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Structural Calculations: 23 Dartmouth Park Hill, NW5

# Introduction

Architecture for London were instructed by the client Ms. Philippa Huckle.

The structural works consist of creating a basement beneath existing section of the property and the proposed new rear extension extending into the garden area.

# Design Codes

The following design codes / guidance were used to carry out the design:

- BS 648: 1964 Weight of Building Materials
- BS 5268: Pt 2: 1991 Structural Timber
- BS 5628: Pt 1: 1992 Masonry
- BS 5950: Pt 1: 1990 Structural Steel
- BS 6399: Pt 1: 1984 Design Loads
- BS 8110: Pt 1: 1997 Structural Use of Concrete

# Ground Conditions

Trial holes and ground investigation carried out by LMB GeoSolutions have confirmed the underlying ground is London clay. For the purposes of these calculations an allowable safe bearing pressure of 110kN/m<sup>2</sup> has been used.

# Substructure Design

Designing new structural retaining walls and underpins forming the new basement.

Superstructure Design

N/A

The Contractor will be responsible for all temporary supports and will be responsible for the stability of the structure during the works.

Loading

The loadings used throughtout the design are shown in the table below:

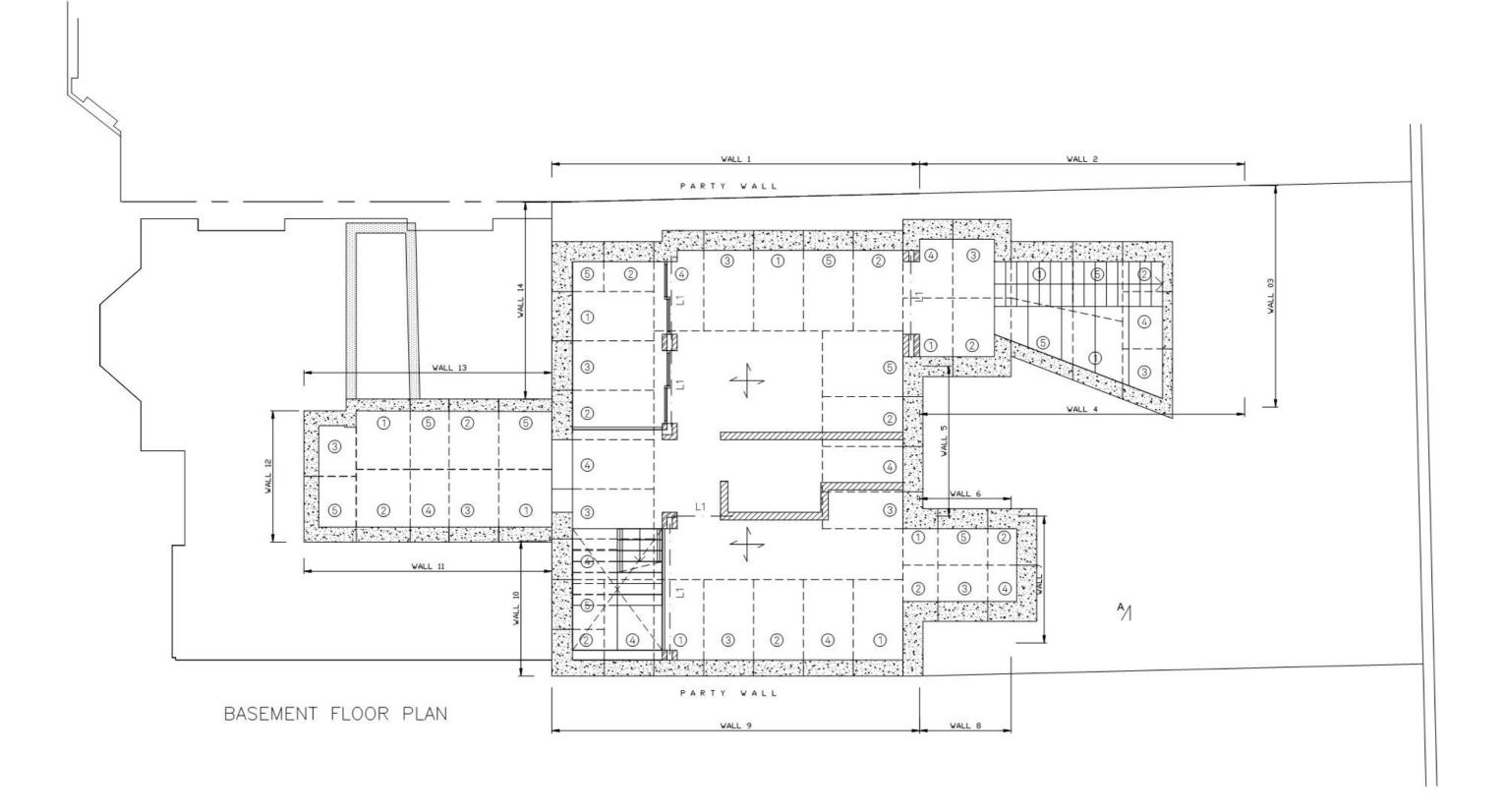
Existing Timber Floor	
Boards	
Joists	
Plasterboard & Skim	
Domestic Floor	
Solid Masonry	
100mm Thick	
15mm Plaster	
215mm Thick	
15mm Plaster	
330mm Thick	
15mm Plaster	
New Cavity	 
102mm Brick	
100mm Block	
Plasterboard & Skim	

DL	Ш
(kPa)	(kPa)
0.15	
0.2	
0.15	
<u>0.5</u>	
	<u>1.5</u>
1.9	
0.3	
<u>2.2</u>	
4.0	
0.3	
<u>4.3</u>	
6.14	
0.3	
<u>6.44</u>	
2.1	
0.8	
0.24	
<u>3.14</u>	

Timber Stud Walls		
Plasterboards	0.20	
Skim Coats	0.15	
Studs (75x50 @400mm c/c)	0.15	
	<u>0.5</u>	
<u>Flat Roof</u>		
Felt & Chippings	0.20	
Decking & Insulations	0.13	
Joists & Firrings	0.20	
Plasterboard & Skim	0.15	
	<u>0.68</u>	
No Access		0.75
Access		<u>1.5</u>
Glazed Window		
Triple Glazing	0.8	
	<u>0.8</u>	
Snow		0.8
Glazed Skylight		
15mm plater	0.92	
	<u>0.92</u>	
No Access		0.75
Public Highway		<u>10.00</u>
Garden		2.50

Tiled Roof Tiles Felt & Battens Rafters Plan Load

	0.75	
	0.06	
	0.06	
	0.87	
20°	0.92	<u>0.75</u>
30°	<u>0.95</u>	<u>0.75</u>
35∘	<u>1.06</u>	<u>0.67</u>
40°	<u>1.13</u>	<u>0.58</u>
45°	<u>1.23</u>	<u>0.5</u>
50°	<u>1.35</u>	0.42



18024/Rev A

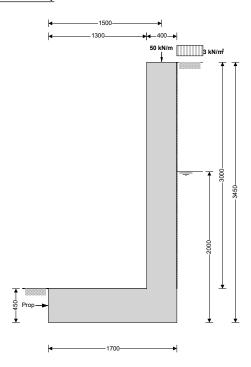
<u>Above:</u> Basement Wall Plan

# **Basement Design**

Job no. 23 Partmonth Park Hill Cales for 19647 **Architecture** Calcs for Refaining Lan 11 1951gn Start page no./Revision for London. Calcs by Calcs date BS of Wall 1 Lood !-Dend Live - Masony wall (h=4:0m) (3.14) - Rooj local (5.0m/2) (lo, 0.75) 12.56 / 2.5 1.875 - Bean & Block Floor (9.1/2) (5.85, 1.5) 6.83 26.62 41.68 8.71 Total \* Garden Surcharge = 2.5/killm2 \* Water lavel (B.G.L) = 1. on (Assumed) SURCHARGE (DL+LL) Libbbbbbbbbbbbbb 350 Ó : Reperto Tedds Calos 3 1650mm \* Wall 2 24 Load:-Dend Live - RC staircase (4.5/2) (5.5,1.5) 12.4 3.40 # Graden Surcharge = 2.5KaN/m2 \* Woter level (B.G.C) = 1.0m (Assumed) Surchauge (OL+LL) to 0 M 22 : Refer to Telds Glas E mail@architectureforlondon.com W architectureforlondon.com A 82 Clerkenwell Road EC1M 5RF T 020 3637 4236

	Project 23 Dartmouth F	Job Ref. 19047				
Architecture for London.	Section Wall 1				Sheet no./rev. 1	
	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date

#### **RETAINING WALL ANALYSIS (BS 8002:1994)**



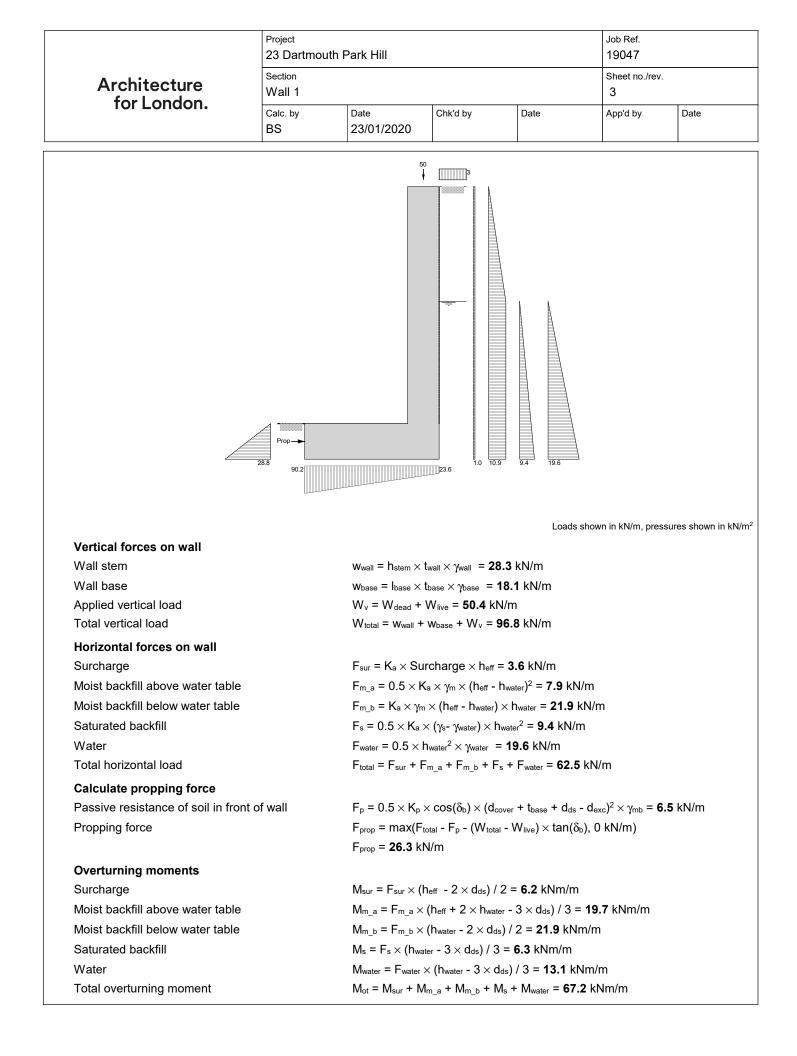
#### Wall details

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

# Cantilever propped at base h<sub>stem</sub> = 3000 mm t<sub>wall</sub> = **400** mm I<sub>toe</sub> = **1300** mm $I_{heel} = 0 \text{ mm}$ $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 1700 \text{ mm}$ t<sub>base</sub> = **450** mm $d_{ds} = 0 \text{ mm}$ l<sub>ds</sub> = **1200** mm t<sub>ds</sub> = **450** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3450 \text{ mm}$ d<sub>cover</sub> = **0** mm $d_{exc} = 0 mm$ h<sub>water</sub> = **2000** mm $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 1550 mm$ γ<sub>wall</sub> = 23.6 kN/m<sup>3</sup> γ<sub>base</sub> = **23.6** kN/m<sup>3</sup> α = **90.0** deg $\beta = 0.0 \text{ deg}$ $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3450 \text{ mm}$

M = 1.5

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Architecture	Section Wall 1		Sheet no./rev. 2			
for London.	Calc. by BS				App'd by	Date
Moist density of retained mater	ial	γ <sub>m</sub> = <b>18.0</b> kN/r	n <sup>3</sup>			
Saturated density of retained m	naterial	γs <b>= 21.0</b> kN/n	n <sup>3</sup>			
Design shear strength		∳' = <b>24.2</b> deg				
Angle of wall friction		$\delta$ = <b>0.0</b> deg				
Base material details						
Moist density		γ <sub>mb</sub> = <b>18.0</b> kN/	/m³			
Design shear strength		φ'₅ = <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>110</b>	kN/m²			
Based on Kerisel & Absi - 'Ac	tive and passive	earth pressure	tables'			
Active pressure coefficient fo	or retained materi	al				
Slope angle ratio		$r_a = \beta / \phi' = 0.0$	00			
Wall friction ratio		$r_{b} = \delta / \phi' = 0.0$	00			
Active pressure coefficient for r	etained material	Ka <b>= 0.419</b>				
Passive pressure coefficient	for base material					
Slope angle ratio		r <sub>a</sub> = 0 deg / φ'ι	o = 0.00			
Wall friction ratio		$r_{b} = \delta_{b} / \phi'_{b} = 0$	).77			
Passive pressure coefficient for	r base material	K <sub>p</sub> = <b>3.754</b>				
At-rest pressure						
At-rest pressure for retained ma	aterial	$K_0 = 1 - \sin(\phi)$	') = <b>0.590</b>			
Loading details						
Surcharge load on plan		Surcharge = 2	2.5 kN/m²			
Applied vertical dead load on w	all	W <sub>dead</sub> = <b>41.7</b> k	κN/m			
Applied vertical live load on wa	II	W <sub>live</sub> = <b>8.7</b> kN	/m			
Position of applied vertical load	l on wall	l <sub>load</sub> = <b>1500</b> m				
Applied horizontal dead load or		F <sub>dead</sub> = <b>0.0</b> kN				
Applied horizontal live load on		F <sub>live</sub> = <b>0.0</b> kN/i	m			
Height of applied horizontal loa	d on wall	h <sub>load</sub> = <b>0</b> mm				



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Architecture for London.	Section Wall 1					
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Restoring moments						

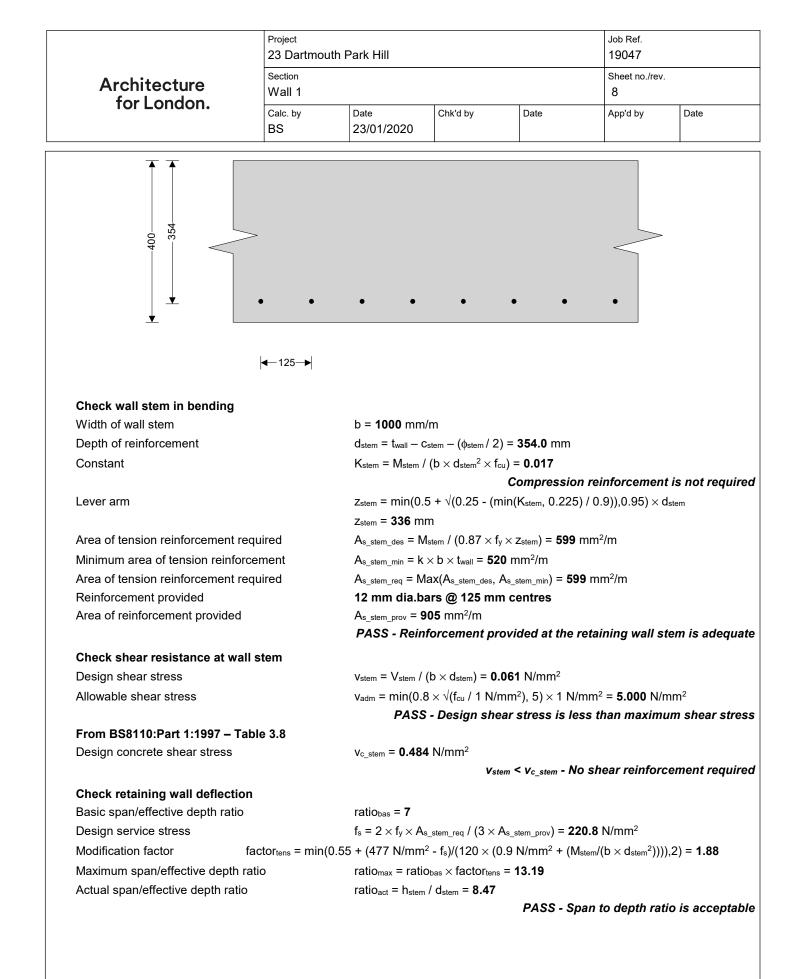
-	
Wall stem	$M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 42.5 \text{ kNm/m}$
Wall base	M <sub>base</sub> = w <sub>base</sub> × I <sub>base</sub> / 2 = <b>15.3</b> kNm/m
Design vertical load	$M_v = W_v \times I_{load} = 75.6 \text{ kNm/m}$
Total restoring moment	$M_{rest}$ = $M_{wall}$ + $M_{base}$ + $M_v$ = <b>133.4</b> kNm/m
Check bearing pressure	
Total moment for bearing	M <sub>total</sub> = M <sub>rest</sub> - M <sub>ot</sub> = <b>66.2</b> kNm/m
Total vertical reaction	R = W <sub>total</sub> = <b>96.8</b> kN/m
Distance to reaction	x <sub>bar</sub> = M <sub>total</sub> / R = <b>684</b> mm
Eccentricity of reaction	e = abs((I <sub>base</sub> / 2) - x <sub>bar</sub> ) = <b>166</b> mm
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 90.2 \text{ kN/m}^2$
Bearing pressure at heel	$p_{heel} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 23.6 \text{ kN/m}^2$
	PASS Maximum backing process is loss than allowable backing process

PASS - Maximum bearing pressure is less than allowable bearing pressure

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for London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
RETAINING WALL DESIGN (I	BS 8002:1994 <u>)</u>					
Ultimate limit state load facto	ors				TEDDS calcula	ation version 1.2.
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 facto	or	γ <sub>f_e</sub> = <b>1.4</b>				
Factored vertical forces on w						
Wall stem		Wwall f = Vf d ×	h <sub>stem</sub> × t <sub>wall</sub> × w	<sub>vall</sub> = <b>39.6</b> kN/m	า	
Wall base		_ · · -		/base = <b>25.3</b> kN/		
Applied vertical load				/ <sub>live</sub> = <b>72.3</b> kN/n		
Total vertical load			• =	v_f = 137.2 kN/		
Factored horizontal at-rest for	orces on wall			_		
Surcharge		$F_{sur} f = \gamma_{f} X K$	× Surcharge	e × h <sub>eff</sub> <b>= 8.1</b> kN	/m	
Moist backfill above water table	e	_ · -	-	≺ (h <sub>eff</sub> - h <sub>water</sub> )² =		
Moist backfill below water table		•-	•	- $h_{water}$ × $h_{water}$		
Saturated backfill		•-	• •	$_{\text{water}}$ × $h_{\text{water}}^2$ = '		
Water		- •-		$\gamma_{\text{water}} = 27.5 \text{ k}$		
Total horizontal load				•	_f = <b>112.9</b> kN/m	
Calculate propping force		· · · · · · · · · · · · · · · ·				
Passive resistance of soil in fro	ont of wall	$F_{p,f} = v_{f,a} \times 0$	$5 \times K_n \times \cos(\delta)$	$(d_{cover} + t_{ba})$	$_{ m se}$ + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup> ×	ν <sub>mb</sub> = <b>9.1</b> kN/
Propping force		· - · -	F <sub>total_f</sub> - F <sub>p_f</sub> - (\	, ,	$_{\rm live}$ ) × tan( $\delta_{\rm b}$ ), 0 k	•
Factored overturning momer	nts					
Surcharge		M <sub>sur_f</sub> = F <sub>sur_f</sub> :	$(h_{eff} - 2 \times d_{ds})$	s) / 2 = <b>14</b> kNm	/m	
Moist backfill above water table	9		·	,	3 = <b>38.8</b> kNm/m	ı
Moist backfill below water table	e			d <sub>ds</sub> ) / 2 = <b>43.1</b>		
Saturated backfill			•	/ 3 = <b>12.3</b> kNm		
Water			,	× d <sub>ds</sub> ) / 3 = <b>18.</b> 3		
Total overturning moment		$M_{ot_f} = M_{sur_f} +$	• M <sub>m_a_f</sub> + M <sub>m_t</sub>	o_f + Ms_f + Mwat	<sub>er_f</sub> = <b>126.6</b> kNm	/m
Restoring moments						
Wall stem		$M_{wall_f} = w_{wall_f}$	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	2) = <b>59.5</b> kNm/ı	m	
Wall base		M <sub>base_f</sub> = w <sub>base</sub>	$_{f} \times I_{base} / 2 = 2$	2 <b>1.5</b> kNm/m		
Design vertical load		$M_{v\_f} = W_{v\_f} \times$	load = 108.4 kM	Nm/m		
		M <sub>rest_f</sub> = M <sub>wall_f</sub>	+ M <sub>base_f</sub> + M <sub>v</sub>	<sub>f</sub> = <b>189.4</b> kNm	ı/m	
Total restoring moment						
Total restoring moment Factored bearing pressure						
-		M <sub>total_f</sub> = M <sub>rest_</sub>	f - M <sub>ot_f</sub> = 62.7	kNm/m		
Factored bearing pressure		M <sub>total_f</sub> = M <sub>rest_</sub> R <sub>f</sub> = W <sub>total_f</sub> =	_	KNM/M		
<b>Factored bearing pressure</b> Total moment for bearing Total vertical reaction Distance to reaction		R <sub>f</sub> = W <sub>total_f</sub> = x <sub>bar_f</sub> = M <sub>total_f</sub>	<b>137.2</b> kN/m / R <sub>f</sub> = <b>457</b> mm	I		
<b>Factored bearing pressure</b> Total moment for bearing Total vertical reaction		R <sub>f</sub> = W <sub>total_f</sub> = x <sub>bar_f</sub> = M <sub>total_f</sub>	<b>137.2</b> kN/m	<b>.</b> 393 mm	cts outside mid	

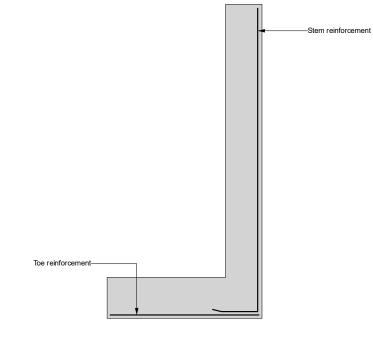
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Architecture for London.	Wall 1			6		
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Bearing pressure at heel		p <sub>heel_f</sub> = 0 kN/	m <sup>2</sup> = <b>0</b> kN/m <sup>2</sup>			
Rate of change of base reactio	n	rate = $p_{toe_f}$ / (	$(3 \times x_{bar_f}) = 14$	<b>5.77</b> kN/m²/m		
Bearing pressure at stem / toe		p <sub>stem_toe_f</sub> = ma	ax(p <sub>toe_f</sub> - (rate	$\times$ I <sub>toe</sub> ), 0 kN/m <sup>2</sup>	<sup>2</sup> ) = <b>10.5</b> kN/m <sup>2</sup>	
Bearing pressure at mid stem		p <sub>stem_mid_f</sub> = m	ax(p <sub>toe_f</sub> - (rate	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	)), 0 kN/m²) = <b>0</b> k	⟨N/m²
Bearing pressure at stem / hee	I	$p_{stem\_heel\_f} = m$	ax(p <sub>toe_f</sub> - (rate	$e \times (I_{toe} + t_{wall})),$	0 kN/m²) = <b>0</b> kN/	m²
Design of reinforced concret	e retaining wal	toe (BS 8002:199	94)			
Material properties						
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mm	1 <sup>2</sup>			
Characteristic strength of reinfo	prcement	f <sub>y</sub> = <b>500</b> N/mr	n²			
Base details						
Minimum area of reinforcemen	t	k = <b>0.13</b> %				
Cover to reinforcement in toe		c <sub>toe</sub> = <b>30</b> mm				
Calculate shear for toe desig	n					
Shear from bearing pressure		V <sub>toe_bear</sub> = (p <sub>to</sub>	e_f + p <sub>stem_toe_f</sub> )	× I <sub>toe</sub> / 2 = <b>136</b> .	<b>8</b> kN/m	
Shear from weight of base		$V_{toe_wt_base} = \gamma$	$f_d  imes \gamma_{base}  imes I_{toe}$	× t <sub>base</sub> = <b>19.3</b> k	N/m	
Total shear for toe design		$V_{toe} = V_{toe\_bear}$	- V <sub>toe_wt_base</sub> =	<b>117.5</b> kN/m		
Calculate moment for toe des	sign					
Moment from bearing pressure		M <sub>toe_bear</sub> = (2 >	<pre>toe_f + pstem_r</pre>	$_{\rm mid_f})  imes (I_{ m toe}$ + $t_{ m wa}$	∥ / 2)² / 6 <b>= 150</b> k	Nm/m
Moment from weight of base					2) <sup>2</sup> / 2) = <b>16.7</b> ki	
Total moment for toe design				= <b>133.3</b> kNm/m		
450	• •	• • •			• •	
450	<ul> <li>•</li> <li>•</li> <li>•</li> <li>•</li> </ul>	• • •			• •	
Check toe in bending	<ul> <li>●</li> <li>●</li> <li>●</li> <li>●</li> </ul>	• • •			• •	
Check toe in bending Width of toe	- •  ←100→	• • • •			• •	
Check toe in bending Width of toe Depth of reinforcement	<ul> <li>•</li> <li>•</li> <li>•</li> <li>•</li> </ul>	$d_{toe} = t_{base} - c$	<sub>toe</sub> – (φ <sub>toe</sub> / 2) =		• •	
Check toe in bending Width of toe Depth of reinforcement Constant	► •   <del>•</del> 100- <b>•</b>	$d_{toe} = t_{base} - c$		• 0.019	• •	
Check toe in bending Width of toe Depth of reinforcement Constant	<ul> <li>•</li> <li>•</li> <li>•</li> </ul>	$d_{toe} = t_{base} - c$ $K_{toe} = M_{toe} / (k$	$t_{toe} - (\phi_{toe} / 2) =$ $0 \times d_{toe}^2 \times f_{cu}) =$ $+ \sqrt{(0.25 - (mi))}$	0.019 Compressio	• • • • • • • • • • • • • • • • • • •	-
Check toe in bending Width of toe Depth of reinforcement		$d_{toe} = t_{base} - c$ $K_{toe} = M_{toe} / (k$ $z_{toe} = min(0.5)$ $z_{toe} = 393 mm$	toe – (φ <sub>toe</sub> / 2) = 0 × d <sub>toe</sub> <sup>2</sup> × f <sub>cu</sub> ) = + √(0.25 - (mi n	0.019 Compressio	(0.9)),0.95) × d <sub>toe</sub>	-

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Tor London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Area of tension reinforcement r	required	A <sub>s_toe_req</sub> = Ma	ax(As_toe_des, As	_ <sub>toe_min</sub> ) = <b>779</b> n	nm²/m	
Reinforcement provided	-		ars @ 100 mn			
Area of reinforcement provided	I	As_toe_prov = 11	131 mm²/m			
		PASS - Re	inforcement p	provided at th	e retaining wall	toe is adequ
Check shear resistance at to	e					
Design shear stress		$v_{toe} = V_{toe} / (b$	× d <sub>toe</sub> ) = <b>0.284</b>	4 N/mm <sup>2</sup>		
Allowable shear stress		v <sub>adm</sub> = min(0.8	8 × √(f <sub>cu</sub> / 1 N/r	mm <sup>2</sup> ), 5) $\times$ 1 N/	mm² <b>= 5.000</b> N/	mm²
		PASS	S - Design she	ear stress is le	ss than maxim	um shear str
From BS8110:Part 1:1997 – T	able 3.8					
Design concrete shear stress		v <sub>c_toe</sub> = <b>0.480</b>				
				v <sub>toe</sub> < v <sub>c_toe</sub> - N	o shear reinfor	cement requi
Design of reinforced concret	e retaining wal	l stem (BS 8002:1	994)			
Material properties						
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mn	n <sup>2</sup>			
Characteristic strength of reinforcement			1			
-		f <sub>y</sub> = <b>500</b> N/mr				
-						
Characteristic strength of reinfo	orcement					
Characteristic strength of reinfo Wall details	prcement t	f <sub>y</sub> = <b>500</b> N/mr	n²			
Characteristic strength of reinfo Wall details Minimum area of reinforcement	prcement t	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> %	n²			
Characteristic strength of reinfo Wall details Minimum area of reinforcement Cover to reinforcement in stem	brcement t	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> % c <sub>stem</sub> = <b>40</b> mm	n²			
Characteristic strength of reinfo Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall	brcement t	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> % c <sub>stem</sub> = <b>40</b> mm c <sub>wall</sub> = <b>30</b> mm	n² 1	ge × (h <sub>eff</sub> - t <sub>base</sub> -	• d <sub>ds</sub> ) = <b>7.1</b> kN/m	
Characteristic strength of reinfo Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for	prcement t prces on stem	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> % c <sub>stem</sub> = <b>40</b> mm c <sub>wall</sub> = <b>30</b> mm F <sub>s_sur_f</sub> = γ <sub>f_l</sub> ×	n² n K₀ × Surcharg		• d <sub>ds</sub> ) = <b>7.1</b> kN/m d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b>	
Characteristic strength of reinfo Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge	prcement t prces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$	n² n Ko × Surcharg × γr_e × Ko × γm	$h \times (h_{eff} - t_{base} - c)$		kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table	prcement t prces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$	$n^2$ N K <sub>0</sub> × Surcharg × $\gamma_{f_e}$ × K <sub>0</sub> × $\gamma_m$ × K <sub>0</sub> × $\gamma_m$ × (he	$h \times (h_{eff} - t_{base} - c)$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b>	kN/m
Characteristic strength of reinfo Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table	prcement t prces on stem	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_a} \times$ $F_{s\_s\_f} = 0.5 \times$	$n^2$ $K_0 \times Surcharg$ $\times \gamma_{f\_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_e)$ $\gamma_{f\_e} \times K_0 \times (\gamma_{s} - \gamma_{s})$	$h \times (h_{eff} - t_{base} - d_{ff})$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m	kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water	prcement t prces on stem	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_a} \times$ $F_{s\_s\_f} = 0.5 \times$	$n^2$ $K_0 \times Surcharg$ $\times \gamma_{f\_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_e)$ $\gamma_{f\_e} \times K_0 \times (\gamma_{s} - \gamma_{s})$	n × (h <sub>eff</sub> - t <sub>base</sub> - α <sub>ff</sub> - t <sub>base</sub> - d <sub>ds</sub> - h γ <sub>water</sub> ) × h <sub>sat</sub> <sup>2</sup> = 4	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m	kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill	prcement t prces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_1} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e} +$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5 \times$	$m^2$ $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_e)$ $\gamma_{f_e} \times K_0 \times (\gamma_{s_e} - \gamma_{t_e})$ $\gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times \gamma_{t_e}$	$h \times (h_{eff} - t_{base} - d_{sf})$ $ff - t_{base} - d_{ds} - h$ $\gamma_{water}) \times h_{sat}^2 = 1$ $h_{sat}^2 = 16.5 \text{ kN}$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m	kN/m kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des	prcement t prces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_1} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e} +$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5 \times$	$m^2$ $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_e)$ $\gamma_{f_e} \times K_0 \times (\gamma_{s_e} - \gamma_{t_e})$ $\gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times \gamma_{t_e}$	$h \times (h_{eff} - t_{base} - d_{sf})$ $ff - t_{base} - d_{ds} - h$ $\gamma_{water}) \times h_{sat}^2 = 1$ $h_{sat}^2 = 16.5 \text{ kN}$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b>   <b>1.1</b> kN/m  /m	kN/m kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Noist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem	prcement t prces on stem	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_1} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$	$\label{eq:K0} \begin{split} &K_0\times Surcharg\\ &\times \gamma_{f\_e}\timesK_0\times\gamma_{m}\\ &\times K_0\times\gamma_m\times(he)\\ &\gamma_{f\_e}\timesK_0\times(\gamma_{s=-})\\ &\gamma_{f\_e}\times\gamma_{f\_e}\times\gamma_{water}\times\\ &f+F_{s\_m\_a\_f}+F_s \end{split}$	$h \times (h_{eff} - t_{base} - d_{sf})$ $ff - t_{base} - d_{ds} - h$ $\gamma_{water}) \times h_{sat}^2 = 1$ $h_{sat}^2 = 16.5 \text{ kN}$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> sat) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des	prcement t prces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_b\_f} = 0.5$ $F_{s\_m\_b\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5 \times$ $V_{stem} = F_{s\_sur\_t}$ $M_{s\_sur} = F_{s\_sur\_t}$	$m^{2}$ $K_{0} \times Surcharg$ $\times \gamma_{f_{e}} \times K_{0} \times \gamma_{m}$ $\times K_{0} \times \gamma_{m} \times (h_{e'})$ $\gamma_{f_{e}} \times K_{0} \times (\gamma_{s-1})$ $\gamma_{f_{e}} \times \gamma_{f_{e}} \times \gamma_{water} \times$ $f_{s} + F_{s_{m_{a}}}f_{s} + F_{s}$ $f_{s} + K_{s_{m_{a}}}f_{s} + F_{s}$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{sat}^2 = 1$ $(h_{sat}^2 = 16.5 \text{ kN} + h_{sat}^2 - 16.5 \text{ kN} + h_{s$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> sat) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>21.4</b> kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_1} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e} \cdot$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_1}$ $M_{s\_sur} = F_{s\_sur\_1}$	$m^{2}$ $K_{0} \times Surcharg$ $\times \gamma_{f_{e}} \times K_{0} \times \gamma_{m}$ $\times K_{0} \times \gamma_{m} \times (h_{e'})$ $\gamma_{f_{e}} \times K_{0} \times (\gamma_{s-1})$ $\gamma_{f_{e}} \times \gamma_{f_{e}} \times \gamma_{water} \times \gamma_{f_{e}} \times (h_{stem} + t_{bas})$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{ds} - d_{ds} - h_{ds} - h_{ds} - h_{sat}^2 = 1$ $(h_{sat}^2 = 16.5 \text{ kN})$ $(h_{sat}^2 - 16.5 \text{ kN})$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> sat) × h <sub>sat</sub> = <b>33.4</b> <b>I1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>21.4</b> kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge Moist backfill above water table	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e} =$ $F_{s\_s\_f} = 0.5 \times 10^{-5} \times 10$	m <sup>2</sup> $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{e'})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s-1})$ $f + F_{s_m_a_f} + F_{s_s}$ $f + F_{s_m_a_f} + F_{s_s}$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{ff} + h_{sat}^2 = 1$ $(h_{sat}^2 = 16.5 \text{ kN})$ $(h_{sm}^2 - 16.5 \text{ kN})$ $(h_{sm}^2 - 16.5 \text{ kN})$ $(h_{sm}^2 - 12.2 \text{ kN})$ $(h_{eff} - d_{ds} + t_{base})$ (25.9  kNm/m)	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> sat) × h <sub>sat</sub> = <b>33.4</b> <b>I1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>21.4</b> kN/m
Characteristic strength of reinfor <b>Wall details</b> Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall <b>Factored horizontal at-rest for</b> Surcharge Moist backfill above water table Saturated backfill Water <b>Calculate shear for stem des</b> Shear at base of stem <b>Calculate moment for stem d</b> Surcharge Moist backfill above water table Moist backfill above water table Moist backfill above water table	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $C_{stem} = 40 \text{ mm}$ $C_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_b\_f} = \gamma_{f\_e} \times$ $F_{s\_m\_b\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5 \times$ $V_{stem} = F_{s\_sur\_f}$ $M_{s\_sur} = F_{s\_sur\_f}$ $M_{s\_m\_a} = F_{s\_m\_m}$ $M_{s\_m\_b} = F_{s\_m\_m}$ $M_{s\_s} = F_{s\_s\_f} \times$	m <sup>2</sup> $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{e^1})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^{-1}})$ $i \times \gamma_{f_e} \times \gamma_{water} \times$ $f + F_{s_m_a_f} + F_{s_1}$ $f + F_{s_m_a_f} + F_{s_1}$ $f + (h_{stem} + t_{bas})$ $a_a f \times (2 \times h_{sat} + f_{s_1})$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{ff} + h_{sat}^2 = 1$ $h_{sat}^2 = 16.5 \text{ kN}$ $h_{sm_b}f + F_{s_s}f + h_{e}) / 2 = 12.2 \text{ kN}$ $h_{eff} - d_{ds} + t_{base}$ $25.9 \text{ kNm/m}$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> sat) × h <sub>sat</sub> = <b>33.4</b> <b>I1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>21.4</b> kN/m



