<b>Tekl</b> a	Project	45 Lancast	Job Ref. 16210 Sheet no./rev.						
Tedds avid A Berle Consulting Engineers	Section								
271 Creighton Avenue			1		1				
London N2 9P	Calc. by	Date 26-Nov-16	Chk'd by	Date	App'd by	Date			
Calculations for retaining wall base	-	prepared by Hartl	eys Projects	Ltd series LG03	3				
SI report shows stiff London clay to	o depth								
surcharge load @ 10kN/m <sup>2</sup>									
TIMBER FLOOR LOADING (1ST I	FLOOR)								
Dead load Boards		Floor <sub>1 D1</sub> = <b>0.1</b>	<b>5</b> kN/m <sup>2</sup>						
Joists		Floor <sub>1_D1</sub> = <b>0.1</b> Floor <sub>1_D2</sub> = <b>0.1</b>							
Ceiling		Floor <sub>1 D3</sub> = <b>0.1</b>							
Total dead load		-		oor1 p2.Floor1 n	<sub>3</sub> ) = <b>0.44</b> kN/m <sup>2</sup>				
Imposed load Imposed load		Floor <sub>1 11</sub> = <b>1.50</b>	$kN/m^2$						
Partitions		Floor <sub>1 12</sub> = $0.00$							
Total imposed load		—		or <sub>1_l2</sub> ) = <b>1.50</b> kN	kN/m <sup>2</sup>				
				(112) = 1.00 km	•/ • • •				
Total 1st floor loads	-			$= -1.04 \text{ kN}/m^2$					
Unfactored foundation design loads Factored design loads	5	w <sub>floor1_u</sub> = Floor <sub>1_DL</sub> + Floor <sub>1_IL</sub> = <b>1.94</b> kN/m <sup>2</sup> w <sub>floor1_f</sub> = 1.4 × Floor <sub>1_DL</sub> + 1.6 × Floor <sub>1_IL</sub> = <b>3.02</b> kN/m <sup>2</sup>							
ROOF LOADING (FLAT TIMBER	ROOF)								
Dead load									
Chippings		Roof <sub>D1</sub> = 0.10	kN/m²						
Felt		Roof <sub>D2</sub> = 0.15							
Insulation and vapour barrier		Roof <sub>D3</sub> = <b>0.05</b>							
Boarding		Roof <sub>D4</sub> = <b>0.10</b>							
Joists		Roof <sub>D5</sub> = 0.15							
Ceiling		$Roof_{D6} = 0.14$							
Services		Roof <sub>D7</sub> = 0.05	KIN/M²						
Total dead load on plan Roof <sub>DL</sub> = sum(Roof <sub>D1</sub> ,Roof <sub>D2</sub> ,Roof <sub>D</sub>			<b>- 0 74</b> kN/m <sup>2</sup>						
·	3,1100104,11001	5,1001 <u>6</u> ,1001 <u>6</u> 7) -	<b>V.7 A</b> (A)(1)						
Imposed load			N1/m2						
Roof imposed load		Roof <sub>IL</sub> = <b>0.75</b> k	IN/111-						
Total roof loads									
Unfactored foundation design loads	S	$W_{roof_u} = Roof_D$			NH 2				
Factored design loads		$W_{mast f} = 1 / 1 \vee F$	<b>(001</b> 0) + 1.6 ×	c Roof <sub>IL</sub> = 2.24 k	(N/m²				
-		W1001_1 - 1.4 × 1							
CAVITY WALL LOADING		W1001_1 - 1. <del>4</del> ^ 1							
		WI001_1 - 1. <del>4</del> ^ 1							

Project Project Project Section Calc. by Calc. by			45 Lancast	ter Grove NW3	Job Ref. 16210		
						Sheet no./rev	<i>I</i> .
							2
			Date 26-Nov-16	Chk'd by	Date	App'd by	Date
Masonry (inner leaf)			CW <sub>D2</sub> = <b>0.80</b> k	κN/m <sup>2</sup>			
Plaster			CW <sub>D3</sub> = <b>0.15</b> k	kN/m²			
Total dead load			CW <sub>DL</sub> = sum(0	CWD1,CWD2,CV	V <sub>D3</sub> ) = <b>3.20</b> kN	/m <sup>2</sup>	
Total cavity wall lo	oad						
Unfactored foundat	tion design loads	i	$w_{cw_u} = CW_{DL}$	= <b>3.20</b> kN/m <sup>2</sup>			
Factored design loa	ads		$w_{cw_f} = 1.4 \times C$	CW <sub>DL</sub> = <b>4.48</b> kN	l/m²		
load to retaining wa	all						
floor dead		1.54	live	5.25			
roof	0.74x3.5	2.59		<u>2.63</u>			
wall	3.20x3	<u>9.60</u>		7.88kN/m			
		13.73kN	l/m				
TAINING WALL AN			1			TEDDS calculat	tion version 1.2.0
<u>RETAINING WALL</u> Wall details	<u>. ANALYSIS (BS</u>			onned at base	s.	TEDDS calculat	tion version 1.2.0
RETAINING WALL Wall details Retaining wall type	<u>. ANALYSIS (BS</u>		Cantilever pro	opped at base	9	TEDDS calculat	tion version 1.2.0
<u>RETAINING WALL</u> Wall details	<u>ANALYSIS (BS</u>		<b>Cantilever pr</b> h <sub>stem</sub> = <b>3200</b> m	nm	3	TEDDS calculat	tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining	<u>ANALYSIS (BS</u>		Cantilever pro	ım	•	TEDDS calculat	tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s	<u>ANALYSIS (BS</u>		<b>Cantilever pr</b> h <sub>stem</sub> = 3200 m t <sub>wall</sub> = 300 mm	ım ı	)	TEDDS calculat	tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s Length of toe	<u>ANALYSIS (BS</u> wall stem tem		<b>Cantilever pr</b> h <sub>stem</sub> = <b>3200</b> m t <sub>wall</sub> = <b>300</b> mm I <sub>toe</sub> = <b>1350</b> mm I <sub>heel</sub> = <b>150</b> mm	ım ı		TEDDS calculat	tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s Length of toe Length of heel	<u>ANALYSIS (BS</u> wall stem tem		<b>Cantilever pr</b> h <sub>stem</sub> = <b>3200</b> m t <sub>wall</sub> = <b>300</b> mm I <sub>toe</sub> = <b>1350</b> mm I <sub>heel</sub> = <b>150</b> mm	nm 11 12 + t <sub>wall</sub> = <b>1800</b>		TEDDS calculat	tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s Length of toe Length of heel Overall length of ba	<u>ANALYSIS (BS</u> wall stem tem		<b>Cantilever pr</b> h <sub>stem</sub> = <b>3200</b> m t <sub>wall</sub> = <b>300</b> mm I <sub>toe</sub> = <b>1350</b> mm I <sub>heel</sub> = <b>150</b> mm I <sub>base</sub> = I <sub>toe</sub> + I <sub>hee</sub>	nm 11 12 + t <sub>wall</sub> = <b>1800</b>		TEDDS calculat	tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining of Thickness of wall st Length of toe Length of heel Overall length of bas Thickness of base Depth of downstand Position of downstand	<u>ANALYSIS (BS</u> wall stem tem ase		Cantilever pro h <sub>stem</sub> = 3200 m $t_{wall}$ = 300 mm $l_{toe}$ = 1350 mm $l_{heel}$ = 150 mm $l_{base}$ = $l_{toe}$ + $l_{heel}$ $t_{base}$ = 350 mm $d_{ds}$ = 500 mm $l_{ds}$ = 0 mm	nm 11 12 + t <sub>wall</sub> = <b>1800</b>		TEDDS calculat	tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s Length of toe Length of heel Overall length of base Depth of downstand Position of downstand	ANALYSIS (BS wall stem tem ase d and stand		Cantilever pro h <sub>stem</sub> = 3200 m t <sub>wall</sub> = 300 mm l <sub>toe</sub> = 1350 mm l <sub>heel</sub> = 150 mm l <sub>base</sub> = l <sub>toe</sub> + l <sub>heel</sub> t <sub>base</sub> = 350 mm d <sub>ds</sub> = 500 mm l <sub>ds</sub> = 0 mm t <sub>ds</sub> = 200 mm	nm n el + t <sub>wall</sub> = <b>1800</b> n	mm	TEDDS calculat	tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s Length of toe Length of toe Length of heel Overall length of base Depth of downstant Position of downstant Thickness of downs Height of retaining	ANALYSIS (BS wall stem tem ase d and stand wall		Cantilever pro h <sub>stem</sub> = 3200 m t <sub>wall</sub> = 300 mm $I_{toe}$ = 1350 mm $I_{heel}$ = 150 mm $I_{heel}$ = 150 mm $I_{base}$ = 150 mm $I_{base}$ = 350 mm $I_{ds}$ = 500 mm $I_{ds}$ = 0 mm $t_{ds}$ = 200 mm h <sub>wall</sub> = h <sub>stem</sub> + t	nm el + t <sub>wall</sub> = <b>1800</b> n :base + dds = <b>405</b>	mm	TEDDS calculat	tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s Length of toe Length of heel Overall length of bas Depth of downstand Position of downstand Height of retaining to Depth of cover in fr	ANALYSIS (BS wall stem tem ase d and stand wall ont of wall		Cantilever prohister = 3200 m $h_{stem}$ = 3200 m $t_{wall}$ = 300 mm $l_{toe}$ = 1350 mm $l_{heel}$ = 150 mm $l_{base}$ = 150 mm $l_{base}$ = 350 mm $d_{ds}$ = 500 mm $l_{ds}$ = 0 mm $t_{ds}$ = 200 mm $h_{wall}$ = $h_{stem}$ + t $d_{cover}$ = 200 mm	nm el + t <sub>wall</sub> = <b>1800</b> n sbase + d <sub>ds</sub> = <b>405</b> m	mm	TEDDS calculat	tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s Length of toe Length of heel Overall length of base Depth of downstan Position of downstan Thickness of downstan Height of retaining Depth of cover in fr Depth of unplanned	ANALYSIS (BS wall stem tem ase d and stand wall ont of wall d excavation		Cantilever pro h <sub>stem</sub> = 3200 m t <sub>wall</sub> = 300 mm l <sub>toe</sub> = 1350 mm l <sub>heel</sub> = 150 mm l <sub>base</sub> = l <sub>toe</sub> + l <sub>heel</sub> t <sub>base</sub> = 350 mm d <sub>ds</sub> = 500 mm l <sub>ds</sub> = 0 mm t <sub>ds</sub> = 200 mm h <sub>wall</sub> = h <sub>stem</sub> + t d <sub>cover</sub> = 200 mm	nm el + t <sub>wall</sub> = <b>1800</b> n ibase + d <sub>ds</sub> = <b>405</b> m	mm	TEDDS calculat	tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s Length of toe Length of heel Overall length of base Depth of downstan Position of downstan Height of retaining Depth of cover in fr Depth of unplanned	ANALYSIS (BS wall stem tem ase d and stand wall ont of wall d excavation ater behind wall		Cantilever pro h <sub>stem</sub> = 3200 m t <sub>wall</sub> = 300 mm $I_{toe}$ = 1350 mm $I_{heel}$ = 150 mm $I_{base}$ = 150 mm $I_{base}$ = 350 mm $I_{ds}$ = 500 mm $I_{ds}$ = 0 mm $I_{ds}$ = 200 mm h <sub>wall</sub> = h <sub>stem</sub> + t d <sub>cover</sub> = 200 mm h <sub>water</sub> = 1500 m	nm el + t <sub>wall</sub> = <b>1800</b> n Sbase + dds = <b>405</b> m nm	mm 5 <b>0</b> mm		tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s Length of toe Length of heel Overall length of bas Depth of downstand Position of downstand Position of downstand Height of retaining Depth of cover in fr Depth of unplanned Height of ground wa	ANALYSIS (BS wall stem tem ase d and stand wall ont of wall d excavation ater behind wall fill above base		Cantilever pro hstem = 3200 m twall = 300 mm $l_{toe} = 1350$ mm $l_{heel} = 150$ mm $l_{base} = l_{toe} + l_{heel}$ tbase = 350 mm $d_{ds} = 500$ mm $l_{ds} = 200$ mm $l_{ds} = 200$ mm hwall = hstem + t d_{cover} = 200 mm hwater = 1500 m hster = max(hwater)	nm el + t <sub>wall</sub> = <b>1800</b> n ibase + d <sub>ds</sub> = <b>405</b> m n nm ter - t <sub>base</sub> - d <sub>ds</sub> , C	mm 5 <b>0</b> mm		tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall si Length of toe Length of heel Overall length of base Depth of downstan Position of downstan Thickness of downs Height of retaining Depth of cover in fr Depth of unplanned Height of ground wa Height of saturated Density of wall cons	ANALYSIS (BS wall stem tem ase d and stand wall ont of wall d excavation ater behind wall fill above base struction		Cantilever pro h <sub>stem</sub> = 3200 m t <sub>wall</sub> = 300 mm l <sub>toe</sub> = 1350 mm l <sub>heel</sub> = 150 mm l <sub>base</sub> = l <sub>toe</sub> + l <sub>heel</sub> t <sub>base</sub> = 350 mm d <sub>ds</sub> = 500 mm l <sub>ds</sub> = 0 mm t <sub>ds</sub> = 200 mm h <sub>wall</sub> = h <sub>stem</sub> + t d <sub>cover</sub> = 200 mm h <sub>wat</sub> = 1500 m h <sub>sat</sub> = max(h <sub>wat</sub> $\gamma_{wall}$ = 23.6 kN/	the formula is the f	mm 5 <b>0</b> mm		tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s Length of toe Length of heel Overall length of base Depth of downstand Position of downstand Position of downstand Thickness of downs Height of retaining Depth of cover in fr Depth of unplanned Height of ground wa Height