{ mm}$

M = 1.5 $\gamma_m = 18.0 \text{ kN/m}^3$

	Project Job no.				Job no.	ob no.	
	1 St Marks Crescent					180507	
Conisbee	Calcs for			Start page no./Re	evision		
1-5 Offord Street		Retaining wall No. 1/31 Rear				2	
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date	
Saturated density of retained n	naterial	γ _s = 21.0 kN	V/m ³		•	•	
Design shear strength		φ' = 24.2 de	g				
Angle of wall friction		$\delta = 18.6$ de	g				
Base material details							
Firm clay							
Moist density		γ _{mb} = 18.0 k	⟨N/m³				
Design shear strength		φ' _b = 24.2 d	eq				
Design base friction		$\delta_{\rm b} = 18.6 {\rm d}$	ea				
Allowable bearing pressure		$P_{\text{bearing}} = 12$	25 kN/m²				
Using Coulomb theory		• bearing - •-					
Active pressure coefficient for	retained material						
$K_{r} = \sin(c)$	$x \pm d')^2 / (\sin(\alpha)^2 >$	$\sin(\alpha - \delta) \times [1 +$	$\sqrt{(\sin(\phi' + \delta))} $	$\sin(\phi' - \beta) / (\sin(\alpha))$	$-\delta$ $\times \sin(\alpha + 1)$	3)))]2) - 0 360	
Passive pressure coefficient fo	r hase material	$\sin(\alpha - 0) \times [1 + $	$\sqrt{3}$	sin(ψ - μ) / (Sin(α	$-0) \times 3 m(\alpha + \beta$	5)))]) = 0.503	
	$K_n = \sin(9)$	0 -) - δ _b) × [1 - √(sin	n(φ' ₅ + δ ₅) × sin(φ'	_b) / (sin(90 + δ	(h)))] ²) = 4 187	
A1	πφ = οπη(ο					5///] / = 4.101	
At-rest pressure	-t- d-l						
At-rest pressure for retained m	aterial	$K_0 = 1 - Sir$	$h(\phi^2) = 0.590$				
Loading details							
Surcharge load on plan		Surcharge	= 10.0 kN/m²				
Applied vertical dead load on v	vall	W _{dead} = 33 .	0 kN/m				
Applied vertical live load on wa		W _{live} = 4.0	KN/m				
Position of applied vertical load	d on wall	$I_{load} = 11/5$	mm				
Applied norizontal dead load o	n wali	F _{dead} = 0.0	KIN/M				
Height of applied horizontal los	wali ad on wall	$F_{\text{live}} = 0.0 \text{ K}$	n/111				
rieignt of applied nonzontal los							
		Prop -	10				
	25.0 Prop	57		28.0			
				Loads shown	in kN/m, pressure	s shown in kN/m [;]	

	Project 1 St Marks Crescent				Job no. 180507	
Conisbee 1-5 Offord Street	Calcs for Retaining wall No. 1/31 Rear				Start page no./Revision 3	
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date

Vertical forces on wall	
Wall stem	$w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall} = 28.9 \text{ kN/m}$
Wall base	$w_{\text{base}} = I_{\text{base}} \times t_{\text{base}} \times \gamma_{\text{base}} = \textbf{11.2 kN}/m$
Applied vertical load	$W_v = W_{dead} + W_{live} = 37 \text{ kN/m}$
Total vertical load	$W_{total} = w_{wall} + w_{base} + W_v = 77.1 \text{ kN/m}$
Horizontal forces on wall	
Surcharge	$F_{sur} = K_a \times cos(90 - \alpha + \delta) \times Surcharge \times h_{eff} = \textbf{13.5 kN/m}$
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2 = \textbf{3.1 kN/m}$
Moist backfill below water table	$F_{m_b} = K_a \times cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 17.9 \text{ kN/m}$
Saturated backfill	$F_{s} = 0.5 \times K_{a} \times cos(90 - \alpha + \delta) \times (\gamma_{s} - \gamma_{water}) \times h_{water}^{2} = 15.9 \text{ kN/m}$
Water	$F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water} = 39.8 \text{ kN/m}$
Total horizontal load	$F_{total} = F_{sur} + F_{m_a} + F_{m_b} + F_s + F_{water} = 90.3 \text{ kN/m}$
Calculate total propping force	
Passive resistance of soil in front of wall	$F_{p} = 0.5 \times K_{p} \times cos(\delta_{b}) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^{2} \times \gamma_{mb} = \textbf{4.4 kN/m}$
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	$M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = 25.9 \text{ kNm/m}$
Moist backfill above water table	$M_{m_a} = F_{m_a} \times (h_{\text{eff}} + 2 \times h_{\text{water}} - 3 \times d_{\text{ds}}) \ / \ 3 = \textbf{10} \ kNm/m$
Moist backfill below water table	$M_{m_b} = F_{m_b} \times (h_{water} - 2 \times d_{ds}) \ / \ 2 = \textbf{25.6} \ kNm/m$
Saturated backfill	$M_{s} = F_{s} \times (h_{water} - 3 \times d_{ds}) / 3 = \textbf{15.1} \text{ kNm/m}$
Water	$M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 37.8 \text{ kNm/m}$
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = \textbf{114.5} \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{\text{wall}} = w_{\text{wall}} \times (I_{\text{toe}} + t_{\text{wall}} / 2) = \textbf{34} \text{ kNm/m}$
Wall base	$M_{base} = w_{base} \times I_{base} / 2 = 7.5 \text{ kNm/m}$
Design vertical dead load	$M_{dead} = W_{dead} \times I_{load} = 38.8 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{dead} = 80.3 \text{ kNm/m}$
Check bearing pressure	
Total vertical reaction	R = W _{total} = 77.1 kN/m
Distance to reaction	x _{bar} = I _{base} / 2 = 675 mm
Eccentricity of reaction	$e = abs((I_{base} / 2) - x_{bar}) = 0 mm$
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 57.1 \text{ kN/m}^2$
Bearing pressure at heel	$p_{\text{heel}} = (R / I_{\text{base}}) + (6 \times R \times e / I_{\text{base}}^2) = 57.1 \text{ kN/m}^2$
PASS -	Maximum bearing pressure is less than allowable bearing pressure
Calculate propping forces to top and base of wa	all
Propping force to top of wall	