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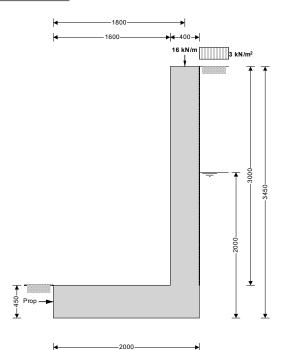
Indicative retaining wall reinforcement diagram



Toe bars - 12 mm dia.@ 100 mm centres -  $(1131 \text{ mm}^2/\text{m})$ Stem bars - 12 mm dia.@ 125 mm centres -  $(905 \text{ mm}^2/\text{m})$ 

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#### **RETAINING WALL ANALYSIS (BS 8002:1994)**



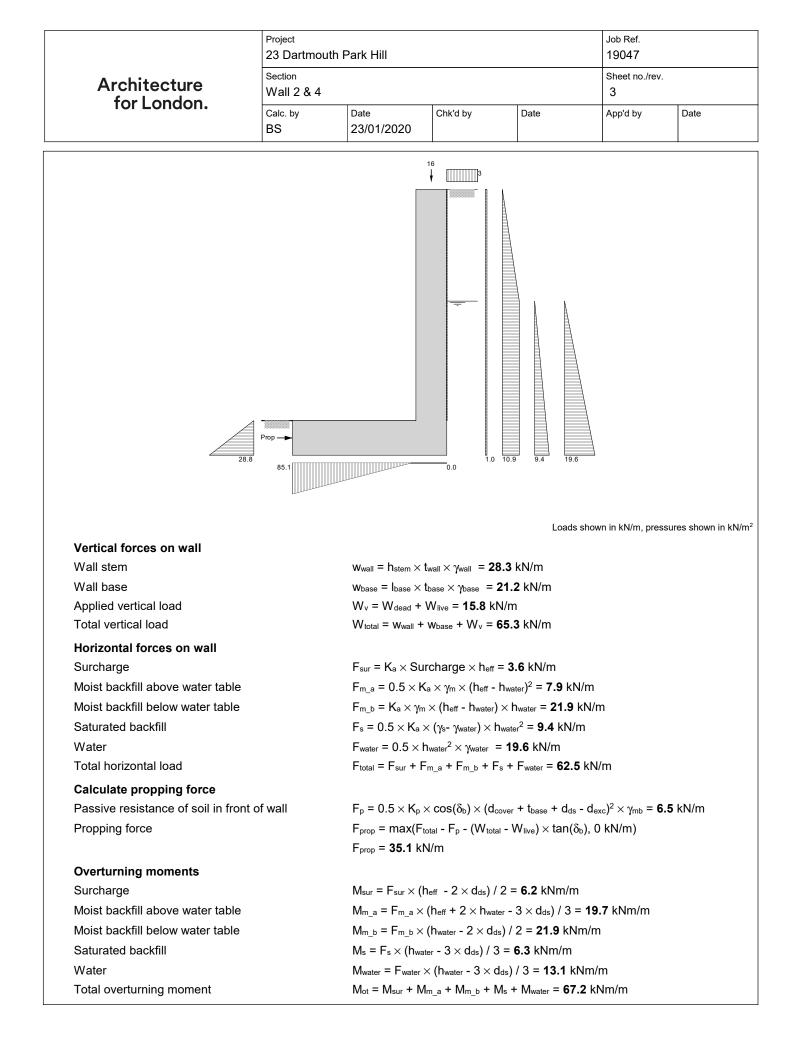
#### Wall details

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

# h<sub>stem</sub> = **3000** mm t<sub>wall</sub> = **400** mm I<sub>toe</sub> = **1600** mm $I_{heel} = 0 \text{ mm}$ $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 2000 \text{ mm}$ t<sub>base</sub> = **450** mm $d_{ds} = 0 \text{ mm}$ l<sub>ds</sub> = **900** mm t<sub>ds</sub> = **450** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3450 \text{ mm}$ $d_{cover} = 0 mm$ $d_{exc} = 0 mm$ h<sub>water</sub> = **2000** mm $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 1550 mm$ γ<sub>wall</sub> = 23.6 kN/m<sup>3</sup> γ<sub>base</sub> = 23.6 kN/m<sup>3</sup> α = **90.0** deg β = **0.0** deg $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3450 \text{ mm}$

Cantilever propped at base

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Retained material details						
Mobilisation factor		M = 1.5				
Moist density of retained mater	ial	γ <sub>m</sub> = <b>18.0</b> kN/i	m <sup>3</sup>			
Saturated density of retained n		γ <sub>s</sub> = <b>21.0</b> kN/r				
Design shear strength		φ' = <b>24.2</b> deg				
Angle of wall friction		δ = <b>0.0</b> deg				
Base material details						
Moist density		γ <sub>mb</sub> = <b>18.0</b> kN	′m³			
Design shear strength		∳'₅ = <b>24.2</b> deg				
Design base friction		$\delta_b$ = <b>18.6</b> deg				
Allowable bearing pressure		P <sub>bearing</sub> = <b>110</b>	kN/m²			
Based on Kerisel & Absi - 'Ao	ctive and passi	ve earth pressure	tables'			
Active pressure coefficient for	or retained mat	terial				
Slope angle ratio		$r_a = \beta / \phi' = 0.$	00			
Wall friction ratio		$r_b = \delta / \phi' = 0.0$	00			
Active pressure coefficient for I	retained materia	al K <sub>a</sub> = <b>0.419</b>				
Passive pressure coefficient	for base mate	rial				
Slope angle ratio		$r_a = 0 \text{ deg } / \phi'_1$	o = 0.00			
Wall friction ratio		$r_b = \delta_b / \phi'_b = 0$	).77			
Passive pressure coefficient fo	r base material	K <sub>p</sub> = <b>3.754</b>				
At-rest pressure						
At-rest pressure for retained m	aterial	K₀ = 1 – sin(ϕ	') = <b>0.590</b>			
Loading details						
Surcharge load on plan		Surcharge = 2				
Applied vertical dead load on w		W <sub>dead</sub> = <b>12.4</b>				
Applied vertical live load on wa		W <sub>live</sub> = <b>3.4</b> kN				
Position of applied vertical load		l <sub>load</sub> = <b>1800</b> m				
Applied horizontal dead load of		F <sub>dead</sub> = <b>0.0</b> kN				
Applied horizontal live load on		F <sub>live</sub> = <b>0.0</b> kN/	m			
Height of applied horizontal loa	ia on Wall	h <sub>load</sub> = <b>0</b> mm				



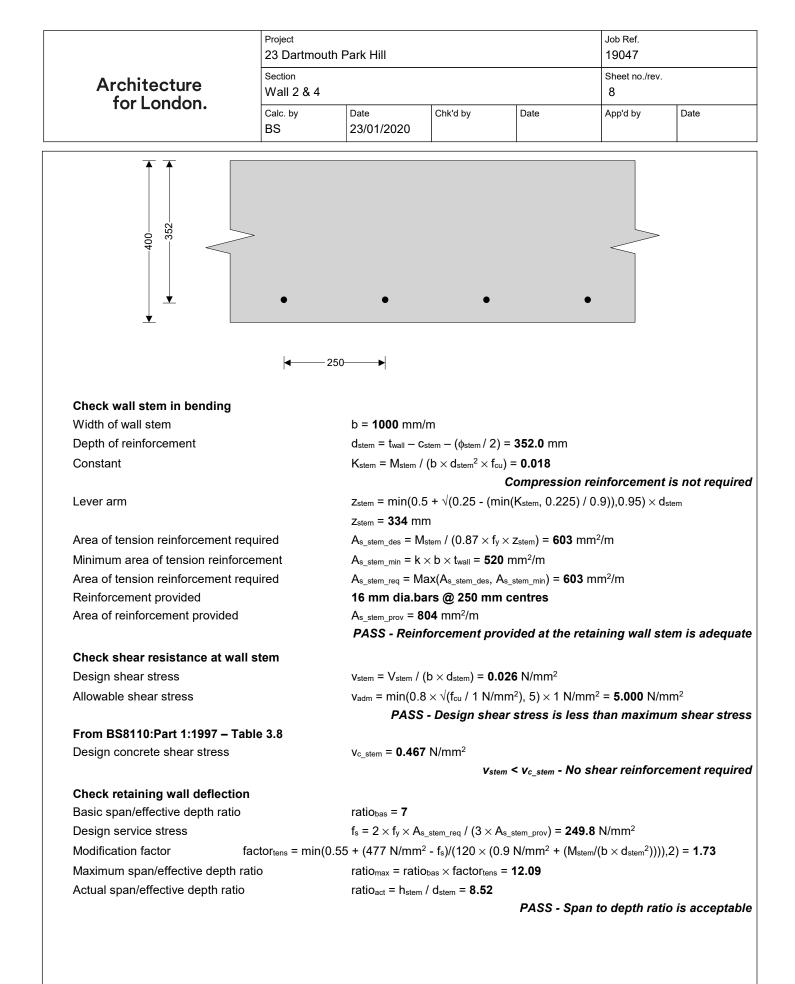
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Restoring moments	
Wall stem	$M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 51 \text{ kNm/m}$
Wall base	$M_{\text{base}} = w_{\text{base}} \times I_{\text{base}} / 2 = 21.2 \text{ kNm/m}$
Design vertical load	$M_v = W_v \times I_{load} = 28.4 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_v = 100.6 \text{ kNm/m}$
Check bearing pressure	
Total moment for bearing	M <sub>total</sub> = M <sub>rest</sub> - M <sub>ot</sub> = <b>33.4</b> kNm/m
Total vertical reaction	R = W <sub>total</sub> = <b>65.3</b> kN/m
Distance to reaction	$x_{bar} = M_{total} / R = 512 mm$
Eccentricity of reaction	e = abs((I <sub>base</sub> / 2) - x <sub>bar</sub> ) = <b>488</b> mm
	Reaction acts outside middle third of base
Bearing pressure at toe	p <sub>toe</sub> = R / (1.5 × x <sub>bar</sub> ) = <b>85.1</b> kN/m <sup>2</sup>
Bearing pressure at heel	$p_{\text{heel}} = 0 \text{ kN/m}^2 = 0 \text{ kN/m}^2$
	PASS - Maximum bearing pressure is less than allowable bearing pressure

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RETAINING WALL DESIGN (	BS 8002:1994)					ation version 1.2
Ultimate limit state load facto	ors				TEDDS Calcul	
Dead load factor		γ <sub>f_d</sub> = <b>1.4</b>				
Live load factor		γ <sub>f_1</sub> = <b>1.6</b>				
Earth and water pressure facto	or	γ <sub>f_e</sub> = <b>1.4</b>				
Factored vertical forces on v	vall					
Wall stem		Wwall f=γfd×	$h_{stem}  imes t_{wall}  imes \gamma_{w}$	wall = <b>39.6</b> kN/m	า	
Wall base		_ • _	-	/base = <b>29.7</b> kN/		
Applied vertical load				/ <sub>live</sub> = <b>22.8</b> kN/n		
Total vertical load			• –	v_f = <b>92.1</b> kN/m		
Factored horizontal at-rest for	orces on wall		-			
Surcharge		$F_{sur\ f} = \gamma_{f\ l} \times K$	‰ × Surcharge	e × h <sub>eff</sub> <b>= 8.1</b> kN	/m	
Moist backfill above water table	e		•	× (h <sub>eff</sub> - h <sub>water</sub> ) <sup>2</sup> =		
Moist backfill below water table	9	· -		- h <sub>water</sub> ) × h <sub>water</sub>		
Saturated backfill			• •	$_{vater}) \times h_{water}^2 = r$		
Water		_ · -		γ <sub>water</sub> = <b>27.5</b> k		
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 + F <sub>s_f</sub> + F <sub>water</sub>	_f = <b>112.9</b> kN/m	
Calculate propping force						
Passive resistance of soil in fro	ont of wall	$F_{p_f} = \gamma_{f_e} \times 0.$	$5 \times K_p \times \cos(\delta)$	$(d_{cover} + t_{ba})$	$_{ m se}$ + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup> ×	γ <sub>mb</sub> = <b>9.1</b> kN
Propping force		F <sub>prop_f</sub> = max( F <sub>prop_f</sub> = <b>74.6</b>	_ · · ·	$W_{total_{f}}$ - $\gamma_{f_{f}}$ $ imes$ $W$	$_{ m live})  imes$ tan( $\delta_{ m b}$ ), 0 k	kN/m)
Factored overturning mome	nts					
Surcharge		M <sub>sur_f</sub> = F <sub>sur_f</sub> :	$\times$ (h <sub>eff</sub> - 2 $\times$ d <sub>ds</sub>	₅) / 2 = <b>14</b> kNm	/m	
Moist backfill above water table	e	$M_{m_a_f} = F_{m_a}$	$_{\rm f} \times ({\rm h}_{\rm eff} + 2 \times {\rm h})$	$n_{water}$ - $3  imes d_{ds}$ ) /	3 = <b>38.8</b> kNm/m	ı
Moist backfill below water table	е	$M_{m_b_f} = F_{m_b}$	$_{\rm f}  imes$ (h <sub>water</sub> - 2 $ imes$	d <sub>ds</sub> ) / 2 = <b>43.1</b>	kNm/m	
Saturated backfill		$M_{s_f} = F_{s_f} \times (I)$	h <sub>water</sub> - $3  imes d_{ds}$ )	/ 3 = <b>12.3</b> kNm	n/m	
Water		$M_{water_f} = F_{water}$	$e_{r_f} \times (h_{water} - 3)$	× d <sub>ds</sub> ) / 3 = <b>18.</b>	<b>3</b> kNm/m	
Total overturning moment		$M_{ot_f} = M_{sur_f} + M_{sur_f}$	+ M <sub>m_a_f</sub> + M <sub>m_t</sub>	o_f + Ms_f + Mwat	<sub>er_f</sub> = <b>126.6</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>71.4</b> kNm/ı	m	
Wall base		M <sub>base_f</sub> = w <sub>base</sub>	$_{e_f} \times I_{base} / 2 = 2$	<b>29.7</b> kNm/m		
Design vertical load		$M_{v\_f} = W_{v\_f} \times$	l <sub>load</sub> = <b>41</b> kNm/	/m		
Total restoring moment		M <sub>rest_f</sub> = M <sub>wall_</sub>	f + M <sub>base_f</sub> + M <sub>v</sub>	<sub>/_f</sub> = <b>142.1</b> kNm	ı/m	
Factored bearing pressure						
Total moment for bearing		M <sub>total_f</sub> = M <sub>rest_</sub>	_f - M <sub>ot_f</sub> = <b>15.4</b>	kNm/m		
Total vertical reaction		$R_f = W_{total_f} =$				
Distance to reaction			/ R <sub>f</sub> = <b>168</b> mm			
Eccentricity of reaction		e <sub>f</sub> = abs((I <sub>base</sub>	/ 2) - x <sub>bar_f</sub> ) = 8		cts outside mid	dla thiust = t

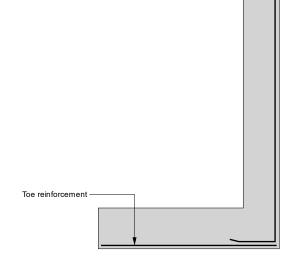
	Project 23 Dartmout	th Park Hill			Job Ref. 19047		
Architecture for London.	Section Wall 2 & 4				Sheet no./rev. 6	Sheet no./rev. 6	
TOF LONGON.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date	
Bearing pressure at heel		p <sub>heel_f</sub> = 0 kN/r	n² <b>= 0</b> kN/m²				
Rate of change of base reaction		rate = $p_{toe_f}$ / (	$3 \times x_{bar_f}$ ) = 72	<b>8.93</b> kN/m²/m			
Bearing pressure at stem / toe		p <sub>stem_toe_f</sub> = ma	x(p <sub>toe_f</sub> - (rate	$\times$ I <sub>toe</sub> ), 0 kN/m <sup>2</sup>	²) = <b>0</b> kN/m²		
Bearing pressure at mid stem		p <sub>stem_mid_f</sub> = ma	ax(p <sub>toe_f</sub> - (rate	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	)), 0 kN/m²) = <b>0</b>	κN/m²	
Bearing pressure at stem / heel		p <sub>stem_heel_f</sub> = m	ax(p <sub>toe_f</sub> - (rate	$ \times (I_{\text{toe}} + t_{\text{wall}})), $	0 kN/m²) = <b>0</b> kN/	′m²	
Design of reinforced concrete re	taining wall t	toe (BS 8002:199	4)				
Material properties		-	<u> </u>				
Characteristic strength of concrete		f <sub>cu</sub> = <b>40</b> N/mm	2				
Characteristic strength of reinforce	ment	f <sub>y</sub> = <b>500</b> N/mm	1 <sup>2</sup>				
Base details							
Minimum area of reinforcement		k = <b>0.13</b> %					
Cover to reinforcement in toe		c <sub>toe</sub> = <b>30</b> mm					
Calculate shear for toe design							
Shear from bearing pressure		$V_{toe\_bear} = 3  \times$	$D_{toe_f}  imes x_{bar_f} / 2$	2 = <b>92.1</b> kN/m			
Shear from weight of base		$V_{toe\_wt\_base} = \gamma_{f}$	_d $ imes \gamma_{\text{base}}  imes I_{\text{toe}}$	× t <sub>base</sub> = <b>23.8</b> k	N/m		
Total shear for toe design		$V_{toe} = V_{toe\_bear}$	- V <sub>toe_wt_base</sub> =	<b>68.4</b> kN/m			
Calculate moment for toe design							
Moment from bearing pressure		$M_{toe\_bear}$ = 3 $ imes$	$p_{toe_f}  imes x_{bar_f}  imes$	(I <sub>toe</sub> - x <sub>bar_f</sub> + t <sub>wa</sub>	all / 2) / 2 = <b>150.4</b>	kNm/m	
Moment from weight of base		M <sub>toe_wt_base</sub> = (	$\gamma_{\rm f_d}  imes \gamma_{ m base}  imes t_{ m base}$	$_{ m se}  imes ({ m I}_{ m toe}$ + ${ m t}_{ m wall}$ /	2) <sup>2</sup> / 2) = <b>24.1</b> k	Nm/m	
Total moment for toe design		$M_{toe} = M_{toe_beau}$	- M <sub>toe_wt_base</sub> =	<b>126.3</b> kNm/m			
450	•	•	•	•	•		
	◀───200─						
Check toe in bending							
Width of toe		b = <b>1000</b> mm/	m				
Depth of reinforcement		$d_{toe} = t_{base} - c_t$	<sub>pe</sub> − (φ <sub>toe</sub> / 2) =	<b>412.0</b> mm			
Constant		$K_{toe} = M_{toe} / (b$	$\times d_{toe}^2 \times f_{cu}) =$				
Lever arm				-	n reinforcemen $(0.9), 0.95) \times d_{tot}$	-	
		z <sub>toe</sub> = <b>391</b> mm					
Area of tension reinforcement requ	ired			z <sub>toe</sub> ) = <b>742</b> mm	n²/m		

	Project 23 Dartmo	uth Park Hill			Job Ref. 19047	
Architecture	Section				Sheet no./rev	
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	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Area of tension reinforcement r	required	A <sub>s_toe_req</sub> = Ma	ax(As_toe_des, As_	<sub>_toe_min</sub> ) = <b>742</b> m	וm²/m	
Reinforcement provided		16 mm dia.b	ars @ 200 mn	n centres		
Area of reinforcement provided	I	As_toe_prov = 10	<b>)05</b> mm²/m			
		PASS - Re	inforcement p	provided at the	e retaining wall	toe is adequ
Check shear resistance at to	e					
Design shear stress		$v_{toe} = V_{toe} / (b$	× d <sub>toe</sub> ) = 0.166	6 N/mm²		
Allowable shear stress		v <sub>adm</sub> = min(0.8	8 × √(f <sub>cu</sub> / 1 N/r	mm²), 5) × 1 N/	mm² <b>= 5.000</b> N/	mm²
		PASS	S - Design she	ear stress is le	ss than maxim	um shear str
From BS8110:Part 1:1997 – T	able 3.8					
Design concrete shear stress		v <sub>c_toe</sub> = <b>0.462</b>				
				$v_{toe} < v_{c_{toe}} - N_{c_{toe}}$	o shear reinfor	cement requ
Design of reinforced concret	e retaining wal	l stem (BS 8002:1	994)			
Material properties						
Material properties Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mm	1 <sup>2</sup>			
Material properties Characteristic strength of conce Characteristic strength of reinfo		f <sub>cu</sub> = <b>40</b> N/mm f <sub>y</sub> = <b>500</b> N/mm				
Characteristic strength of conc						
Characteristic strength of conce Characteristic strength of reinfo	orcement					
Characteristic strength of conce Characteristic strength of reinfo Wall details	prcement t	f <sub>y</sub> = <b>500</b> N/mr	n²			
Characteristic strength of conce Characteristic strength of reinfor <b>Wall details</b> Minimum area of reinforcement Cover to reinforcement in stem	prcement t	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> %	n²			
Characteristic strength of conce Characteristic strength of reinfor <b>Wall details</b> Minimum area of reinforcement	brcement t	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> % c <sub>stem</sub> = <b>40</b> mm	n²			
Characteristic strength of conce Characteristic strength of reinfor <b>Wall details</b> Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall	brcement t	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> % c <sub>stem</sub> = <b>40</b> mm c <sub>wall</sub> = <b>30</b> mm	n² 1	$ge  imes (h_{eff} - t_{base} -$	• d <sub>ds</sub> ) = <b>7.1</b> kN/m	
Characteristic strength of conce Characteristic strength of reinfor <b>Wall details</b> Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall <b>Factored horizontal at-rest for</b>	brcement t brces on stem	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> % c <sub>stem</sub> = <b>40</b> mm c <sub>wall</sub> = <b>30</b> mm F <sub>s_sur_f</sub> = γ <sub>f_l</sub> ×	n² n K₀ × Surcharg			
Characteristic strength of conce Characteristic strength of reinfor <b>Wall details</b> Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall <b>Factored horizontal at-rest for</b> Surcharge	prcement t prces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$	n² n Ko × Surcharg × γr_e × Ko × γm	$h \times (h_{eff} - t_{base} - c)$	dds) = <b>7.1</b> kN/m dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> sat) × h <sub>sat</sub> = <b>33.4</b>	kN/m
Characteristic strength of conce Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table	prcement t prces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e} \approx$	n <sup>2</sup> Ν Κο × Surcharg × γř_e × Κο × γm × Κο × γm × (her	$h \times (h_{eff} - t_{base} - c)$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b>	kN/m
Characteristic strength of conce Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table	prcement t prces on stem	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e} \times$ $F_{s\_s\_f} = 0.5 \times$	$n^2$ $K_0 \times Surcharg$ $\times \gamma_{f\_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef}$ $\gamma_{f\_e} \times K_0 \times (\gamma_{s-} \gamma_m)$	$h_{\rm m}  imes ({\sf h}_{\rm eff} - {\sf t}_{ m base} - {\sf d}_{ m ds}$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m	kN/m
Characteristic strength of conce Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water	prcement t prces on stem	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e} \times$ $F_{s\_s\_f} = 0.5 \times$	$n^2$ $K_0 \times Surcharg$ $\times \gamma_{f\_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef}$ $\gamma_{f\_e} \times K_0 \times (\gamma_{s-} \gamma_m)$	$h \times (h_{eff} - t_{base} - d_{sff})$ $h_{eff} - t_{base} - d_{ds} - h_{sff}$ $\gamma_{water}) \times h_{sat}^2 = 1$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m	kN/m
Characteristic strength of conce Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill	prcement t prces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_1} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_a\_2}$ $F_{s\_s\_f} = 0.5 \times \gamma$ $F_{s\_water\_f} = 0.5$	$\begin{array}{l} m^2\\ K_0\times Surcharg\\ \times \gamma_{f\_e}\times K_0\times \gamma_{m}\\ \times K_0\times \gamma_{m}\times (h_{ef}\\ \gamma_{f\_e}\times K_0\times (\gamma_{s^{e}} \uparrow_{s^{e}}) \\ \gamma_{f\_e}\times \gamma_{f\_e}\times \gamma_{water}\times \end{array}$	$h \times (h_{eff} - t_{base} - c_{off} - t_{base} - d_{ds} - h_{sff}$ $\gamma_{water}) \times h_{sat}^2 = 1$ $\langle h_{sat}^2 = 16.5 \text{ kN}$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b>   <b>1.1</b> kN/m I/m	kN/m kN/m
Characteristic strength of conce Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem	prcement t prces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_1} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_a\_2}$ $F_{s\_s\_f} = 0.5 \times \gamma$ $F_{s\_water\_f} = 0.5$	$\begin{array}{l} m^2\\ K_0\times Surcharg\\ \times \gamma_{f\_e}\times K_0\times \gamma_{m}\\ \times K_0\times \gamma_{m}\times (h_{ef}\\ \gamma_{f\_e}\times K_0\times (\gamma_{s^{e}} \uparrow_{s^{e}}) \\ \gamma_{f\_e}\times \gamma_{f\_e}\times \gamma_{water}\times \end{array}$	$h \times (h_{eff} - t_{base} - c_{off} - t_{base} - d_{ds} - h_{sff}$ $\gamma_{water}) \times h_{sat}^2 = 1$ $\langle h_{sat}^2 = 16.5 \text{ kN}$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m	kN/m kN/m
Characteristic strength of conce Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des	prcement t prces on stem	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_a\_s}$ $F_{s\_s\_f} = 0.5 \times \gamma$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$	m <sup>2</sup> K <sub>0</sub> × Surcharg × $\gamma_{f_e} × K_0 × \gamma_m$ × K <sub>0</sub> × $\gamma_m × (h_{el}$ $\gamma_{f_e} × K_0 × (\gamma_{s_e} - \gamma_{s_e})$ $\gamma_{f_e} × \gamma_{f_e} × \gamma_{water} ×$ $f + F_{s_m_a_f} + F_{s_m}$	$h \times (h_{eff} - t_{base} - c_{df} - t_{base} - d_{ds} - h_{s}$ $f - t_{base} - d_{ds} - h_{s}$ $\gamma_{water}) \times h_{sat}^{2} = 1$ $\langle h_{sat}^{2} = 16.5 \text{ kN}$ $s_{m_{b}f} + F_{s_{s}f} + $	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> I <b>1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m
Characteristic strength of conce Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des	prcement t prces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_b\_f} = 0.5$ $F_{s\_m\_b\_f} = 0.5 \times \gamma$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$ $M_{s\_sur} = F_{s\_sur\_f}$	m <sup>2</sup> $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{el})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^{-1}})$ $j \times \gamma_{f_e} \times \gamma_{water} \times$ $f + F_{s_m_a_f} + F_{s_f}$ $f + (h_{stem} + t_{bas})$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{ff}$ $ff - t_{base} - d_{ds} - h_{ff}$ $\gamma_{water}) \times h_{sat}^2 = 1$ $(h_{sat}^2 = 16.5 \text{ kN}$ $s_{s_m_b_f} + F_{s_s_f} + f_{s_s}$ $h_{se}) / 2 = 12.2 \text{ kN}$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> I <b>1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>9.2</b> kN/m
Characteristic strength of conce Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge Moist backfill above water table	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_a\_2}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$ $M_{s\_sur} = F_{s\_sur\_f}$	m <sup>2</sup> $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s} - \gamma_{s})$ $\gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times$ $f + F_{s_m_a_f} + F_{s_a}$ $f + F_{s_m_a_f} + F_{s_a}$ $f + (h_{stem} + t_{bass})$ $a_a f \times (2 \times h_{sat} + f_{s})$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{sff} - t_{base} - d_{ds} - h_{sf}$ $\gamma_{water}) \times h_{sat}^2 = 1$ $\langle h_{sat}^2 = 16.5 \text{ kN}$ $s_{m_b}f + F_{s_s}f +$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> I <b>1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>9.2</b> kN/m
Characteristic strength of conce Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge Moist backfill above water table Surcharge Moist backfill above water table Moist backfill above water table	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_a} \times$ $F_{s\_s\_f} = 0.5 \times 7$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$ $M_{s\_sur} = F_{s\_sur\_f}$ $M_{s\_m\_a} = F_{s\_m\_m}$ $M_{s\_m\_b} = F_{s\_m\_m}$	m <sup>2</sup> $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{el})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^{-1}} + F_s)$ $f + F_{s_m_a_f} + F_s$ $f + F_{s_m_a_f} + F_s$ $f + (h_{stem} + t_{bass})$ $a_f \times (2 \times h_{sat} + f_s)$ $b_f \times h_{sat} / 2 = 2$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{s}$ $\gamma_{water} + h_{sat}^2 = 1$ $\langle h_{sat}^2 = 16.5 \text{ kN}$ $s_{m_b}f + F_{s_s}f + h_{s}$ $h_{s} + h_{eff} - d_{ds} + t_{base}$ 25.9  kNm/m	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> I <b>1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>9.2</b> kN/m
Characteristic strength of conce Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge Moist backfill above water table	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $C_{stem} = 40 \text{ mm}$ $C_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_1} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_a\_2} \times$ $F_{s\_s\_f} = 0.5 \times 7$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$ $M_{s\_sur} = F_{s\_sur\_m}$ $M_{s\_m\_b} = F_{s\_m\_m}$ $M_{s\_m\_b} = F_{s\_m\_m}$ $M_{s\_s} = F_{s\_s\_f} \times 7$	m <sup>2</sup> $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s} - \gamma_{s})$ $\gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times$ $f + F_{s_m_a_f} + F_{s_a}$ $f + F_{s_m_a_f} + F_{s_a}$ $f + (h_{stem} + t_{bass})$ $a_a f \times (2 \times h_{sat} + f_{s})$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{sff} - t_{base} - d_{ds} - h_{sff} - t_{base} - d_{ds} - h_{sf} + \gamma_{water}) \times h_{sat}^2 = 1$ $(h_{sat}^2 = 16.5 \text{ kN} + h_{sat}^2 + F_{s_s_f} + F_{s_s_f} + F_{s_s_f} + h_{eff} - d_{ds} + t_{base}$ $(h_{eff} - d_{ds} + t_{base} + t_{b$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> I <b>1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>9.2</b> kN/m



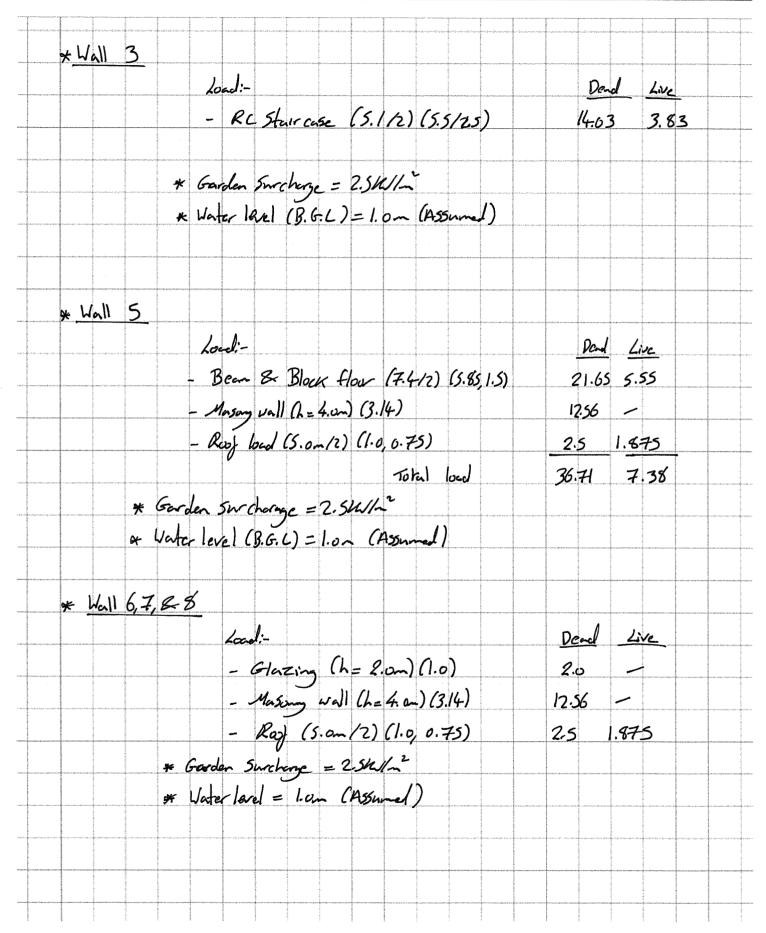
	Project 23 Dartmou	uth Park Hill			Job Ref. 19047	
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Tor London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Indicative retaining wall rein	forcement diagr	am				