of saturated Density of wall cons	ANALYSIS (BS wall stem tem ase d and stand wall ont of wall d excavation ater behind wall fill above base struction		Cantilever pro hstem = 3200 m twall = 300 mm ltoe = 1350 mm lheel = 150 mm lbase = ltoe + lheet tbase = 350 mm dds = 500 mm lds = 0 mm tds = 200 mm hwall = hstem + t dcover = 200 mm hwater = 1500 m hsat = max(hwat $\gamma$ wall = 23.6 kN/ $\gamma$ base = 23.6 kN/	the formula is the f	mm 5 <b>0</b> mm		tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s Length of toe Length of heel Overall length of base Thickness of base Depth of downstan Position of downstan Position of downstan Depth of cover in fr Depth of cover in fr Depth of unplanned Height of saturated Density of wall com Density of base cor Angle of rear face of	ANALYSIS (BS wall stem tem ase d and stand wall ont of wall d excavation ater behind wall fill above base struction nstruction		Cantilever pro- h <sub>stem</sub> = 3200 m t <sub>wall</sub> = 300 mm l <sub>toe</sub> = 1350 mm l <sub>heel</sub> = 150 mm l <sub>base</sub> = l <sub>toe</sub> + l <sub>heel</sub> t <sub>base</sub> = 350 mm d <sub>ds</sub> = 500 mm l <sub>ds</sub> = 200 mm h <sub>wall</sub> = h <sub>stem</sub> + t d <sub>cover</sub> = 200 mm h <sub>wat</sub> = 1500 m h <sub>sat</sub> = max(h <sub>wal</sub> $\gamma_{wall}$ = 23.6 kN $\alpha$ = 90.0 deg	the formula is the f	mm 5 <b>0</b> mm		tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall s Length of toe Length of heel Overall length of base Depth of downstan Position of downstan Thickness of downs Height of retaining Depth of cover in fr Depth of unplanned Height of ground wa Height of saturated Density of wall cons Density of base cor Angle of rear face of Angle of soil surface	ANALYSIS (BS wall stem tem ase d and stand wall ont of wall d excavation ater behind wall fill above base struction nstruction of wall we behind wall	<u>5 8002:1994)</u>	Cantilever pro hstem = 3200 m twall = 300 mm ltoe = 1350 mm lheel = 150 mm lbase = ltoe + lheet tbase = 350 mm dds = 500 mm lds = 0 mm tds = 200 mm hwall = hstem + t dcover = 200 mm hwater = 1500 m hsat = max(hwat $\gamma$ wall = 23.6 kN, $\gamma$ base = 23.6 kN, $\alpha$ = 90.0 deg $\beta$ = 0.0 deg	the formula is the second sec	mm 5 <b>0</b> mm ) mm) = <b>650</b> m		tion version 1.2.0
RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall si Length of toe Length of heel Overall length of base Depth of downstan Position of downstan Thickness of downs Height of retaining Depth of cover in fr Depth of unplanned Height of ground wa Height of saturated Density of wall cons Density of base cor Angle of rear face of Angle of soil surface	ANALYSIS (BS wall stem tem ase d and stand wall ont of wall d excavation ater behind wall fill above base struction hstruction of wall e behind wall wirtual back of wa	<u>5 8002:1994)</u>	Cantilever pro hstem = 3200 m twall = 300 mm ltoe = 1350 mm lheel = 150 mm lbase = ltoe + lheet tbase = 350 mm dds = 500 mm lds = 0 mm tds = 200 mm hwall = hstem + t dcover = 200 mm hwater = 1500 m hsat = max(hwat $\gamma$ wall = 23.6 kN, $\gamma$ base = 23.6 kN, $\alpha$ = 90.0 deg $\beta$ = 0.0 deg	the formula is the f	mm 5 <b>0</b> mm ) mm) = <b>650</b> m		tion version 1.2.0
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RETAINING WALL Wall details Retaining wall type Height of retaining Thickness of wall si Length of toe Length of heel Overall length of base Depth of downstan Position of downstan Thickness of downs Height of retaining Depth of cover in fr Depth of unplanned Height of ground wa Height of saturated Density of wall cons Density of base cor Angle of rear face of Angle of soil surface	ANALYSIS (BS wall stem tem ase d and stand wall ont of wall d excavation ater behind wall fill above base struction hstruction of wall e behind wall virtual back of wa details	<u>5 8002:1994)</u>	Cantilever pro h <sub>stem</sub> = 3200 m t <sub>wall</sub> = 300 mm l <sub>toe</sub> = 1350 mm l <sub>heel</sub> = 150 mm l <sub>base</sub> = 150 mm l <sub>base</sub> = 350 mm d <sub>ds</sub> = 500 mm l <sub>ds</sub> = 0 mm t <sub>ds</sub> = 200 mm h <sub>wall</sub> = h <sub>stem</sub> + t d <sub>cover</sub> = 200 mm h <sub>wall</sub> = 200 mm h <sub>wat</sub> = 1500 m h <sub>sat</sub> = max(h <sub>wal</sub> $\gamma$ <sub>wall</sub> = 23.6 kN, $\alpha$ = 90.0 deg $\beta$ = 0.0 deg	the formation the second state is the second	mm 5 <b>0</b> mm ) mm) = <b>650</b> m		tion version 1.2.0

<b>Tekla</b> Tedds	Project	45 Lancas	ter Grove NW	3	Job Ref.	Job Ref. 16210		
David A Berle Consulting Engineers	Section		Sheet no./rev	3				
271 Creighton Avenue London N2 9P	Calc. by	Date 26-Nov-16	Chk'd by	Date	App'd by	Date		
Saturated density of retained mater	ial	γs <b>= 20.0</b> kN/n	1 <sup>3</sup>					
Design shear strength		<b>φ' = 24.2</b> deg						
Angle of wall friction		δ = <b>18.6</b> deg						
Base material details								
Stiff clay								
Moist density		γ <sub>mb</sub> = <b>18.0</b> kN/	m <sup>3</sup>					
Design shear strength		φ' <sub>b</sub> = <b>24.2</b> deg						
Design base friction		δ <sub>b</sub> = <b>18.6</b> deg						
Allowable bearing pressure		P <sub>bearing</sub> = <b>150</b>	⟨N/m²					
Using Coulomb theory		Ŭ						
Active pressure coefficient for retain	ned material							