Propping force to base of wall

$$\begin{split} F_{prop_top} = (M_{ot} - M_{rest} + R \times I_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = \textbf{20.541} \text{ kN/m} \\ F_{prop_base} = F_{prop} - F_{prop_top} = \textbf{40.801} \text{ kN/m} \end{split}$$

P	Project 1 St Marks Crescent				Job no. 180507		
Conisbee C	alcs for	Retaining wal	Retaining wall No. 1/31 Rear			Revision 4	
London C N1 1DH	alcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved da	
RETAINING WALL DESIGN (BS	8002:1994)					
Ultimate limit state load factors					TEDDS calculatio	n version 1.2.0	
Dead load factor		$\gamma_{f_d} = 1.4$					
Live load factor		$\gamma_{f_l} = 1.6$					
Earth and water pressure factor		$\gamma_{f_e} = 1.4$					
Factored vertical forces on wall							
Wall stem		$W_{wall_f} = \gamma_{f_d}$	imes h _{stem} $ imes$ t _{wall} $ imes$ '	γ _{wall} = 40.5 kN/m	ı		
Wall base		$W_{base_f} = \gamma_{f_c}$	$_{ m J} imes {\sf I}_{ m base} imes {\sf t}_{ m base} imes$	γ _{base} = 15.6 kN/	′m		
Applied vertical load		$W_{v_f} = \gamma_{f_d}$	$\langle W_{dead} + \gamma_{f_l} \times V_{dead}$	<i>N</i> _{live} = 52.6 kN/m	ı		
Total vertical load		$W_{total_f} = W_w$	vall_f + Wbase_f + V	N _{v_f} = 108.7 kN/r	m		
Factored horizontal at-rest force	es on wall						
Surcharge		$F_{sur f} = \gamma_{f} > 1$	$\langle K_0 \times Surcharg$	le × h _{eff} = 36.3 kl	N/m		
Moist backfill above water table		Fm a f=γfe	$\times 0.5 \times K_0 \times \gamma_m$	$\times (h_{eff} - h_{water})^2 =$	- 7.4 kN/m		
Moist backfill below water table		Fm b f = γfe	\times K ₀ \times γ_m \times (h _e	_{ff} - h _{water}) × h _{water}	= 42.4 kN/m		
Saturated backfill		$F_{s f} = \gamma_{f e} \times 0.5 \times K_{0} \times (\gamma_{s} \cdot \gamma_{water}) \times h_{water}^{2} = 37.5 \text{ kN/m}$					
Water	$F_{water f} = \gamma_{f}$	$\times 0.5 \times h_{water}^2$	× ‱ter = 55.8 k	N/m			
Total horizontal load		F _{total f} = F _{sur}	r f + Fm a f + Fm	$b f + F_s f + F_{water}$	f = 179.5 kN/n	n	
Calculate total propping force		_			_		
Passive resistance of soil in front	of wall	$F_{p_f} = \gamma_{f_e} \times$	$0.5 imes K_p imes cos($	$(\delta_b) imes (d_{cover} + t_{ba})$	se + d _{ds} - d _{exc}) ²	$\times \gamma_{mb} = 6.1$	
KIV/M		Γ			$\rightarrow \gamma + \cos(S_{1}) = 0$	k N l/m	
Propping force		$F_{prop_f} = \Pi a$ $F_{prop_f} = 138$	8.9 kN/m	(VV total_f - Ύf_l × VV	live) × tarr(ob), U	KIN/111)	
Factored overturning moments							
Surcharge		$M_{sur_f} = F_{sur_f}$	$_{f} \times (h_{eff} - 2 \times d)$	_{ds}) / 2 = 70 kNm	/m		
Moist backfill above water table		$M_{m_a_f} = F_{m_a}$	$_a_f \times (h_{eff} + 2 \times$	h_{water} - 3 \times dds) /	3 = 23.7 kNm/	m	
Moist backfill below water table		$M_{m_b_f} = F_{m}$	$_{b_f} \times (h_{water} - 2)$	× d _{ds}) / 2 = 60.4	kNm/m		
Saturated backfill		$M_{s_f} = F_{s_f} \times$	$<$ (h _{water} - 3 \times d _{ds}	s) / 3 = 35.7 kNm	ı/m		
Water		$M_{water_f} = F_{v}$	$_{ m vater_f} imes$ (h _{water} - 3	$3 \times d_{ds}) / 3 = 53$	kNm/m		
Total overturning moment		$M_{ot_f} = M_{sur_}$	$_f + M_{m_a_f} + M_m$	$b_f + M_{s_f} + M_{wat}$	_{er_f} = 242.7 kNr	m/m	
Restoring moments							
Wall stem		$M_{wall_f} = W_{wal}$	$_{all_f} \times (I_{toe} + t_{wall} /$	2) = 47.6 kNm/r	m		
Wall base		$M_{base_f} = w_b$	$_{ase_f} \times I_{base} / 2 =$	10.5 kNm/m			
Design vertical load		$M_{v_f} = W_{v_f}$	$M_{v_f} = W_{v_f} \times I_{load} = \textbf{61.8} \text{ kNm/m}$				
Total restoring moment		$M_{rest_f} = M_{was}$	$all_f + M_{base_f} + N$	/l _{v_f} = 119.9 kNm	/m		
Factored bearing pressure							
Total vertical reaction		$R_f = W_{total_f}$	= 108.7 kN/m				
Distance to reaction		$x_{\text{bar}_f} = I_{\text{base}}$	/ 2 = 675 mm				
Eccentricity of reaction		$e_f = abs((I_{bas}))$	_{ase} / 2) - x _{bar_f}) =	0 mm <i>Reaction acts</i>	within middle	e third of h	
Bearing pressure at toe		$p_{\text{toe}} = (R_f)$	$(I_{base}) - (6 \times R_{f})$	$\langle e_{\rm f} / l_{\rm base}^2 \rangle = 80.1$	5 kN/m ²		
Bearing pressure at heel		$p_{\text{heel }f} = (R_f)$	$/ I_{base}$) + (6 × R	$\times e_f / I_{base^2} = 80$).5 kN/m²		
Rate of change of base reaction		rate = (p_{toe})	f - Pheel f) / Ibase	= 0.00 kN/m²/m			
Bearing pressure at stem / toe		Dstem toe f =	max(p _{toe f} - (rat	$e \times I_{toe}$), 0 kN/m ²	²) = 80.5 kN/m ²	2	