-Stem reinforcement



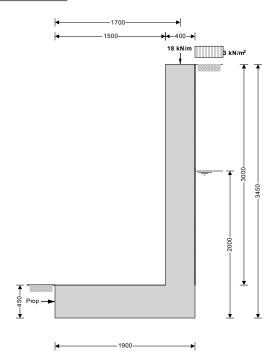
Toe bars - 16 mm dia.@ 200 mm centres -  $(1005 \text{ mm}^2/\text{m})$ Stem bars - 16 mm dia.@ 250 mm centres -  $(804 \text{ mm}^2/\text{m})$ 

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	Client	Calcs by Calcs date



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#### **RETAINING WALL ANALYSIS (BS 8002:1994)**

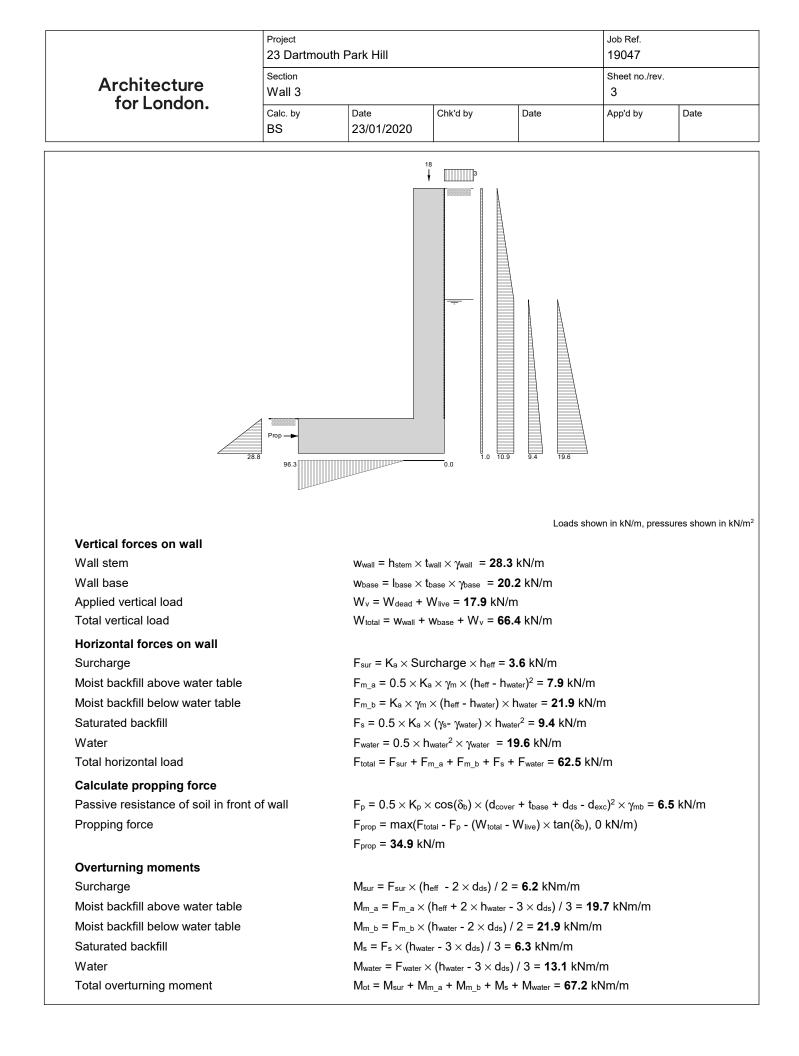


#### Wall details

Retaining wall type Cantilever propped at base Height of retaining wall stem Thickness of wall stem t<sub>wall</sub> = 400 mm Itoe = **1500** mm Length of toe Length of heel I<sub>heel</sub> = 0 mm Overall length of base Thickness of base t<sub>base</sub> = **450** mm Depth of downstand d<sub>ds</sub> = **0** mm I<sub>ds</sub> = **0** mm Position of downstand t<sub>ds</sub> = **450** mm Thickness of downstand Height of retaining wall Depth of cover in front of wall d<sub>cover</sub> = **0** mm Depth of unplanned excavation  $d_{exc} = 0 mm$ 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 α = **90.0** deg Angle of soil surface behind wall  $\beta$  = **0.0** deg Effective height at virtual back of wall **Retained material details** Mobilisation factor M = 1.5

h<sub>stem</sub> = **3000** mm  $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 1900 \text{ mm}$  $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3450 \text{ mm}$ h<sub>water</sub> = **2000** mm  $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 1550 mm$ γ<sub>wall</sub> = 23.6 kN/m<sup>3</sup>  $\gamma_{\text{base}} = 23.6 \text{ kN/m}^3$  $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3450 \text{ mm}$ 

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Architecture	Section Wall 3				Sheet no./rev. 2	
for London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Moist density of retained mater	ial	γ <sub>m</sub> = <b>18.0</b> kN/r	n <sup>3</sup>			
Saturated density of retained m	naterial	γ <sub>s</sub> = <b>21.0</b> kN/n	n <sup>3</sup>			
Design shear strength		∳' = <b>24.2</b> deg				
Angle of wall friction		$\delta$ = <b>0.0</b> deg				
Base material details						
Moist density		γ <sub>mb</sub> = <b>18.0</b> kN/	/m³			
Design shear strength		φ' <sub>b</sub> = <b>24.2</b> deg				
Design base friction		$\delta_b$ = <b>18.6</b> deg				
Allowable bearing pressure		P <sub>bearing</sub> = <b>110</b>	kN/m²			
Based on Kerisel & Absi - 'Ac	tive and passive	earth pressure	tables'			
Active pressure coefficient fo	or retained materi	al				
Slope angle ratio		$r_a = \beta / \phi' = 0.0$	00			
Wall friction ratio		$r_b = \delta / \phi' = 0.0$	00			
Active pressure coefficient for r	etained material	Ka <b>= 0.419</b>				
Passive pressure coefficient	for base material					
Slope angle ratio		r <sub>a</sub> = 0 deg / φ'ι	o = 0.00			
Wall friction ratio		$r_b = \delta_b / \phi'_b = 0$	).77			
Passive pressure coefficient for	r base material	K <sub>p</sub> = <b>3.754</b>				
At-rest pressure						
At-rest pressure for retained ma	aterial	$K_0 = 1 - sin(\phi$	') = <b>0.590</b>			
Loading details						
Surcharge load on plan		Surcharge =	<b>2.5</b> kN/m²			
Applied vertical dead load on w	vall	W <sub>dead</sub> = <b>14.0</b>	κN/m			
Applied vertical live load on wa	II	W <sub>live</sub> = <b>3.8</b> kN	/m			
Position of applied vertical load	on wall	l <sub>load</sub> = <b>1700</b> m	m			
Applied horizontal dead load or	n wall	F <sub>dead</sub> = <b>0.0</b> kN	/m			
Applied horizontal live load on		F <sub>live</sub> = <b>0.0</b> kN/	m			
Height of applied horizontal loa	d on wall	h <sub>load</sub> = <b>0</b> mm				



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Architecture	Section Wall 3				Sheet no./rev 4	<u>.</u>
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Restoring moments						
Restoring moments Wall stem		$M_{wall}$ = $w_{wall}$ ×	(I <sub>toe</sub> + t <sub>wall</sub> / 2) :	= <b>48.1</b> kNm/m		
-		M <sub>wall</sub> = w <sub>wall</sub> × M <sub>base</sub> = w <sub>base</sub> ;	,			
Wall stem			× I <sub>base</sub> / 2 = <b>19</b> .	<b>.2</b> kNm/m		

M<sub>total</sub> = M<sub>rest</sub> - M<sub>ot</sub> = **30.5** kNm/m

e = abs((l<sub>base</sub> / 2) - x<sub>bar</sub>) = **490** mm

R = W<sub>total</sub> = **66.4** kN/m

 $x_{\text{bar}} = M_{\text{total}} / R = 460 \text{ mm}$ 

# Check bearing pressure

Total moment for bearing Total vertical reaction Distance to reaction Eccentricity of reaction

Bearing pressure at toe Bearing pressure at heel  $p_{toe} = R / (1.5 \times x_{bar}) = 96.3 \text{ kN/m}^2$  $p_{heel} = 0 \text{ kN/m}^2 = 0 \text{ kN/m}^2$ 

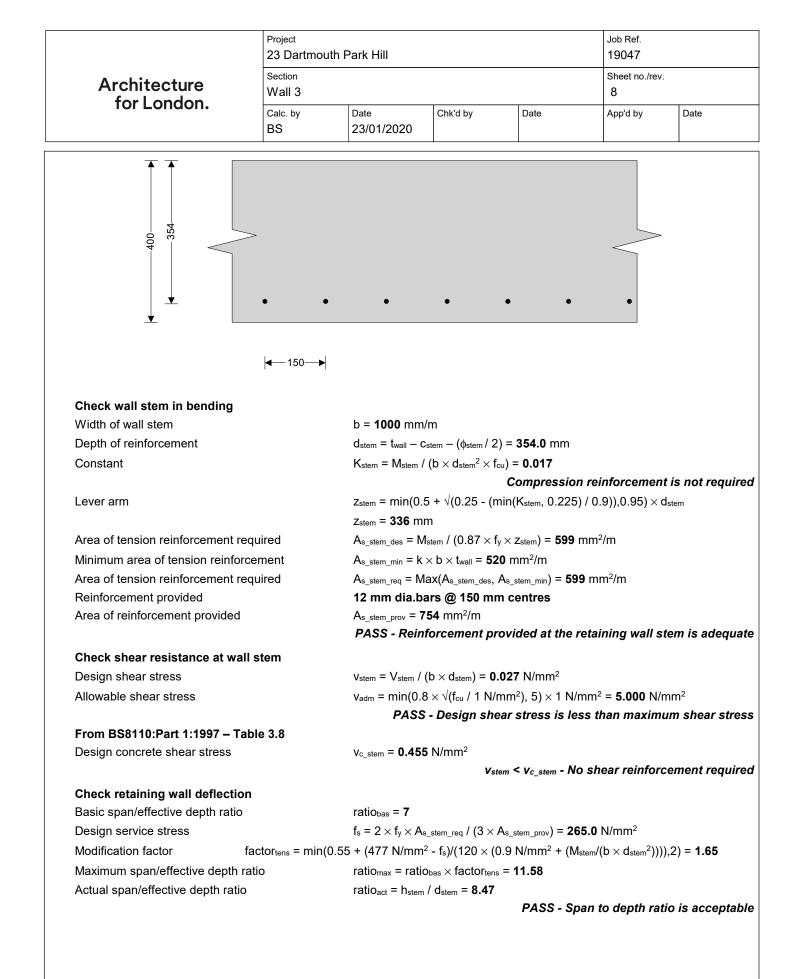
Reaction acts outside middle third of base

PASS - Maximum bearing pressure is less than allowable bearing pressure

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Architecture for London.	Section Wall 3		Sheet no./rev. 5					
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RETAINING WALL DESIGN (	BS 8002:1994)					ation version 1.2		
Ultimate limit state load fact	ors				TEDDS Calcul			
Dead load factor		$\gamma_{f_d} = 1.4$						
Live load factor		γ <sub>f_l</sub> = 1.6						
Earth and water pressure facto	or	$\gamma_{f_e} = 1.4$						
Factored vertical forces on v	wall							
Wall stem		$W_{wall_f} = \gamma_{f_d} \times$	$h_{stem}  imes t_{wall}  imes \gamma_{t}$	<sub>vall</sub> = <b>39.6</b> kN/m	า			
Wall base		_ · · -		/base = <b>28.2</b> kN/				
Applied vertical load		$W_{v_f} = \gamma_{f_d} \times V$	$V_{dead}$ + $\gamma_{f_{-l}}  imes W$	/ <sub>live</sub> = <b>25.8</b> kN/n	n			
Total vertical load		W <sub>total_f</sub> = w <sub>wall_</sub>	f + W <sub>base_f</sub> + W	<sub>v_f</sub> = <b>93.7</b> kN/m	1			
Factored horizontal at-rest for	orces on wall							
Surcharge		$F_{sur_{f}} = \gamma_{f_{l}} \times K$	$\mathbb{Z}_0  imes \mathbf{Surcharge}$	× h <sub>eff</sub> <b>= 8.1</b> kN	/m			
Moist backfill above water tabl	е	$F_{m_a_f} = \gamma_{f_e} \times$	$0.5  imes K_0  imes \gamma_m$ :	× (h <sub>eff</sub> - h <sub>water</sub> ) <sup>2</sup> =	= <b>15.6</b> kN/m			
Moist backfill below water table	e	$F_{m_b_f} = \gamma_{f_e} \times$	$K_0  imes \gamma_m  imes (h_{eff}$	- $h_{water}$ ) × $h_{water}$	= <b>43.1</b> kN/m			
Saturated backfill	$F_{s_f} = \gamma_{f_e} \times 0.$	$F_{s_{-}f} = \gamma_{f_{-}e} \times 0.5 \times K_0 \times (\gamma_{s^{-}} \gamma_{water}) \times h_{water}^2 = 18.5 \text{ kN/m}$						
Water		$F_{water_f} = \gamma_{f_e} \times$	$0.5  imes h_{water}^2  imes$	γ <sub>water</sub> = <b>27.5</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>	_f = <b>112.9</b> kN/m			
Calculate propping force								
Passive resistance of soil in fro	ont of wall	$F_{p_f} = \gamma_{f_e} \times 0.$	$5  imes K_p  imes \cos(\delta)$	$(d_{cover} + t_{ba})$	$_{ m se}$ + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup> $ imes$	γ <sub>mb</sub> = <b>9.1</b> kN		
Propping force		F <sub>prop_f</sub> = max( F <sub>prop_f</sub> = <b>74.3</b>	•	$N_{total_f}$ - $\gamma_{f_l}  imes W$	$_{ m live}) imes$ tan( $\delta_{ m b}$ ), 0 k	N/m)		
Factored overturning mome	nts							
Surcharge		$M_{sur_f} = F_{sur_f}$	$\times$ (h <sub>eff</sub> - 2 $\times$ d <sub>d</sub>	s) / 2 = <b>14</b> kNm	/m			
Moist backfill above water tabl	e	$M_{m_a_f} = F_{m_a}$	$f \times (h_{eff} + 2 \times h)$	Nwater - $3  imes d_{ds}$ ) /	3 = <b>38.8</b> kNm/m	1		
Moist backfill below water table	е	$M_{m_b_f} = F_{m_b}$	$_{\rm f}  imes$ (h <sub>water</sub> - 2 $ imes$	d <sub>ds</sub> ) / 2 = <b>43.1</b>	kNm/m			
Saturated backfill		$M_{s_f} = F_{s_f} \times (I)$	$n_{water}$ - $3  imes d_{ds}$ )	/ 3 = <b>12.3</b> kNm	n/m			
Water		$M_{water_f} = F_{water}$	er_f × (h <sub>water</sub> - 3	× d <sub>ds</sub> ) / 3 = <b>18.</b> :	<b>3</b> kNm/m			
Total overturning moment		$M_{ot_f} = M_{sur_f} + M_{sur_f}$	- M <sub>m_a_f</sub> + M <sub>m_l</sub>	<sub>f</sub> + M <sub>s_f</sub> + M <sub>wat</sub>	<sub>er_f</sub> = <b>126.6</b> kNm	/m		
Restoring moments								
Wall stem		$M_{wall_f} = w_{wall_f}$	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	2) = <b>67.4</b> kNm/ı	m			
Wall base		$M_{base_f} = w_{base}$	$_{\rm f} \times I_{\rm base} / 2 = 2$	2 <b>6.8</b> kNm/m				
Design vertical load		$M_{v\_f} = W_{v\_f} \times$	l <sub>load</sub> = <b>43.8</b> kNi	m/m				
Total restoring moment		M <sub>rest_f</sub> = M <sub>wall_f</sub>	+ M <sub>base_f</sub> + M	<sub>′_f</sub> = <b>138</b> kNm/n	n			
rotal rootoning momont								
Factored bearing pressure			- M 11 /	kNm/m				
Factored bearing pressure Total moment for bearing		M <sub>total_f</sub> = M <sub>rest_</sub>						
<b>Factored bearing pressure</b> Total moment for bearing Total vertical reaction		$R_f = W_{total_f} =$	<b>93.7</b> kN/m					
<b>Factored bearing pressure</b> Total moment for bearing Total vertical reaction Distance to reaction		$R_{f} = W_{total_{f}} = x_{bar_{f}} = M_{total_{f}}$	<b>93.7</b> kN/m / R <sub>f</sub> = <b>122</b> mm					
<b>Factored bearing pressure</b> Total moment for bearing Total vertical reaction		$R_{f} = W_{total_{f}} = x_{bar_{f}} = M_{total_{f}}$	<b>93.7</b> kN/m	828 mm	cts outside mid	dla third of		

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Bearing pressure at heel		p <sub>heel_f</sub> = 0 kN/i	m <sup>2</sup> = <b>0</b> kN/m <sup>2</sup>						
Rate of change of base reactio	n	rate = p <sub>toe_f</sub> / (	$3 \times x_{bar_f}$ ) = 14	00.12 kN/m²/n	n				
Bearing pressure at stem / toe		p <sub>stem_toe_f</sub> = ma	ax(p <sub>toe_f</sub> - (rate	$\times$ I <sub>toe</sub> ), 0 kN/m <sup>2</sup>	<sup>2</sup> ) = <b>0</b> kN/m <sup>2</sup>				
Bearing pressure at mid stem		$p_{stem_mid_f} = m_f$	ax(p <sub>toe_f</sub> - (rate	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	2)), 0 kN/m²) = <b>0</b> k	κN/m²			
Bearing pressure at stem / hee	9	$p_{stem\_heel\_f} = m$	ax(p <sub>toe_f</sub> - (rate	$e \times (I_{toe} + t_{wall})),$	$0 \text{ kN/m}^2$ ) = <b>0</b> kN/	m²			
Design of reinforced concret	e retaining wal	l toe (BS 8002:199	<u>4)</u>						
Material properties									
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mm	2						
Characteristic strength of reinfo	orcement	f <sub>y</sub> = <b>500</b> N/mn	1 <sup>2</sup>						
Base details									
Minimum area of reinforcemen	t	k = <b>0.13</b> %							
Cover to reinforcement in toe		c <sub>toe</sub> = <b>30</b> mm							
Calculate shear for toe desig	n								
Shear from bearing pressure		$V_{toe\_bear} = 3 \times$	$p_{toe_f} \times x_{bar_f} / 2$	2 = <b>93.7</b> kN/m					
Shear from weight of base		·	$V_{toe\_wt\_base} = \gamma_{f\_d} \times \gamma_{base} \times I_{toe} \times t_{base} = 22.3 \text{ kN/m}$						
Total shear for toe design		$V_{toe} = V_{toe\_bear}$	- V <sub>toe_wt_base</sub> =	<b>71.4</b> kN/m					
Calculate moment for toe dea	-								
Moment from bearing pressure	•				<sub>/all</sub> / 2) / 2 = <b>147.8</b>				
Moment from weight of base Total moment for toe design				<sub>ise</sub> × (I <sub>toe</sub> + t <sub>wall</sub> / = <b>126.3</b> kNm/m	/ 2) <sup>2</sup> / 2) = <b>21.5</b> kM	Nm/m			
450	•	• •	•		•				
	<b> 4</b> ──150── <b>▶</b>	•							
Check toe in bending									
Width of toe		b = <b>1000</b> mm							
Depth of reinforcement			$toe - (\phi_{toe} / 2) =$						
		$\kappa_{toe} = M_{toe} / (k$	$\times d_{toe}^2 \times f_{cu}$ =		n roinforo				
Constant				compressio	on reinforcement				
		z <sub>toe</sub> = min(0.5 z <sub>toe</sub> = <b>393</b> mm		n(K <sub>toe</sub> , 0.225)	/ 0.9)),0.95) × d <sub>toe</sub>	-			
Constant	required	z <sub>toe</sub> = <b>393</b> mm	1	n(K <sub>toe</sub> , 0.225) z <sub>toe</sub> ) = <b>738</b> mr		-			

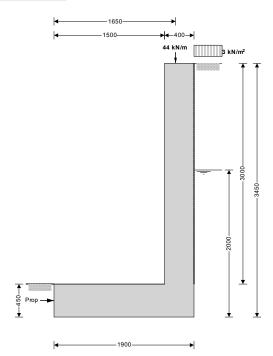
	Project 23 Dartmo	uth Park Hill			Job Ref. 19047	
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	Wall 3				7	
	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Area of tension reinforcement r	equired	A <sub>s_toe_req</sub> = Ma	IX(As_toe_des, As_	_ <sub>toe_min</sub> ) = <b>738</b> n	nm²/m	
Reinforcement provided			ars @ 150 mn			
Area of reinforcement provided		As_toe_prov = 7	<b>54</b> mm²/m			
		PASS - Re	inforcement p	provided at th	e retaining wall	toe is adequ
Check shear resistance at to	9					
Design shear stress		v <sub>toe</sub> = V <sub>toe</sub> / (b	× d <sub>toe</sub> ) = 0.172	2 N/mm <sup>2</sup>		
Allowable shear stress		v <sub>adm</sub> = min(0.5	3 × √(f <sub>cu</sub> / 1 N/r	mm²), 5) × 1 N/	′mm² <b>= 5.000</b> N/r	mm²
			•		ess than maxim	
From BS8110:Part 1:1997 – T	able 3.8					
Design concrete shear stress		v <sub>c_toe</sub> = 0.419	N/mm <sup>2</sup>			
			1	v <sub>toe</sub> < v <sub>c_toe</sub> - N	o shear reinford	cement requ
Design of reinforced concret	e retaining wal	l stem (BS 8002:1	994)			
Material properties	<u> </u>	<b>`</b>	<u> </u>			
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mn	1 <sup>2</sup>			
Characteristic strength of reinfo		f <sub>y</sub> = <b>500</b> N/mr				
Wall details		,				
Minimum area of reinforcemen	ł	k = <b>0.13</b> %				
Cover to reinforcement in stem		<sub>Cstem</sub> = <b>40</b> mm	'n			
		Cwall = <b>30</b> mm				
Cover to reinforcement in wall	arcas on stam	c <sub>wall</sub> = <b>30</b> mm				
Cover to reinforcement in wall Factored horizontal at-rest for	rces on stem			1e × (hoff - those -	- d <sub>ds</sub> ) = <b>7 1</b> kN/m	
Cover to reinforcement in wall Factored horizontal at-rest for Surcharge		$F_{s\_sur\_f} = \gamma_{f\_l} \times$	$K_0  imes Surcharg$		• d <sub>ds</sub> ) = <b>7.1</b> kN/m	
Cover to reinforcement in wall <b>Factored horizontal at-rest fo</b> Surcharge Moist backfill above water table	;	F <sub>s_sur_f</sub> = γ <sub>f_l</sub> × F <sub>s_m_a_f</sub> = 0.5	$K_0  imes Surcharg \  imes \gamma_{\mathtt{f}_{\mathtt{e}}}  imes K_0  imes \gamma_{\mathtt{m}}$	$h \times (h_{eff} - t_{base} - 0)$	$d_{ds} - h_{sat})^2 = 15.6$	kN/m
Cover to reinforcement in wall <b>Factored horizontal at-rest fo</b> Surcharge Moist backfill above water table Moist backfill below water table	;	F <sub>s_sur_f</sub> = γ <sub>f_l</sub> × F <sub>s_m_a_f</sub> = 0.5 F <sub>s_m_b_f</sub> = γ <sub>f_e</sub>	$f K_0 imes Surcharg  imes f X_0 imes f Y_{t_e} imes f K_0 imes f \gamma_m  imes f (h_{ef}$	$h \times (h_{eff} - t_{base} - q_{ff})$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b>	kN/m
Cover to reinforcement in wall <b>Factored horizontal at-rest fo</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill	;	$F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times 100$	$\begin{array}{l} K_0\times Surcharg\\ \times \gamma_{f\_e}\timesK_0\times\gamma_{m}\\ \times K_0\times\gamma_{m}\times(h_{ef}\\ \gamma_{f\_e}\timesK_0\times(\gamma_{s}\text{-}\gamma_{m}) \end{array}$	$h \times (h_{eff} - t_{base} - d_{ds})$ ff - $t_{base} - d_{ds} - h_{gase}$ $\gamma_{water}) \times h_{sat}^2 = \gamma_{gas}^2$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> k <b>11.1</b> kN/m	kN/m
Cover to reinforcement in wall <b>Factored horizontal at-rest fo</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water	2	$F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times 100$	$\begin{array}{l} K_0\times Surcharg\\ \times \gamma_{f\_e}\timesK_0\times\gamma_{m}\\ \times K_0\times\gamma_{m}\times(h_{ef}\\ \gamma_{f\_e}\timesK_0\times(\gamma_{s}\text{-}\gamma_{m}) \end{array}$	$h \times (h_{eff} - t_{base} - q_{ff})$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> k <b>11.1</b> kN/m	kN/m
Cover to reinforcement in wall <b>Factored horizontal at-rest fo</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water <b>Calculate shear for stem des</b>	2	$F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times F_{s\_water\_f} = 0.5$	$\begin{array}{l} K_0\times Surcharg\\ \times \gamma_{\mathrm{f}_{-}\mathrm{e}}\timesK_0\times\gamma_{\mathrm{m}}\\ \times K_0\times\gamma_{\mathrm{m}}\times(h_{\mathrm{ef}}\\ \gamma_{\mathrm{f}_{-}\mathrm{e}}\timesK_0\times(\gamma_{\mathrm{s}^{-}}\gamma_{\mathrm{water}}\times\gamma_{\mathrm{f}_{-}\mathrm{e}}\times\gamma_{\mathrm{water}}\times \end{array}$	$h \times (h_{eff} - t_{base} - 0)$ $ff - t_{base} - d_{ds} - h$ $\gamma_{water}) \times h_{sat}^2 = \gamma^2$ $h_{sat}^2 = 16.5 \text{ kM}$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> k <b>11.1</b> kN/m V/m	kN/m kN/m
Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des	2	$F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times F_{s\_water\_f} = 0.5$	$\begin{array}{l} K_0\times Surcharg\\ \times \ \gamma_{\mathrm{f}_{-}\mathrm{e}}\times K_0\times \gamma_{\mathrm{m}}\\ \times \ K_0\times \gamma_{\mathrm{m}}\times (h_{\mathrm{ef}}\\ \gamma_{\mathrm{f}_{-}\mathrm{e}}\times K_0\times (\gamma_{\mathrm{s}^{-}}\gamma_{\mathrm{water}}\times \gamma_{\mathrm{f}_{-}\mathrm{e}}\times \gamma_{\mathrm{water}}\times \end{array}$	$h \times (h_{eff} - t_{base} - 0)$ $ff - t_{base} - d_{ds} - h$ $\gamma_{water}) \times h_{sat}^2 = \gamma^2$ $h_{sat}^2 = 16.5 \text{ kM}$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> k <b>11.1</b> kN/m	kN/m kN/m
Cover to reinforcement in wall <b>Factored horizontal at-rest fo</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water	ign	$F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_i}$	$\begin{array}{l} K_0 \times Surcharg \\ \times \gamma_{f\_e} \times K_0 \times \gamma_{m} \\ \times K_0 \times \gamma_m \times (h_{ef} \\ \gamma_{f\_e} \times K_0 \times (\gamma_{s-} \gamma \\ \times \gamma_{f\_e} \times \gamma_{water} \times \\ \end{array}$	$h \times (h_{eff} - t_{base} - 0)$ $ff - t_{base} - d_{ds} - h$ $\gamma_{water}) \times h_{sat}^2 = \gamma$ $h_{sat}^2 = 16.5 \text{ kM}$ $h_{sat}^2 = h_{s_s} + h_{s_s} + h_{s_s}$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> k <b>11.1</b> kN/m V/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m
Cover to reinforcement in wall <b>Factored horizontal at-rest fo</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water <b>Calculate shear for stem des</b> Shear at base of stem	ign	$F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_i}$ $M_{s\_sur} = F_{s\_sur\_i}$	$K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^-} \gamma_{s^-} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times f_{s^-} + F_{s_m_a_f} + F_{s_s}$ $f_f \times (h_{stem} + t_{base})$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{sat}^2 = f_{sat}^2 = f_{sat}^2 = f_{sat}^2 = f_{sat}^2 - f_{sat}^2$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> H <b>11.1</b> kN/m V/m F <sub>s_water_f</sub> - F <sub>prop_f</sub> H	kN/m kN/m = <b>9.4</b> kN/m
Cover to reinforcement in wall <b>Factored horizontal at-rest fo</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water <b>Calculate shear for stem des</b> Shear at base of stem <b>Calculate moment for stem d</b>	ign esign	$F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_i}$ $M_{s\_sur} = F_{s\_sur\_i}$	$K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^-} \gamma_{s^-} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times f_{s^-} + F_{s_m_a_f} + F_{s_s}$ $f_f \times (h_{stem} + t_{base})$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{sat}^2 = f_{sat}^2 = f_{sat}^2 = f_{sat}^2 = f_{sat}^2 - f_{sat}^2$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> k <b>11.1</b> kN/m V/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>9.4</b> kN/m
Cover to reinforcement in wall <b>Factored horizontal at-rest fo</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water <b>Calculate shear for stem des</b> Shear at base of stem <b>Calculate moment for stem d</b> Surcharge	ign esign	$F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_i}$ $M_{s\_sur} = F_{s\_sur\_i}$ $M_{s\_m\_a} = F_{s\_sur\_i}$	$K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^-} \gamma_{s^-} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times f_{s^-} + F_{s_m_a_f} + F_{s_s}$ $f_f \times (h_{stem} + t_{base})$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{ff} + h_{sat}^2 = f_{sat}^2 = f_{sat}^2 + f_{sat}^2 = f_{sat}^2 + f_{sat}^2 $	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> H <b>11.1</b> kN/m V/m F <sub>s_water_f</sub> - F <sub>prop_f</sub> H	kN/m kN/m = <b>9.4</b> kN/m
Cover to reinforcement in wall <b>Factored horizontal at-rest fo</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water <b>Calculate shear for stem des</b> Shear at base of stem <b>Calculate moment for stem d</b> Surcharge Moist backfill above water table	ign esign	$F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$ $M_{s\_sur} = F_{s\_sur\_f}$ $M_{s\_m\_a} = F_{s\_m\_m}$ $M_{s\_m\_b} = F_{s\_m\_m}$	$K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef}$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^-} \gamma_{s^-} \times \gamma_{f_e} \times \gamma_{water} \times f_{s^-} + F_{s_m_a_f} + F_{s_s}$ $f_* + F_{s_m_a_f} + f_{base}$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{ff} + f_{sat}^2 = f_{sat}^2 + f_{sat}^2 = f_{sat}^2 + f_{sat}^2 = f_{sat}^2 + f_{sat}^2 $	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> k <b>11.1</b> kN/m V/m F <sub>s_water_f</sub> - F <sub>prop_f</sub> f	kN/m kN/m = <b>9.4</b> kN/m
Cover to reinforcement in wall <b>Factored horizontal at-rest for</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water <b>Calculate shear for stem des</b> Shear at base of stem <b>Calculate moment for stem d</b> Surcharge Moist backfill above water table Moist backfill below water table	ign esign	$F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$ $M_{s\_sur} = F_{s\_sur\_f}$ $M_{s\_m\_a} = F_{s\_m\_m}$ $M_{s\_m\_b} = F_{s\_m\_m}$	$K_0 \times Surcharg$ $\times \gamma_{f\_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef}$ $\gamma_{f\_e} \times K_0 \times (\gamma_{s-1} + \gamma_{f\_e} \times \gamma_$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{ff} + h_{sat}^2 = f_{sat}^2 + f_{sat}^2 $	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> k <b>11.1</b> kN/m V/m F <sub>s_water_f</sub> - F <sub>prop_f</sub> f	kN/m kN/m = <b>9.4</b> kN/m



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TOT LONGON.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date	
Indicative retaining wall reir	nforcement diagram	<u>1</u>					
Τα	e reinforcement			——Stem reinforcement			
Toe bars - 12 mm dia.@ 150	mm centres - (754 m ) mm centres - (754						
		•					

						Job Ref. 19047	
Architecture for London.	Section Wall 5					Sheet no./rev. 1	
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### **RETAINING WALL ANALYSIS (BS 8002:1994)**

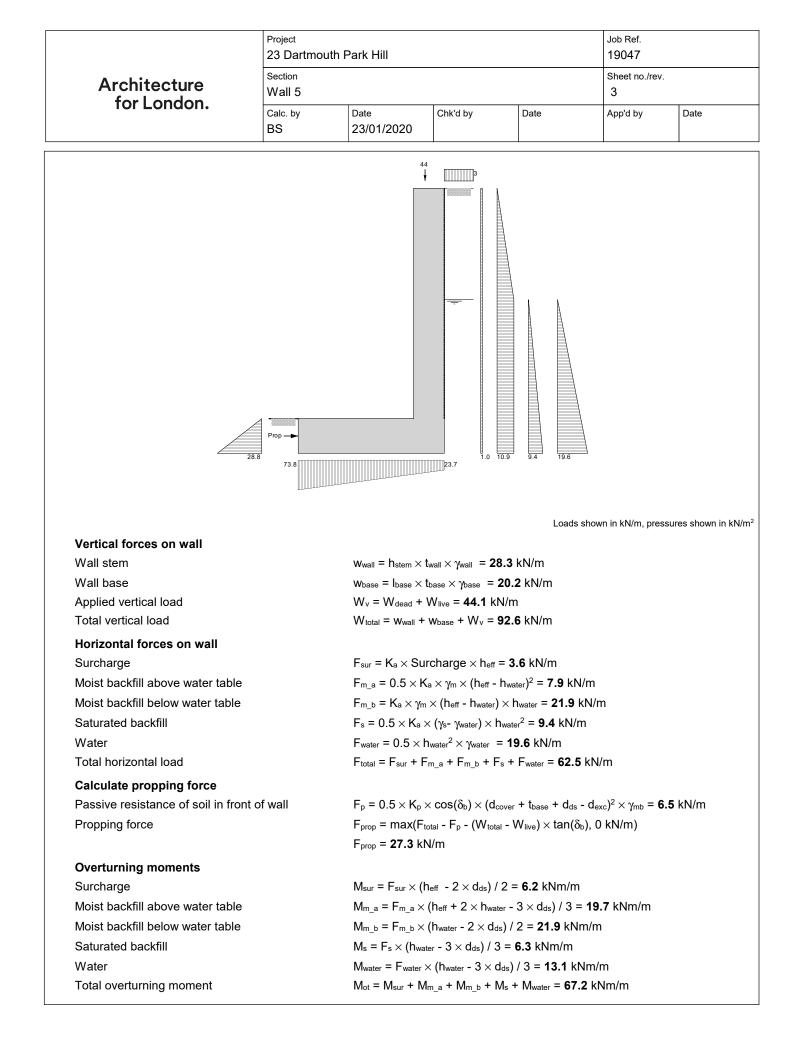


#### Wall details

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

# Cantilever propped at base h<sub>stem</sub> = **3000** mm t<sub>wall</sub> = 400 mm Itoe = **1500** mm I<sub>heel</sub> = 0 mm $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 1900 \text{ mm}$ t<sub>base</sub> = **450** mm d<sub>ds</sub> = **0** mm l<sub>ds</sub> = **1350** mm t<sub>ds</sub> = **450** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3450 \text{ mm}$ d<sub>cover</sub> = **0** mm $d_{exc} = 0 mm$ h<sub>water</sub> = **2000** mm $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 1550 mm$ γ<sub>wall</sub> = 23.6 kN/m<sup>3</sup> $\gamma_{\text{base}} = 23.6 \text{ kN/m}^3$ α = **90.0** deg $\beta$ = **0.0** deg $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3450 \text{ mm}$