		$(\alpha)^2 \times \sin(\alpha - \delta) \times [1]$	$\pm \sqrt{(\sin(b') \pm \delta)}$	$) \times ein(A' - B) / (e$	$\sin(\alpha - \delta) \times \sin(\alpha)$	+ B)))12) - <b>0 36</b>		
Passive pressure coefficient for bas	.,	$(\alpha - 0) \times [1]$	+ ν <b>(Siii</b> (ψ + 0	) × sin(φ - μ) / (s	$\sin(\alpha - \sigma) \times \sin(\alpha$	+ p)))] ) = <b>0.3</b> 0		
rassive pressure coefficient for bas		sin(90 - փ' <sub>b</sub> )² / (sin(9	00 - & ) ~ [1 - 1	$(\sin(\phi' + \delta)) \times c$	in(4', ) / (sin(00 )	+ & )))12) - <b>/ 1</b> 5		
	Кр <b>–</b> 3	$\sin(30 - \psi_{\rm B}) / (\sin(3))$	/U - 0b) × [1 - \	(3Π(ψ <sub>b</sub> · O <sub>b</sub> ) × 3		· (0))))] ) - <b>4.10</b>		
At-rest pressure								
At-rest pressure for retained materia	al	$K_0 = 1 - \sin(\phi') = 0.590$						
Loading details								
Surcharge load on plan		Surcharge = 1	<b>0.0</b> kN/m <sup>2</sup>					
Applied vertical dead load on wall		W <sub>dead</sub> = <b>13.7</b> k	:N/m					
Applied vertical live load on wall		W <sub>live</sub> = <b>7.9</b> kN/						
Position of applied vertical load on v		l <sub>load</sub> = <b>1500</b> mi						
Applied horizontal dead load on wal	I	F <sub>dead</sub> = <b>0.0</b> kN						
Applied horizontal live load on wall		F <sub>live</sub> = <b>0.0</b> kN/m						
Height of applied horizontal load on	wall	h <sub>load</sub> = <b>0</b> mm						
Vertical forces on wall								
Wall stem		$w_{wall} = h_{stem} \times 1$	$t_{wall} \times \gamma_{wall} = 2$	2.7 kN/m				
Wall base		$w_{base} = I_{base} \times I_{base}$	$t_{base} \times \gamma_{base} =$	<b>14.9</b> kN/m				
Wall downstand		$w_{\text{ds}} = d_{\text{ds}} \times t_{\text{ds}}$	×γ <sub>base</sub> = <b>2.4</b>	kN/m				
Surcharge		w <sub>sur</sub> = Surchar	ge × I <sub>heel</sub> = 1.	<b>5</b> kN/m				
Moist backfill to top of wall		$\mathbf{W}_{m_w} = \mathbf{I}_{heel} \times 0$	h <sub>stem</sub> - h <sub>sat</sub> ) × r	γm = <b>6.1</b> kN/m				
Saturated backfill		$w_s = I_{heel} \times h_{sat}$	×γs = <b>1.9</b> kN	l/m				
Soil in front of wall		$w_p = I_{toe} \times d_{cov}$	$er \times \gamma_{mb} = 4.9$	kN/m				
Applied vertical load		$W_v = W_{dead} + V_{dead}$	N <sub>live</sub> = <b>21.6</b> kM	N/m				
Total vertical load		W <sub>total</sub> = w <sub>wall</sub> +	Wbase + Wds +	Wsur + Wm_w + Ws	s + w <sub>p</sub> + W <sub>v</sub> = 75	5 <b>.9</b> kN/m		
Horizontal forces on wall								
Surcharge		$F_{sur} = K_a \times cos$	s(90 - α + δ) ×	Surcharge × h <sub>ef</sub>	<sub>ff</sub> = <b>14.2</b> kN/m			
Moist backfill above water table			. ,	$(1 + \delta) \times \gamma_m \times (h_{eff})$		kN/m		
Moist backfill below water table				$\times \gamma_{\rm m} \times (h_{\rm eff} - h_{\rm wate})$	,			
Saturated backfill			. ,	$\delta \times (\gamma_{s} - \gamma_{water}) \times$				
Water		$F_{water} = 0.5 \times h$	•	,,				
Total horizontal load			•	$F_{s} + F_{water} = 68.8$	kN/m			
		i iotai — Fsur Ŧ F	iii_a · I m_b + r	s • • water - 00.0	IXIN/111			

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Calculate propping force										
Passive resistance of soil in front of	wall	$F_p = 0.5 \times K_p$	$\times \cos(\delta_b) \times (d_c$	over + $t_{base}$ + $d_{ds}$	- $d_{exc}$ ) <sup>2</sup> × $\gamma_{mb}$ = 2	<b>5.8</b> kN/m				
Propping force		F <sub>prop</sub> = max(Ft F <sub>prop</sub> = <b>22.3</b> k <b>i</b>		al - Wsur - Wp - W	l <sub>ive</sub> ) × tan(δ <sub>b</sub> ), 0 k	N/m)				
Overturning moments										
Surcharge		$M_{sur} = F_{sur} \times (H_{sur})$	$n_{eff}$ - 2 $ imes$ d <sub>ds</sub> ) /	2 = <b>21.6</b> kNm/	m					
Moist backfill above water table		$M_{m_a} = F_{m_a} \times$	$(h_{eff} + 2 \times h_{wat}$	$_{ter}$ - 3 $ imes$ d <sub>ds</sub> ) / 3	= <b>33.7</b> kNm/m					
Moist backfill below water table		$M_{m_b} = F_{m_b} \times$	(h <sub>water</sub> - $2 \times d_c$	<sub>is</sub> ) / 2 = <b>5.4</b> kNr	n/m					
Soil in front of wall		$M_{p_o} = F_p \times [2]$	imes d <sub>ds</sub> - t <sub>base</sub> - c	d <sub>cover</sub> + d <sub>exc</sub> ] / 3	= <b>5.6</b> kNm/m					
Total overturning moment		$M_{ot} = M_{sur} + N$	I <sub>m_a</sub> + M <sub>m_b</sub> + I	M <sub>p_o</sub> = <b>66.2</b> kNr	m/m					
Restoring moments										
Wall stem		$M_{wall}$ = $w_{wall}$ ×	$(I_{toe} + t_{wall} / 2)$	= <b>34</b> kNm/m						
Wall base		M <sub>base</sub> = w <sub>base</sub> >	< I <sub>base</sub> / 2 = <b>13</b> .	. <b>4</b> kNm/m						
Wall downstand		$M_{ds} = w_{ds} \times (I_{ds})$	s + t <sub>ds</sub> / 2) = <b>0</b> .	. <b>2</b> kNm/m						
Moist backfill		Mm_r = (wm_w >	$M_{m_r} = (w_{m_w} \times (I_{base} - I_{heel} / 2) + w_{m_s} \times (I_{base} - I_{heel} / 3)) = 10.6 \text{ kNm/m}$							
Saturated backfill		$M_{s_r} = W_s \times (I_{base} - I_{heel} / 2) = 3.4 \text{ kNm/m}$								
Design vertical dead load		M <sub>dead</sub> = W <sub>dead</sub> × I <sub>load</sub> = <b>20.6</b> kNm/m								
Total restoring moment		M <sub>rest</sub> = M <sub>wall</sub> +	$M_{rest} = M_{wall} + M_{base} + M_{ds} + M_{m_r} + M_{s_r} + M_{dead} = 82.1 \text{ kNm/m}$							
Check bearing pressure										
Surcharge		$M_{sur_r} = w_{sur} \times$	(I <sub>base</sub> - I <sub>heel</sub> / 2)	) = <b>2.6</b> kNm/m						
Soil in front of wall		$M_{p_r} = w_p \times I_{toe}$	, / 2 <b>= 3.3</b> kNn	n/m						