	Project				Job no			
	1 St Marks Crescent			18	30507			
Conishee	Calcs for				Start page no./F	Revision		
1-5 Offord Street		Retaining wal	Retaining wall No. 1/31 Rear			5		
London	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date		
N1 1DH	HH	13/06/2018						
Bearing pressure at mid stem		Determ mid 6 -	max(n	1te × (luce + ture) / 2)) $0 k N (m^2) - 3$	80 5 kN/m ²		
Bearing pressure at this stem / her		Pstem_mid_i =	$\max(p_{\text{toe}_{1}}) = (rate$	$t = x (t_{top} + t_{wall})$	$(0 \text{ kN/m}^2) = 80$	5 kN/m ²		
Oslaulata areaning foress to	ton and hear				o (a () in) = 00 .			
Propping force to top of wall	top and base	e of wall						
Fropping force to top of wall	Farra tan (– (Max (- Maxa) (+ B)	× / 2 - F			– 46 757 kN/m		
Propping force to base of wall	i prop_top_t	$= (\text{IVIO}_{-} + \text{IVI}\text{res}_{-} + \text{IVI}$ $= \text{F}_{\text{prop} \text{ base } f} = \text{F}_{\text{prop}}$	$= E_{\text{prop} f} - E_{\text{prop} f}$	$op_1 \times tbase 72) 7 (ff)$	n	- 40.737 KN/III		
Design of reinforced concret	te retaining w	all toe (BS 8002:1	<u>994)</u>					
Material properties			2					
Characteristic strength of conc	crete .	f _{cu} = 40 N/r	nm²					
Unaracteristic strength of reinf	orcement	$t_y = 500 \text{ N/m}$	mm-					
Base details								
Minimum area of reinforcemen	It	k = 0.13 %						
Cover to reinforcement in toe		Ctoe = 50 m	111					
Calculate shear for toe desig	ŋn) I (0 00 -	1.51/			
Shear from bearing pressure		V _{toe_bear} = (Otoe_f + Pstem_toe_	$f) \times I_{\text{toe}} / 2 = 80.5$	kN/m			
Shear from weight of base		V _{toe_wt_base} =	$V_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times I_{toe} \times t_{base} = 11.6 \text{ kN/m}$					
I otal shear for toe design		$V_{toe} = V_{toe_t}$	ear - Vtoe_wt_base	= 68.9 kN/m				
Calculate moment for toe de	sign		_					
Moment from bearing pressure	9	$M_{toe_bear} = ($	$2 \times p_{toe_f} + p_{ster}$	$m_{mid_f} \times (I_{toe} + t_{wa})$	$(/ 2)^2 / 6 = 55.$	6 kNm/m		
Moment from weight of base		M _{toe_wt_base} =	= $(\gamma_{f_d} \times \gamma_{base} \times$	$t_{base} \times (I_{toe} + t_{wall} / $	$(2)^{2}/(2) = 8 \text{ kN}$	m/m		
Total moment for toe design		$M_{toe} = M_{toe}$	bear - Mtoe_wt_bas	_e = 47.6 kNm/m				
294-	>							
35					\leq			
⊥	•	• •	•	• •	•			
▼								
	← 150 →	►						
Check toe in bending								
Width of toe		b = 1000 m	ım/m					
Depth of reinforcement		$d_{toe} = t_{base}$ -	$-c_{toe} - (\phi_{toe} / 2)$	= 294.0 mm				
Constant		$K_{toe} = M_{toe}$ /	$(b \times d_{toe}^2 \times f_{cu})$) = 0.014				
			(Compression re	inforcement is	s not required		
Lever arm		$z_{toe} = min(0)$	0.5 + √(0.25 - (min(K _{toe} , 0.225) /	$(0.9)), (0.95) \times c$	t _{oe}		
		z _{toe} = 279 n	nm		0.4			
Area of tension reinforcement	required	$A_{s_toe_des} =$	M_{toe} / (0.87 × f _y	(× z _{toe}) = 392 mm	1²/m			
Minimum area of tension reinfo	orcement	$A_{s_toe_min} =$	$k \times b \times t_{base} = 4$	155 mm²/m	0.1			
Area of tension reinforcement	required	$A_{s_toe_req} = I$	Max(A _{s_toe_des} ,	As_toe_min) = 455 m	nm²/m			
Reinforcement provided	4	12 mm dia	.bars @ 150 n	nm centres				
	1	As the prov =	/ 34 mm²/m					
Area of reinforcement provided			forcoment	avidad at the me	loining wall +-	vo lo odocust-		