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Moist density of retained mater	ial	γm = <b>18.0</b> kN/r	m <sup>3</sup>					
Saturated density of retained m	naterial	γ <sub>s</sub> = <b>21.0</b> kN/r	n <sup>3</sup>					
Design shear strength		∳' = <b>24.2</b> deg						
Angle of wall friction		δ = <b>0.0</b> deg						
Base material details								
Moist density		γ <sub>mb</sub> = <b>18.0</b> kN	/m³					
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		$P_{\text{bearing}} = 110 \text{ kN/m}^2$						
Based on Kerisel & Absi - 'Ac	tive and passive	earth pressure	tables'					
Active pressure coefficient fo	or retained materi	al						
Slope angle ratio		$r_a = \beta / \phi' = 0.$	00					
Wall friction ratio		$r_{b} = \delta / \phi' = 0.0$	00					
Active pressure coefficient for r	etained material	Ka = <b>0.419</b>						
Passive pressure coefficient	for base material							
Slope angle ratio		r <sub>a</sub> = 0 deg / φ'	o <b>= 0.00</b>					
Wall friction ratio		$r_{b} = \delta_{b} / \phi'_{b} = 0$	).77					
Passive pressure coefficient fo	r base material	K <sub>p</sub> = <b>3.754</b>						
At-rest pressure								
At-rest pressure for retained ma	aterial	$K_0 = 1 - sin(\phi)$	') = <b>0.590</b>					
Loading details								
Surcharge load on plan		Surcharge = 2	<b>2.5</b> kN/m²					
Applied vertical dead load on w	vall	W <sub>dead</sub> = <b>36.7</b>	kN/m					
Applied vertical live load on wa	II	W <sub>live</sub> = <b>7.4</b> kN	/m					
Position of applied vertical load	on wall	l <sub>load</sub> = <b>1650</b> m						
Applied horizontal dead load or	n wall	F <sub>dead</sub> = <b>0.0</b> kN	/m					
Applied horizontal live load on		F <sub>live</sub> = <b>0.0</b> kN/	m					
Height of applied horizontal loa	d on wall	h <sub>load</sub> = <b>0</b> mm						



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Wall base Design vertical load Total restoring moment

#### Check bearing pressure

Total moment for bearing Total vertical reaction Distance to reaction Eccentricity of reaction

Bearing pressure at toe Bearing pressure at heel 
$$\begin{split} M_{\text{wall}} &= w_{\text{wall}} \times (I_{\text{toe}} + t_{\text{wall}} / 2) = \textbf{48.1 kNm/m} \\ M_{\text{base}} &= w_{\text{base}} \times I_{\text{base}} / 2 = \textbf{19.2 kNm/m} \\ M_{\text{v}} &= W_{\text{v}} \times I_{\text{load}} = \textbf{72.7 kNm/m} \\ M_{\text{rest}} &= M_{\text{wall}} + M_{\text{base}} + M_{\text{v}} = \textbf{140.1 kNm/m} \end{split}$$

$$\begin{split} M_{total} &= M_{rest} - M_{ot} = \textbf{72.9 kNm/m} \\ R &= W_{total} = \textbf{92.6 kN/m} \\ x_{bar} &= M_{total} / R = \textbf{787 mm} \\ e &= abs((I_{base} / 2) - x_{bar}) = \textbf{163 mm} \end{split}$$

Reaction acts within middle third of base

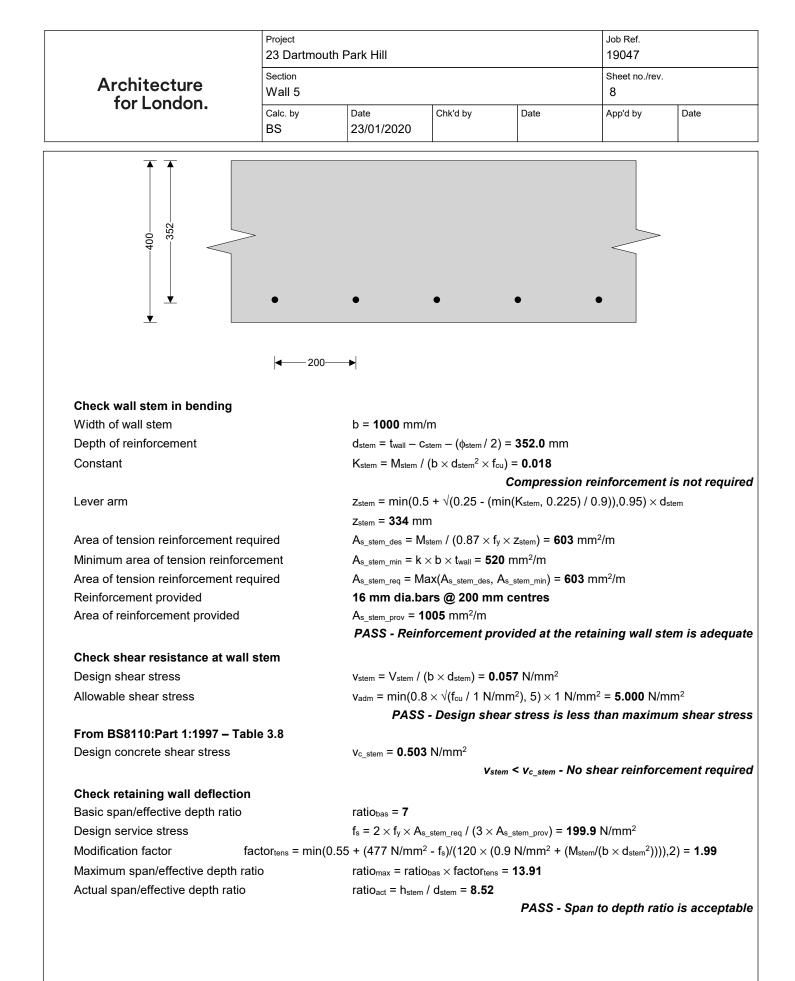
 $p_{toe} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 73.8 \text{ kN/m}^2$ 

 $p_{heel} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 23.7 \text{ kN/m}^2$ 

	Project 23 Dartmo	uth Park Hill			Job Ref. 19047	
Architecture for London.	Section Wall 5				Sheet no./rev 5	<i>'</i> .
Tor London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
RETAINING WALL DESIGN (	BS 8002:1994)					ation varian 1.0
Ultimate limit state load fact	ors				TEDDS calcul	ation version 1.2
Dead load factor		γ <sub>f_d</sub> = <b>1.4</b>				
Live load factor		γ <sub>f_1</sub> = 1.6				
Earth and water pressure facto	or	γ <sub>f_e</sub> = 1.4				
Factored vertical forces on v	vall					
Wall stem		$W_{wall_f} = \gamma_{f_d} \times$	$h_{stem}  imes t_{wall}  imes \gamma_{wall}$	<sub>vall</sub> = <b>39.6</b> kN/m	า	
Wall base		_ • -	-	/base = <b>28.2</b> kN/		
Applied vertical load				/ <sub>live</sub> = <b>63.2</b> kN/m		
Total vertical load		W <sub>total_f</sub> = w <sub>wall_</sub>	_f + W <sub>base_f</sub> + W	v_f = <b>131.1</b> kN/i	m	
Factored horizontal at-rest fe	orces on wall					
Surcharge		$F_{sur_f} = \gamma_{f_i} \times K$	‰ × Surcharge	× h <sub>eff</sub> <b>= 8.1</b> kN	/m	
Moist backfill above water tabl	e	$F_{m_a_f} = \gamma_{f_e} \times$	$0.5 \times K_0 \times \gamma_m$	< (h <sub>eff</sub> - h <sub>water</sub> ) <sup>2</sup> =	= <b>15.6</b> kN/m	
Moist backfill below water table	е	Fm b f=γfe×	$K_0 \times \gamma_m \times (h_{eff})$	- h <sub>water</sub> ) × h <sub>water</sub>	= <b>43.1</b> kN/m	
Saturated backfill		$F_{s f} = \gamma_{f e} \times 0.$	5 × K <sub>0</sub> × (γ <sub>s</sub> - γ <sub>v</sub>	<sub>vater</sub> ) × h <sub>water</sub> <sup>2</sup> = *	<b>18.5</b> kN/m	
Water		F <sub>water f</sub> = γ <sub>fe</sub> ×	$0.5 \times h_{water}^2 \times$	γ <sub>water</sub> = <b>27.5</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 + F <sub>s_f</sub> + F <sub>water</sub>	_f = <b>112.9</b> kN/m	
Calculate propping force						
Passive resistance of soil in fro	ont of wall	$F_{p_f} = \gamma_{f_e} \times 0.$	$5  imes K_p  imes \cos(\delta$	$(d_{cover} + t_{bas})$	$_{ m se}$ + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup> ×	γ <sub>mb</sub> = <b>9.1</b> kN
Propping force		F <sub>prop_f</sub> = max( F <sub>prop_f</sub> = <b>63.6</b>		$N_{total_{f}}$ - $\gamma_{f_{I}}  imes W$	$_{ m live})  imes$ tan( $\delta_{ m b}$ ), 0 k	N/m)
Factored overturning mome	nts					
Surcharge		$M_{sur_f} = F_{sur_f}$	$\times$ (h <sub>eff</sub> - 2 $\times$ d <sub>ds</sub>	s) / 2 = <b>14</b> kNm	/m	
Moist backfill above water tabl	e	$M_{m_a_f} = F_{m_a}$	$f \times (h_{eff} + 2 \times h)$	Nwater - $3 \times d_{ds}$ /	3 = <b>38.8</b> kNm/m	ı
Moist backfill below water table	е	$M_{m_b_f} = F_{m_b}$	$_{\rm f}  imes$ (h <sub>water</sub> - 2 $ imes$	d <sub>ds</sub> ) / 2 = <b>43.1</b>	kNm/m	
Saturated backfill		$M_{s_f} = F_{s_f} \times (I)$	h <sub>water</sub> - $3  imes d_{ds}$ )	/ 3 = <b>12.3</b> kNm	n/m	
Water		$M_{water_f} = F_{water}$	$e_{r_f} \times (h_{water} - 3)$	× d <sub>ds</sub> ) / 3 = <b>18.</b> 3	<b>3</b> kNm/m	
Total overturning moment		$M_{ot_f} = M_{sur_f} + M_{sur_f}$	• M <sub>m_a_f</sub> + M <sub>m_t</sub>	<sub>_f</sub> + M <sub>s_f</sub> + M <sub>wate</sub>	<sub>er_f</sub> = <b>126.6</b> kNm	/m
Restoring moments						
Wall stem		$M_{wall_f} = w_{wall_f}$	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	2) = <b>67.4</b> kNm/r	m	
Wall base		$M_{base_f} = w_{base}$	$e_f \times I_{base} / 2 = 2$	2 <b>6.8</b> kNm/m		
Design vertical load		$M_{v\_f} = W_{v\_f} \times$	l <sub>load</sub> = 104.3 kM	Nm/m		
Total restoring moment		M <sub>rest_f</sub> = M <sub>wall_f</sub>	f + M <sub>base_f</sub> + M <sub>v</sub>	<sub>/_f</sub> = <b>198.5</b> kNm	ı/m	
Factored bearing pressure						
Total moment for bearing		M <sub>total_f</sub> = M <sub>rest_</sub>	_f - M <sub>ot_f</sub> = 71.9	kNm/m		
Total vertical reaction		$R_f = W_{total_f} =$				
		x <sub>bar_f</sub> = M <sub>total_f</sub>	/ R <sub>f</sub> = <b>548</b> mm	I		
Distance to reaction						
Distance to reaction Eccentricity of reaction		e <sub>f</sub> = abs((I <sub>base</sub>	/ 2) - x <sub>bar_f</sub> ) = 4		cts outside mid	

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for London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Bearing pressure at heel		p <sub>heel_f</sub> = 0 kN/i	m² = <b>0</b> kN/m²			
Rate of change of base reaction		rate = p <sub>toe_f</sub> / (	$3 \times x_{bar_f}$ ) = 96	5 <b>.87</b> kN/m²/m		
Bearing pressure at stem / toe		p <sub>stem_toe_f</sub> = ma	ax(p <sub>toe_f</sub> - (rate	$\times$ I <sub>toe</sub> ), 0 kN/m <sup>2</sup>	<sup>2</sup> ) = <b>14.1</b> kN/m <sup>2</sup>	
Bearing pressure at mid stem		$p_{stem_mid_f} = matrix$	ax(p <sub>toe_f</sub> - (rate	$\times$ (I <sub>toe</sub> + t <sub>wall</sub> / 2	2)), 0 kN/m²) = <b>0</b> k	kN/m²
Bearing pressure at stem / heel		$p_{\text{stem\_heel}_f} = m$	ax(p <sub>toe_f</sub> - (rate	$e \times (I_{toe} + t_{wall})),$	$0 \text{ kN/m}^2$ ) = <b>0</b> kN/	m²
Design of reinforced concrete	retaining wal	toe (BS 8002:199	<u>4)</u>			
Material properties						
Characteristic strength of concre	ete	f <sub>cu</sub> = <b>40</b> N/mm	2			
Characteristic strength of reinfor	rcement	f <sub>y</sub> = <b>500</b> N/mn	1 <sup>2</sup>			
Base details						
Minimum area of reinforcement		k = 0.13 %				
Cover to reinforcement in toe		c <sub>toe</sub> = <b>30</b> mm				
Calculate shear for toe design	l				4 1 5 17	
Shear from bearing pressure				$\times$ I <sub>toe</sub> / 2 = 130.		
Shear from weight of base		·	-	× t <sub>base</sub> = 22.3 k	in/m	
Total shear for toe design	• • •	V <sub>toe</sub> = V <sub>toe_bear</sub>	<ul> <li>v toe_wt_base =</li> </ul>	101.0 KIN/III		
Calculate moment for toe desi	ign	M - (0)	n + n			kNm/m
Moment from bearing pressure Moment from weight of base					all / 2) <sup>2</sup> / 6 = <b>153.5</b> ( 2) <sup>2</sup> / 2) = <b>21.5</b> kl	
Total moment for toe design		M <sub>toe_wt_base</sub> – ( M <sub>toe</sub> = M <sub>toe_bea</sub>			<i>2)   2) - <b>21.3</b> Ki</i>	NI 1/11
450	>					
L L	•	• •	•	•	•	
Check toe in bonding	●   <b>∢</b> — 175—	••	•	•	•	
Check toe in bending Width of toe	●   <b>4</b> — 175—	• •	• 'm	•	•	
-	●   <b>∢</b> — 175—	• • • • • • • • • • • • • • • • • • •		• 412.0 mm	•	
Width of toe	●   <b>∢</b> — 175—		<sub>oe</sub> – (φ <sub>toe</sub> / 2) =		•	
Width of toe Depth of reinforcement	●  ← 175—	d <sub>toe</sub> = t <sub>base</sub> – c	<sub>oe</sub> – (φ <sub>toe</sub> / 2) =	• 0.019	• n reinforcement	t is not req
Width of toe Depth of reinforcement	●  ← 175—	d <sub>toe</sub> = t <sub>base</sub> – c K <sub>toe</sub> = M <sub>toe</sub> / (b	<sub>oe</sub> – (φ <sub>toe</sub> / 2) = × d <sub>toe</sub> <sup>2</sup> × f <sub>cu</sub> ) = + √(0.25 - (mi	0.019 Compressio	• <i>n reinforcemen</i> ( 0.9)),0.95) × dtoe	-
Width of toe Depth of reinforcement Constant		$d_{toe} = t_{base} - c_{toe}$ $K_{toe} = M_{toe} / (b_{toe} - m_{toe})$ $z_{toe} = min(0.5)$ $z_{toe} = 391 mm$	$d_{oe} - (\phi_{toe} / 2) =$ × $d_{toe}^2 \times f_{cu}$ ) = + $\sqrt{0.25}$ - (mi	0.019 Compressio	( 0.9)),0.95) × d <sub>toe</sub>	-

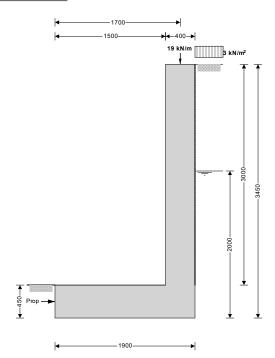
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Architecture	Section				Sheet no./rev	
for London.	Wall 5				7	
	Calc. by	Date	Chk'd by	Date	App'd by	Date
	BS	23/01/2020				
Area of tension reinforcement	required	A <sub>s toe reg</sub> = Ma	ax(As toe des, As	<sub>toe min</sub> ) = <b>776</b> r	nm²/m	
Reinforcement provided			ars @ 175 mn	,		
Area of reinforcement provided	ł	As_toe_prov = 1'	<b>149</b> mm²/m			
		PASS - Re	inforcement p	provided at th	e retaining wall	toe is adequ
Check shear resistance at to	e					
Design shear stress		$v_{toe} = V_{toe} / (b$	× d <sub>toe</sub> ) = <b>0.262</b>	<b>2</b> N/mm <sup>2</sup>		
Allowable shear stress		v <sub>adm</sub> = min(0.8	$8  imes \sqrt{(f_{cu} / 1 N/r)}$	mm²), 5) × 1 N	/mm <sup>2</sup> = <b>5.000</b> N/	mm²
		PASS	S - Design she	ear stress is le	ess than maxim	um shear str
From BS8110:Part 1:1997 – T	able 3.8					
Design concrete shear stress		v <sub>c_toe</sub> = <b>0.483</b>				
				Vtoe < Vc_toe - N	lo shear reinfor	cement requ
Design of reinforced concret	e retaining wal	l stem (BS 8002:1	994)			
Material properties						
Material properties Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mn	n <sup>2</sup>			
		f <sub>cu</sub> = <b>40</b> N/mn f <sub>y</sub> = <b>500</b> N/mr				
Characteristic strength of conc Characteristic strength of reinfo						
Characteristic strength of conc	orcement					
Characteristic strength of conc Characteristic strength of reinfo Wall details	orcement t	f <sub>y</sub> = <b>500</b> N/mr	m²			
Characteristic strength of conc Characteristic strength of reinfo <b>Wall details</b> Minimum area of reinforcemen	orcement t	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> %	n²			
Characteristic strength of conc Characteristic strength of reinfo <b>Wall details</b> Minimum area of reinforcemen Cover to reinforcement in stem	orcement t	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> % c <sub>stem</sub> = <b>40</b> mm	n²			
Characteristic strength of conc Characteristic strength of reinfo <b>Wall details</b> Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall	orcement t	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> % c <sub>stem</sub> = <b>40</b> mm c <sub>wall</sub> = <b>30</b> mm	n²	$ge  imes (h_{eff} - t_{base})$	- d <sub>ds</sub> ) = <b>7.1</b> kN/m	
Characteristic strength of conc Characteristic strength of reinfo Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for	orcement t prces on stem	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> % c <sub>stem</sub> = <b>40</b> mm c <sub>wall</sub> = <b>30</b> mm F <sub>s_sur_f</sub> = γ <sub>f_l</sub> ×	m² n K₀ × Surcharg		- d <sub>ds</sub> ) = <b>7.1</b> kN/m d <sub>ds</sub> - h <sub>sat</sub> )² = <b>15.6</b>	
Characteristic strength of conc Characteristic strength of reinfor <b>Wall details</b> Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall <b>Factored horizontal at-rest for</b> Surcharge	brcement t b <b>rces on stem</b>	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$	$n^2$ n K <sub>0</sub> × Surcharg × γ <sub>I_e</sub> × K <sub>0</sub> × γ <sub>m</sub>	$h \times (h_{eff} - t_{base} - t_{base})$		kN/m
Characteristic strength of conc Characteristic strength of reinfor Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table	brcement t b <b>rces on stem</b>	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$	m <sup>2</sup> n × $\gamma_{f_e} \times K_0 \times \gamma_m$ × $K_0 \times \gamma_m \times (h_{eff})$	$h \times (h_{eff} - t_{base} - t_{base})$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> n <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b>	kN/m
Characteristic strength of conc Characteristic strength of reinfor Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table	brcement t b <b>rces on stem</b>	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$	$m^2$ $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef}$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^*} - \gamma_{s^*})$	$h \times (h_{eff} - t_{base} - t_{base} - t_{base} - t_{base} - t_{ds} - t_{base} - t_{ds} - t_{base} $	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> n <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m	kN/m
Characteristic strength of conc Characteristic strength of reinfor Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water	orcement t orces on stem	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$	$m^2$ $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef}$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^*} - \gamma_{s^*})$	m × (heff - t <sub>base</sub> - hff - t <sub>base</sub> - d <sub>ds</sub> - h γwater) × h <sub>sat</sub> <sup>2</sup> = -	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> n <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m	kN/m
Characteristic strength of conc Characteristic strength of reinfor Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill	orcement t orces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$	$\begin{array}{l} m^2\\ K_0\times Surcharg\\ \times \gamma_{f\_e}\timesK_0\times\gamma_m\\ \times K_0\times\gamma_m\times(her)\\ \gamma_{f\_e}\timesK_0\times(\gamma_{s^{-1}})\\ \gamma_{f\_e}\times\gamma_{f\_e}\times\gamma_{water}\times \end{array}$	n × (heff - t <sub>base</sub> - ff - t <sub>base</sub> - dds - h γ <sub>water</sub> ) × h <sub>sat</sub> <sup>2</sup> = < h <sub>sat</sub> <sup>2</sup> = <b>16.5</b> kN	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> n <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m	kN/m kN/m
Characteristic strength of conc Characteristic strength of reinfor Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem	orcement t orces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$	$\begin{array}{l} m^2\\ K_0\times Surcharg\\ \times \gamma_{f\_e}\timesK_0\times\gamma_m\\ \times K_0\times\gamma_m\times(her)\\ \gamma_{f\_e}\timesK_0\times(\gamma_{s^{-1}})\\ \gamma_{f\_e}\times\gamma_{f\_e}\times\gamma_{water}\times \end{array}$	n × (heff - t <sub>base</sub> - ff - t <sub>base</sub> - dds - h γ <sub>water</sub> ) × h <sub>sat</sub> <sup>2</sup> = < h <sub>sat</sub> <sup>2</sup> = <b>16.5</b> kN	d <sub>ds</sub> - h <sub>sat</sub> )² = 15.6 n <sub>sat</sub> ) × h <sub>sat</sub> = 33.4 11.1 kN/m N/m	kN/m kN/m
Characteristic strength of conc Characteristic strength of reinfor Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des	orcement t orces on stem	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$	$\label{eq:starsess} \begin{split} & m^2 \\ & K_0 \times \mathbf{Surcharg} \\ & \times \gamma_{f\_e} \times K_0 \times \gamma_{m} \\ & \times K_0 \times \gamma_{m} \times (h_{ef} \\ & \gamma_{f\_e} \times K_0 \times (\gamma_{s-1} \\ & \gamma_{s-1} \\$	n × (heff - t <sub>base</sub> - ff - t <sub>base</sub> - dds - h γwater) × h <sub>sat</sub> <sup>2</sup> = < h <sub>sat</sub> <sup>2</sup> = <b>16.5</b> kh s_m_b_f + F <sub>s_s_f</sub> +	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> n <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m N/m ∙ Fs_water_f - Fprop_f	kN/m kN/m
Characteristic strength of conc Characteristic strength of reinfor Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge	orcement t orces on stem e e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5 \times$ $V_{stem} = F_{s\_sur\_l}$ $M_{s\_sur} = F_{s\_sur\_l}$	m <sup>2</sup> $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{el})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^{-1}} \times \gamma_{f_e} \times \gamma_{water} \times \gamma_{f_e} \times \gamma_{water} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times \gamma_{f_e} \times (h_{stem} + t_{base})$	$h \times (h_{eff} - t_{base} - f_{bff} - t_{base} - f_{ds} - h_{ds} - h_{sat}^2 = f_{sat}^2 =$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> n <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m N/m · F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>20.1</b> kN/m
Characteristic strength of conc Characteristic strength of reinfo Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge Moist backfill above water table	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_i}$ $M_{s\_sur} = F_{s\_sur\_i}$	m <sup>2</sup> $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s} - \gamma_{s})$ $\gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times$ $f + F_{s_m_a_f} + F_{s_a}$ $f + F_{s_m_a_f} + F_{s_a}$ $f + C_{s_m_a_f} + C_{s_a}$	n × (heff - tbase - ff - tbase - dds - h γwater) × hsat <sup>2</sup> = + < hsat <sup>2</sup> = <b>16.5</b> kh s_m_b_f + Fs_s_f + se) / 2 = <b>12.2</b> kh + heff - dds + tbas	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> n <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m N/m ∙ Fs_water_f - Fprop_f	kN/m kN/m = <b>20.1</b> kN/m
Characteristic strength of conc Characteristic strength of reinfor Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge Moist backfill above water table Surcharge Moist backfill above water table Surcharge	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_l}$ $M_{s\_m\_a} = F_{s\_m!}$ $M_{s\_m\_a} = F_{s\_m!}$	m <sup>2</sup> $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{el})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^{-1}} \times \gamma_{f_e} \times \gamma_{water} \times \gamma_{f_e} \times \gamma_{water} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times (f_e + F_s)$ $f_e + F_s - f_e + f_s$ $f_e + f_s - f_e + f_s$ $f_e + f_s + f_s$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{eff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{ff} + h_{sat}^2 = 16.5 \text{ k}h_{sat}^2 = 16.5 \text{ k}h_{sat}^2 = 16.5 \text{ k}h_{sat}^2 = 12.2 \text{ k}h_{eff} - d_{ds} + t_{bas}$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> n <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m N/m · F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>20.1</b> kN/m
Characteristic strength of conc Characteristic strength of reinfo Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge Moist backfill above water table	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5 \times$ $V_{stem} = F_{s\_sur\_f}$ $M_{s\_sur} = F_{s\_sur\_f}$ $M_{s\_m\_b} = F_{s\_m\_m}$ $M_{s\_m\_b} = F_{s\_m\_m}$ $M_{s\_s} = F_{s\_s\_f} \times$	m <sup>2</sup> $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s} - \gamma_{s})$ $\gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times$ $f + F_{s_m_a_f} + F_{s_a}$ $f + F_{s_m_a_f} + F_{s_a}$ $f + C_{s_m_a_f} + C_{s_a}$	$h \times (h_{eff} - t_{base} - d_{ds} - h_{sff} - t_{base} - d_{ds} - h_{sff} - t_{base} - d_{ds} - h_{sat}^2 = 16.5 kh_{sat}^2 = 16.5 kh_{sat}^2 = 16.5 kh_{sat}^2 = 16.5 kh_{sat}^2 = 12.2 kh_{se} / 2 = 12.2 kh_{se} + h_{eff} - d_{ds} + t_{bas}$ 25.9 kNm/m	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> n <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m N/m · F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>20.1</b> kN/m



	Project 23 Dartmouth	Park Hill			Job Ref. 19047	
Architecture for London.	Section Wall 5				Sheet no./rev 9	
	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Indicative retaining wall rein	forcement diagram	<u>l</u>				
Toe ı	reinforcement			Stem reinforcement		
Toe bars - 16 mm dia.@ 175 n Stem bars - 16 mm dia.@ 200						

	Project 23 Dartmouth F	Park Hill			Job Ref. 19047	
Architecture for London.	Section Wall 6,7 & 8				Sheet no./rev. 1	
	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date

#### RETAINING WALL ANALYSIS (BS 8002:1994)



#### Wall details

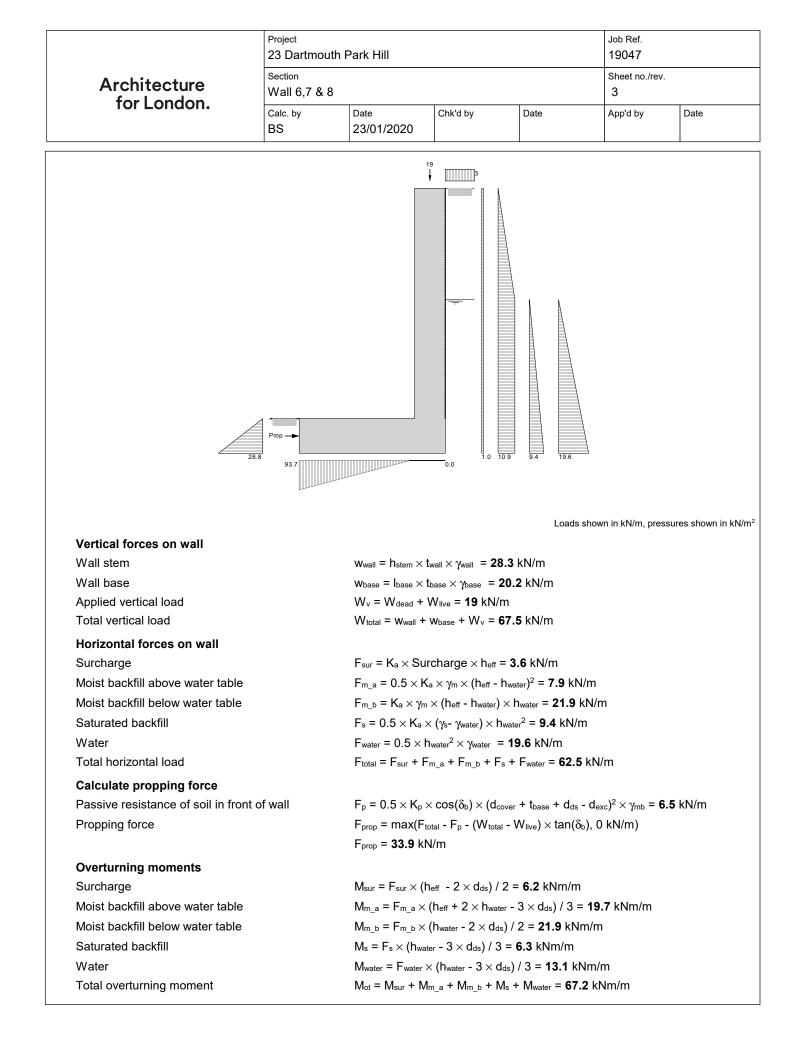
Retaining wall type Height of retaining wall stem Thickness of wall stem t<sub>wall</sub> = 400 mm Length of toe Length of heel I<sub>heel</sub> = 0 mm Overall length of base Thickness of base Depth of downstand d<sub>ds</sub> = **0** mm Position of downstand Thickness of downstand Height of retaining wall Depth of cover in front of wall Depth of unplanned excavation  $d_{exc} = 0 mm$ 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  $\beta$  = **0.0** deg Effective height at virtual back of wall **Retained material details** Mobilisation factor M = 1.5

# Cantilever propped at base

$$\begin{split} t_{wall} &= 400 \text{ mm} \\ t_{toe} &= 1500 \text{ mm} \\ t_{heel} &= 0 \text{ mm} \\ t_{base} &= t_{toe} + t_{heel} + t_{wall} = 1900 \text{ mm} \\ t_{base} &= 450 \text{ mm} \\ t_{ds} &= 900 \text{ mm} \\ t_{ds} &= 900 \text{ mm} \\ t_{ds} &= 450 \text{ mm} \\ t_{wall} &= t_{base} + t_{base} + d_{ds} = 3450 \text{ mm} \\ d_{exc} &= 0 \text{ mm} \\ d_{exc} &= 0 \text{ mm} \\ d_{exc} &= 0 \text{ mm} \\ t_{water} &= 2000 \text{ mm} \\ t_{base} &= 23.6 \text{ kN/m}^3 \\ \gamma_{base} &= 23.6 \text{ kN/m}^3 \\ \alpha &= 90.0 \text{ deg} \\ \beta &= 0.0 \text{ deg} \\ t_{eff} &= t_{wall} + t_{heel} \times tan(\beta) = 3450 \text{ mm} \end{split}$$

# TEDDS calculation version 1.2.01.06

	Project 23 Dartmouth	Park Hill			Job Ref. 19047	
Architecture	Section Wall 6,7 & 8				Sheet no./rev. 2	
for London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Moist density of retained mater	ial	γ <sub>m</sub> = <b>18.0</b> kN/r	m <sup>3</sup>			
Saturated density of retained n	naterial	γs <b>= 21.0</b> kN/n	n <sup>3</sup>			
Design shear strength		∳' = <b>24.2</b> deg				
Angle of wall friction		$\delta$ = <b>0.0</b> deg				
Base material details						
Moist density		γ <sub>mb</sub> = <b>18.0</b> kN/	/m³			
Design shear strength		φ'₅ = <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>110</b>	kN/m²			
Based on Kerisel & Absi - 'Ao	ctive and passive	earth pressure	tables'			
Active pressure coefficient for	or retained materia	al				
Slope angle ratio		$r_a = \beta / \phi' = 0.$	00			
Wall friction ratio		$r_b = \delta / \phi' = 0.0$	00			
Active pressure coefficient for I	retained material	Ka <b>= 0.419</b>				
Passive pressure coefficient	for base material					
Slope angle ratio		r <sub>a</sub> = 0 deg / φ'ι	o = 0.00			
Wall friction ratio		$r_b = \delta_b / \phi'_b = 0$	).77			
Passive pressure coefficient fo	r base material	K <sub>p</sub> = <b>3.754</b>				
At-rest pressure						
At-rest pressure for retained m	aterial	$K_0 = 1 - sin(\phi$	') = <b>0.590</b>			
Loading details						
Surcharge load on plan		Surcharge =	<b>2.5</b> kN/m²			
Applied vertical dead load on w	vall	W <sub>dead</sub> = <b>17.1</b>	κN/m			
Applied vertical live load on wa	II	W <sub>live</sub> = <b>1.9</b> kN	/m			
Position of applied vertical load	l on wall	l <sub>load</sub> = <b>1700</b> m				
Applied horizontal dead load of		F <sub>dead</sub> = <b>0.0</b> kN				
Applied horizontal live load on		F <sub>live</sub> = <b>0.0</b> kN/	m			
Height of applied horizontal loa	nd on wall	h <sub>load</sub> = <b>0</b> mm				