Design vertical live load		$M_{live} = W_{live} \times$	$M_{live} = W_{live} \times I_{load} = 11.8 \text{ kNm/m}$							
Total moment for bearing		$M_{total} = M_{rest} - M_{ot} + M_{sur_r} + M_{p_r} + M_{live} = 33.6 \text{ kNm/m}$								
Total vertical reaction		R = W <sub>total</sub> = <b>75.9</b> kN/m								
Distance to reaction		x <sub>bar</sub> = M <sub>total</sub> / R = <b>442</b> mm								
Eccentricity of reaction		e = abs((l <sub>base</sub> /	( 2) - x <sub>bar</sub> ) = <b>45</b>	<b>8</b> mm						
					ts outside mida	lle third of ba				
Bearing pressure at toe		p <sub>toe</sub> = R / (1.5		<b>↓</b> kN/m²						
Bearing pressure at heel		p <sub>heel</sub> = 0 kN/m <b>PASS - Maximum</b>		sura is lass tl	han allowablo b	arina prossu				
		FASS - Maximum	bearing pres	sule is less li		eaning pressu				
RETAINING WALL DESIGN (BS 8	<u>002:1994)</u>				TEDDS calculat	ion version 1.2.01				
Ultimate limit state load factors										
Dead load factor		γ <sub>f_d</sub> = <b>1.4</b>								
Live load factor		γ <sub>f I</sub> = <b>1.6</b>								
Earth and water pressure factor		γ <sub>f_e</sub> = <b>1.4</b>								
Factored vertical forces on wall										
Wall stem		Wwall f = $\gamma_{fd} \times$	$h_{stem} \times t_{wall} \times \gamma_{v}$	wall = <b>31.7</b> kN/n	n					
Wall base		$W_{wall_f} = \gamma_{f_d} \times h_{stem} \times t_{wall} \times \gamma_{wall} = 31.7 \text{ kN/m}$ $W_{base_f} = \gamma_{f_d} \times I_{base} \times t_{base} \times \gamma_{base} = 20.8 \text{ kN/m}$								
Wall downstand			Wbase_t = $\gamma_{f_d} \times d_{ds} \times t_{base} \times \gamma_{base} = 20.6 \text{ kN/m}$ Wds_f = $\gamma_{f_d} \times d_{ds} \times t_{ds} \times \gamma_{base} = 3.3 \text{ kN/m}$							
			$W_{ds_f} = \gamma_{f_d} \times d_{ds} \times t_{ds} \times \gamma_{base} = 3.3 \text{ KN/m}$ $W_{sur_f} = \gamma_{f_l} \times \text{Surcharge} \times I_{heel} = 2.4 \text{ kN/m}$							

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Moist backfill to top of wall		$W_{m_w_f} = \gamma_{f_d} \times$	I <sub>heel</sub> × (h <sub>stem</sub> - h	n <sub>sat</sub> ) × γ <sub>m</sub> = <b>8.6</b>	kN/m				
Saturated backfill		$W_{s_f} = \gamma_{f_d} \times I_{hee}$	$h_{sat} \times h_{sat} \times \gamma_s =$	<b>2.7</b> kN/m					
Soil in front of wall		$w_{p_f} = \gamma_{f_d} \times I_{toe}$	$x \times d_{cover}  imes \gamma_{mb}$	= <b>6.8</b> kN/m					
Applied vertical load		$W_{v\_f} = \gamma_{f\_d} \times W$	dead + $\gamma_{f_l} \times W_{li}$	<sub>ive</sub> = <b>31.8</b> kN/m	1				
Total vertical load kN/m		W <sub>total_f</sub> = w <sub>wall_f</sub>	+ W <sub>base_f</sub> + W <sub>d</sub>	ls_f + Wsur_f + Wn	n_w_f + Ws_f + Wp_f	+ W <sub>v_f</sub> = 108.2			
Factored horizontal active forces	on wall								
Surcharge		$F_{sur_f} = \gamma_{f_l} \times K_a$	$a \times \cos(90 - \alpha)$	+ $\delta$ ) × Surchar	ge × h <sub>eff</sub> = <b>22.7</b> kl	N/m			
Moist backfill above water table		$F_{m_a_f} = \gamma_{f_e} \times 0$	$0.5  imes K_a  imes \cos \theta$	(90 - α + δ) × γι	$m \times (h_{eff} - h_{water})^2 =$	= <b>25.5</b> kN/m			
Moist backfill below water table		$F_{m\_b\_f} = \gamma_{f\_e} \times F$	$x_a  imes \cos(90 - c)$	$(\alpha + \delta) \times \gamma_m \times (h)$	$_{ m eff}$ - $h_{ m water}$ ) $ imes$ $h_{ m water}$	= <b>30</b> kN/m			
Saturated backfill		$F_{s_f} = \gamma_{f_e} \times 0.5$	$5 \times K_a \times cos(90)$	$(\gamma_{s}-\alpha+\delta)\times(\gamma_{s}-\alpha+\delta)$	$\gamma_{water}$ ) × $h_{water}^2$ =	<b>5.6</b> kN/m			
Water		$F_{water_f} = \gamma_{f_e} \times$	$0.5  imes h_{water}^2  imes$	γ <sub>water</sub> = <b>15.5</b> k	N/m				
Total horizontal load		F <sub>total_f</sub> = F <sub>sur_f</sub> +	- F <sub>m_a_f</sub> + F <sub>m_b</sub>	_f + Fs_f + F <sub>water</sub>	<sub>r_f</sub> = <b>99.2</b> kN/m				
Calculate propping force									
Passive resistance of soil in front of	fwall	$F_{p_f} = \gamma_{f_e} \times 0.5$	$5  imes K_{p}  imes cos(\delta_{b})$	$(d_{cover} + t_{bas}) \times (d_{cover} + t_{bas})$	se + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup> × $\gamma$	<sub>mb</sub> = <b>36.1</b> kN/m			
Propping force kN/m)				$F_{prop\_f} = max(F_{total\_f} - F_{p\_f} - (W_{total\_f} - w_{sur\_f} - w_{p\_f} - \gamma_{f\_i} \times W_{live}) \times tan(\delta_{b}), 0$					
		F <sub>prop_f</sub> = <b>34.0</b> k	N/m						
Factored overturning moments									
Surcharge		$M_{sur_f} = F_{sur_f} \times$	(h <sub>eff</sub> - $2 \times d_{ds}$	) / 2 = <b>34.6</b> kNi	m/m				
Moist backfill above water table		$M_{m\_a\_f} = F_{m\_a\_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 47.1 \text{ kNm/m}$							
Moist backfill below water table		$M_{m\_b\_f} = F_{m\_b\_f} \times (h_{water} - 2 \times d_{ds}) / 2 = 7.5 \text{ kNm/m}$							
Soil in front of wall		$M_{p\_o\_f} = F_{p\_f} \times [2 \times d_{ds} - t_{base} - d_{cover} + d_{exc}] / 3 = 7.8 \text{ kNm/m}$							
Total overturning moment		$M_{ot_f} = M_{sur_f} +$	$M_{m_a_f} + M_{m_b}$	<sub>f</sub> + M <sub>p_o_f</sub> = 97	<b>/</b> kNm/m				
Restoring moments									
Wall stem		$M_{wall_f} = w_{wall_f}$	$\times$ (I <sub>toe</sub> + t <sub>wall</sub> / 2	2) = <b>47.6</b> kNm/	m				
Wall base		$M_{base_f} = w_{base_f}$	$_{f} \times I_{base} / 2 = 1$	l <b>8.7</b> kNm/m					