	Project	Job no. 180507						
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CONISDEE	Cales Ioi	Retaining wall No. 1/31 Rear			Start page 10./h	6		
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date		
	- I				•			
Check shear resistance at to	e							
Design shear stress		$v_{toe} = V_{toe} \; / \;$	$(b \times d_{toe}) = 0.2$	35 N/mm²				
Allowable shear stress		$v_{adm} = min($	0.8 × √(f _{cu} / 1 №	N/mm²), 5) × 1 N/ı	mm² = 5.000 N	/mm²		
		PASS -	Design shear	r stress is less tl	han maximum	shear stress		
From BS8110:Part 1:1997 – 1	Table 3.8							
Design concrete shear stress		Vc_toe = 0.5 ()7 N/mm² Vto	e < Vc toe - No sh	ear reinforcen	nent required		
Design of reinforced concre	te retaining wall	stem (BS 8002	:1994)					
Material properties	<u> </u>	(/					
Characteristic strength of conc	roto	f – 40 N/n	nm ²					
Characteristic strength of reinf	orcement	$f_{v} = 500 \text{ N/r}$	mm ²					
Wall details	oroomone	iy = 000 i i,i						
Minimum area of reinforcemen	•	k – 0 13 %						
Cover to reinforcement in ster	1	R = 0.15 / 8	nm					
Cover to reinforcement in wall		C _{wall} = 50 m	m					
Factored horizontal at-rest for	orces on stem							
Surcharge		F _{s sur f} = γ _f	\times K ₀ \times Surcha	$rge imes (h_{eff} - t_{base} - t_{base})$	d _{ds}) = 33 kN/m	1		
Moist backfill above water tabl	е	$F_{s_m_a_f} = 0.5 \times \gamma_{f_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2 = 7.4 \text{ kN/m}$						
Moist backfill below water table	e	Fsmbf=γf	$_{e} \times K_{0} \times \gamma_{m} \times (1)$	h _{eff} - t _{base} - d _{ds} - h _s	at) × h _{sat} = 37.2	kN/m		
Saturated backfill		Fs s f = 0.5	 ×γ _{fe} ×K ₀ ×(γ _s	s- γ_{water}) × $h_{sat}^2 = 2$.9 kN/m			
Water		$F_{s_water_f} = 0.5 \times \gamma_{f_e} \times \gamma_{water} \times h_{sat}^2 = 42.9 \text{ kN/m}$						
Calculate shear for stem des	sign							
Surcharge	-	$V_{s_sur_f} = 5$	$\times F_{s_{sur_f}} / 8 = 2$	20.7 kN/m				
Moist backfill above water tabl	e	$V_{s_m_a_f} = F$	$s_m_a_f \times b_l \times ((5))$	5 imesL ²) - bl ²) / (5 $ imes$	L ³) = 2 kN/m			
Moist backfill below water table	e	$V_{s_m_b_f} = F$	s_m_b_f × (8 - (n ²	$^{2} \times (4 - n))) / 8 = 2$	2 9.1 kN/m			
Saturated backfill		$V_{s_s_f} = F_{s_s}$	$_{f} \times (1 - (a^{2} \times ($	(5 × L) - a _l) / (20 >	< L ³))) = 25.6 k	N/m		
Water		$V_{s_water_f} = F_{s_water_f} \times (1 - (a_1^2 \times ((5 \times L) - a_1) / (20 \times L^3))) = 38.1 \text{ kN/m}$						
Total shear for stem design		$V_{stem} = V_{s_sur_f} + V_{s_m_a_f} + V_{s_m_b_f} + V_{s_s_f} + V_{s_water_f} = \textbf{115.4 kN/m}$						
Calculate moment for stem of	lesign							
Surcharge		$M_{s_sur} = F_{s_sr}$	_{sur_f} × L / 8 = 1	5.2 kNm/m				
Moist backfill above water tabl	е	$M_{s_m_a} = F_{s_a}$	$_{m_a_f} \times b_l \times ((5$	imes L ²) - (3 $ imes$ b _l ²)) /	(15 × L ²) = 2.4	kNm/m		
Moist backfill below water table	e	$M_{s_m_b} = F_{s_b}$	$_{m_b_f} \times a_l \times (2 -$	• n) ² / 8 = 20.1 kN	m/m			
Saturated backfill		$M_{s_s} = F_{s_s_}$	$f \times a_1 \times ((3 \times a_1^2) - (1$	15×a¦×L)+(20×L²))	/(60×L²) = 13.	7 kNm/m		
Water		$M_{s_water} = F_s$	s_water_f ×aI×((3×	$(15 \times a_1 \times L) + (2)$	0×L²))/(60×L²)	= 20.4		
kNm/m								
Total moment for stem design		M _{stem} = M _{s_s}	sur + Ms_m_a + N	$M_{s_m_b} + M_{s_s} + M_{s_s}$	_water = 71.8 kN	m/m		
Calculate moment for wall de	esign							
Surcharge		$M_{w_sur} = 9 \times$	$F_{s_sur_f} \times L / 12$	28 = 8.5 kNm/m				
Moist backfill above water tabl	е	$M_{w_m_a} = F_s$	$_m_a_f \times 0.577 \times$	$b_{l} \times [(b_{l}^{3} + 5 \times a_{l} \times L^{2})/($	(5×L³)-0.577²/3] = 2.7		
kNm/m								
Moist backfill below water table	e	$M_{w_m_b} = F_s$	$_m_b_f \times a_l \times [((8)$	3-n²×(4-n))² /16)-4	+n×(4-n)]/8 = ⁻	10.4 kNm/m		
Saturated backfill		$M_{w_s} = F_{s_s}$	$f \times [al^2 \times x \times ((5 \times l)^2)]$	_)-aı)/(20×L ³)-(x-b	$(3 \times a^2) = 5.$	2 kNm/m		
Water		$M_{w_water} = F$	$s_{water_f} \times [a_{l}^2 \times x]$	×((5×L)-aı)/(20×L ³	$(x-b_1)^3 / (3 \times a_1^2)^3$)] = 7.8		
kNm/m								



	Project				Job no.	
	1 St Marks Crescent				180507	
Conisbee 1-5 Offord Street	Calcs for Retaining wall No. 1/31 Rear				Start page no./Revision 8	
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date