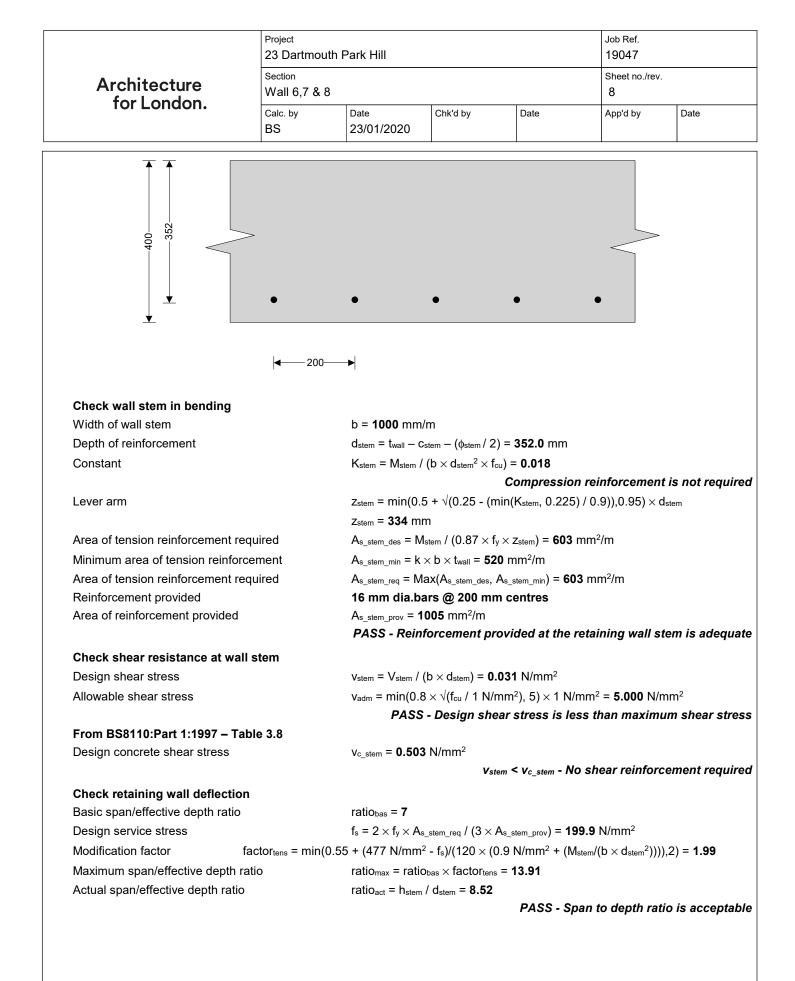
	Project 23 Dartmouth F	Park Hill			Job Ref. 19047	
Architecture for London.	Section Wall 6,7 & 8				Sheet no./rev. 4	
TOT LONGON.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date

Restoring moments	
Wall stem	$M_{wall}$ = $w_{wall} \times (I_{toe} + t_{wall} / 2)$ = <b>48.1</b> kNm/m
Wall base	M <sub>base</sub> = w <sub>base</sub> × I <sub>base</sub> / 2 = <b>19.2</b> kNm/m
Design vertical load	$M_v = W_v \times I_{load} = 32.3 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_v = 99.6 \text{ kNm/m}$
Check bearing pressure	
Total moment for bearing	M <sub>total</sub> = M <sub>rest</sub> - M <sub>ot</sub> = <b>32.4</b> kNm/m
Total vertical reaction	R = W <sub>total</sub> = <b>67.5</b> kN/m
Distance to reaction	x <sub>bar</sub> = M <sub>total</sub> / R = <b>480</b> mm
Eccentricity of reaction	e = abs((I <sub>base</sub> / 2) - x <sub>bar</sub> ) = <b>470</b> mm
	Reaction acts outside middle third of base
Bearing pressure at toe	p <sub>toe</sub> = R / (1.5 × x <sub>bar</sub> ) = <b>93.7</b> kN/m <sup>2</sup>
Bearing pressure at heel	$p_{\text{heel}} = 0 \text{ kN/m}^2 = 0 \text{ kN/m}^2$

Architecture for London.       Section Wall 6,7 8 Calc. by BS         RETAINING WALL DESIGN (BS 8002:1994)         Ultimate limit state load factors Dead load factor Live load factor Earth and water pressure factor         Factored vertical forces on wall Wall stem Wall base         Applied vertical load Total vertical load         Total vertical load         Surcharge         Moist backfill above water table         Saturated backfill         Water         Total horizontal load         Calculate propping force         Passive resistance of soil in front of wall         Propping force         Passive resistance of soil in front of wall         Propping force         Surcharge         Moist backfill below water table         Surcharge         Moist backfill below water table         Surcharge         Moist backfill above water table         Surcharge         Moist backfill below water table         Saturated backfill	Date 23/01/2020 $\gamma_{f_{-d}} = 1.4$ $\gamma_{f_{-l}} = 1.6$ $\gamma_{f_{-e}} = 1.4$ $W_{wall_{-f}} = \gamma_{f_{-d}} \times$ $W_{v_{-f}} = \gamma_{f_{-d}} \times$ $W_{v_{-f}} = \gamma_{f_{-d}} \times N$ $W_{total_{-f}} = W_{wall_{-f}}$ $F_{sur_{-f}} = \gamma_{f_{-l}} \times N$ $F_{m_{-a}} = \gamma_{f_{-e}} \times$	Chk'd by hstem × twall × γw ⟨ Ibase × tbase × γ N <sub>dead</sub> + γ <sub>f_l</sub> × W _f + Wbase_f + W	<sub>base</sub> = <b>28.2</b> kN <sub>live</sub> = <b>26.9</b> kN/n	n	Date
Calc. by BS         RETAINING WALL DESIGN (BS 8002:1994)         Ultimate limit state load factors         Dead load factor         Live load factor         Earth and water pressure factor         Factored vertical forces on wall         Wall stem         Wall base         Applied vertical load         Total vertical load         Factored horizontal at-rest forces on wall         Surcharge         Moist backfill above water table         Saturated backfill         Water         Total horizontal load         Calculate propping force         Passive resistance of soil in front of wall         Propping force         Surcharge         Moist backfill above water table         Surcharge         Moist backfill above water table         Surcharge         Moist backfill above water table         Surcharge         Moist backfill below water table         Saturated backfill         Water         Total overturning moments         Saturated backfill         Water         Total overturning moment         Restoring moments         Wall stem         Wall stem	$\begin{array}{c} 23/01/2020\\ \hline\\ \gamma_{f\_d} = 1.4\\ \gamma_{f\_l} = 1.6\\ \gamma_{f\_e} = 1.4\\ \hline\\ W_{wall\_f} = \gamma_{f\_d} \times\\ W_{base\_f} = \gamma_{f\_d} \times\\ W_{v\_f} = \gamma_{f\_d} \times\\ W_{total\_f} = W_{wall\_f}\\ \hline\\ F_{sur\_f} = \gamma_{f\_l} \times\\ H\\ \hline\\ F_{m\_a\_f} = \gamma_{f\_e} \times\\ \end{array}$	hstem × t <sub>wall</sub> × γw < Ibase × tbase × γ N dead + γ <sub>f_l</sub> × W	<sup>/all</sup> = <b>39.6</b> kN/n base = <b>28.2</b> kN/n live = <b>26.9</b> kN/n	TEDDS calcula	Date
Ultimate limit state load factors Dead load factor Live load factor Earth and water pressure factor Factored vertical forces on wall Wall stem Wall base Applied vertical load Total vertical load Factored horizontal at-rest forces on wall Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load Calculate propping force Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill below water table Moist backfill above water table Moist backfill above water table Roist backfill above water table Propping force Factored overturning moments Surcharge Moist backfill below water table Saturated backfill Water Total overturning moment Restoring moment Bestoring moment Mall base Design vertical load	$\gamma_{f\_l} = 1.6$ $\gamma_{f\_e} = 1.4$ $W_{wall\_f} = \gamma_{f\_d} \times$ $W_{base\_f} = \gamma_{f\_d} \times$ $W_{v\_f} = \gamma_{f\_d} \times W$ $W_{total\_f} = W_{wall\_f}$ $F_{sur\_f} = \gamma_{f\_l} \times H$ $F_{m\_a\_f} = \gamma_{f\_e} \times$	$ imes I_{base}  imes t_{base}  imes \gamma$ $N_{dead}$ + $\gamma_{f_{-}I}  imes W$	<sub>base</sub> = <b>28.2</b> kN <sub>live</sub> = <b>26.9</b> kN/n	n	tion version 1.2.
Dead load factor Live load factor Earth and water pressure factor Factored vertical forces on wall Wall stem Wall base Applied vertical load Total vertical load Factored horizontal at-rest forces on wall Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load Calculate propping force Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load Calculate propping force Factored overturning moments Surcharge Moist backfill below water table Moist backfill below mater table	$\gamma_{f\_l} = 1.6$ $\gamma_{f\_e} = 1.4$ $W_{wall\_f} = \gamma_{f\_d} \times$ $W_{base\_f} = \gamma_{f\_d} \times$ $W_{v\_f} = \gamma_{f\_d} \times W$ $W_{total\_f} = W_{wall\_f}$ $F_{sur\_f} = \gamma_{f\_l} \times H$ $F_{m\_a\_f} = \gamma_{f\_e} \times$	$ imes I_{base}  imes t_{base}  imes \gamma$ $N_{dead}$ + $\gamma_{f_{-}I}  imes W$	<sub>base</sub> = <b>28.2</b> kN <sub>live</sub> = <b>26.9</b> kN/n	n	
Live load factor Earth and water pressure factor Factored vertical forces on wall Wall stem Wall base Applied vertical load Total vertical load Total vertical load Factored horizontal at-rest forces on wall Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load Calculate propping force Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moments Surcharge Moist backfill below water table Moist backfill below water table Saturated backfill Water Total overturning moment Restoring moments Wall stem Wall base Design vertical load	$\gamma_{f\_l} = 1.6$ $\gamma_{f\_e} = 1.4$ $W_{wall\_f} = \gamma_{f\_d} \times$ $W_{base\_f} = \gamma_{f\_d} \times$ $W_{v\_f} = \gamma_{f\_d} \times W$ $W_{total\_f} = W_{wall\_f}$ $F_{sur\_f} = \gamma_{f\_l} \times H$ $F_{m\_a\_f} = \gamma_{f\_e} \times$	$ imes I_{base}  imes t_{base}  imes \gamma$ $N_{dead}$ + $\gamma_{f_{-}I}  imes W$	<sub>base</sub> = <b>28.2</b> kN <sub>live</sub> = <b>26.9</b> kN/n		
Earth and water pressure factor Factored vertical forces on wall Wall stem Wall base Applied vertical load Total vertical load Factored horizontal at-rest forces on wall Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load Calculate propping force Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moments Surcharge Moist backfill below water table Moist backfill below water table Moist backfill below mater table	$\gamma_{f_e} = 1.4$ $w_{wall_f} = \gamma_{f_d} \times$ $w_{base_f} = \gamma_{f_d} \times$ $W_{v_f} = \gamma_{f_d} \times W$ $W_{total_f} = W_{wall_f}$ $F_{sur_f} = \gamma_{f_l} \times H$ $F_{m_a_f} = \gamma_{f_e} \times$	$ imes I_{base}  imes t_{base}  imes \gamma$ $N_{dead}$ + $\gamma_{f_{-}I}  imes W$	<sub>base</sub> = <b>28.2</b> kN <sub>live</sub> = <b>26.9</b> kN/n		
Factored vertical forces on wallWall stemWall baseApplied vertical loadTotal vertical loadFactored horizontal at-rest forces on wallSurchargeMoist backfill above water tableMoist backfill below water tableSaturated backfillWaterTotal horizontal loadCalculate propping forcePassive resistance of soil in front of wallPropping forceSurchargeMoist backfill above water tableSurchargeMoist backfill above water tableSurchargeMoist backfill above water tableSurchargeMoist backfill above water tableSurchargeMoist backfill above water tableMoist backfill opelow water tableMoist backfill above mater tableMoist backfill above mater tableMoist backfill above mater tableMoist backfill opelow mater tableMoist backfill above mater tableMoist backfill below mater tableMoist backfill above mater tableMaterTotal overturning momentRestoring momentsWall stemWall baseDesign vertical load	$W_{wall_f} = \gamma_{f_d} \times W_{base_f} = \gamma_{f_d} \times W_{v_f} = \gamma_{f_d} \times W_{v_f} = \gamma_{f_d} \times W_{total_f} = W_{wall_f}$ $W_{total_f} = \gamma_{f_d} \times W_{total_f} $	$ imes I_{base}  imes t_{base}  imes \gamma$ $N_{dead}$ + $\gamma_{f_{-}I}  imes W$	<sub>base</sub> = <b>28.2</b> kN <sub>live</sub> = <b>26.9</b> kN/n		
Wall stem Wall stem Wall base Applied vertical load Total vertical load Factored horizontal at-rest forces on wall Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load Calculate propping force Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment Restoring moments Wall stem Wall base Design vertical load	$W_{base_f} = \gamma_{f_d} \times W_{v_f} = \gamma_{f_d} \times W_{v_f} = \gamma_{f_d} \times W_{total_f} = W_{wall}$ $F_{sur_f} = \gamma_{f_l} \times H_{F_{m_a_f}} = \gamma_{f_e} \times H_{F_{m_a_f}} = \gamma_{f_e} \times H_{f_{m_a_f}}$	$ imes I_{base}  imes t_{base}  imes \gamma$ $N_{dead}$ + $\gamma_{f_{-}I}  imes W$	<sub>base</sub> = <b>28.2</b> kN <sub>live</sub> = <b>26.9</b> kN/n		
Wall stem Wall stem Wall base Applied vertical load Total vertical load Factored horizontal at-rest forces on wall Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load Calculate propping force Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment Restoring moments Wall stem Wall base Design vertical load	$W_{base_f} = \gamma_{f_d} \times W_{v_f} = \gamma_{f_d} \times W_{v_f} = \gamma_{f_d} \times W_{total_f} = W_{wall}$ $F_{sur_f} = \gamma_{f_l} \times H_{F_{m_a_f}} = \gamma_{f_e} \times H_{F_{m_a_f}} = \gamma_{f_e} \times H_{f_{m_a_f}}$	$ imes I_{base}  imes t_{base}  imes \gamma$ $N_{dead}$ + $\gamma_{f_{-}I}  imes W$	<sub>base</sub> = <b>28.2</b> kN <sub>live</sub> = <b>26.9</b> kN/n		
Applied vertical load Total vertical load Factored horizontal at-rest forces on wall Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load Calculate propping force Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment Restoring moment Restoring moments Wall stem Wall base Design vertical load	$W_{base_f} = \gamma_{f_d} \times W_{v_f} = \gamma_{f_d} \times W_{v_f} = \gamma_{f_d} \times W_{total_f} = W_{wall}$ $F_{sur_f} = \gamma_{f_l} \times H_{F_{m_a_f}} = \gamma_{f_e} \times H_{F_{m_a_f}} = \gamma_{f_e} \times H_{f_{m_a_f}}$	$ imes I_{base}  imes t_{base}  imes \gamma$ $N_{dead}$ + $\gamma_{f_{-}I}  imes W$	<sub>base</sub> = <b>28.2</b> kN <sub>live</sub> = <b>26.9</b> kN/n		
Applied vertical load Total vertical load Factored horizontal at-rest forces on wall Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load Calculate propping force Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment Restoring moment Restoring moments Wall stem Wall base Design vertical load	$W_{v_f} = \gamma_{f_d} \times V$ $W_{total_f} = W_{wall_f}$ $F_{sur_f} = \gamma_{f_l} \times K$ $F_{m_a_f} = \gamma_{f_e} \times K$	$N_{dead}$ + $\gamma_{f_{-}l}$ $ imes$ W	<sub>live</sub> = <b>26.9</b> kN/n		
Total vertical load Factored horizontal at-rest forces on wall Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load Calculate propping force Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill below water table Moist backfill below water table Saturated backfill Water Total overturning moments Saturated backfill Water Total overturning moment Restoring moment Wall stem Wall base Design vertical load	$W_{total_f} = W_{wall}$ $F_{sur_f} = \gamma_{f_l} \times H$ $F_{m_a_f} = \gamma_{f_e} \times H$	• –			
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load <b>Calculate propping force</b> Passive resistance of soil in front of wall Propping force <b>Factored overturning moments</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment <b>Restoring moments</b> Wall stem Wall base Design vertical load	$F_{sur_f} = \gamma_{f_l} \times k$ $F_{m_a_f} = \gamma_{f_e} \times k$		<sub>v_f</sub> = <b>94.8</b> kN/m		
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load <b>Calculate propping force</b> Passive resistance of soil in front of wall Propping force <b>Factored overturning moments</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment <b>Restoring moments</b> Wall stem Wall base Design vertical load	$F_{m_a_f} = \gamma_{f_e} \times$		_		
Moist backfill above water table Moist backfill below water table Saturated backfill Water Total horizontal load <b>Calculate propping force</b> Passive resistance of soil in front of wall Propping force <b>Factored overturning moments</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment <b>Restoring moments</b> Wall stem Wall base Design vertical load	$F_{m_a_f} = \gamma_{f_e} \times$	$K_0  imes Surcharge$	× h <sub>eff</sub> = <b>8.1</b> kN	l/m	
Moist backfill below water table Saturated backfill Water Total horizontal load <b>Calculate propping force</b> Passive resistance of soil in front of wall Propping force <b>Factored overturning moments</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment <b>Restoring moments</b> Wall stem Wall base Design vertical load		$0.5 \times K_0 \times \gamma_m >$			
Water Total horizontal load <b>Calculate propping force</b> Passive resistance of soil in front of wall Propping force <b>Factored overturning moments</b> Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment <b>Restoring moments</b> Wall stem Wall base Design vertical load	⊏m h f= ?/fe X	$K_0 \times \gamma_m \times (h_{eff})$	· /		
Total horizontal load Calculate propping force Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment Restoring moments Wall stem Wall base Design vertical load		$.5  imes K_0  imes (\gamma_{s}- \gamma_{m})$			
Calculate propping force Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment Restoring moments Wall stem Wall base Design vertical load		$< 0.5 \times h_{water}^2 \times$			
Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment Restoring moments Wall stem Wall base Design vertical load			•	<sub>f</sub> = <b>112.9</b> kN/m	
Passive resistance of soil in front of wall Propping force Factored overturning moments Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment Restoring moments Wall stem Wall base Design vertical load				-	
Propping force Factored overturning moments Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment Restoring moments Wall stem Wall base Design vertical load	$F_{n,f} = \gamma_{f,e} \times 0$	$5 \times K_{\rm p} \times \cos(\delta$	h) × (dcover + tha	$_{\rm ase}$ + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup> × <sup>7</sup>	Vmb = <b>9.1 kN</b> /
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment <b>Restoring moments</b> Wall stem Wall base Design vertical load	· – · –	F <sub>total_f</sub> - F <sub>p_f</sub> - (V	, ,	$V_{live}$ ) × tan( $\delta_b$ ), 0 kl	-
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment <b>Restoring moments</b> Wall stem Wall base Design vertical load					
Moist backfill above water table Moist backfill below water table Saturated backfill Water Total overturning moment <b>Restoring moments</b> Wall stem Wall base Design vertical load	M <sub>sur f</sub> = F <sub>sur f</sub>	imes (h <sub>eff</sub> - 2 $ imes$ d <sub>ds</sub>	s) / 2 = <b>14</b> kNm	ı/m	
Saturated backfill Water Total overturning moment <b>Restoring moments</b> Wall stem Wall base Design vertical load		•	-	′ 3 = <b>38.8</b> kNm/m	
Water Total overturning moment <b>Restoring moments</b> Wall stem Wall base Design vertical load		_f × (h <sub>water</sub> - 2 ×			
Total overturning moment <b>Restoring moments</b> Wall stem Wall base Design vertical load		- ` h <sub>water</sub> - 3 × d <sub>ds</sub> )			
Restoring moments Wall stem Wall base Design vertical load		er_f × (h <sub>water</sub> - 3			
Wall stem Wall base Design vertical load	$M_{ot_f} = M_{sur_f} \cdot$	+ M <sub>m_a_f</sub> + M <sub>m_k</sub>	_f + M <sub>s_f</sub> + M <sub>wat</sub>	<sub>ter_f</sub> = <b>126.6</b> kNm/	m
Wall stem Wall base Design vertical load					
Design vertical load	$M_{wall_f} = w_{wall_f}$	$_{\rm f}  imes$ (I <sub>toe</sub> + t <sub>wall</sub> / 2	2) = <b>67.4</b> kNm/	m	
-	M <sub>base_f</sub> = w <sub>bas</sub>	$_{e_f} \times I_{base} / 2 = 2$	2 <b>6.8</b> kNm/m		
Total restoring moment	$M_{v_{f}}=W_{v_{f}}\times$	- I <sub>load</sub> = <b>45.8</b> kNr	n/m		
	$M_{rest_f} = M_{wall_}$	_f + M <sub>base_f</sub> + M <sub>v</sub>	_f = <b>140</b> kNm/r	n	
Factored bearing pressure					
Total moment for bearing		_f - Mot_f = 13.4	kNm/m		
Total vertical reaction	M <sub>total_f</sub> = M <sub>rest_</sub>	<b>94.8</b> kN/m			
Distance to reaction	M <sub>total_f</sub> = M <sub>rest_</sub> R <sub>f</sub> = W <sub>total_f</sub> =	/ R <sub>f</sub> = <b>141</b> mm			
Eccentricity of reaction	$R_f = W_{total_f} =$	e / 2) - x <sub>bar_f</sub> ) = <b>8</b>			
Bearing pressure at toe	$R_f = W_{total_f} = x_{bar_f} = M_{total_f}$		Reaction ac 7.1 kN/m <sup>2</sup>	cts outside mide	dle third of b

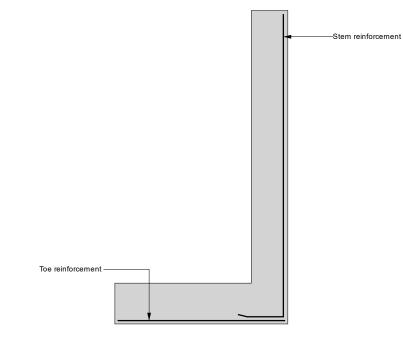
	Project 23 Dartmou	uth Park Hill			Job Ref. 19047	
Architecture for London.	Section Wall 6,7 &	8			Sheet no./rev. 6	
Tor London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Bearing pressure at heel		p <sub>heel_f</sub> = 0 kN/r	m² <b>= 0</b> kN/m²			
Rate of change of base reaction		rate = p <sub>toe_f</sub> / (	$3 \times x_{bar_f}$ ) = 10	54.11 kN/m²/m	n	
Bearing pressure at stem / toe		p <sub>stem_toe_f</sub> = ma	x(p <sub>toe_f</sub> - (rate	$\times$ I <sub>toe</sub> ), 0 kN/m <sup>2</sup>	²) = <b>0</b> kN/m²	
Bearing pressure at mid stem		$p_{stem_mid_f} = ma$	ax(p <sub>toe_f</sub> - (rate	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	2)), 0 kN/m²) = <b>0</b>	kN/m²
Bearing pressure at stem / heel		$p_{stem\_heel\_f} = m$	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	etaining wall	toe (BS 8002:199	4)			
Material properties			_			
Characteristic strength of concret	e	f <sub>cu</sub> = <b>40</b> N/mm	2			
Characteristic strength of reinford	ement	f <sub>y</sub> = <b>500</b> N/mm	1 <sup>2</sup>			
Base details						
Minimum area of reinforcement		k = <b>0.13</b> %				
Cover to reinforcement in toe		c <sub>toe</sub> = <b>30</b> mm				
Calculate shear for toe design						
Shear from bearing pressure		$V_{toe\_bear}$ = 3 ×	p <sub>toe_f</sub> × x <sub>bar_f</sub> / 2	2 = <b>94.8</b> kN/m		
Shear from weight of base		$V_{toe_wt_base} = \gamma_f$	_d $ imes \gamma_{base}  imes I_{toe}$	× t <sub>base</sub> = <b>22.3</b> k	N/m	
Total shear for toe design		$V_{toe} = V_{toe\_bear}$	- V <sub>toe_wt_base</sub> =	<b>72.5</b> kN/m		
Calculate moment for toe desig	ın					
Moment from bearing pressure					<sub>all</sub> / 2) / 2 = <b>147.8</b>	
Moment from weight of base Total moment for toe design				<sub>ise</sub> × (I <sub>toe</sub> + t <sub>wall</sub> / = <b>126.3</b> kNm/m	(2) <sup>2</sup> /2) = <b>21.5</b> kl	Nm/m
412	•	•	•		•	
	◀	250				
Check toe in bending						
Width of toe		b = <b>1000</b> mm/				
Depth of reinforcement		$d_{toe} = t_{base} - c_t$				
Constant		$K_{toe} = M_{toe} / (b)$	imes d <sub>toe</sub> <sup>2</sup> $ imes$ f <sub>cu</sub> ) =			
Lever arm		z <sub>toe</sub> = min(0.5 z <sub>toe</sub> = <b>391</b> mm		-	n reinforcemen ( 0.9)),0.95) × dtoo	-
Area of tension reinforcement rec	luired	$A_{s\_toe\_des} = M_{to}$	$_{ m e}$ / (0.87 $ imes$ fy $ imes$	z <sub>toe</sub> ) = <b>742</b> mn	n²/m	

	Project 23 Dartmo	uth Park Hill			Job Ref. 19047	
Architecture	Section	0			Sheet no./rev.	
for London.	Wall 6,7 &				7	
	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Area of tension reinforcement r	equired	A <sub>s_toe_req</sub> = Ma	ax(As_toe_des, As_	_ <sub>toe_min</sub> ) = <b>742</b> m	ım²/m	
Reinforcement provided			ars @ 250 mm			
Area of reinforcement provided	I	As_toe_prov = 80	<b>)4</b> mm²/m			
		PASS - Re	inforcement p	provided at the	e retaining wall	toe is adequ
Check shear resistance at to	e					
Design shear stress		v <sub>toe</sub> = V <sub>toe</sub> / (b	× d <sub>toe</sub> ) = 0.176	6 N/mm <sup>2</sup>		
Allowable shear stress		$v_{adm} = min(0.3)$	8 × √(f <sub>cu</sub> / 1 N/n	2), 5) × 1 N/r	mm² <b>= 5.000</b> N/r	nm²
					ss than maxim	
From BS8110:Part 1:1997 – T	able 3.8					
Design concrete shear stress		v <sub>c_toe</sub> = <b>0.429</b>	N/mm <sup>2</sup>			
			١	v <sub>toe</sub> < v <sub>c_toe</sub> - No	o shear reinford	ement requ
Design of reinforced concret	e retaining wal	l stem (BS 8002:1	994)			
Material properties		<b>`</b>	<u> </u>			
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mn	n <sup>2</sup>			
Characteristic strength of reinfo		f <sub>y</sub> = <b>500</b> N/mr				
Wall details		,				
Minimum area of reinforcemen	ł	k = <b>0.13</b> %				
Cover to reinforcement in stem		<sub>Cstem</sub> = <b>40</b> mm	h			
Cover to reinforcement in wall		$c_{wall} = 30 \text{ mm}$				
	orces on stem					
Factored horizontal at-rest fo						
Factored horizontal at-rest fo		Fs sur f = ∿f i ×	K <sub>0</sub> × Surchard	$e \times (h_{eff} - t_{base} -$	$d_{ds}$ ) = 7.1 kN/m	
Surcharge		·-	-	$e \times (h_{eff} - t_{base} - d) \times (h_{eff} - t_{base} - d)$		kN/m
Surcharge Moist backfill above water table	9	$F_{s_m_a_f} = 0.5$	$\times \gamma_{f_e} \times K_0 \times \gamma_m$	$\times$ (h <sub>eff</sub> - t <sub>base</sub> - d	ds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b>	
Surcharge Moist backfill above water table Moist backfill below water table	9	$F_{s_m_a_f} = 0.5$ $F_{s_m_b_f} = \gamma_{f_e}$	$\times \gamma_{f_e} \times K_0 \times \gamma_m \\ \times K_0 \times \gamma_m \times (h_{ef}$	× (h <sub>eff</sub> - t <sub>base</sub> - d <sub>ff</sub> - t <sub>base</sub> - d <sub>ds</sub> - h <sub>s</sub>	lds - h <sub>sat</sub> )² = <b>15.6</b> at) × h <sub>sat</sub> = <b>33.4</b> k	
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill	9	$F_{s_m_a_f} = 0.5$ $F_{s_m_b_f} = \gamma_{f_e}$ $F_{s_s_f} = 0.5 \times$	$ imes$ $\gamma_{f_e}  imes K_0  imes \gamma_m$ $ imes K_0  imes \gamma_m  imes (h_{ef}$ $\gamma_{f_e}  imes K_0  imes (\gamma_{s}- \gamma_{s})$	× (h <sub>eff</sub> - t <sub>base</sub> - d f - t <sub>base</sub> - d <sub>ds</sub> - h <sub>s</sub> y <sub>water</sub> ) × h <sub>sat</sub> <sup>2</sup> = 1	lds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> at) × h <sub>sat</sub> = <b>33.4</b> k <b>1.1</b> kN/m	
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water	9	$F_{s_m_a_f} = 0.5$ $F_{s_m_b_f} = \gamma_{f_e}$ $F_{s_s_f} = 0.5 \times$	$ imes$ $\gamma_{f_e}  imes K_0  imes \gamma_m$ $ imes K_0  imes \gamma_m  imes (h_{ef}$ $\gamma_{f_e}  imes K_0  imes (\gamma_{s}- \gamma_{s})$	× (h <sub>eff</sub> - t <sub>base</sub> - d <sub>ff</sub> - t <sub>base</sub> - d <sub>ds</sub> - h <sub>s</sub>	lds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> at) × h <sub>sat</sub> = <b>33.4</b> k <b>1.1</b> kN/m	
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des	9	$F_{s_m_a_f} = 0.5$ $F_{s_m_b_f} = \gamma_{f_e}$ $F_{s_s_f} = 0.5 \times$ $F_{s_water_f} = 0.5$		× ( $h_{eff} - t_{base} - d_{ff}$ $ff - t_{base} - d_{ds} - h_{s}$ $ff - t_{base} - d_{ds} - h_{s}$ $ff - t_{base} - d_{s}$ $f - h_{sat}^2 = 1$ $h_{sat}^2 = 16.5 \text{ kN}$	lds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>at</sub> ) × h <sub>sat</sub> = <b>33.4</b> k <b>1.1</b> kN/m /m	kN/m
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem	ign	$F_{s_m_a_f} = 0.5$ $F_{s_m_b_f} = \gamma_{f_e}$ $F_{s_s_f} = 0.5 \times$ $F_{s_water_f} = 0.5$		× ( $h_{eff} - t_{base} - d_{ff}$ $ff - t_{base} - d_{ds} - h_{s}$ $ff - t_{base} - d_{ds} - h_{s}$ $ff - t_{base} - d_{s}$ $h_{sat}^2 = 1$ $h_{sat}^2 = 16.5 \text{ kN}$	lds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> at) × h <sub>sat</sub> = <b>33.4</b> k <b>1.1</b> kN/m	kN/m
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem d	ign	$F_{s_m_a_f} = 0.5$ $F_{s_m_b_f} = \gamma_{f_e}$ $F_{s_s_f} = 0.5 \times$ $F_{s_water_f} = 0.5$ $V_{stem} = F_{s_sur_f}$		× ( $h_{eff} - t_{base} - d_{s}$ ff - $t_{base} - d_{ds} - h_{s}$ fwater) × $h_{sat}^2 = 1$ $h_{sat}^2 = 16.5 \text{ kN}$ $m_b_f + F_{s_f} + h_{s_f}$	lds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> at) × h <sub>sat</sub> = <b>33.4</b> k <b>1.1</b> kN/m /m Fs_water_f - Fprop_f	kN/m
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge	ign lesign	$F_{s_m_a_f} = 0.5$ $F_{s_m_b_f} = \gamma_{f_e}$ $F_{s_s_f} = 0.5 \times$ $F_{s_water_f} = 0.5$ $V_{stem} = F_{s_sur_f}$ $M_{s_sur} = F_{s_sur_f}$	$\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef}$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^-} \gamma_{s^-} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{f_e}$ $f + F_{s_m_a_f} + F_{s_e}$ $f \times (h_{stem} + t_{base})$	× (heff - tbase - d ff - tbase - dds - hs ywater) × hsat <sup>2</sup> = 1 hsat <sup>2</sup> = 16.5 kN _m_b_f + Fs_s_f + b) / 2 = 12.2 kN	lds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> at) × h <sub>sat</sub> = <b>33.4</b> k <b>1.1</b> kN/m /m Fs_water_f - Fprop_f ∺ m/m	«N/m = <b>10.9</b> kN/m
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem d	ign lesign	$F_{s_m_a_f} = 0.5$ $F_{s_m_b_f} = \gamma_{f_e}$ $F_{s_s_f} = 0.5 \times$ $F_{s_water_f} = 0.5$ $V_{stem} = F_{s_sur_f}$ $M_{s_sur} = F_{s_sur_f}$ $M_{s_m_a} = F_{s_m_s}$	$\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef}$ $\gamma_{f_e} \times K_0 \times (\gamma_{s} - \gamma_{s})$ $\gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times$ $f + F_{s_m_a_f} + F_{s_s}$ $f \times (h_{stem} + t_{base})$ $a_f \times (2 \times h_{sat} + f_{s})$	× (h <sub>eff</sub> - t <sub>base</sub> - d $f_{f}$ - t <sub>base</sub> - d <sub>ds</sub> - h <sub>s</sub> $f_{water}$ ) × h <sub>sat</sub> <sup>2</sup> = 1 $h_{sat}^{2}$ = 16.5 kN $\_m\_b\_f$ + $F_{s\_s\_f}$ + $f_{e}$ ) / 2 = 12.2 kN $h_{eff}$ - d <sub>ds</sub> + t <sub>base</sub>	lds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> at) × h <sub>sat</sub> = <b>33.4</b> k <b>1.1</b> kN/m /m Fs_water_f - Fprop_f	«N/m = <b>10.9</b> kN/m
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge	ign lesign	$F_{s_m_a_f} = 0.5$ $F_{s_m_b_f} = \gamma_{f_e}$ $F_{s_s_f} = 0.5 \times$ $F_{s_water_f} = 0.5$ $V_{stem} = F_{s_sur_f}$ $M_{s_sur} = F_{s_sur_f}$ $M_{s_m_a} = F_{s_m_s}$	$\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef}$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^-} \gamma_{s^-} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{f_e}$ $f + F_{s_m_a_f} + F_{s_e}$ $f \times (h_{stem} + t_{base})$	× (h <sub>eff</sub> - t <sub>base</sub> - d $f_{f}$ - t <sub>base</sub> - d <sub>ds</sub> - h <sub>s</sub> $f_{water}$ ) × h <sub>sat</sub> <sup>2</sup> = 1 $h_{sat}^{2}$ = 16.5 kN $\_m\_b\_f$ + $F_{s\_s\_f}$ + $f_{e}$ ) / 2 = 12.2 kN $h_{eff}$ - d <sub>ds</sub> + t <sub>base</sub>	lds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> at) × h <sub>sat</sub> = <b>33.4</b> k <b>1.1</b> kN/m /m Fs_water_f - Fprop_f ∺ m/m	«N/m = <b>10.9</b> kN/m
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge Moist backfill above water table	ign lesign	$F_{s_m_a_f} = 0.5$ $F_{s_m_b_f} = \gamma_{f_e}$ $F_{s_s_f} = 0.5 \times$ $F_{s_water_f} = 0.5$ $V_{stem} = F_{s_sur_f}$ $M_{s_sur} = F_{s_sur_f}$ $M_{s_m_a} = F_{s_m_f}$ $M_{s_m_b} = F_{s_m_f}$	$\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef}$ $\gamma_{f_e} \times K_0 \times (\gamma_{s} - \gamma_{s})$ $\gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times$ $f + F_{s_m_a_f} + F_{s_s}$ $f \times (h_{stem} + t_{base})$ $a_f \times (2 \times h_{sat} + f_{s})$	× (heff - tbase - d ff - tbase - dds - hs ywater) × hsat <sup>2</sup> = 1 hsat <sup>2</sup> = 16.5 kN $m_b f + F_{s_s} f + f_{s_s}$ heff - dds + tbase 25.9 kNm/m	lds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> at) × h <sub>sat</sub> = <b>33.4</b> k <b>1.1</b> kN/m /m Fs_water_f - Fprop_f ∺ m/m	«N/m = <b>10.9</b> kN/m
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water <b>Calculate shear for stem des</b> Shear at base of stem <b>Calculate moment for stem d</b> Surcharge Moist backfill above water table Moist backfill below water table	ign lesign	$F_{s_m_a_f} = 0.5$ $F_{s_m_b_f} = \gamma_{f_e}$ $F_{s_s_f} = 0.5 \times$ $F_{s_water_f} = 0.5$ $V_{stem} = F_{s_sur_1}$ $M_{s_sur} = F_{s_sur_1}$ $M_{s_m_a} = F_{s_m_1}$ $M_{s_m_b} = F_{s_m_2}$ $M_{s_s} = F_{s_s_f} \times$	$\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{ef}$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^-} \gamma_{s^-} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{f_e}$ $f + F_{s_m_a_f} + F_{s_e}$ $f + (h_{stem} + t_{base})$ $f + (2 \times h_{sat} + f_{b_e})$	× (h <sub>eff</sub> - t <sub>base</sub> - d ff - t <sub>base</sub> - d <sub>ds</sub> - h <sub>s</sub> fwater) × h <sub>sat</sub> <sup>2</sup> = 1 h <sub>sat</sub> <sup>2</sup> = 16.5 kN _m_b_f + F <sub>s_s_f</sub> + e) / 2 = 12.2 kN h <sub>eff</sub> - d <sub>ds</sub> + t <sub>base</sub> 25.9 kNm/m KNm/m	lds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> at) × h <sub>sat</sub> = <b>33.4</b> k <b>1.1</b> kN/m /m Fs_water_f - Fprop_f ∺ m/m	«N/m = <b>10.9</b> kN/m