Wall downstand		$M_{ds\_f} = w_{ds\_f} \times$	$(I_{ds} + t_{ds} / 2) =$	<b>0.3</b> kNm/m					
Surcharge		$M_{sur_r_f} = w_{sur_f}$	$\times$ (l_base - $l_{heel}$ /	2) = <b>4.1</b> kNm/r	m				
Moist backfill		$M_{m\_r\_f} = (w_{m\_w\_}$	$_{f} \times (I_{base} - I_{heel})$	/ 2) + W <sub>m_s_f</sub> × (	(I <sub>base</sub> - I <sub>heel</sub> / 3)) =	<b>14.8</b> kNm/m			
Saturated backfill		$M_{s_r_f} = W_{s_f} \times 0$	(I <sub>base</sub> - I <sub>heel</sub> / 2)	= <b>4.7</b> kNm/m					
Soil in front of wall		$M_{p\_r\_f} = w_{p\_f} \times$	l <sub>toe</sub> / 2 = <b>4.6</b> kM	Nm/m					
Design vertical load		$M_{v_f} = W_{v_f} \times I_{load} = 47.7 \text{ kNm/m}$							
Total restoring moment		$M_{rest_f} = M_{wall_f}$	+ M <sub>base_f</sub> + M <sub>c</sub>	ls_f + M <sub>sur_r_f</sub> + I	$M_{m\_r\_f} + M_{s\_r\_f} + N$	l <sub>p_r_f</sub> + M <sub>v_f</sub> =			
<b>142.6</b> kNm/m									
Factored bearing pressure									
Total moment for bearing		M <sub>total_f</sub> = M <sub>rest_f</sub>		kNm/m					
Total vertical reaction		$R_f = W_{total_f} = 1$							
Distance to reaction		$x_{bar_f} = M_{total_f} / R_f = 421 \text{ mm}$							
Eccentricity of reaction		e <sub>f</sub> = abs((I <sub>base</sub> /	2) - Xbar_f) = <b>4</b>		to outoide mid-	la third of La-			
Bearing pressure at toe		$p_{toe_f} = R_f / (1.5)$	5 × x <sub>bar_f</sub> ) = <b>17</b>		ts outside midd	ie unita of das			

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Bearing pressure at heel		p <sub>heel_f</sub> = 0 kN/m	$n^2 = 0 \text{ kN/m}^2$							
Rate of change of base reaction		rate = $p_{toe_f} / (3$	8 × x <sub>bar_f</sub> ) = <b>13</b>	<b>5.38</b> kN/m²/m						
Bearing pressure at stem / toe		p <sub>stem_toe_f</sub> = mai	x(p <sub>toe_f</sub> - (rate	$\times$ I <sub>toe</sub> ), 0 kN/m	<sup>2</sup> ) = <b>0</b> kN/m <sup>2</sup>					
Bearing pressure at mid stem		p <sub>stem_mid_f</sub> = ma	x(p <sub>toe_f</sub> - (rate	$e \times (I_{toe} + t_{wall} / 2)$	2)), 0 kN/m²) = <b>0</b> k	N/m²				
Bearing pressure at stem / heel		p <sub>stem_heel_f</sub> = ma	ax(p <sub>toe_f</sub> - (rate	$e \times (I_{toe} + t_{wall})),$	0 kN/m²) = <b>0</b> kN/	m²				
Design of reinforced concrete ret	aining wall	toe (BS 8002:1994	)							
Material properties										
Characteristic strength of concrete		f <sub>cu</sub> = <b>35</b> N/mm <sup>2</sup>								
Characteristic strength of reinforcer	nent	f <sub>y</sub> = <b>500</b> N/mm <sup>2</sup>	2							
Base details										
Minimum area of reinforcement		k = <b>0.13</b> %								
Cover to reinforcement in toe		c <sub>toe</sub> = <b>40</b> mm								
Calculate shear for toe design										
Shear from bearing pressure		$V_{toe\_bear} = 3 \times p$	Dtoe_f × Xbar_f / 2	2 = <b>108.2</b> kN/n	า					
Shear from weight of base		$V_{toe\_wt\_base} = \gamma_{f\_}$	$_{\rm d}  imes \gamma_{\rm base}  imes {\sf I}_{\rm toe}$	× t <sub>base</sub> = 15.6 k	۸/m					
Shear from weight of downstand		$V_{toe\_wt\_ds} = \gamma_{f\_d}$	× $\gamma_{base}$ × $d_{ds}$ ×	t <sub>ds</sub> = <b>3.3</b> kN/m	ı					
Shear from weight of soil		$V_{toe_wt_soil} = w_{p_f} - (\gamma_{f_d} \times \gamma_m \times I_{toe} \times d_{exc}) = 0.8 \text{ kN/m}$								
Total shear for toe design	Fotal shear for toe design			Vtoe = Vtoe_bear - Vtoe_wt_base - Vtoe_wt_ds - Vtoe_wt_soil = <b>88.5</b> kN/m						
Calculate moment for toe design										
Moment from bearing pressure		$M_{toe\_bear} = 3 \times 1$	$D_{toe_f} \times X_{bar_f} \times$	$(I_{toe} - x_{bar_f} + t_v)$	<sub>vall</sub> / 2) / 2 = <b>116.7</b>	kNm/m				
Moment from weight of base		$M_{toe\_wt\_base} = (\gamma$	$f_{d}  imes \gamma_{base}  imes \mathbf{t}_{base}$	$_{ase}  imes (I_{toe} + t_{wall})$	/ 2) <sup>2</sup> / 2) = <b>13</b> kNr	n/m				
Moment from weight of downstand		$M_{toe\_wt\_ds} = \gamma_{f\_d}$	$\times \gamma_{\text{base}} \times d_{\text{ds}} >$	$\times t_{ds} \times (I_{toe} - I_{ds} + I_{ds})$	+ $(t_{wall} - t_{ds}) / 2) = -$	<b>4.6</b> kNm/m				
Moment from weight of soil		$M_{toe\_wt\_soil} = (w_{p\_f} - (\gamma_{f\_d} \times \gamma_m \times I_{toe} \times d_{exc})) \times (I_{toe} + t_{wall}) / 2 = 0.6 \text{ kNm/m}$								
Total moment for toe design		$M_{toe} = M_{toe\_bear}$	- M <sub>toe_wt_base</sub> ·	- M <sub>toe_wt_ds</sub> - M <sub>to</sub>	<sub>oe_wt_soil</sub> = <b>98.4</b> kN	m/m				
Check toe in bending										
Width of toe		b = <b>1000</b> mm/r	n							
Depth of reinforcement		$d_{toe} = t_{base} - c_{to}$	<sub>e</sub> – (φ <sub>toe</sub> / 2) =	305.0 mm						
Constant		$K_{toe} = M_{toe} / (b$	$\times d_{toe}^2 \times f_{cu}) =$							
			1	-	n reinforcement	is not required				
Lever arm		•	⊦ √(0.25 - (mi	n(K <sub>toe</sub> , 0.225) /	0.9)),0.95) × d <sub>toe</sub>					
Area of toncion rainforment as mi	rod	z <sub>toe</sub> = <b>290</b> mm	/ (0 07 5		$m^2/m$					
Area of tension reinforcement requi		$A_{s_{toe_{des}}} = M_{toe}$			n-/m					
Minimum area of tension reinforcen		$A_{s\_toe\_min} = k \times$			mm <sup>2</sup> /m					
Area of tension reinforcement requi Reinforcement provided	ieu	A <sub>s_toe_req</sub> = Max 10 mm dia.ba								
Area of reinforcement provided		As_toe_prov = 78	-							
, and of real or control provided				provided at th	e retaining wall	toe is adequate				
Check shear resistance at toe			- 1		5					