Check retaining wall deflection	on	
Basic span/effective depth ratio)	ratio _{bas} = 20
Design service stress		$f_{s} = 2 \times f_{y} \times A_{s_stem_req} \ / \ (3 \times A_{s_stem_prov}) = \textbf{261.4} \ N/mm^{2}$
Modification factor	factor _{tens} = min(0.55	+ (477 N/mm ² - f _s)/(120 × (0.9 N/mm ² + (M _{stem} /(b × d _{stem} ²)))),2) = 1.59
Maximum span/effective depth	ratio	ratio _{max} = ratio _{bas} × factor _{tens} = 31.76
Actual span/effective depth rati	0	ratio _{act} = h _{stem} / d _{stem} = 11.90
		PASS - Span to depth ratio is acceptable

	Project				Job no.		
		1 St Mark	s Crescent		18	30507	
Conisbee	Calcs for		Start page no./	Start page no./Revision			
1-5 Offord Street		Retaining wall No. 1/31 Rear				9	
London N1 1DH	Calcs by HH	Calcs date 13/06/2018	Checked by	Checked date	Approved by	Approved date	
	· · · · · · · · · · · · · · · · · · ·			· · · · · · · · · · · · · · · · · · ·			
Indicative retaining wall	rainforcoment dia	aram					



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

Tekla Tedds	Project 1 St. Marks Crescent NW1-7TS					Job no. 180507	
Conisbee 1-5 Offord Street	Calcs for	Steel Wa	ling Beam		Start page no./Re	evision 1	
N1 1DH	Calcs by DB	Calcs date 25/07/2018	Checked by	Checked date	Approved by	Approved date	

STEEL BEAM ANALYSIS & DESIGN (BS5950)

In accordance with BS5950-1:2000 incorporating Corrigendum No.1

TEDDS calculation version 3.0.05







Support conditions					
Support A	Vertically restrained				
	Rotationally free				
Support B	Vertically restrained				
	Rotationally free				
Support C	Vertically restrained				
	Rotationally free				
Support D	Vertically restrained				
	Rotationally free				
Support E	Vertically restrained				
	Rotationally free				
Support F	Vertically restrained				
	Rotationally free				
Applied loading					
Beam loads	Other full UDL 44.3 kN/m				
Load combinations					
Load combination 1	Support A	$\text{Dead} \times 1.40$			
		Imposed $ imes$ 1.60			

Tekla	Project 1 St. Marks Crescent NW1-7TS			Job no. 180507			
Tedds							
1-5 Offord Street	Calos for Steel Waling Beam		n	Start page no./Revision			
London	Calcs by	Calce date Checked b	Checked date	Approved by			
N1 1DH	DB	25/07/2018	y Onecked date	Approved by	Approved date		
			Other>	Other × 1.00			
	Span 1		Dead >	$Dead \times 1.40$			
			Impose	ed × 1.60			
	Support B		Other	< 1.00			
			Dead >	$Dead \times 1.40$			
			Impose	Imposed \times 1.60			
			Other	< 1.00			
		Span 2	Dead >	< 1.40			
			Impose	ed imes 1.60			
			Other	< 1.00			
		Support C	Dead >	< 1.40			
			Impose	Imposed \times 1.60			
			Other>	$Other \times 1.00$			
	Span 3		Dead >	$Dead \times 1.40$			
			Impose	Imposed \times 1.60			
			Other>	< 1.00			
		Support D	Dead >	< 1.40			
			Impose	Imposed \times 1.60			
			Other	< 1.00			
		Span 4	Dead >	< 1.40			
			Impose	ed × 1.60			
			Other>	< 1.00			
		Support E	Dead >	< 1.40			
			Impose	Imposed × 1.60			
			Other>	< 1.00			
		Span 5	Dead >	< 1.40			
			Impose	Imposed × 1.60			
			Other	< 1.00			
		Support F	Dead >	< 1.40			
			Impose	ed × 1.60			
			Other>	< 1.00			
Analysis results							
Maximum moment		M _{max} = 21.2 kNm	M _{min} =	M _{min} = -28.7 kNm			
Maximum moment span 1		$M_{s1_max} = 5.6 \text{ kNm}$	Ms1_min	M_{s1} _min = -28.7 kNm			
Maximum moment span 2		M_{s2} max = 21.2 KNM	IVIs2_min	$V_{122}_{min} = -20.7 \text{ KINIII}$			
Maximum moment span 3		$M_{a4} = 0 \text{ kNm}$	IVIs3_min Ma4_min	M_{c4} min = -20.0 KN111 M_{c4} min = -28.7 kNm			
Maximum moment span 5		$M_{s5 max} = 5.6 kNm$	Ms4_min Ms5_min	$M_{s5 min} = -28.7 \text{ kNm}$			
Maximum shear		V _{max} = 66.5 kN	$V_{min} = $	V _{min} = -66.5 kN			
Maximum shear span 1	V _{s1_max} = 22.4 kN V _{s1_min} = -55.2 kN						
Maximum shear span 2	$V_{s2_max} = 66.5 \text{ kN}$ $V_{s2_min} = -66.4 \text{ kN}$						
Maximum shear span 3		V _{s3_max} = 55.4 kN V _{s3_min} = -55.4 kN					
Maximum shear span 4	V _{s4_max} = 66.4 kN V _{s4_min} = -66.5 kN						
Maximum shear span 5		V _{s5_max} = 55.2 kN	Vs5_min	Vs5_min = -22.4 kN			
Deflection		$\delta_{max} = 4 \text{ mm}$	$\delta_{min} = 0$).3 mm			
두 Tekla	Project Job no.						
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Tedds	1 St. Marks Crescent NW1-7TS					180507	
Conisbee 1-5 Offord Street	Calcs for	Steel Wa	Start page no./Revision 3				
London	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date	
N1 1DH	DB	25/07/2018					
Deflection span 1		$\delta_{s1_max} = 0.$	1 mm	$\delta_{s1_min} =$	• 0.3 mm		
Deflection span 2		$\delta_{s2_max} = 4$ i	mm	$\delta_{s2_{min}} =$	• 0 mm		
Deflection span 3		$\delta_{s3 max} = 0.7$	1 mm	δ_{s3} min =	• 0.3 mm		
Deflection span 4		$\delta_{s4 max} = 4$ i	mm	$\delta_{s4 min} =$	• 0 mm		
Deflection span 5		$\delta_{s5 max} = 0.7$	1 mm	$\delta_{s5 min} =$	0.3 mm		
Maximum reaction at support A		R _{A max} = 22	.4 kN	Ra min =	22.4 kN		
Unfactored other load reaction at	support A	$R_{A_{Other}} = 2$	2.4 kN	_			
Maximum reaction at support B		R _{B_max} = 12	1.6 kN	R _{B_min} =	121.6 kN		
Unfactored other load reaction at	support B	$R_{B_{Other}} = 12$	21.6 kN				
Maximum reaction at support C		Rc_max = 12	1.8 kN	Rc_min =	= 121.8 kN		
Unfactored other load reaction at	support C	$R_{C_{Other}} = 1$	21.8 kN				
Maximum reaction at support D		R _{D_max} = 12	1.8 kN	R _{D_min} =	= 121.8 kN		
Unfactored other load reaction at	support D	$R_{D_{Other}} = 1$	21.8 kN				
Maximum reaction at support E		R _{E_max} = 12	1.6 kN	R _{E_min} = 121.6 kN			
Unfactored other load reaction at	support E	$R_{E_{Other}} = 12$	21.6 kN				
Maximum reaction at support F		R _{F_max} = 22	.4 kN	R _{F_min} =	22.4 kN		
Unfactored other load reaction at	support F	$R_{F_{Other}} = 22$	2.4 kN				
Section details							
Section type		UC 152x15	2x30 (BS4-1)				
Steel grade		S275					
From table 9: Design strength	р _у						
Thickness of element		max(T, t) =	9.4 mm				
Design strength		p _y = 275 N/	mm ²				
Modulus of elasticity		E = 205000) N/mm ²				
Ť	<u>6</u> <u>4</u> .						
	T						
157.6	1		-6.5				
	▲ • • • • • • • • • •	152.9-		→			
Lateral restraint							
		Span 1 has	s lateral restrai	nt at supports only	y		
		Span 2 has	s full lateral res	straint			
		Span 3 has	full lateral res	straint			
		Span 4 has full lateral restraint					