	Project 23 Dartmouth Park Hill					
Architecture for London.	Section Wall 6,7 &	8				
TOT LONGON.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
					4	4

Indicative retaining wall reinforcement diagram



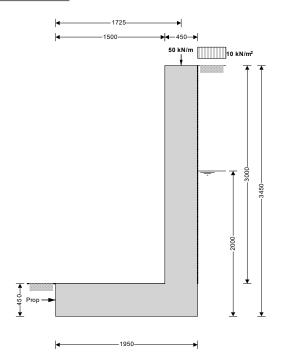
Toe bars - 16 mm dia.@ 250 mm centres - (804 mm<sup>2</sup>/m) Stem bars - 16 mm dia.@ 200 mm centres - (1005 mm<sup>2</sup>/m)

Project Job no. Partmonth Park Hill 9047 Architecture Calcs fo Retaining wall Design Start page no./Revision for London. Calcs by Calcs date BS \* Wall 9 Londi-Live Dend - Masing wall (h = 4.0m) (3.14) 2.56 - Ray bud (S. 0-12) (1.0, 0.75) 2.5 1.88 - Ben & Black Flour (9.1/2) (3.85, 1.5) 26.62 6.83 41.68 8.71 Total & Surcharge = loll/lm2 & Water level = 1.0m (B.G.L) (Assumed) ge Wall 10 Local-Dend Lise - Masony Wall (h= 3.5-) (3.14) / 11.00 - Rug load (5.2/2) (1.9 0.75) 2.6 1.95 - Clazing (2.3/2) (0.95, 0.75) 1.1 0.863 - Stair ase (2.3/2) (5.85, 1.5) 6.73 1.73 Total law 21.42 4.543 \* Surcharge = 7. Vatel level = 1.0n (Assumed) \* Wall 11 Lordi-Dand LNR - Masany vall (h= 9.5...) (4.3) 40.85 & Surchage = - Pitched Roof (5.3/2) (0.83, 0.75) 2.2 2.0 on Water level = 1.cm Ground flour (2.8/2) (1.0,1.5) 1.4 2.1 Tokal :-First floor (2.8/2) (1.0, 1.5) 1.4 Z. 1 49.6W/m - Second floor (2.8/2) (1.9/5) - Luft (2.8/2) (1.0/.5) 1.4 2.1 Dead = 1.4 2.1 11.45 KMlive - Flat Rugt (2.8/2) (0.7, 0.75) 0.952 1.05

	Project 23 Dartmouth Park Hill					Job Ref. 19047	
Architecture for London.	Section Wall 9		Sheet no./rev. 1				
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TEDDS calculation version 1.2.01.06

#### **RETAINING WALL ANALYSIS (BS 8002:1994)**



#### Wall details

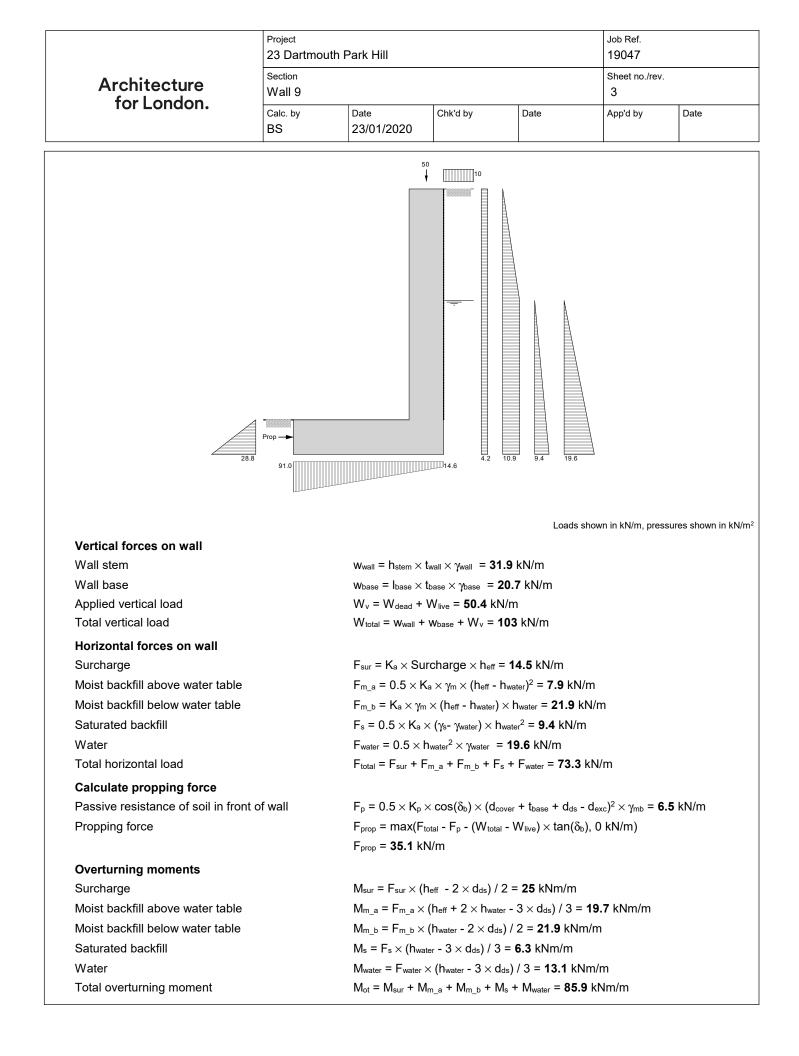
Retaining wall type Height of retaining wall stem Thickness of wall stem Length of toe Length of heel Overall length of base Thickness of base Depth of downstand Position of downstand Thickness of downstand Height of retaining wall Depth of cover in front of wall Depth of unplanned excavation Height 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

## Cantilever propped at base h<sub>stem</sub> = **3000** mm t<sub>wall</sub> = **450** mm I<sub>toe</sub> = **1500** mm $I_{heel} = 0 \text{ mm}$ $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 1950 \text{ mm}$ t<sub>base</sub> = **450** mm $d_{ds} = \mathbf{0} mm$ I<sub>ds</sub> = **900** mm t<sub>ds</sub> = **450** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3450 \text{ mm}$ d<sub>cover</sub> = 0 mm $d_{exc} = 0 mm$ h<sub>water</sub> = **2000** mm $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 1550 mm$ γ<sub>wall</sub> = 23.6 kN/m<sup>3</sup> γ<sub>base</sub> = 23.6 kN/m<sup>3</sup> α = **90.0** deg

 $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3450 \text{ mm}$ 

 $\beta$  = **0.0** deg

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Architecture	Section Wall 9				Sheet no./rev. 2			
for London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date		
Moist density of retained mater	ial	γ <sub>m</sub> = <b>18.0</b> kN/r	n <sup>3</sup>					
Saturated density of retained m	naterial	γ <sub>s</sub> = <b>21.0</b> kN/n	n <sup>3</sup>					
Design shear strength		∳' = <b>24.2</b> deg						
Angle of wall friction		$\delta$ = <b>0.0</b> deg						
Base material details								
Moist density		γ <sub>mb</sub> = <b>18.0</b> kN/	′m³					
Design shear strength		φ'₅ = <b>24.2</b> deg						
Design base friction		δ <sub>b</sub> = <b>18.6</b> deg						
Allowable bearing pressure		$P_{\text{bearing}} = 110 \text{ kN/m}^2$						
Based on Kerisel & Absi - 'Ao	ctive and passive	earth pressure	tables'					
Active pressure coefficient for	or retained materi	al						
Slope angle ratio		$r_a = \beta / \phi' = 0.0$	00					
Wall friction ratio		$r_{\rm b} = \delta / \phi' = 0.0$	00					
Active pressure coefficient for r	retained material	Ka = <b>0.419</b>						
Passive pressure coefficient	for base material							
Slope angle ratio		r <sub>a</sub> = 0 deg / ¢'t	o = 0.00					
Wall friction ratio		$r_{\rm b}$ = $\delta_{\rm b}$ / $\phi'_{\rm b}$ = C	).77					
Passive pressure coefficient fo	r base material	K <sub>p</sub> = <b>3.754</b>						
At-rest pressure								
At-rest pressure for retained m	aterial	$K_0 = 1 - \sin(\phi)$	') = <b>0.590</b>					
Loading details								
Surcharge load on plan		Surcharge = 1	10.0 kN/m <sup>2</sup>					
Applied vertical dead load on w	/all	W <sub>dead</sub> = <b>41.7</b> k	kN/m					
Applied vertical live load on wa	II	W <sub>live</sub> = <b>8.7</b> kN	/m					
Position of applied vertical load		l <sub>load</sub> = <b>1725</b> m						
Applied horizontal dead load or		F <sub>dead</sub> = <b>0.0</b> kN						
Applied horizontal live load on		F <sub>live</sub> = <b>0.0</b> kN/i	m					
Height of applied horizontal loa	id on wall	h <sub>load</sub> = <b>0</b> mm						



	Project 23 Dartmo			Job Ref. 19047			
Architecture for London.	Section Wall 9	Sheet no./rev. 4					
tor London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by Date		
Restoring moments							
Restoring moments Wall stem		${\sf M}_{\sf wall}$ = ${\sf w}_{\sf wall}$ $ imes$	(I <sub>toe</sub> + t <sub>wall</sub> / 2)	= <b>55</b> kNm/m			
•		$M_{wall} = w_{wall} \times M_{base} = w_{base} \times$	,				
Wall stem			× I <sub>base</sub> / 2 = <b>20</b>	<b>.2</b> kNm/m			

Check bearing pressure

Total moment for bearing Total vertical reaction Distance to reaction Eccentricity of reaction

Bearing pressure at toe Bearing pressure at heel M<sub>total</sub> = M<sub>rest</sub> - M<sub>ot</sub> = **76.2** kNm/m R = W<sub>total</sub> = **103.0** kN/m  $x_{\text{bar}} = M_{\text{total}} / R = 740 \text{ mm}$ e = abs((I<sub>base</sub> / 2) - x<sub>bar</sub>) = **235** mm

Reaction acts within middle third of base

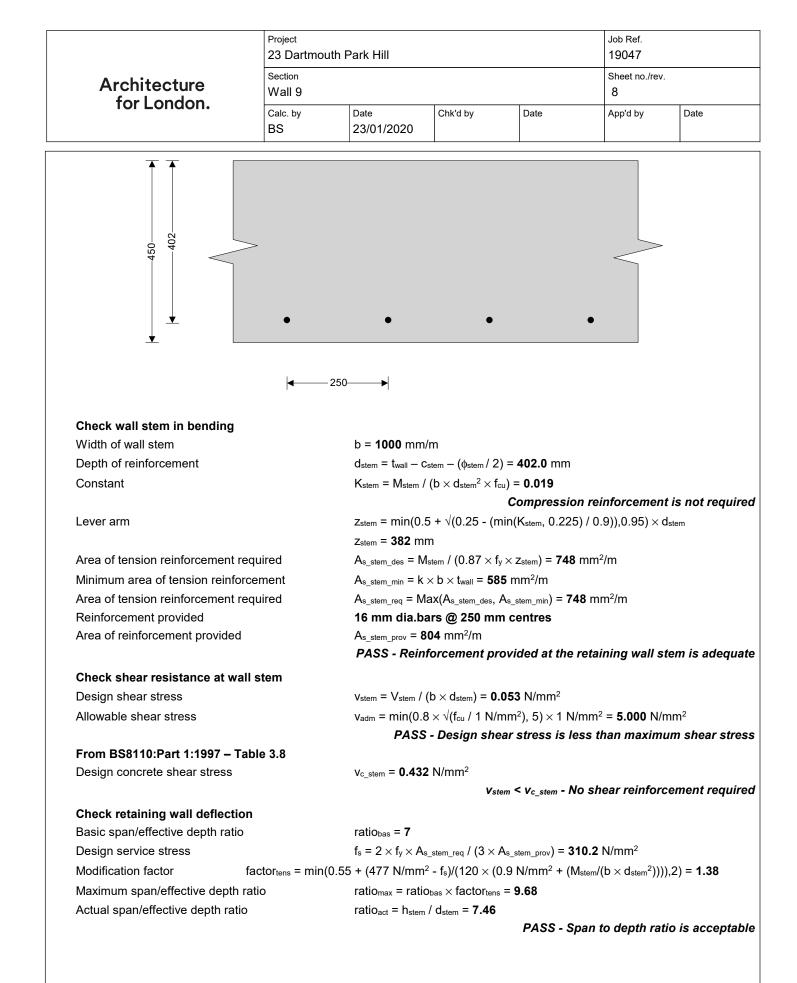
 $p_{toe} = (R \ / \ I_{base}) + (6 \times R \times e \ / \ I_{base}^2) = \textbf{91} \ kN/m^2$ 

 $p_{heel} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 14.6 \text{ kN/m}^2$ 

	Project 23 Dartmo	uth Park Hill			Job Ref. 19047			
Architecture	Section Wall 9				Sheet no./rev 5			
for London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date		
RETAINING WALL DESIGN (	BS 8002:1994)					ation version 1.2		
Ultimate limit state load facto	ors				TEDDS Calcul			
Dead load factor		γ <sub>f_d</sub> = <b>1.4</b>						
Live load factor		γ <sub>f_1</sub> = 1.6						
Earth and water pressure facto	or	γ <sub>f_e</sub> = <b>1.4</b>						
Factored vertical forces on v	vall							
Wall stem		$W_{wall f} = \gamma_{f d} \times$	$h_{stem}  imes t_{wall}  imes \gamma_{w}$	<sub>vall</sub> = <b>44.6</b> kN/m	า			
Wall base		•	∕ <sub>base</sub> <b>= 29</b> kN/m					
Applied vertical load			/ <sub>live</sub> = <b>72.3</b> kN/n					
Total vertical load			• =	/ <sub>v_f</sub> = <b>145.9</b> kN/i				
Factored horizontal at-rest for	orces on wall		_					
Surcharge		$F_{sur} f = \gamma_{f} I \times K$	‰ × Surcharae	e × h <sub>eff</sub> = <b>32.6</b> kl	N/m			
Moist backfill above water table	е		-	× (h <sub>eff</sub> - h <sub>water</sub> ) <sup>2</sup> =				
Moist backfill below water table			•	- h <sub>water</sub> ) × h <sub>water</sub>				
Saturated backfill		$F_{s_{f}} = \gamma_{f_{e}} \times 0.5 \times K_{0} \times (\gamma_{s} - \gamma_{water}) \times h_{water}^{2} = 18.5 \text{ kN/m}$						
Water		$F_{water_{f}} = \gamma_{f_{e}} \times 0.5 \times h_{water}^{2} \times \gamma_{water} = 27.5 \text{ kN/m}$						
Total horizontal load		$F_{total_f} = F_{sur_f} + F_{m_a_f} + F_{m_b_f} + F_{s_f} + F_{water_f} = 137.3 \text{ kN/m}$						
Calculate propping force					_			
Passive resistance of soil in fro	ont of wall	$F_{p,f} = \gamma_{f,e} \times 0$	$5 \times K_n \times \cos(\delta)$	in) × (dcover + tha	$_{ m se}$ + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup> ×	ν <sub>mb</sub> = <b>9.1</b> kN		
Propping force			F <sub>total_f</sub> - F <sub>p_f</sub> - (\	, ,	$_{live}) \times tan(\delta_b), 0 k$	•		
Factored overturning momen	nts							
Surcharge		M <sub>sur_f</sub> = F <sub>sur_f</sub> >	× (h <sub>eff</sub> - $2 \times d_{ds}$	s) / 2 = <b>56.2</b> kN	m/m			
Moist backfill above water table	е	$M_{m_a_f} = F_{m_a_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 38.8 \text{ kNm/m}$						
Moist backfill below water table	e	$M_{m\_b\_f} = F_{m\_b\_f}$	$M_{m_b_f} = F_{m_b_f} \times (h_{water} - 2 \times d_{ds}) / 2 = 43.1 \text{ kNm/m}$					
Saturated backfill			$M_{s f} = F_{s f} \times (h_{water} - 3 \times d_{ds}) / 3 = 12.3 \text{ kNm/m}$					
Water		$M_{water_f} = F_{water_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 18.3 \text{ kNm/m}$						
Total overturning moment		$M_{ot_{f}} = M_{sur_{f}} + M_{m_{a_{f}}} + M_{m_{b_{f}}} + M_{s_{f}} + M_{water_{f}} = 168.8 \text{ kNm/m}$						
Restoring moments								
Wall stem		$M_{wall_f} = w_{wall_f}$	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	2) = <b>76.9</b> kNm/ı	m			
Wall base		M <sub>base_f</sub> = w <sub>base</sub>	$e_f \times I_{base} / 2 = 2$	28.3 kNm/m				
Design vertical load		$M_{v_{f}} = W_{v_{f}} \times I_{load} = 124.7 \text{ kNm/m}$						
Total restoring moment				f = <b>229.9</b> kNm	ı/m			
Factored bearing pressure								
Total moment for bearing		M <sub>total_f</sub> = M <sub>rest_</sub>	_f - Mot_f = 61.1	kNm/m				
Total vertical reaction		$R_f = W_{total_f} =$	<b>145.9</b> kN/m					
Distance to reaction		$\mathbf{x}_{bar_f} = \mathbf{M}_{total_f}$	/ R <sub>f</sub> = <b>419</b> mm	1				
		$a_1 = aba/(l_1$	$(2) \times (1-1)$	556 mm				
Eccentricity of reaction		et - abs((Ibase	/ 2) - X <sub>bar_f</sub> ) = {		cts outside mid			

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Bearing pressure at heel		p <sub>heel_f</sub> = 0 kN/r	n <sup>2</sup> = <b>0</b> kN/m <sup>2</sup>			
Rate of change of base reaction	n	rate = p <sub>toe_f</sub> / (	$3 \times x_{bar_f}$ ) = 18	<b>4.57</b> kN/m²/m		
Bearing pressure at stem / toe		p <sub>stem_toe_f</sub> = ma	x(p <sub>toe_f</sub> - (rate	$\times$ I <sub>toe</sub> ), 0 kN/m <sup>2</sup>	<sup>2</sup> ) <b>= 0</b> kN/m <sup>2</sup>	
Bearing pressure at mid stem		$p_{stem_mid_f} = ma$	ax(p <sub>toe_f</sub> - (rate	$\times$ (I <sub>toe</sub> + t <sub>wall</sub> / 2	2)), 0 kN/m²) = <b>0</b> k	N/m²
Bearing pressure at stem / hee	el l	$p_{stem\_heel\_f} = m$	ax(p <sub>toe_f</sub> - (rate	$e \times (I_{toe} + t_{wall})),$	$0 \text{ kN/m}^2$ ) = <b>0</b> kN/n	m²
Design of reinforced concret	e retaining wall	toe (BS 8002:199	<u>4)</u>			
Material properties						
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mm	2			
Characteristic strength of reinfo	orcement	f <sub>y</sub> = <b>500</b> N/mn	1 <sup>2</sup>			
Base details						
inimum area of reinforcement		k = <b>0.13</b> %				
Cover to reinforcement in toe		c <sub>toe</sub> = <b>30</b> mm				
Calculate shear for toe desig	n					
Shear from bearing pressure				2 = <b>145.9</b> kN/m		
Shear from weight of base		·	•	$\times$ t <sub>base</sub> = 22.3 k	KN/m	
Total shear for toe design	_	V <sub>toe</sub> = V <sub>toe_bear</sub>	- V <sub>toe_wt_base</sub> =	123.6 KIN/M		
Calculate moment for toe de	-		_	4		L-N I (
Moment from bearing pressure		-			$(2)^2 (2) = 22.4 \text{ km}$	
Moment from weight of base Total moment for toe design				<sub>ase</sub> × (I <sub>toe</sub> + t <sub>wall</sub> / = <b>168.4</b> kNm/m	/ 2) <sup>2</sup> / 2) = <b>22.1</b> kN	111/111
450	•	•	•	•	•	
	<b>∢</b> ───200					
Check toe in bending	<b>⊲</b> —— 200	<b>└──</b> ▶				
Width of toe	◀─── 200	b = <b>1000</b> mm/				
Width of toe Depth of reinforcement	<b> ⊲</b> —200	b = <b>1000</b> mm/ d <sub>toe</sub> = t <sub>base</sub> – cr	<sub>oe</sub> – (φ <sub>toe</sub> / 2) =			
-	◀─── 200	b = <b>1000</b> mm/	<sub>oe</sub> – (φ <sub>toe</sub> / 2) =	- 0.025		
Width of toe Depth of reinforcement	<b> 4</b> −−− 200	b = <b>1000</b> mm/ d <sub>toe</sub> = t <sub>base</sub> – cr K <sub>toe</sub> = M <sub>toe</sub> / (b	$d_{\text{toe}} - (\phi_{\text{toe}} / 2) =$ $\times d_{\text{toe}}^2 \times f_{\text{cu}}) =$ + $\sqrt{(0.25 - (\text{min})^2)}$	0.025 Compressio	o <b>n reinforcement</b> / 0.9)),0.95) × d <sub>toe</sub>	is not requ
Width of toe Depth of reinforcement Constant		b = <b>1000</b> mm/ $d_{toe} = t_{base} - c_t$ $K_{toe} = M_{toe} / (b_t)$ $z_{toe} = min(0.5)$ $z_{toe} = 391 mm$	$d_{\text{toe}} - (\phi_{\text{toe}} / 2) =$ $\times d_{\text{toe}}^2 \times f_{\text{cu}} =$ + $\sqrt{(0.25 - (\text{min}))}$	0.025 Compressio	/ 0.9)),0.95) × d <sub>toe</sub>	is not requ

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	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
	00	23/01/2020				
Area of tension reinforcement r	required	A <sub>s_toe_req</sub> = Ma	ax(As_toe_des, As	_ <sub>toe_min</sub> ) <b>= 989</b> r	nm²/m	
Reinforcement provided		16 mm dia.b	ars @ 200 mn	n centres		
Area of reinforcement provided	I	As_toe_prov = 10	<b>)05</b> mm²/m			
		PASS - Re	inforcement p	provided at th	e retaining wall	toe is adequ
Check shear resistance at to	е					
Design shear stress		$v_{toe} = V_{toe} / (b$	$\times$ d <sub>toe</sub> ) = 0.300	0 N/mm <sup>2</sup>		
Allowable shear stress		v <sub>adm</sub> = min(0.8	8 × √(f <sub>cu</sub> / 1 N/r	mm²), 5) × 1 N/	/mm² = <b>5.000</b> N/i	mm²
		PASS	S - Design she	ear stress is le	ess than maxim	um shear str
From BS8110:Part 1:1997 – T	able 3.8					
Design concrete shear stress		v <sub>c_toe</sub> = <b>0.462</b>				
				Vtoe < Vc_toe - N	lo shear reinfor	cement requ
Design of reinforced concret	e retaining wal	l stem (BS 8002:1	994 <u>)</u>			
Material properties						
		6 60 NV	0			
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mn	1 <sup>2</sup>			
Characteristic strength of conc Characteristic strength of reinfo		f <sub>cu</sub> = <b>40</b> N/mn f <sub>y</sub> = <b>500</b> N/mr				
Characteristic strength of reinfo						
-	orcement					
Characteristic strength of reinfo Wall details	prcement t	f <sub>y</sub> = <b>500</b> N/mr	n²			
Characteristic strength of reinfo Wall details Minimum area of reinforcemen	prcement t	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> %	n²			
Characteristic strength of reinfo Wall details Minimum area of reinforcemen Cover to reinforcement in stem	brcement t	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> % c <sub>stem</sub> = <b>40</b> mm	n²			
Characteristic strength of reinfo Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall	brcement t	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> % C <sub>stem</sub> = <b>40</b> mm c <sub>wall</sub> = <b>30</b> mm	n² 1	ge × (h <sub>eff</sub> - t <sub>base</sub> ⋅	- d <sub>ds</sub> ) = <b>28.3</b> kN/r	n
Characteristic strength of reinfor Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for	brcement t brces on stem	f <sub>y</sub> = <b>500</b> N/mr k = <b>0.13</b> % c <sub>stem</sub> = <b>40</b> mm c <sub>wall</sub> = <b>30</b> mm F <sub>s_sur_f</sub> = γ <sub>f_l</sub> ×	n² n K₀ × Surcharg		- d <sub>ds</sub> ) = <b>28.3</b> kN/r d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b>	
Characteristic strength of reinfo Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge	brcement t brces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$	n² h Ko × Surcharg × γi_e × Ko × γm	$h \times (h_{eff} - t_{base} - t_{base})$		kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table	brcement t brces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$	n² Ko × Surcharg × γř_e × Ko × γm × Ko × γm × (he	$h \times (h_{eff} - t_{base} - t_{base})$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>hsat</sub> ) × h <sub>sat</sub> = <b>33.4</b>	kN/m
Characteristic strength of reinfo Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table	brcement t brces on stem	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$	$n^2$ $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_e)$ $\gamma_{f_e} \times K_0 \times (\gamma_{s_e} - \gamma_{s_e})$	$h \times (h_{eff} - t_{base} - t_{base} - t_{base} - t_{base} - t_{ds} - t_{base} - t_{ds} - t_{base} $	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> I <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m	kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill	prcement t prces on stem	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$	$n^2$ $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_e)$ $\gamma_{f_e} \times K_0 \times (\gamma_{s_e} - \gamma_{s_e})$	n × (h <sub>eff</sub> - t <sub>base</sub> - <sub>ff</sub> - t <sub>base</sub> - d <sub>ds</sub> - h γ <sub>water</sub> ) × h <sub>sat</sub> <sup>2</sup> = -	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> I <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m	kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water	prcement t prces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_1} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$	$m^2$ $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_e)$ $\gamma_{f_e} \times K_0 \times (\gamma_{s_e} - \gamma_{s_e} \times \gamma_{f_e} \times \gamma_{water} \times \gamma_{s_e})$	$h \times (h_{eff} - t_{base} - f_{off})$ $f_{ff} - t_{base} - d_{ds} - h_{ds} - h_{ds}$ $\gamma_{water}) \times h_{sat}^2 = f_{off}^2$ $\propto h_{sat}^2 = 16.5 \text{ km}$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> I <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m	kN/m kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des	prcement t prces on stem	$f_y = 500 \text{ N/mr}$ k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_1} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$	$m^2$ $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_e)$ $\gamma_{f_e} \times K_0 \times (\gamma_{s_e} - \gamma_{s_e} \times \gamma_{f_e} \times \gamma_{water} \times \gamma_{s_e})$	$h \times (h_{eff} - t_{base} - f_{off})$ $f_{ff} - t_{base} - d_{ds} - h_{ds} - h_{ds}$ $\gamma_{water}) \times h_{sat}^2 = f_{off}^2$ $\propto h_{sat}^2 = 16.5 \text{ km}$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> l <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m N/m	kN/m kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Noist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem	prcement t prces on stem	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$	$\label{eq:K0} \begin{split} &K_0\times Surcharg\\ &\times \gamma_{f\_e}\timesK_0\times\gamma_{m}\\ &\times K_0\times\gamma_m\times(he)\\ &\gamma_{f\_e}\timesK_0\times(\gamma_{s=-})\\ &\gamma_{f\_e}\times\gamma_{f\_e}\times\gamma_{water}\times\\ &f+F_{s\_m\_a\_f}+F_s \end{split}$	$h \times (h_{eff} - t_{base} - f_{off})$ $f_{ff} - t_{base} - d_{ds} - h_{ds} - h_{ds}$ $\gamma_{water}) \times h_{sat}^2 = f_{off}^2$ $\propto h_{sat}^2 = 16.5 \text{ km}$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> lsat) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m N/m Fs_water_f - Fprop_f	kN/m kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_b\_f} = \gamma_{f\_e} =$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$ $M_{s\_sur} = F_{s\_sur\_f}$	$m^{2}$ $K_{0} \times Surcharg$ $\times \gamma_{f_{e}} \times K_{0} \times \gamma_{m}$ $\times K_{0} \times \gamma_{m} \times (h_{e'})$ $\gamma_{f_{e}} \times K_{0} \times (\gamma_{s-1})$ $\gamma_{f_{e}} \times \gamma_{f_{e}} \times \gamma_{water} \times \gamma_{f_{e}} \times (h_{stem} + t_{bas})$	$h \times (h_{eff} - t_{base} - f_{ff} - t_{base} - f_{ds} - f_{ds} - f_{ds} - f_{ds} - f_{ds} - f_{sat}^{2} = f_{sat}^{2} - f_{sat}^{2} = f_{sat}^{2} - f_{sat}$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> lsat) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m N/m Fs_water_f - Fprop_f	kN/m kN/m = <b>21.2</b> kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e} +$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5 \times$ $V_{stem} = F_{s\_sur\_1}$ $M_{s\_sur} = F_{s\_sur\_1}$	$m^{2}$ $K_{0} \times Surcharg$ $\times \gamma_{f_{e}} \times K_{0} \times \gamma_{m}$ $\times K_{0} \times \gamma_{m} \times (h_{e'})$ $\gamma_{f_{e}} \times K_{0} \times (\gamma_{s-1})$ $\gamma_{f_{e}} \times \gamma_{f_{e}} \times \gamma_{water} \times \gamma_{f_{e}} \times (h_{stem} + t_{bas})$	n × (h <sub>eff</sub> - t <sub>base</sub> - ff - t <sub>base</sub> - dds - h γwater) × h <sub>sat</sub> <sup>2</sup> = < h <sub>sat</sub> <sup>2</sup> = <b>16.5</b> kN s_m_b_f + F <sub>s_s_f</sub> + s <sub>e</sub> ) / 2 = <b>48.9</b> kN + h <sub>eff</sub> - dds + t <sub>bas</sub>	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> a <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m N/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>21.2</b> kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge Moist backfill above water table	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e} =$ $F_{s\_s\_f} = 0.5 \times 10^{-5} \times 10$	m <sup>2</sup> $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{e'})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s-1})$ $f + F_{s_m_a_f} + F_{s_s}$ $f + F_{s_m_a_f} + F_{s_s}$	n × (heff - t <sub>base</sub> - 4 ff - t <sub>base</sub> - dds - h γwater) × h <sub>sat</sub> <sup>2</sup> = 4 < h <sub>sat</sub> <sup>2</sup> = <b>16.5</b> kN s_m_b_f + F <sub>s_s_f</sub> + we) / 2 = <b>48.9</b> kN + heff - dds + t <sub>bas</sub> <b>25.9</b> kNm/m	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> a <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m N/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>21.2</b> kN/m
Characteristic strength of reinfor Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge Moist backfill above water table Surcharge Moist backfill above water table Moist backfill above water table	orcement t orces on stem e ign lesign	$f_{y} = 500 \text{ N/mr}$ $k = 0.13 \%$ $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_b\_f} = \gamma_{f\_e} \times$ $F_{s\_m\_b\_f} = \gamma_{f\_e} \times$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5 \times$ $V_{stem} = F_{s\_sur\_f}$ $M_{s\_sur} = F_{s\_sur\_f}$ $M_{s\_m\_a} = F_{s\_m\_m}$ $M_{s\_m\_b} = F_{s\_m\_m}$ $M_{s\_s} = F_{s\_s\_f} \times$	m <sup>2</sup> $K_0 \times Surcharg$ $\times \gamma_{f_e} \times K_0 \times \gamma_m$ $\times K_0 \times \gamma_m \times (h_{e^1})$ $\gamma_{f_e} \times K_0 \times (\gamma_{s^{-1}})$ $i \times \gamma_{f_e} \times \gamma_{water} \times$ $f + F_{s_m_a_f} + F_{s_1}$ $f + F_{s_m_a_f} + F_{s_1}$ $f + (h_{stem} + t_{bas})$ $a_a f \times (2 \times h_{sat} + f_{s_1})$	$h \times (h_{eff} - t_{base} - f_{ff} - t_{base} - d_{ds} - h_{ff} - t_{base} - d_{ds} - h_{ff} - t_{base} - f_{ff} + h_{sat}^2 = f_{ff}^2 + f_{fs} - f_{ff} + f_{fs} + h_{eff} - d_{ds} + t_{bas}$ $25.9 \text{ kNm/m}$	dds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> a <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>11.1</b> kN/m N/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>21.2</b> kN/m