Design shear stress		$v_{toe} = V_{toe} / (b >$	( d <sub>toe</sub> ) = <b>0.290</b>	<b>)</b> N/mm <sup>2</sup>						
Allowable shear stress					′mm² = <b>4.733</b> N/m	1m²				
		•	•		ess than maximu					

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From BS8110:Part 1:1997 – Table	38								
Design concrete shear stress	0.0	v <sub>c toe</sub> = <b>0.481</b>	N/mm <sup>2</sup>						
5				v <sub>toe</sub> < v <sub>c toe</sub> - No	o shear reinforc	ement requ			
Design of reinforced concrete ret	aining wall	haal (BS 8002-100		-					
	anning wan	Tieel (BS 6002.193	<u>4)</u>						
Material properties		f <sub>cu</sub> = <b>35</b> N/mm	>						
Characteristic strength of concrete Characteristic strength of reinforcen	nent	f <sub>v</sub> = <b>500</b> N/mm							
-	lent	ly – <b>300</b> N/IIII							
Base details									
Minimum area of reinforcement		k = 0.13 %							
Cover to reinforcement in heel		c <sub>heel</sub> = <b>40</b> mm							
Calculate shear for heel design									
Shear from weight of base				$_{\rm eel}  imes t_{ m base}$ = 1.7 k	κN/m				
Shear from weight of moist backfill		V <sub>heel_wt_m</sub> = w <sub>m</sub>		m					
Shear from weight of saturated back	<b>cfill</b>	V <sub>heel_wt_s</sub> = w <sub>s_</sub>							
Shear from surcharge		V <sub>heel_sur</sub> = w <sub>sur_f</sub> = <b>2.4</b> kN/m V <sub>heel</sub> = V <sub>heel_wt_base</sub> + V <sub>heel_wt_m</sub> + V <sub>heel_wt_s</sub> + V <sub>heel_sur</sub> = <b>15.4</b> kN/m							
Total shear for heel design		V <sub>heel</sub> = V <sub>heel_wt</sub>	base + Vheel_wt	_m + V <sub>heel_wt_s</sub> +	$V_{heel\_sur} = 15.4 \text{ Km}$	N/M			
Calculate moment for heel design	ı								
Moment from weight of base					∥ / 2)² / 2) = <b>0.5</b> k	Nm/m			
Moment from weight of moist backfi			•	t <sub>wall</sub> ) / 2 = <b>1.9</b> kN					
Moment from weight of saturated ba	ackfill			) / 2 = <b>0.6</b> kNm/					
Moment from surcharge				ı) / 2 = <b>0.5</b> kNm					
Total moment for heel design		M <sub>heel</sub> = M <sub>heel_w</sub>	_base + Mheel_w	vt_m + M <sub>heel_wt_s</sub> ·	+ M <sub>heel_sur</sub> = <b>3.6</b> k	Nm/m			
Check heel in bending									
Width of heel		b = <b>1000</b> mm/	n						
Depth of reinforcement		$d_{heel} = t_{base} - c_{heel} - (\phi_{heel} / 2) = 305.0 \text{ mm}$							
Constant		$K_{heel} = M_{heel} / ($	$b \times d_{heel}^2 \times f_{cl}$						
			,	-	n reinforcement	-			
Lever arm		z <sub>heel</sub> = min(0.5 z <sub>heel</sub> = <b>290</b> mm		nin(K <sub>heel</sub> , 0.225)	/ 0.9)),0.95) × dh	eel			
Area of tension reinforcement requir	red			× z <sub>heel</sub> ) = <b>29</b> mi	m²/m				
Minimum area of tension reinforcem		As heel min = $k \times b \times t_{base} = 455 \text{ mm}^2/\text{m}$							
Area of tension reinforcement requir	red			As_heel_min) = <b>45</b>	<b>5</b> mm²/m				
Reinforcement provided		B785 mesh							
Area of reinforcement provided	A <sub>s_heel_prov</sub> = 785 mm <sup>2</sup> /m PASS - Reinforcement provided at the retaining wall heel is adequ								
Check shear resistance at heel									
Design shear stress		v <sub>heel</sub> = V <sub>heel</sub> / (I	$\mathbf{b} \times \mathbf{d}_{heel}$ = 0.0	<b>)51</b> N/mm <sup>2</sup>					
Allowable shear stress		$v_{adm} = min(0.8 \times \sqrt{(f_{cu} / 1 \text{ N/mm}^2)}, 5) \times 1 \text{ N/mm}^2 = 4.733 \text{ N/mm}^2$							
			•		ss than maximu				
			-						
From BS8110:Part 1:1997 – Table	3.8								

두 Tekla	Project	45 Lancast	er Grove NW	/3	Job Ref.	16210			
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avid A Berle Consulting Engineers						8			
271 Creighton Avenue London N2 9P	Calc. by	Date 26-Nov-16	Chk'd by	Date	App'd by	Date			
			Vt	heel < Vc. heel - NO	shear reinforc	ement reau			
Design of reinforced concrete ret	aining wall	downstand (BS 80		···· ·_···		<b>,</b> -			
Material properties									
Characteristic strength of concrete		f <sub>cu</sub> = <b>35</b> N/mm <sup>2</sup>	2						
Characteristic strength of reinforcen	nent	f <sub>y</sub> = <b>500</b> N/mm							
-									
Base details		L. 0.10.0/							
Minimum area of reinforcement	.1	k = 0.13 %							
Cover to reinforcement in downstan		c <sub>ds</sub> = <b>40</b> mm							
Calculate shear for downstand de Total shear for downstand design	esign								
		$V_{down} = \gamma_{f_e}$	$\times K_p \times cos(\delta_b)$	b) × $\gamma_m$ × d <sub>ds</sub> × (d	l <sub>cover</sub> + t <sub>base</sub> + d <sub>ds</sub>	/ 2) = <b>35.6</b> k			
Calculate moment for downstand	design								
Total moment for downstand design	ı								
$M_{down}$ = $\gamma_{f_e} \times K_p \times$	$\text{cos}(\delta_{\text{b}}) \times \gamma_{\text{n}}$	$_{n}  imes d_{ds}  imes$ [(d <sub>cover</sub> + t <sub>ba</sub>	$_{se}) \times (t_{base} + d$	$d_{ds}$ ) + $d_{ds} \times (t_{base})$	$/2 + 2 \times d_{ds} / 3)$ ]	/ 2 = <b>16</b> kNi			
Check downstand in bending									
Width of downstand		b = <b>1000</b> mm/m							
Depth of reinforcement		$d_{down} = t_{ds} - c_{ds}$	$= (\phi_{down}/2)$	= <b>155.0</b> mm					
Constant		K <sub>down</sub> = M <sub>down</sub> /							
					n reinforcement	is not reau			
Lever arm		z <sub>down</sub> = Min(0.5	5 + √(0.25 - (r	-	5) / 0.9)),0.95) × c	-			
		z <sub>down</sub> = <b>147</b> mr			,,,,,,				