Span 5 has full lateral restraint

두 Tekla	Project Job no.					0507		
Tedds	1 St. Marks Crescent NW 1-71S				180507			
CONISDEE	Calcs for Steel Waling Beam			Start page no./Revision				
London	Calcs by Calcs date Checked by Checked date /				Approved by	Approved date		
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	I		1	ļ	I			
Effective length factors								
Effective length factor in major a	xis	K _x = 1.00						
Effective length factor in minor a	xis	K _y = 1.00						
Effective length factor for lateral	torsional bucklin	$1g K_{LT.A} = 1.00$						
		$K_{LT,B} = 1.00$						
		K _{LT.D} = 1.00						
		Klt.e = 1.00	I					
		K _{LT.F} = 1.00						
Classification of cross sectior	s - Section 3.5							
		ε = √[275 N	/mm ² / p _y] = 1.0	0				
Internal compression parts - T	able 11							
Depth of section		d = 123.6 n	ım					
		d / t = 19.0	$3 \times 6 = 80 \times \epsilon$	Class 1	plastic			
Outstand flanges - Table 11								
Width of section		b = B / 2 =	76.5 mm					
		b / T = 8.1 :	$< \epsilon <= 9 \times \epsilon$	Class 1	plastic			
					Section is a	class 1 plastic		
Shear capacity - Section 4.2.3								
Design shear force		F _v = max(a	$os(V_{max})$, $abs(V_{max})$	_{nin})) = 66.5 kN				
		d / t < 70 ×	ε					
			Web does n	ot need to be c	hecked for s	hear buckling		
Shear area		$A_v = t \times D =$	1024 mm²					
Design snear resistance		$P_v = 0.6 \times p$	$D_y \times A_v = 169 \text{ KIN}$	ar rocistance o	vaaade dasia	un choar forco		
		FAJ	5 - Design she		ceeus desig	III SHEAF IOFCE		
Moment capacity at span 1 - S	ection 4.2.5	M - max/ak	$nc(M, \cdot) abc($	(M · · ·)) - 28 7	(Nm			
Moment capacity low shear - cl	1252	$M_{o} = min(n_{o})$	$\times S_{xx} = 1.5 \times n_x$	$(VISI_min)) = 20.7$	n			
		$\mathbf{C} = \mathbf{C} \mathbf{C} \mathbf{C}$	· · · · · · · · · · · · · · · · · · ·					
Effective length for lateral torsion	al buckling	- Section 4.3.3						
Slenderness ratio	lai bucking	$L_E = 1.0 \times L$	-s1 = 1750 mm					
	ion 4067	/ – LE / Tyy -						
Equivalent sienderness - Sect	ion 4.3.6.7							
Torsional index		u = 0.049 x = 15.999						
Slenderness factor		v = 1 / [1 +	0.05 × (λ / x)²] ^{0.2}	²⁵ = 0.918				
Ratio - cl.4.3.6.9		β _W = 1.000						
Equivalent slenderness - cl.4.3.6	6.7	$\lambda_{LT} = \mathbf{u} \times \mathbf{v}$	$\times \lambda \times \sqrt{[\beta_W]} = 35$.615				
Limiting slenderness - Annex B.	2.2	$\lambda_{L0}=0.4\times$	$(\pi^2 \times E / p_y)^{0.5} =$	34.310				
		$\lambda_{LT} > \lambda_{L0} - \lambda_{L0}$	Allowance sho	uld be made for	r lateral-torsi	onal buckling		
Bending strength - Section 4.3	8.6.5							
Robertson constant		$\alpha_{\text{LT}} = 7.0$						
Perry factor		η∟⊤ = max(o	$lpha_{ ext{LT}} imes (\lambda_{ ext{LT}} - \lambda_{ ext{L0}}) \; /$	1000, 0) = 0.00	9			
Euler stress		$p_E = \pi^2 \times E$	$p_{E} = \pi^{2} \times E / \lambda_{LT}^{2} = 1595.1 \text{ N/mm}^{2}$					
		$\phi_{LT} = (p_y + ($	η_{LT} + 1) × p _E) / 2	2 = 942.3 N/mm ²	!			