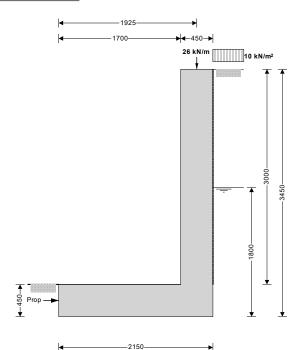


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	Section				Sheet no./rev.	
Architecture	Wall 9					
for London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Indicative retaining wall rein	forcement diagr	am				
Toe re	einforcement			Stem reinforcement		
Toe bars - 16 mm dia.@ 200 n Stem bars - 16 mm dia.@ 250						

	,					Job Ref. 19047	
Architecture for London.	Section Wall 10			Sheet no./rev. 1			
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TEDDS calculation version 1.2.01.06

#### **RETAINING WALL ANALYSIS (BS 8002:1994)**



#### Wall details

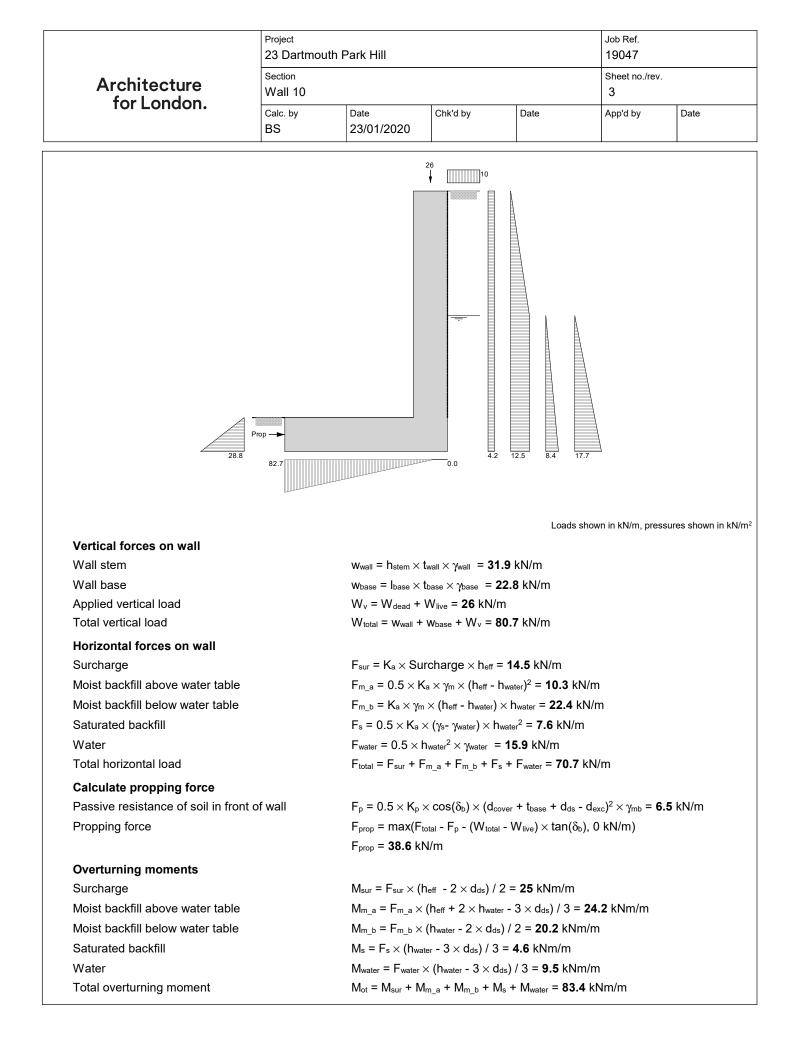
Retaining wall type Height of retaining wall stem Thickness of wall stem Length of toe Length of heel Overall length of base Thickness of base Depth of downstand Position of downstand Thickness of downstand Height of retaining wall Depth of cover in front of wall Depth of unplanned excavation Height 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

## h<sub>stem</sub> = **3000** mm t<sub>wall</sub> = **450** mm I<sub>toe</sub> = **1700** mm $I_{heel} = 0 \text{ mm}$ $I_{\text{base}} = I_{\text{toe}} + I_{\text{heel}} + t_{\text{wall}} = 2150 \text{ mm}$ t<sub>base</sub> = **450** mm $d_{ds} = 0 \text{ mm}$ l<sub>ds</sub> = **900** mm t<sub>ds</sub> = **450** mm $h_{wall} = h_{stem} + t_{base} + d_{ds} = 3450 \text{ mm}$ $d_{cover} = 0 mm$ $d_{exc} = 0 mm$ h<sub>water</sub> = **1800** mm $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 1350 mm$ γ<sub>wall</sub> = 23.6 kN/m<sup>3</sup> γ<sub>base</sub> = 23.6 kN/m<sup>3</sup> α = **90.0** deg β = **0.0** deg

Cantilever propped at base

 $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3450 \text{ mm}$ 

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for London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date			
Retained material details									
Mobilisation factor		M = 1.5							
Moist density of retained mater	ial	γ <sub>m</sub> = <b>18.0</b> kN/r	n <sup>3</sup>						
Saturated density of retained m	naterial	γ <sub>s</sub> = <b>21.0</b> kN/n	1 <sup>3</sup>						
Design shear strength		φ' = <b>24.2</b> deg							
Angle of wall friction		δ = <b>0.0</b> deg							
Base material details									
Moist density		γ <sub>mb</sub> = <b>18.0</b> kN/	′m³						
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>110</b>	P <sub>bearing</sub> = 110 kN/m <sup>2</sup>						
Based on Kerisel & Absi - 'Ad	tive and passiv	e earth pressure	tables'						
Active pressure coefficient for		•							
Slope angle ratio		$r_a = \beta / \phi' = 0.0$	00						
Wall friction ratio		$r_{\rm b} = \delta / \phi' = 0.0$							
Active pressure coefficient for r	etained material	K <sub>a</sub> = <b>0.419</b>							
Passive pressure coefficient	for base materia	al							
Slope angle ratio		r <sub>a</sub> = 0 deg / φ'ι	o = 0.00						
Wall friction ratio		$\mathbf{r}_{\rm b} = \mathbf{\delta}_{\rm b} / \mathbf{\phi}_{\rm b}^{\prime} = 0.77$							
Passive pressure coefficient fo	r base material	K <sub>p</sub> = <b>3.754</b>							
At-rest pressure									
At-rest pressure for retained m	aterial	$K_0 = 1 - \sin(\phi)$	) = 0.590						
Loading details									
Surcharge load on plan		Surcharge = '	1 <b>0.0</b> kN/m²						
Applied vertical dead load on w	vall	W <sub>dead</sub> = <b>21.4</b>	κN/m						
Applied vertical live load on wa	II	W <sub>live</sub> = <b>4.5</b> kN	/m						
Position of applied vertical load		l <sub>load</sub> = <b>1925</b> m							
Applied horizontal dead load or		F <sub>dead</sub> = <b>0.0</b> kN							
Applied horizontal live load on		F <sub>live</sub> = <b>0.0</b> kN/	n						
Height of applied horizontal loa	d on wall	h <sub>load</sub> <b>= 0</b> mm							



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tor London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date	
Restoring moments							
Wall stem		$M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 61.3 \text{ kNm/m}$					
Wall base		M <sub>base</sub> = w <sub>base</sub> :	< I <sub>base</sub> / 2 = <b>24</b>	. <b>5</b> kNm/m			

Design vertical load Total restoring moment

Check bearing pressure

Total moment for bearing Total vertical reaction Distance to reaction Eccentricity of reaction

Bearing pressure at toe Bearing pressure at heel 
$$\begin{split} M_{\text{base}} &= w_{\text{base}} \times I_{\text{base}} / 2 = \textbf{24.5 kNm/m} \\ M_v &= W_v \times I_{\text{load}} = \textbf{50 kNm/m} \\ M_{\text{rest}} &= M_{\text{wall}} + M_{\text{base}} + M_v = \textbf{135.9 kNm/m} \end{split}$$

$$\begin{split} M_{total} &= M_{rest} - M_{ot} = \textbf{52.5 kNm/m} \\ R &= W_{total} = \textbf{80.7 kN/m} \\ x_{bar} &= M_{total} / R = \textbf{650 mm} \\ e &= abs((I_{base} / 2) - x_{bar}) = \textbf{425 mm} \end{split}$$

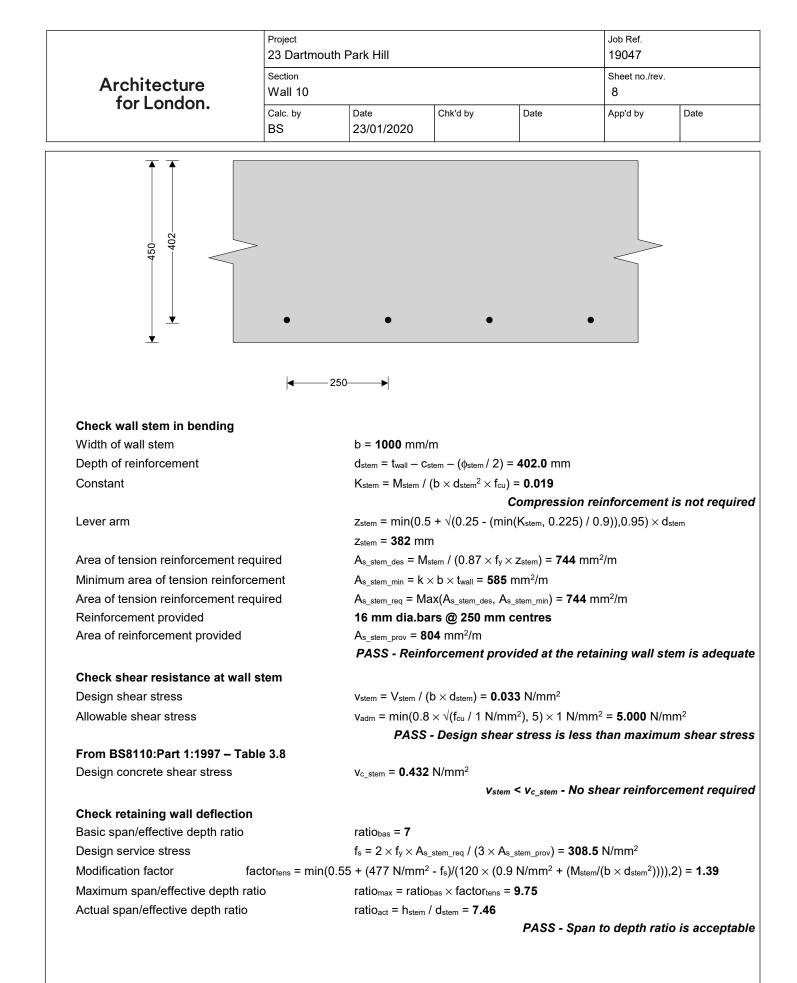
Reaction acts outside middle third of base

$$\label{eq:ptoe} \begin{split} p_{toe} &= R \; / \; (1.5 \times x_{bar}) = \textbf{82.7} \; kN/m^2 \\ p_{heel} &= 0 \; kN/m^2 = \textbf{0} \; kN/m^2 \end{split}$$

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RETAINING WALL DESIGN (	BS 8002:1994 <u>)</u>							
Ultimate limit state load facto	ors				TEDDS calcula	ation version 1.2		
Dead load factor		γ <sub>f_d</sub> = <b>1.4</b>						
Live load factor		γ <sub>⊑</sub> ⊧ γ <sub>f_l</sub> = 1.6						
Earth and water pressure facto	or	γ <sub>f_e</sub> = <b>1.4</b>						
Factored vertical forces on v		·-						
Wall stem		$W_{wall f} = \gamma_{f d} \times$	$h_{stem}  imes t_{wall}  imes \gamma_{w}$	<sub>vall</sub> = <b>44.6</b> kN/m	n			
Wall base			•	/ <sub>base</sub> = <b>32</b> kN/m				
Applied vertical load	_ · · -		/ <sub>live</sub> = 37.3 kN/n					
Total vertical load	- •-	• -	v_f = <b>113.8</b> kN/i					
Factored horizontal at-rest for	orces on wall							
Surcharge	$F_{sur} f = \gamma_{f} I \times K$	‰ × Surcharge	e × h <sub>eff</sub> = <b>32.6</b> kl	N/m				
Moist backfill above water table	_ · -	-	≺ (h <sub>eff</sub> - h <sub>water</sub> )² =					
Moist backfill below water table	e		•	- h <sub>water</sub> ) × h <sub>water</sub>				
Saturated backfill		$F_{s_{1}f} = \gamma_{f_{1}e} \times 0.5 \times K_{0} \times (\gamma_{s} - \gamma_{water}) \times h_{water}^{2} = 15 \text{ kN/m}$						
Water		$F_{water_f} = \gamma_{f_e} \times 0.5 \times h_{water}^2 \times \gamma_{water} = 22.2 \text{ kN/m}$						
Total horizontal load		$F_{total_{f}} = F_{sur_{f}} + F_{m_{a_{f}}} + F_{m_{b_{f}}} + F_{s_{f}} + F_{water_{f}} = 134.2 \text{ kN/m}$						
Calculate propping force								
Passive resistance of soil in fro	ont of wall	$F_{p_f} = \gamma_{f_e} \times 0.$	$5  imes K_p  imes \cos(\delta)$	$(d_{cover} + t_{ba})$	$_{ m se}$ + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup> $ imes$	γ <sub>mb</sub> = <b>9.1</b> kN		
Propping force		F <sub>prop_f</sub> = max( F <sub>prop_f</sub> = <b>89.3</b>		$N_{total_f}$ - $\gamma_{f_I}  imes W$	$J_{ m live})  imes$ tan( $\delta_{ m b}$ ), 0 k	N/m)		
Factored overturning momen	nts							
Surcharge		$M_{sur_f} = F_{sur_f}$	× (h <sub>eff</sub> - 2 × d <sub>ds</sub>	s) / 2 = <b>56.2</b> kN	m/m			
Moist backfill above water table	е	$M_{m\_a\_f} = F_{m\_a\_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 47.6 \text{ kNm/m}$						
Moist backfill below water table	e	$M_{m_b_f} = F_{m_b_f} \times (h_{water} - 2 \times d_{ds}) / 2 = 39.7 \text{ kNm/m}$						
Saturated backfill		$M_{s_f} = F_{s_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 9 \text{ kNm/m}$						
Water		$M_{water_f} = F_{water_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 13.3 \text{ kNm/m}$						
Total overturning moment		$M_{ot_{f}} = M_{sur_{f}} + M_{m_{a_{f}}} + M_{m_{b_{f}}} + M_{s_{f}} + M_{water_{f}} = 165.8 \text{ kNm/m}$						
Restoring moments								
Wall stem		$M_{wall_f} = w_{wall_f}$	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	2) = <b>85.9</b> kNm/ı	m			
Wall base		$M_{base_f} = w_{base}$	$e_f \times I_{base} / 2 = 3$	<b>34.4</b> kNm/m				
Design vertical load		$M_{v_{f}} = W_{v_{f}} \times I_{load} = 71.7 \text{ kNm/m}$						
Total restoring moment		M <sub>rest_f</sub> = M <sub>wall_f</sub>	f + M <sub>base_f</sub> + M <sub>v</sub>	<sub>′_f</sub> = <b>191.9</b> kNm	ı/m			
Factored bearing pressure								
Total moment for bearing		M <sub>total_f</sub> = M <sub>rest_</sub>	_f - M <sub>ot_f</sub> = <b>26.1</b>	kNm/m				
Total vertical reaction		$R_f = W_{total_f} =$						
Distance to reaction		$x_{bar_f} = M_{total_f} / R_f = 229 mm$						
Eccentricity of reaction		$e_f = abs((I_{base}))$	/ 2) - x <sub>bar_f</sub> ) = 8		cts outside mid	alla thind of		

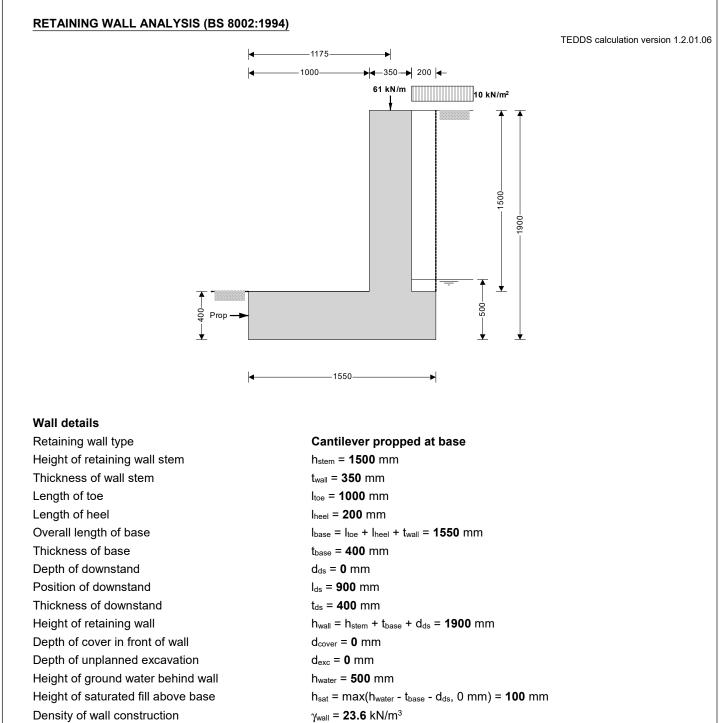
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for London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date		Date		
Bearing pressure at heel		p <sub>heel_f</sub> = 0 kN/r	n² <b>= 0</b> kN/m²					
Rate of change of base reaction	on	rate = $p_{toe_f}$ / (	$3 \times x_{bar_f}$ ) = 48	<b>0.80</b> kN/m²/m				
Bearing pressure at stem / toe		p <sub>stem_toe_f</sub> = ma	x(p <sub>toe_f</sub> - (rate	$\times$ I <sub>toe</sub> ), 0 kN/m <sup>2</sup>	²) = <b>0</b> kN/m²			
Bearing pressure at mid stem		$p_{stem_mid_f} = ma$	ax(p <sub>toe_f</sub> - (rate	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	2)), 0 kN/m²) = <b>0</b> k	N/m²		
Bearing pressure at stem / hee	el	$p_{stem\_heel\_f} = m$	ax(p <sub>toe_f</sub> - (rate	$e \times (I_{toe} + t_{wall})),$	0 kN/m <sup>2</sup> ) = <b>0</b> kN/r	m²		
Design of reinforced concret	te retaining wall	toe (BS 8002:199	4)					
Material properties								
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mm	2					
Characteristic strength of reinfo	orcement	f <sub>y</sub> = <b>500</b> N/mm	1 <sup>2</sup>					
Base details								
Minimum area of reinforcemen	ıt	k = <b>0.13</b> %						
Cover to reinforcement in toe		c <sub>toe</sub> = <b>30</b> mm						
Calculate shear for toe desig	jn							
Shear from bearing pressure		$V_{toe\_bear}$ = 3 × $p_{toe\_f}$ × $x_{bar\_f}$ / 2 = <b>113.8</b> kN/m						
Shear from weight of base		$V_{toe\_wt\_base} = \gamma_{f\_d} \times \gamma_{base} \times I_{toe} \times t_{base} = \textbf{25.3 kN/m}$						
Total shear for toe design		V <sub>toe</sub> = V <sub>toe_bear</sub> - V <sub>toe_wt_base</sub> = <b>88.6</b> kN/m						
Calculate moment for toe de	sign							
Moment from bearing pressure	9	-						
Moment from weight of base		$M_{toe_wt_base} = (\gamma$	$\gamma_{\rm f_d}  imes \gamma_{ m base}  imes { m t}_{ m base}$	$_{ m se}  imes ({\sf I}_{ m toe}$ + ${\sf t}_{ m wall}$ /	( 2) <sup>2</sup> / 2) = <b>27.5</b> kN	lm/m		
Total moment for toe design		M <sub>toe</sub> = M <sub>toe_bea</sub>	- M <sub>toe_wt_base</sub> =	<b>165.5</b> kNm/m	1			
450	•	•	•	•	•			
	<b> ←</b> ──200	▶						
Check toe in bending	<b> ←</b> 200	<b>→</b>						
<b>Check toe in bending</b> Width of toe	<b> ⊲</b> — 200		m					
Width of toe	<b>⊲</b> 200	b = <b>1000</b> mm/ d <sub>toe</sub> = t <sub>base</sub> – c <sub>t</sub>	be − (φ <sub>toe</sub> / 2) =					
-	<b> ⊲</b> —200	b = <b>1000</b> mm/	be − (φ <sub>toe</sub> / 2) =	0.024				
Width of toe Depth of reinforcement Constant	<b> ⊲</b> —200	b = <b>1000</b> mm/ d <sub>toe</sub> = t <sub>base</sub> – c <sub>t</sub> K <sub>toe</sub> = M <sub>toe</sub> / (b	$be - (\phi_{toe} / 2) =$ $\times d_{toe}^2 \times f_{cu}) =$ + $\sqrt{(0.25 - (mi))}$	0.024 Compressio	o <b>n reinforcement</b> ( 0.9)),0.95) × d <sub>toe</sub>	is not requ		
Width of toe Depth of reinforcement		b = <b>1000</b> mm/ $d_{toe} = t_{base} - c_t$ $K_{toe} = M_{toe} / (b$ $z_{toe} = min(0.5)$ $z_{toe} = 391 mm$	$d_{be} - (\phi_{toe} / 2) =$ × $d_{toe}^2 \times f_{cu}) =$ + $\sqrt{0.25}$ - (mi	0.024 Compressio	/ 0.9)),0.95) × d <sub>toe</sub>	is not requ		

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Area of tension reinforcement	required	A <sub>s_toe_req</sub> = Ma	IX(As_toe_des, As	<sub>s_toe_min</sub> ) = <b>972</b> n	nm²/m		
Reinforcement provided		16 mm dia.b	ars @ 200 mr	n centres			
Area of reinforcement provided	l	As_toe_prov = 10					
		PASS - Re	inforcement	provided at th	e retaining wall	toe is adequ	
Check shear resistance at to	e						
Design shear stress	$v_{toe} = V_{toe} / (b$	× d <sub>toe</sub> ) = 0.218	5 N/mm <sup>2</sup>				
Allowable shear stress		v <sub>adm</sub> = min(0.8	$3 \times \sqrt{(f_{cu} / 1 N/r)}$	mm²), 5) × 1 N/	/mm <sup>2</sup> = <b>5.000</b> N/r	mm²	
		PASS	- Design she	ear stress is le	ess than maxim	um shear str	
From BS8110:Part 1:1997 - 1	able 3.8						
Design concrete shear stress		v <sub>c_toe</sub> = <b>0.462</b>					
				$v_{toe} < v_{c_{toe}} - N$	o shear reinford	cement requi	
Design of reinforced concret	e retaining wal	l stem (BS 8002:1	994)				
Material properties							
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mm	1 <sup>2</sup>				
Characteristic strength of reinfo		f <sub>y</sub> = <b>500</b> N/mr	n²				
Wall details							
Minimum area of reinforcemen	t	k = 0.13 %					
Cover to reinforcement in sterr		c <sub>stem</sub> = <b>40</b> mm	ı				
Cover to reinforcement in wall		c <sub>wall</sub> = <b>30</b> mm					
Factored horizontal at-rest for	orces on stem						
Surcharge		$F_{s_{sur_{f}}} = \gamma_{f_{l}} \times$	K <sub>0</sub> × Surcharg	${\sf ge}  imes ({\sf h}_{\sf eff}$ - ${\sf t}_{\sf base}$ -	- d <sub>ds</sub> ) = <b>28.3</b> kN/r	n	
Moist backfill above water table		$F_{s\_m\_a\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2 = \textbf{20.2 kN/m}$					
Moist backfill below water table	•		• –	•	<sub>sat</sub> ) × h <sub>sat</sub> = <b>33.1</b> ∣		
Saturated backfill							
Water		$F_{s\_s\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times (\gamma_{s-} \gamma_{water}) \times h_{sat}^2 = 8.4 \text{ kN/m}$ $F_{s \text{ water } f} = 0.5 \times \gamma_{f=e} \times \gamma_{water} \times h_{sat}^2 = 12.5 \text{ kN/m}$					
Calculate shear for stem des	ian		•- •				
Shear at base of stem		V <sub>stam</sub> = F <sub>s</sub> out i	+ Fs m s + F.	smbf+F~~f+	Fs_water_f - Fprop_f	= <b>13.4</b> kN/m	
	looian	• stern • s_Sul_i	· 3_11_4_1 · 1 8	<u>, ,, , , , , , , , , , , , , , , , , ,</u>	. o_water_r i prop_r		
Coloulate moment for stars	lesign	M - E		<sub>se</sub> ) / 2 = <b>48.9</b> kN	lm/m		
Calculate moment for stem of		IVIS sur — 🗆 s sur				no /mo	
Surcharge			$(\gamma)(\gamma) \vee h$				
Surcharge Moist backfill above water table		$M_{s\_m\_a}=F_{s\_m\_}$			$e^{-2}$	[[]/[]]	
Surcharge Moist backfill above water table Moist backfill below water table		M <sub>s_m_a</sub> = F <sub>s_m_</sub> M <sub>s_m_b</sub> = F <sub>s_m_</sub>	_b_f × h <sub>sat</sub> / 2 = 2	<b>22.4</b> kNm/m	e / 2) / 3 – <b>43</b> kiv		
Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill		Ms_m_a = Fs_m_ Ms_m_b = Fs_m_ Ms_s = Fs_s_f ×	_b_f × h <sub>sat</sub> / 2 = 3 h <sub>sat</sub> / 3 = <b>3.8</b> k	<b>22.4</b> kNm/m kNm/m	e / 2) / 5 – <b>45</b> kiv		
Surcharge Moist backfill above water table Moist backfill below water table		M <sub>s_m_a</sub> = F <sub>s_m_</sub> M <sub>s_m_b</sub> = F <sub>s_m_</sub> M <sub>s_s</sub> = F <sub>s_s_f</sub> × M <sub>s_water</sub> = F <sub>s_w</sub>	_b_f × h <sub>sat</sub> / 2 = 1 h <sub>sat</sub> / 3 = <b>3.8</b> k ater_f × h <sub>sat</sub> / 3 =	<b>22.4</b> kNm/m kNm/m = <b>5.6</b> kNm/m	<sub>s_water</sub> = <b>123.7</b> kN		



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Indicative retaining wall rein	forcement diagra	im				
Toe rein	forcement			Stem reinforce	ment	
Toe bars - 16 mm dia.@ 200 n Stem bars - 16 mm dia.@ 250						

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γ<sub>base</sub> = **23.6** kN/m<sup>3</sup>

. α = **90.0** deg

β = **0.0** deg

Density of base construction

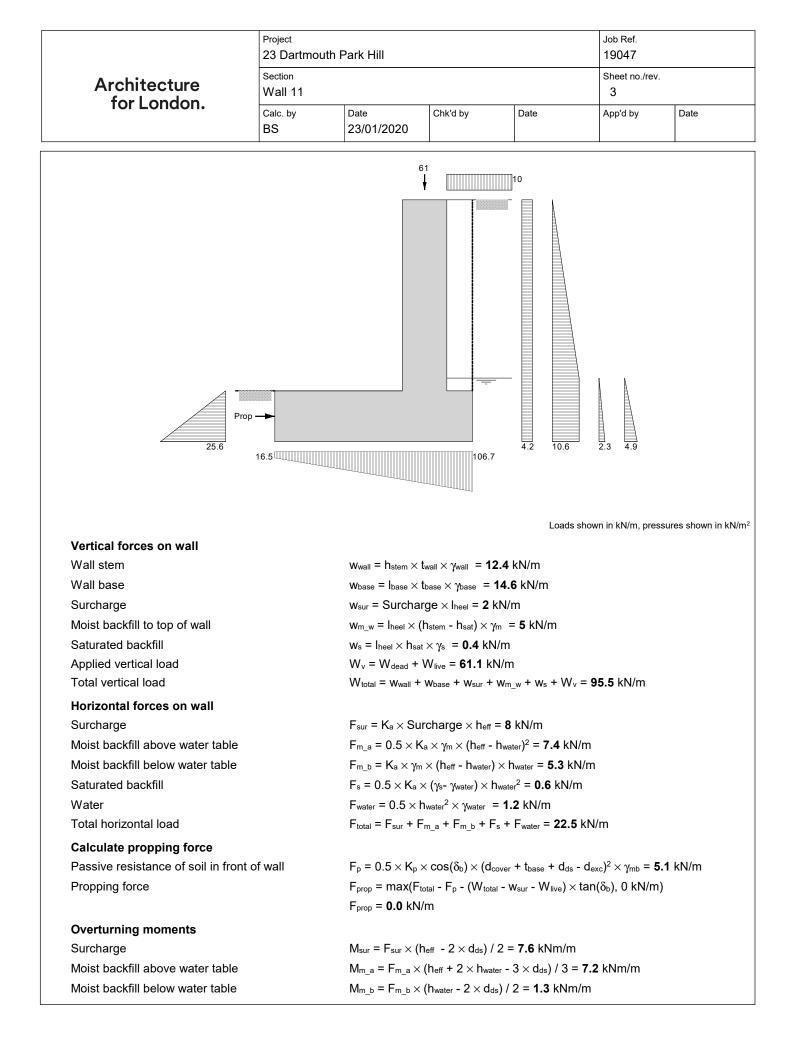
Angle of soil surface behind wall

Effective height at virtual back of wall

Angle of rear face of wall

 $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 1900 \text{ mm}$ 

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for London.	Wall 11	Wall 11			2			
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Retained material details								
Mobilisation factor		M = 1.5						
Moist density of retained materia	al	γ <sub>m</sub> = <b>18.0</b> kN/r	m <sup>3</sup>					
Saturated density of retained material		γ <sub>s</sub> = <b>21.0</b> kN/n						
Design shear strength		φ' = <b>24.2</b> deg						
Angle of wall friction		$\delta = 0.0 \text{ deg}$						
Base material details		5						
Moist density		γ <sub>mb</sub> = <b>18.0</b> kN/	′m³					
Design shear strength		∳'₅ = <b>24.2</b> deg						
Design base friction		δ <sub>b</sub> = <b>18.6</b> deg						
Allowable bearing pressure			$P_{\text{bearing}} = 110 \text{ kN/m}^2$					
Based on Kerisel & Absi - 'Ac	tive and passiv	e earth pressure	tables'					
Active pressure coefficient fo	r retained mate	erial						
Slope angle ratio		$r_a = \beta / \phi' = 0.0$	00					
Wall friction ratio		$r_{\rm b} = \delta / \phi' = 0.0$	00					
Active pressure coefficient for re	etained material	K <sub>a</sub> = <b>0.419</b>						
Passive pressure coefficient f	or base materi	al						
Slope angle ratio		r <sub>a</sub> = 0 deg / φ'ι	o = 0.00					
Wall friction ratio		$r_{\rm b} = \delta_{\rm b} / \phi'_{\rm b} = 0.77$						
Passive pressure coefficient for	base material	K <sub>p</sub> = <b>3.754</b>						
At-rest pressure								
At-rest pressure for retained ma	terial	K₀ = 1 – sin(φ	<sup>'</sup> ) = <b>0.590</b>					
Loading details								
Surcharge load on plan		Surcharge = '	10.0 kN/m <sup>2</sup>					
Applied vertical dead load on wa		W <sub>dead</sub> = <b>49.6</b> kN/m						
Applied vertical live load on wall		W <sub>live</sub> = <b>11.5</b> kl						
Position of applied vertical load		l <sub>load</sub> = <b>1175</b> m						
Applied horizontal dead load on		F <sub>dead</sub> = <b>0.0</b> kN						
Applied horizontal live load on w		F <sub>live</sub> = <b>0.0</b> kN/	m					
Height of applied horizontal load	i on wall	h <sub>load</sub> = <b>0</b> mm						



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Saturated backfill	$M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3 = 0.1 \text{ kNm/m}$
Water	$M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3 = 0.2 \text{ kNm/m}$
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a} + M_{m_b} + M_s + M_{water} = 16.3 \text{ kNm/m}$
Restoring moments	
Wall stem	$M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 14.6 \text{ kNm/m}$
Wall base	$M_{base} = w_{base} \times I_{base} / 2 = 11.3 \text{ kNm/m}$
Surcharge	M <sub>sur_r</sub> = w <sub>sur</sub> × (I <sub>base</sub> - I <sub>heel</sub> / 2) = <b>2.9</b> kNm/m
Moist backfill	$M_{m_r} = (w_{m_w} \times (I_{base} - I_{heel} / 2) + w_{m_s} \times (I_{base} - I_{heel} / 3)) = 7.3 \text{ kNm/m}$
Saturated backfill	$M_{s_r} = w_s \times (I_{base} - I_{heel} / 2) = 0.6 \text{ kNm/m}$
Design vertical load	$M_v = W_v \times I_{load} = 71.7 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{sur_r} + M_{m_r} + M_{s_r} + M_v = 108.4 \text{ kNm/m}$
Check bearing pressure	
Total moment for bearing	M <sub>total</sub> = M <sub>rest</sub> - M <sub>ot</sub> = <b>92.1</b> kNm/m
Total vertical reaction	R = W <sub>total</sub> = <b>95.5</b> kN/m
Distance to reaction	x <sub>bar</sub> = M <sub>total</sub> / R = <b>964</b> mm
Eccentricity of reaction	e = abs((I <sub>base</sub> / 2) - x <sub>bar</sub> ) = <b>189</b> mm
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 16.5 \text{ kN/m}^2$
Bearing pressure at heel	$p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 106.7 \text{ kN/m}^2$
	PASS - Maximum bearing pressure is less than allowable bearing pressure