Area of tension reinforcement requi	red	$A_{s\_down\_des} = M_{down} / (0.87 \times f_y \times z_{down}) = 250 \text{ mm}^2/\text{m}$							
Minimum area of tension reinforcem		$A_{s_{down_{min}}} = k \times b \times t_{ds} = 260 \text{ mm}^2/\text{m}$							
Area of tension reinforcement requi	red	 A <sub>s_down_req</sub> = Max(A <sub>s_down_des</sub> , A <sub>s_down_min</sub> ) = <b>260</b> mm <sup>2</sup> /m							
Reinforcement provided		10 mm dia.bars @ 100 mm centres							
Area of reinforcement provided		A <sub>s_down_prov</sub> = <b>785</b> mm <sup>2</sup> /m							
	F	PASS - Reinforcem		d at the retainin	ng wall downsta	nd is adequ			
Check shear resistance at downs	tand								
Design shear stress		$v_{down}$ = $V_{down}$ / (b × d <sub>down</sub> ) = <b>0.229</b> N/mm <sup>2</sup>							
Allowable shear stress		v <sub>adm</sub> = min(0.8 × √(f <sub>cu</sub> / 1 N/mm²), 5) × 1 N/mm² = <b>4.733</b> N/mm²							
		PASS	- Design she	ear stress is les	ss than maximu	m shear sti			
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Design concrete shear stress		vc_down = <b>0.714</b>	N/mm <sup>2</sup>						
			Vdov	wn < vc_down - No	o shear reinforc	ement requ			
Design of reinforced concrete ret	aining wall	stem (BS 8002:19	<u>94)</u>						
Material properties									
Characteristic strength of concrete		f <sub>cu</sub> = <b>35</b> N/mm <sup>2</sup>							
Characteristic strength of reinforcen	nent	f <sub>y</sub> = <b>500</b> N/mm	2						
Wall details									
		k = <b>0.13</b> %							
Minimum area of reinforcement		$c_{\text{stem}} = 40 \text{ mm}$							

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London N2 9P	- ,	26-Nov-16	- ,					
Cover to reinforcement in wall		c <sub>wall</sub> = <b>40</b> mm						
Factored horizontal active forces	on stem							
Surcharge		$F_{s\_sur\_f} = \gamma_{f\_l} \times P$	$X_a  imes \cos(90 - c)$	$\alpha + \delta$ ) × Surcha	$rge  imes (h_{eff} - t_{base} - t_{base})$	- d <sub>ds</sub> ) = <b>17.9</b>		
kN/m Moist backfill above water table		$F_{s_m_a_f} = 0.5 \times$	$\gamma_{f_e} \times K_a \times co$	s(90 - α + δ) ×	$\gamma_{m}  imes$ (h <sub>eff</sub> - t <sub>base</sub> - c	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> =		
<b>25.5</b> kN/m								
Moist backfill below water table kN/m		$F_{s_m_b_f} = \gamma_{f_e} \times$	$K_a \times cos(90 -$	$(\alpha + \delta) \times \gamma_m \times (I)$	h <sub>eff</sub> - t <sub>base</sub> - d <sub>ds</sub> - h	sat) × h <sub>sat</sub> = <b>1</b> 3		
Saturated backfill		$F_{s,s,f} = 0.5 \times \gamma_f$	$e \times K_a \times \cos(9)$	$90 - \alpha + \delta) \times (\gamma_s$	s-γ <sub>water</sub> ) × h <sub>sat</sub> ² = ′	<b>1.1</b> kN/m		
Water		$F_{s_water_f} = 0.5$		,		•••••		
			1o Tindiol X					
Calculate shear for stem design Shear at base of stem		V <sub>stem</sub> = F <sub>s_sur_f</sub> ·	+ F <sub>s_m_a_f</sub> + F <sub>s_</sub>	_m_b_f + F <sub>s_s_f</sub> +	Fs_water_f - Fprop_f	= <b>26.3</b> kN/m		
Calculate moment for stem desig	n							
Surcharge		Ms_sur = Fs_sur_f	$\times$ (h <sub>stem</sub> + t <sub>base</sub>	e) / 2 <b>= 31.8</b> kN	m/m			
Moist backfill above water table		$M_{s_m_a} = F_{s_m_a_f} \times (2 \times h_{sat} + h_{eff} - d_{ds} + t_{base} / 2) / 3 = 42.7 \text{ kNm/m}$						
Moist backfill below water table		$M_{s_m_b} = F_{s_m_b_f} \times h_{sat} / 2 = 4.2 \text{ kNm/m}$						
Saturated backfill		$M_{s_s} = F_{s_s_f} \times h_{sat} / 3 = 0.2 \text{ kNm/m}$						
Water		$M_{s\_water} = F_{s\_water_f} \times h_{sat} / 3 = 0.6 \text{ kNm/m}$						
Total moment for stem design		M <sub>stem</sub> = M <sub>s_sur</sub> +	⊦ M <sub>s_m_a</sub> + M <sub>s_</sub>	<sub>.m_b</sub> + M <sub>s_s</sub> + M <sub>s</sub>	s_water <b>= 79.5</b> kNm	ı/m		
Check wall stem in bending								
Width of wall stem		b = <b>1000</b> mm/r	n					
Depth of reinforcement		$d_{stem} = t_{wall} - c_{stem} - (\phi_{stem} / 2) = 255.0 \text{ mm}$						
Constant		$K_{stem} = M_{stem} / (b \times d_{stem}^2 \times f_{cu}) = 0.035$						
				-	n reinforcement	-		
Lever arm		z <sub>stem</sub> = min(0.5 z <sub>stem</sub> = <b>242</b> mm		in(K <sub>stem</sub> , 0.225)	) / 0.9)),0.95) × d₅	stem		
Area of tension reinforcement requir	ed	As_stem_des = Ms	$_{\rm stem}$ / (0.87 $ imes$ fy	× Z <sub>stem</sub> ) = <b>755</b>	mm²/m			
Minimum area of tension reinforcem	ent	$A_{s_{s_{min}}} = k >$	< b × t <sub>wall</sub> = <b>39</b>	<b>0</b> mm²/m				
Area of tension reinforcement require	ed	A <sub>s_stem_req</sub> = Ma	ax(A <sub>s_stem_des</sub> , /	A <sub>s_stem_min</sub> ) = <b>75</b>	55 mm²/m			
Reinforcement provided		10 mm dia.ba	rs @ 100 mm	centres				
Area of reinforcement provided		As_stem_prov = <b>785</b> mm²/m						
		PASS - Reinf	orcement pro	ovided at the r	etaining wall ste	em is adequa		
Check shear resistance at wall st	əm							
Design shear stress		$v_{stem} = V_{stem} / (l$	b × d <sub>stem</sub> ) = <b>0.</b> ′	103 N/mm <sup>2</sup>				
Allowable shear stress		$v_{adm}$ = min(0.8 × $\sqrt{(f_{cu} / 1 N/mm^2)}$ , 5) × 1 N/mm <sup>2</sup> = <b>4.733</b> N/mm <sup>2</sup>						
		PASS	- Design shea	ar stress is les	ss than maximu	m shear stre		
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Design concrete shear stress		vc_stem = <b>0.534</b>						
			Vster	m < Vc_stem - NC	shear reinforce	ement requir		