Tekla Tedds Conisbee 1-5 Offord Street	Project	1 St. Marks Cre	scent NW1-71	ſS	Job no.	0507			
Iedds Conisbee 1-5 Offord Street	Cales for								
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1-5 Offord Street	Conisbee Calcs for				Start page no./F	Revision			
London		Steel Wa	ling Beam	5					
N1 1DH	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date			
	DB	25/07/2018							
Bending strength - Annex B.2.	1	$p_b = p_E \times p_y$	/ (φ _{LT} + (φ _{LT} ² -	p _E × p _y) ^{0.5}) = 272	N/mm ²				
Equivalent uniform moment	factor - Section 4	4.3.6.6							
Moment at quarter point of sec	ment	M2 = 5.5 kN	lm						
Moment at centre-line of segm	ent	M ₃ = 2.6 kN	M ₃ = 2.6 kNm						
Moment at three quarter point of segment		M ₄ = 8.8 kNm							
Maximum moment in segment		M _{abs} = 28.7 kNm							
Maximum moment governing buckling resistance		e M _{LT} = M _{abs} =	M _{LT} = M _{abs} = 28.7 kNm						
Equivalent uniform moment fac	ctor for lateral-tors	sional buckling							
		$m_{LT} = max(0)$).2 + (0.15 × M	$I_2 + 0.5 \times M_3 + 0.1$	$15 imes M_4$) / M_{abs}	, 0.44) = 0.440			
Buckling resistance moment	- Section 4.3.6.4	Ļ							
Buckling resistance moment		$M_b = p_b \times S_b$	_{xx} = 67.4 kNm						
		$M_{b} / m_{LT} = 1$	I 53.1 kNm						
		PA	SS - Moment	capacity excee	ds design ben	ding moment			
Check vertical deflection - S	ection 2.5.2								
Consider deflection due to othe	er loads								
Limiting deflection		$\delta_{\text{lim}} = L_{s4} / 3$	60 = 8.333 mr	n					
Maximum deflection apon 4		$\delta = \max(ab)$	s(δ _{max}), abs(δ _m	(m)) = 4.046 mm					
waximum denection span 4		0							

	Project	1 St. Marks Cre	St. Marks Crescent NW1-7TS				
Conisbee	Calcs for				Start page no./Revision		
1-5 Offord Street		Steel Tempora	try Works Stru	ut	1		
N1 1DH	Calcs by DB	Calcs date 25/07/2018	Checked by	Checked date	Approved by	Approved c	
			<u> </u>				
STEEL MEMBER DESIGN	(BS5950)						
In accordance with BS595	50-1:2000 incorpora	ating Corrigend	um No.1		TEDDS calcu	lation version 3	
Section details							
Section type		UC 152x15	2x30 (BS4-1)				
Steel grade		S275					
From table 9: Design stre	ngth p _y						
Thickness of element		max(T, t) =	9.4 mm				
Design strength		$p_y = 275 \text{ N/}$	mm²				
Modulus of elasticity		E = 205000	N/mm²				
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	▲ 6 4 4 4 4 4 4 4 4						
	Ť						
		152.9-		→			
Lateral restraint							
Distance between major ax	is restraints	L _x = 5000 n	ım				
Distance between minor ax	is restraints	L _y = 5000 n	ım				
Effective length factors							
Effective length factor in ma	ajor axis	K _x = 1.00					
Effective length factor in mi	nor axis	K _y = 1.00					
Effective length factor for la	teral-torsional buckl	ing K _{LT} = 1.00					
Classification of cross se	ctions - Section 3.	5					
		ε = √[275 N	$/mm^{2} / p_{y}] = 1$.00			
Internal compression part	ts - Table 11						
Depth of section		d = 123.6 n	ım				
Stress ratios		r1 = min(F₅	/ (d \times t \times p _{yw}),	1) = 1			
		$r2 = F_{c} / (A$	× p _{yw}) = 0.232	2			
		d / t = 19.0	×ε<= max(80	$0 \times \epsilon / (1 + r1), 40 \times$	ε) Clas	ss 1 plastic	
Outstand flanges - Table	11						
Width of section		b = B / 2 =	76.5 mm				
		. –					
		b / T = 8 1 ·	3 × 9 => 3 >	Class 1	plastic		

두 Tekla	Project	1 St. Marka Cr	2000 pt NW/1 7		Job no.	0507		
Tedds	Oslas fa					180507		
1-5 Offord Street	Calcs for	Steel Tempor	arv Works Stri	ıt	Start page no./	Revision 2		
London -	Calcs by	Calcs date	Approved by					
N1 1DH	DB	25/07/2018	Unconcer by		Approved by			
Moment capacity - Section 4.2.	5							
Design bending moment	•	M = 1 kNm						
Moment capacity low shear - cl.4	.2.5.2	M _c = min(p	$_{y} \times S_{xx}, 1.2 \times p_{y}$	_y × Z _{xx}) = 68.1 kN	lm			
Effective length for lateral-tors	ional buckli	ng - Section 4.3.	5					
Effective length for lateral torsion	al buckling	L _E = 1.0 × 1	_y = 5000 mm					
Slenderness ratio		$\lambda = L_E \ / \ r_{yy}$	= 130.643					
Equivalent slenderness - Secti	on 4.3.6.7							
Buckling parameter		u = 0.849						
Torsional index		x = 15.999						
Slenderness factor		v = 1 / [1 +	$0.05\times(\lambda/x)^2]$	^{0.25} = 0.693				
Ratio - cl.4.3.6.9		βw = 1.000						
Equivalent slenderness - cl.4.3.6	.7	$\lambda_{LT} = u \times v$	$\times \lambda \times \sqrt{[\beta w]} = 7$	6.829				
Limiting slenderness - Annex B.2	.2	$\lambda_{L0}=0.4\times$	$(\pi^2 \times E / p_y)^{0.5}$	= 34.310				
		$\lambda_{LT} > \lambda_{LO}$ -	Allowance sh	ould be made f	or lateral-tors	ional buckling		
Bending strength - Section 4.3	.6.5							
Robertson constant		$\alpha_{LT} = 7.0$						
Perry factor $\eta_{LT} = \max(\alpha_{LT} \times (\lambda_{LT} - \lambda_{LO}))$					98			
Euler stress $p_{E} = \pi^{2} \times E / \lambda_{LT^{2}} = 342.8 \text{ N/mm}^{2}$								
		$\phi_{LT} = (p_y + $	(η _{LT} + 1) × p _E) ,	/ 2 = 359.9 N/mn	n ²			
Bending strength - Annex B.2.1		$p_b = p_E \times p_E$	_/ / (φ _{LT} + (φ _{LT} ² -	$p_E \times p_y)^{0.5}$ = 172	2.1 N/mm ²			
Equivalent uniform moment fac	ctor - Sectio	on 4.3.6.6						
Equivalent uniform moment facto	r for LTB	m∟⊤ = 1.00	D					
Buckling resistance moment -	Section 4.3	6.4						
Buckling resistance moment		$M_b = p_b \times S$	5 _{xx} = 42.6 kNm					
		$M_b / m_{LT} = 0$	42.6 kNm					
		PASS - Buckli	ng resistance	moment excee	ds design bei	nding moment		
Compression members - Section	on 4.7							
Design compression force		F _c = 243.6	kN					
Effective length for major (x-x)	axis buckli	ng - Section 4.7.3	}					
Effective length for buckling		$L_{Ex} = L_x \times F$	K _x = 5000 mm					
Slenderness ratio - cl.4.7.2		$\lambda_x = L_{Ex} / r_x$	_x = 73.975					
Compressive strength - Section	n 4.7.5							
Limiting slenderness		$\lambda_0 = 0.2 \times ($	$\pi^2 \times E / p_{y})^{0.5} =$	17.155				
Strut curve - Table 23		b						
Robertson constant		$\alpha_{\rm x}=3.5$						
Perry factor		$\eta_{x} = \alpha_{x} \times (\lambda_{x})$.x - λο) / 1000 =	= U.199				
Euler stress		$p_{Ex} = \pi^2 \times E$	$L / \lambda_x^2 = 369.7$		2			
Compropolite strength Arrow O	4	$\phi_{x} = (p_{y} + (1))$	$\eta_x + 1$ \times p _{Ex}) /	2 = 359.1 N/mm ²	- 			
Compressive strength - Annex C	. 1	$p_{cx} = p_{Ex} \times$	µy / (φx + (φx [∠] -	$p_{Ex} \times p_y)^{0.0} = 193$	5.9 IN/MM ²			
Compression resistance - Sect	ion 4.7.4							
Compression resistance - cl.4.7.4	4	$P_{cx} = A \times p$	_{cx} = 742 kN					
		PASS - Con	pression res	stance exceeds	s design com	pression force		

	Project Jot 1 St. Marks Crescent NW1-7TS					0507			
Conisbee	Calcs for	Start page no./Revision							
1-5 Offord Street		Steel Tempor	ary Works Stru	ut	3				
London N1 1DH	Calcs by DB	Calcs date 25/07/2018	Checked by	Checked date	Approved by	Approved date			
Effective length for minor (y-	/) axis buckling	g - Section 4.7.3	i						
Effective length for buckling		$L_{Ey} = L_y \times k$	K _y = 5000 mm						
Slenderness ratio - cl.4.7.2	$\lambda_y = L_{Ey} / r_{yy} =$ 130.643								
Compressive strength - Section	on 4.7.5								
Limiting slenderness		$\lambda_0 = 0.2 \times 0$	$(\pi^2 \times E / p_y)^{0.5} =$	= 17.155					
Strut curve - Table 23		с	C						
Robertson constant	$\alpha_y = 5.5$	α _y = 5.5							
Perry factor		$\eta_y = \alpha_y \times (\lambda_y)$	$\eta_y = \alpha_y \times (\lambda_y - \lambda_0) \ / \ 1000 = \textbf{0.624}$						
Euler stress		$p_{Ey} = \pi^2 \times E / \lambda_y^2 = 118.5 \text{ N/mm}^2$							
		$\phi_y = (p_y + f)$	η _y + 1) × p _{Ey}) /	2 = 233.8 N/mm ²	2				
Compressive strength - Annex	$p_{cy} = p_{Ey} \times$	$p_y / (\phi_y + (\phi_y^2 -$	$p_{Ey} \times p_y)^{0.5}) = 85.2$	3 N/mm ²					
Compression resistance - Se	ction 4.7.4								
Compression resistance - cl.4.7	7.4	$P_{cy} = A \times p$	_{cy} = 326.3 kN						
		PASS - Con	npression res	istance exceeds	s design com	pression force			
Compression members with	moments - Sec	tion 4.8.3							
Comb.compression & bending	check - cl.4.8.3.	$F_c / (A \times p_y)$) + M / M _c = 0.	246					
		PASS	Combined b	ending and com	pression che	ck is satisfied			
Member buckling resistance	- Section 4.8.3.	.3							
Max major axis moment govern	iing M₀	$M_{LT} = M_x =$	1.00 kNm						
Equivalent uniform moment fac	tor for major ax	is flexural bucklir	ng						
		m _x = 1.000							
		m _y = 1.000							
Buckling resistance checks - cl	.4.8.3.3.2	$F_c / P_{cx} + n$	$m_x \times M / M_c \times (1)$	+ $0.5 \times F_c / P_{cx}$)	= 0.345				
		$F_c / P_{cy} + n$	$n_{LT} \times M_{LT} / M_{b} =$	= 0.770					
		1	PASS - Memb	er buckling resi	stance check	s are satisfied			