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TOT LONGON.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date		
RETAINING WALL DESIGN (	BS 8002:1994)							
Ultimate limit state load facto	ors				I EDDS calcul	ation version 1.2		
Dead load factor		γ <sub>f_d</sub> = <b>1.4</b>						
Live load factor		γ <sub>f_1</sub> = 1.6						
Earth and water pressure facto	or	γ <sub>f_e</sub> = <b>1.4</b>						
Factored vertical forces on v	vall							
Wall stem		Wwall f = $\gamma$ f d $\times$	$h_{stem}  imes t_{wall}  imes \gamma_{wall}$	<sub>vall</sub> = <b>17.3</b> kN/n	n			
Wall base		_ · -	-	<sub>base</sub> = <b>20.5</b> kN				
Surcharge		_ · · -	Surcharge × Ihe					
Moist backfill to top of wall			•	n <sub>sat</sub> ) × γ <sub>m</sub> = <b>7.1</b>	kN/m			
Saturated backfill			eel×hsat×γs =	<i>,</i> .				
Applied vertical load		_ · -		/ <sub>live</sub> = <b>87.8</b> kN/n	n			
Total vertical load			• -		v <sub>s_f</sub> + W <sub>v_f</sub> = <b>136</b>	. <b>4</b> kN/m		
Factored horizontal at-rest for	orces on wall							
Surcharge		$F_{sur f} = \gamma_{f} \times K$	$\zeta_0  imes$ Surcharge	× h <sub>eff</sub> = <b>17.9</b> k	N/m			
Moist backfill above water table	Э	_ • _	-	< (h <sub>eff</sub> - h <sub>water</sub> ) <sup>2</sup> =				
Moist backfill below water table	9	· -	-	- h <sub>water</sub> ) × h <sub>water</sub>				
Saturated backfill		· -		, <sub>/ater</sub> ) × h <sub>water</sub> ² = '				
Water		- •-		γ <sub>water</sub> = <b>1.7</b> kN				
Total horizontal load				•	_ <sub>f</sub> = <b>45.8</b> kN/m			
Calculate propping force								
Passive resistance of soil in fro	ont of wall	$F_{p_f} = \gamma_{f_e} \times 0.$	$5  imes K_p  imes cos(\delta$	$_{ m b})  imes ({\sf d}_{ m cover}$ + ${\sf t}_{ m back}$	$_{ m se}$ + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup> ×	γ <sub>mb</sub> = <b>7.2</b> kN		
Propping force		F <sub>prop_f</sub> = max( F <sub>prop_f</sub> = <b>0.0</b> k		Ntotal_f - Wsur_f - ′	$\gamma_{f_l}  imes W_{live})  imes tan($	[δ⊳), 0 kN/m)		
Factored overturning momen	nts							
Surcharge		$M_{sur_f} = F_{sur_f}$	× (h <sub>eff</sub> - 2 × d <sub>ds</sub>	s) / 2 = <b>17</b> kNm	/m			
Moist backfill above water table	Э	$M_{m_a_f} = F_{m_a}$	$f \times (h_{eff} + 2 \times h)$	Nwater - $3  imes d_{ds}$ /	3 = <b>14.1</b> kNm/m	ı		
Moist backfill below water table	9	$M_{m_b_f} = F_{m_b}$	$_{f} \times (h_{water} - 2 \times$	d <sub>ds</sub> ) / 2 = <b>2.6</b> k	Nm/m			
Saturated backfill		$M_{s_f} = F_{s_f} \times (I)$	h <sub>water</sub> - $3  imes d_{ds}$ )	/ 3 = <b>0.2</b> kNm/	'n			
Water		$M_{water_f} = F_{water}$	$e_{r_f} \times (h_{water} - 3)$	× d <sub>ds</sub> ) / 3 = <b>0.3</b>	kNm/m			
Total overturning moment		$M_{ot_f} = M_{sur_f} + M_{sur_f}$	+ M <sub>m_a_f</sub> + M <sub>m_k</sub>	o_f + Ms_f + Mwat	<sub>ter_f</sub> = <b>34.2</b> kNm/r	n		
Restoring moments								
Wall stem		$M_{wall_f} = w_{wall_f}$	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	2) = <b>20.4</b> kNm/	m			
Wall base		$M_{base_f} = w_{base}$	$e_f \times I_{base} / 2 = 1$	<b>15.9</b> kNm/m				
Surcharge		$M_{sur_r_f} = W_{sur_f}$	$_{\rm f}  imes$ (I <sub>base</sub> - I <sub>heel</sub> /	2) = <b>4.6</b> kNm/	m			
Moist backfill		$M_{m\_r\_f} = (w_{m\_w}$	$I_{f} \times (I_{base} - I_{heel})$	/ 2) + w <sub>m_s_f</sub> × (	(I <sub>base</sub> - I <sub>heel</sub> / 3)) =	<b>10.2</b> kNm/m		
Saturated backfill		$M_{s_r_f} = w_{s_f} \times$	(I <sub>base</sub> - I <sub>heel</sub> / 2)	= <b>0.9</b> kNm/m				
Design vertical load		$M_{v\_f} = W_{v\_f} \times$	$M_{v_{f}} = W_{v_{f}} \times I_{load} = 103.1 \text{ kNm/m}$					
Total restoring moment		M	6 + Mhaaa 6 + Ma		$M_{s_r_f} + M_{v_f} = 18$	55 1 kNm/m		

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Factored bearing pressure								
Total moment for bearing		M <sub>total f</sub> = M <sub>rest f</sub>	f - M <sub>ot f</sub> = <b>120.</b>	<b>9</b> kNm/m				
Total vertical reaction		$R_f = W_{total f} = T$	-					
Distance to reaction		x <sub>bar_f</sub> = M <sub>total_f</sub> /	/ R <sub>f</sub> = <b>886</b> mm					
Eccentricity of reaction		$e_f = abs((I_{base}))$	/ 2) - x <sub>bar_f</sub> ) = 1		acts within mide	dle third of		
Bearing pressure at toe		$D_{\text{top}} f = (R_f / I_{\text{bas}})$		$e_f / I_{base^2}) = 50.2$				
Bearing pressure at heel				$\langle e_f / I_{base}^2 \rangle = 12$				
Rate of change of base reaction			, ,	-48.83 kN/m <sup>2</sup> /				
Bearing pressure at stem / toe					), 0 kN/m²) <b>= 99</b> l	⟨N/m²		
Bearing pressure at mid stem					/ 2)), 0 kN/m²) =			
Bearing pressure at stem / heel					/m²) = <b>116.1</b> kN/i			
Design of reinforced concrete r	etaining wall to			-				
Material properties			-					
Characteristic strength of concret	e	f <sub>cu</sub> = <b>40</b> N/mm	l <sup>2</sup>					
Characteristic strength of reinforc		$f_y = 500 \text{ N/mm}^2$						
Base details								
Minimum area of reinforcement		k = <b>0.13</b> %						
Cover to reinforcement in toe		c <sub>toe</sub> = <b>30</b> mm						
Calculate shear for toe design								
Shear from bearing pressure		V <sub>toe_bear</sub> = (p <sub>toe</sub>	e_f + p <sub>stem_toe_f</sub> )	× I <sub>toe</sub> / 2 = <b>74.6</b>	i kN/m			
Shear from weight of base		$V_{toe_wt_base} = \gamma_{f}$	_d $ imes \gamma_{\text{base}}  imes I_{\text{toe}}$	imes t <sub>base</sub> = 13.2 k	N/m			
Total shear for toe design		$V_{toe} = V_{toe\_bear}$	- V <sub>toe_wt_base</sub> =	<b>61.4</b> kN/m				
Calculate moment for toe desig	ın							
Moment from bearing pressure					11 / 2) <sup>2</sup> / 6 = <b>47.8</b>			
Moment from weight of base					2) <sup>2</sup> / 2) = <b>9.1</b> kN	m/m		
Total moment for toe design		M <sub>toe</sub> = M <sub>toe_bea</sub>	r - M <sub>toe_wt_base</sub> =	= <b>38.7</b> kNm/m				
364	• •	٠	٠	• •	•			
Check toe in bending	<b>∢</b> —150—►							
		b = <b>1000</b> mm/						
Width of toe	Depth of reinforcement							

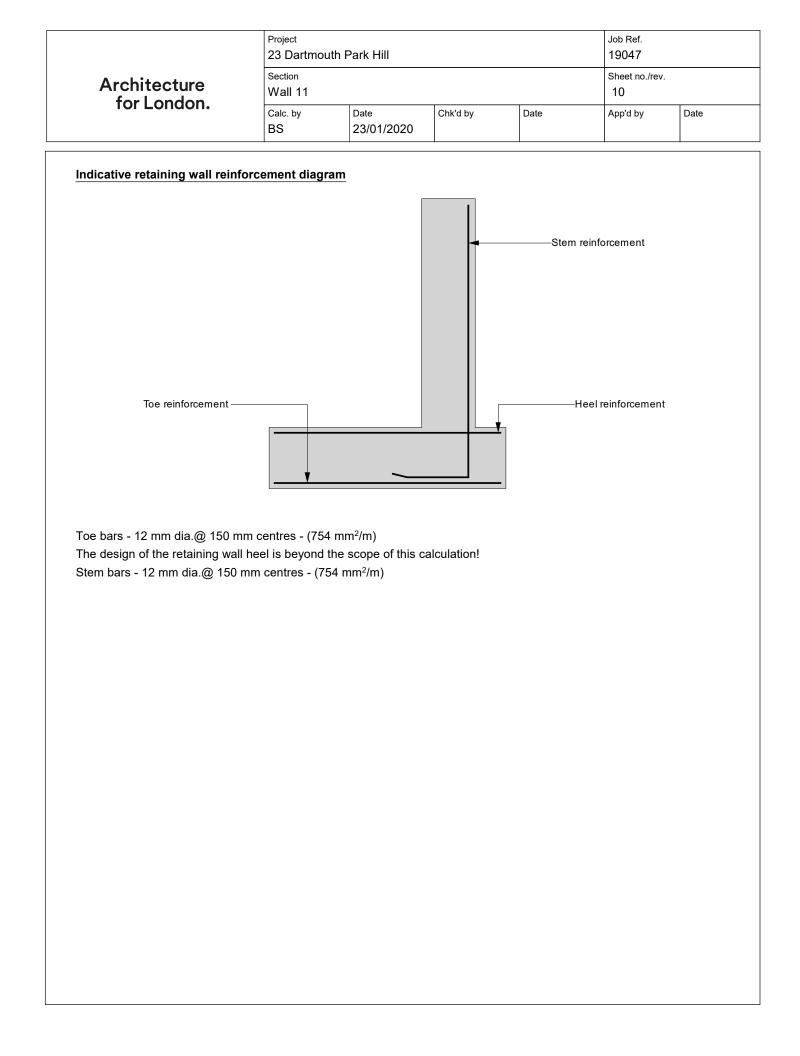
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Constant		K <sub>toe</sub> = M <sub>toe</sub> / (b	$0 \times d_{toe^2} \times f_{cu}) =$	0.007				
				Compressio	n reinforcement	is not requ		
Lever arm		z <sub>toe</sub> = min(0.5 z <sub>toe</sub> = <b>346</b> mm		n(K <sub>toe</sub> , 0.225) /	$0.9)), 0.95) \times d_{toe}$			
Area of tension reinforcement	required			z <sub>toe</sub> ) = <b>257</b> mm	1 <sup>2</sup> /m			
Minimum area of tension reinfo	-		: b × t <sub>base</sub> = <b>52</b>					
Area of tension reinforcement				<sub>_toe_min</sub> ) = <b>520</b> n	nm²/m			
Reinforcement provided	- 1	12 mm dia.ba	•					
Area of reinforcement provideo	ł	As toe prov = 75	-					
·				provided at the	e retaining wall t	toe is adeq		
Check shear resistance at to	e							
Design shear stress		$v_{toe} = V_{toe} / (b$	× d <sub>toe</sub> ) = 0.169	N/mm²				
Allowable shear stress		v <sub>adm</sub> = min(0.8	3 × √(f <sub>cu</sub> / 1 N/r	nm²), 5) × 1 N/	mm² <b>= 5.000</b> N/m	1m <sup>2</sup>		
		PASS	- Design she	ar stress is le	ss than maximu	m shear st		
From BS8110:Part 1:1997 – 1	Table 3.8							
		V 0 440	N1/mama2					
Design concrete shear stress Design of reinforced concret	te retaining wal	v <sub>c_toe</sub> = 0.448 I heel (BS 8002:19		V <sub>toe</sub> < V <sub>c_toe</sub> - N	o shear reinforco	ement requ		
Design of reinforced concret Material properties		l heel (BS 8002:19	<u>94)</u>	V <sub>toe</sub> < V <sub>C_toe</sub> - N	o shear reinforco	ement requ		
Design of reinforced concret Material properties Characteristic strength of conc	rete	<mark>l heel (BS 8002:19</mark> f <sub>cu</sub> = <b>40</b> N/mm	<b>94)</b> 1 <sup>2</sup>	V <sub>toe</sub> < V <sub>C_toe</sub> - N	o shear reinforco	ement requ		
Design of reinforced concret Material properties	rete	l heel (BS 8002:19	<b>94)</b> 1 <sup>2</sup>	Vtoe < Vc_toe - N	o shear reinforco	ement requ		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details	rete orcement	<mark>I heel (BS 8002:19</mark> f <sub>cu</sub> = <b>40</b> N/mm f <sub>y</sub> = <b>500</b> N/mn	<b>94)</b> 1 <sup>2</sup>	Vtoe < Vc_toe - N	o shear reinforco	ement requ		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details Minimum area of reinforcemen	erete orcement it	<mark>I heel (BS 8002:19</mark> f <sub>cu</sub> = <b>40</b> N/mm f <sub>y</sub> = <b>500</b> N/mn k = <b>0.13</b> %	<b>94)</b> 1 <sup>2</sup> 1 <sup>2</sup>	Vtoe < Vc_toe - N	o shear reinforco	ement requ		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details	erete orcement it	<mark>I heel (BS 8002:19</mark> f <sub>cu</sub> = <b>40</b> N/mm f <sub>y</sub> = <b>500</b> N/mn	<b>94)</b> 1 <sup>2</sup> 1 <sup>2</sup>	Vtoe < Vc_toe - N	o shear reinforco	ement requ		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details Minimum area of reinforcemen	crete orcement it	<mark>I heel (BS 8002:19</mark> f <sub>cu</sub> = <b>40</b> N/mm f <sub>y</sub> = <b>500</b> N/mn k = <b>0.13</b> %	<b>94)</b> 1 <sup>2</sup> 1 <sup>2</sup>	Vtoe < Vc_toe - N	o shear reinforco	ement requ		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details Minimum area of reinforcement Cover to reinforcement in heel	crete orcement it	I heel (BS 8002:19 f <sub>cu</sub> = 40 N/mm f <sub>y</sub> = 500 N/mn k = 0.13 % <sub>Cheel</sub> = 30 mm	<b>94)</b> 1 <sup>2</sup> 1 <sup>2</sup>	/toe < ∨c_toe - No f) × I <sub>heel</sub> / 2 = <b>2</b> 0		ement requ		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details Minimum area of reinforcemen Cover to reinforcement in heel Calculate shear for heel desi	crete orcement it	I heel (BS 8002:19 f <sub>cu</sub> = 40 N/mm f <sub>y</sub> = 500 N/mn k = 0.13 % c <sub>heel</sub> = 30 mm V <sub>heel_bear</sub> = (ph	<b>94)</b> 1 <sup>2</sup> η <sup>2</sup> eel_f + Pstem_heel_		<b>4.2</b> kN/m	ement requ		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details Minimum area of reinforcement Cover to reinforcement in heel Calculate shear for heel desi Shear from bearing pressure	erete orcement it i <b>gn</b>	$f_{cu} = 40 \text{ N/mm}$ $f_y = 500 \text{ N/mm}$ $k = 0.13 \%$ $C_{heel} = 30 \text{ mm}$ $V_{heel\_bear} = (p_{heel\_wt\_base} = \gamma)$	<b>94)</b> 1 <sup>2</sup> η <sup>2</sup> eel_f + Pstem_heel_	f) × I <sub>heel</sub> / 2 = <b>2</b> 4 al × t <sub>base</sub> = <b>2.6</b> k	<b>4.2</b> kN/m	ement requ		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details Minimum area of reinforcement Cover to reinforcement in heel Calculate shear for heel desi Shear from bearing pressure Shear from weight of base Shear from weight of moist bac Shear from weight of saturated	erete orcement it i <b>gn</b> ekfill	$f_{cu} = 40 \text{ N/mm}$ $f_y = 500 \text{ N/mm}$ $k = 0.13 \%$ $C_{heel} = 30 \text{ mm}$ $V_{heel\_bear} = (p_{heel\_wt\_base} = \gamma)$	94) 1 <sup>2</sup> η <sup>2</sup> eel_f + Pstem_heel_ /f_d × γbase × Iner n_w_f = <b>7.1</b> kN/r	f) × I <sub>heel</sub> / 2 = <b>2</b> 4 al × t <sub>base</sub> = <b>2.6</b> k	<b>4.2</b> kN/m	ement requ		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfor Base details Minimum area of reinforcement Cover to reinforcement in heel Calculate shear for heel desi Shear from bearing pressure Shear from weight of base Shear from weight of moist bac Shear from weight of saturated Shear from surcharge	erete orcement it i <b>gn</b> ekfill	I heel (BS 8002:19) $f_{cu} = 40 \text{ N/mm}$ $f_y = 500 \text{ N/mm}$ k = 0.13 % $C_{heel} = 30 \text{ mm}$ $V_{heel_bear} = (p_{he})$ $V_{heel_wt_base} = \gamma$ $V_{heel_wt_m} = w_m$ $V_{heel_wt_m} = w_m$ $V_{heel_wt_s} = w_s$ $V_{heel_sur} = w_{sur}$	94) p <sup>2</sup> n <sup>2</sup> /f_d × γbase × Inee _w_f = 7.1 kN/r f = 0.6 kN/m _f = 3.2 kN/m	f) × I <sub>heel</sub> / 2 = <b>2</b> 4 al × t <sub>base</sub> = <b>2.6</b> k ∩	<b>4.2</b> kN/m N/m			
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details Minimum area of reinforcement Cover to reinforcement in heel Calculate shear for heel desi Shear from bearing pressure Shear from weight of base Shear from weight of moist bac Shear from weight of saturated	erete orcement it i <b>gn</b> ekfill	I heel (BS 8002:19) $f_{cu} = 40 \text{ N/mm}$ $f_y = 500 \text{ N/mm}$ k = 0.13 % $C_{heel} = 30 \text{ mm}$ $V_{heel_bear} = (p_{he})$ $V_{heel_wt_base} = \gamma$ $V_{heel_wt_m} = w_m$ $V_{heel_wt_m} = w_m$ $V_{heel_wt_s} = w_s$ $V_{heel_sur} = w_{sur}$	94) p <sup>2</sup> n <sup>2</sup> /f_d × γbase × Inee _w_f = 7.1 kN/r f = 0.6 kN/m _f = 3.2 kN/m	f) × I <sub>heel</sub> / 2 = <b>2</b> 4 al × t <sub>base</sub> = <b>2.6</b> k ∩	<b>4.2</b> kN/m			
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfor Base details Minimum area of reinforcement Cover to reinforcement in heel Calculate shear for heel desi Shear from bearing pressure Shear from weight of base Shear from weight of moist bac Shear from weight of saturated Shear from surcharge	erete orcement it i <b>gn</b> ckfill i backfill	I heel (BS 8002:19) $f_{cu} = 40 \text{ N/mm}$ $f_y = 500 \text{ N/mm}$ k = 0.13 % $C_{heel} = 30 \text{ mm}$ $V_{heel_bear} = (p_{he})$ $V_{heel_wt_base} = \gamma$ $V_{heel_wt_m} = w_m$ $V_{heel_wt_m} = w_m$ $V_{heel_wt_s} = w_s$ $V_{heel_sur} = w_{sur}$	94) p <sup>2</sup> n <sup>2</sup> /f_d × γbase × Inee _w_f = 7.1 kN/r f = 0.6 kN/m _f = 3.2 kN/m	f) × I <sub>heel</sub> / 2 = <b>2</b> 4 al × t <sub>base</sub> = <b>2.6</b> k ∩	<b>4.2</b> kN/m N/m			
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details Minimum area of reinforcement Cover to reinforcement in heel Calculate shear for heel desi Shear from bearing pressure Shear from weight of base Shear from weight of moist bac Shear from weight of saturated Shear from surcharge Total shear for heel design	erete orcement it i <b>gn</b> ckfill i backfill	I heel (BS 8002:19) $f_{cu} = 40 \text{ N/mm}$ $f_y = 500 \text{ N/mm}$ k = 0.13 % $C_{heel} = 30 \text{ mm}$ $V_{heel_bear} = (p_{he})$ $V_{heel_wt_base} = \gamma$ $V_{heel_wt_m} = w_m$ $V_{heel_wt_m} = w_m$ $V_{heel_wt_s} = w_s$ $V_{heel_sur} = w_{sur}$ $V_{heel} = - V_{heel_sur}$	94) p <sup>2</sup> n <sup>2</sup> /f_d × γbase × Inee _w_f = 7.1 kN/r _f = 0.6 kN/m _f = 3.2 kN/m _bear + Vheel_wt_b	f) × I <sub>heel</sub> / 2 = <b>2</b> 4 el × t <sub>base</sub> = <b>2.6</b> k ∩ ase + V <sub>heel_wt_m</sub> -	<b>4.2</b> kN/m N/m	<sub>sur</sub> = <b>-10.7</b> k		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details Minimum area of reinforcemen Cover to reinforcement in heel Calculate shear for heel desi Shear from bearing pressure Shear from weight of base Shear from weight of saturated Shear from surcharge Total shear for heel design Calculate moment for heel d	erete orcement it i <b>gn</b> ckfill i backfill	I heel (BS 8002:19) $f_{cu} = 40 \text{ N/mm}$ $f_y = 500 \text{ N/mm}$ k = 0.13 % $C_{heel} = 30 \text{ mm}$ $V_{heel\_bear} = (p_{he})$ $V_{heel\_wt\_base} = \gamma$ $V_{heel\_wt\_base} = \gamma$ $V_{heel\_wt\_a} = w_{su}$ $V_{heel\_sur} = w_{sur}$ $V_{heel\_sur} = w_{sur}$ $V_{heel} = - V_{heel}$ $M_{heel\_bear} = (2)$	<b>94)</b> p <sup>2</sup> n <sup>2</sup> wel_f + Pstem_heel_ yf_d × γbase × Ihen h_w_f = <b>7.1</b> kN/r f = <b>0.6</b> kN/m f = <b>3.2</b> kN/m bear + Vheel_wt_b × Pheel_f + Pstem	f) × I <sub>heel</sub> / 2 = <b>2</b> el × t <sub>base</sub> = <b>2.6</b> k n ase + V <sub>heel_wt_m</sub> - _mid_f) × (I <sub>heel</sub> + 1	<b>4.2</b> kN/m N/m + V <sub>heel_wt_s</sub> + V <sub>heel_s</sub>	<sub>sur</sub> = <b>-10.7</b> k kNm/m		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details Minimum area of reinforcement Cover to reinforcement in heel Calculate shear for heel desi Shear from bearing pressure Shear from weight of base Shear from weight of moist bac Shear from weight of saturated Shear from surcharge Total shear for heel design Calculate moment for heel d Moment from bearing pressure	erete orcement it i <b>gn</b> ckfill i backfill <b>esign</b>	I heel (BS 8002:19) $f_{cu} = 40 \text{ N/mm}$ $f_y = 500 \text{ N/mm}$ k = 0.13 % $C_{heel} = 30 \text{ mm}$ $V_{heel\_bear} = (p_{he})$ $V_{heel\_wt\_base} = \gamma$ $V_{heel\_wt\_m} = w_{su}$ $V_{heel\_wt\_m} = w_{su}$ $V_{heel\_sur} = w_{sur}$ $V_{heel\_sur} = w_{sur}$ $V_{heel\_bear} = (2$ $M_{heel\_bear} = (2$ $M_{heel\_wt\_base} = 1$	94) $p^2$ $p^$	f) × I <sub>heel</sub> / 2 = <b>2</b> el × t <sub>base</sub> = <b>2.6</b> k n ase + V <sub>heel_wt_m</sub> - _mid_f) × (I <sub>heel</sub> + 1	4.2 kN/m N/m + V <sub>heel_wt_s</sub> + V <sub>heel_s</sub> t <sub>wall</sub> / 2) <sup>2</sup> / 6 = 8.4 I / 2) <sup>2</sup> / 2) = 0.9 kN	<sub>sur</sub> = <b>-10.7</b> k kNm/m		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfor Base details Minimum area of reinforcement Cover to reinforcement in heel Calculate shear for heel desi Shear from bearing pressure Shear from weight of base Shear from weight of saturated Shear from surcharge Total shear for heel design Calculate moment for heel d Moment from bearing pressure Moment from weight of base	erete orcement it i <b>gn</b> ckfill d backfill <b>esign</b> e packfill	I heel (BS 8002:19) $f_{cu} = 40 \text{ N/mm}$ $f_y = 500 \text{ N/mm}$ k = 0.13 % $C_{heel} = 30 \text{ mm}$ $V_{heel\_bear} = (p_{he})$ $V_{heel\_wt\_base} = \gamma$ $V_{heel\_wt\_base} = \gamma$ $V_{heel\_wt\_s} = w_{sur}$ $V_{heel\_sur} = w_{sur}$ $V_{heel\_sur} = v_{heel}$ $M_{heel\_bear} = (2$ $M_{heel\_wt\_base} = \psi$ $M_{heel\_wt\_base} = \psi$	$\begin{array}{l} \underline{94}\\ \\ \underline{94}\\ \\ \\ \underline{94}\\ \\ \\ \underline{94}\\ \underline{94}\\ \\ \underline{94}\\ $	f) × I <sub>heel</sub> / 2 = <b>2</b> 4 el × t <sub>base</sub> = <b>2.6</b> k n ase + V <sub>heel_wt_m</sub> - _mid_f) × (I <sub>heel</sub> + 1 ase × (I <sub>heel</sub> + t <sub>wall</sub>	4.2 kN/m N/m + V <sub>heel_wt_s</sub> + V <sub>heel_s</sub> t <sub>wall</sub> / 2)² / 6 = 8.4 k / 2)² / 2) = 0.9 kN lm/m	<sub>sur</sub> = <b>-10.7</b> k kNm/m		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details Minimum area of reinforcement Cover to reinforcement in heel Calculate shear for heel desi Shear from bearing pressure Shear from weight of base Shear from weight of saturated Shear from surcharge Total shear for heel design Calculate moment for heel de Moment from bearing pressure Moment from weight of base	erete orcement it i <b>gn</b> ckfill d backfill <b>esign</b> e packfill	I heel (BS 8002:19) $f_{cu} = 40 \text{ N/mm}$ $f_y = 500 \text{ N/mm}$ k = 0.13 % $C_{heel} = 30 \text{ mm}$ $V_{heel\_bear} = (p_{hu})$ $V_{heel\_wt\_m} = w_{m}$ $V_{heel\_wt\_m} = w_{su}$ $V_{heel\_wt\_m} = w_{su}$ $V_{heel\_sur} = w_{sur}$ $V_{heel\_sur} = w_{sur}$ $V_{heel\_bear} = (2$ $M_{heel\_bear} = (2$ $M_{heel\_bear} = (2$ $M_{heel\_wt\_m} = w_{m}$ $M_{heel\_wt\_m} = w_{su}$	$\begin{array}{l} \begin{array}{l} \begin{array}{l} \begin{array}{l} \begin{array}{l} \begin{array}{l} \begin{array}{l} \begin{array}{l} $	f) × I <sub>heel</sub> / 2 = <b>2</b> of × t <sub>base</sub> = <b>2.6</b> k n ase + V <sub>heel_wt_m</sub> - _mid_f) × (I <sub>heel</sub> + 1 ase × (I <sub>heel</sub> + t <sub>wall</sub> rall) / 2 = <b>1.9</b> kN	4.2 kN/m N/m + Vheel_wt_s + Vheel_s twall / 2)² / 6 = 8.4 l / 2)² / 2) = 0.9 kN lm/m m	<sub>sur</sub> = <b>-10.7</b> k kNm/m		
Design of reinforced concret Material properties Characteristic strength of conc Characteristic strength of reinfo Base details Minimum area of reinforcement Cover to reinforcement in heel Calculate shear for heel desi Shear from bearing pressure Shear from weight of base Shear from weight of saturated Shear from surcharge Total shear for heel design Calculate moment for heel d Moment from bearing pressure Moment from weight of base	erete orcement it i <b>gn</b> ckfill d backfill <b>esign</b> e packfill	I heel (BS 8002:19) $f_{cu} = 40 \text{ N/mm}$ $f_y = 500 \text{ N/mm}$ k = 0.13 % Cheel = 30  mm $V_{heel_bear} = (p_h)$ $V_{heel_wt_base} = \gamma$ $V_{heel_wt_base} = \gamma$ $V_{heel_wt_s} = w_{s_s}$ $V_{heel_sur} = w_{sur}$ $V_{heel} = - V_{heel_sur}$ $M_{heel_wt_base} = 0$ $M_{heel_wt_base} = 0$ $M_{heel_wt_s} = w_{s_s}$ $M_{heel_wt_s} = w_{s_s}$ $M_{heel_sur} = w_{sur}$	$\begin{array}{l} \underline{94}\\ \\\underline{94}\\ \\\underline{92}\\ \underline{92}\\ \\\underline{92}\\ \underline{92}\\ $	f) × Iheel / 2 = 2 el × tbase = 2.6 k n ase + Vheel_wt_m - _mid_f) × (Iheel + t ase × (Iheel + twall /all) / 2 = 1.9 kN / 2 = 0.2 kNm/ / 2 = 0.9 kNm/	4.2 kN/m N/m + Vheel_wt_s + Vheel_s twall / 2)² / 6 = 8.4 l / 2)² / 2) = 0.9 kN lm/m m	<sub>sur</sub> = <b>-10.7</b> k kNm/m lm/m		

As the moment is negative the design of the retaining wall heel is beyond the scope of this calculation

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

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Architecture	Section Wall 11				Sheet no./rev. 8		
for London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date	
Motorial proportion							
Material properties Characteristic strength of conce	oto	f <sub>cu</sub> = <b>40</b> N/mn	n <sup>2</sup>				
Characteristic strength of reinfo		f <sub>y</sub> = <b>500</b> N/mr					
Wall details		ly 000 l ()					
Minimum area of reinforcement		k = <b>0.13</b> %					
Cover to reinforcement in stem		c <sub>stem</sub> = <b>40</b> mm	n				
Cover to reinforcement in wall		C <sub>wall</sub> = <b>30</b> mm					
Factored horizontal at-rest fo	roos on stom						
Surcharge	ICES ON SLEIN	$\mathbf{F}_{\mathbf{r}} = \mathbf{v}_{\mathbf{r}} \cdot \mathbf{v}_{\mathbf{r}}$	K <sub>a</sub> × Surcharo	le × (ht.	d <sub>ds</sub> ) = <b>14.2</b> kN/m	1	
Moist backfill above water table		· -	-	•	$(u_{ds}) = 14.2 \text{ KN/II}$ $(ds - h_{sat})^2 = 14.6$		
			•= •				
Moist backfill below water table					<sub>at</sub> ) × h <sub>sat</sub> = <b>2.1</b> kN	I/IT1	
Saturated backfill			•= ••	$\gamma_{water}$ × $h_{sat}^2 = 0$			
Water		⊢ <sub>s_water_f</sub> = 0.5	$0  imes \gamma_{f_e}  imes \gamma_{water}  imes$	k h <sub>sat</sub> ² <b>= 0.1</b> kN/r	n		
Calculate shear for stem des	ign						
Shear at base of stem		V <sub>stem</sub> = F <sub>s_sur_</sub>	$f + F_{s_m_a_f} + F_{s_m}$	s_m_b_f + Fs_s_f +	F <sub>s_water_f</sub> = <b>30.9</b> k	N/m	
Calculate moment for stem d	esign						
Surcharge		$M_{s_{sur}} = F_{s_{sur}}$	$_{f} \times (h_{stem} + t_{bas})$	<sub>e</sub> ) / 2 <b>= 13.5</b> kNi	m/m		
Moist backfill above water table	•	Ms_m_a = Fs_m	_a_f $\times$ (2 $\times$ h <sub>sat</sub> +	- h <sub>eff</sub> - d <sub>ds</sub> + t <sub>base</sub>	/ 2) / 3 = <b>11.2</b> ki	Nm/m	
Moist backfill below water table		$M_{s_m_b} = F_{s_m}$	_b_f × h <sub>sat</sub> / 2 =	<b>0.1</b> kNm/m			
Saturated backfill			: h <sub>sat</sub> / 3 <b>= 0</b> kN				
Water			<sub>/ater_f</sub> × h <sub>sat</sub> / 3 =				
Total moment for stem design					water = <b>24.7</b> kNm	/m	
▲ 350 304	• •	•	•	• •	•		
	<b>∢</b> —150— <b>→</b>						
Check wall stem in bending							
Width of wall stem		b = <b>1000</b> mm	/m				
		$d_{stem} = t_{wall} - c$	c <sub>stem</sub> − (φ <sub>stem</sub> / 2	) = <b>304.0</b> mm			
Depth of reinforcement		K <sub>stem</sub> = M <sub>stem</sub> /	$(b \times d_{stem}^2 \times f_c)$	cu) = <b>0.007</b>			
Depth of reinforcement Constant				Compression	reinforcement	is not requi	
		z <sub>stem</sub> = min(0. z <sub>stem</sub> = <b>289</b> m		าin(K <sub>stem</sub> , 0.225)	/ 0.9)),0.95) × d	stem	
Constant	equired	z <sub>stem</sub> = <b>289</b> m	m	nin(K <sub>stem</sub> , 0.225) <sub>v</sub> × z <sub>stem</sub> ) = <b>197</b> r		stem	

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Architecture for London.	Section Wall 11		Sheet no./rev. 9	Sheet no./rev. 9			
for London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date	
Area of tension reinforcement	required	As_stem_req = M	ax(A <sub>s_stem_des</sub> ,	As_stem_min) = <b>4</b>	<b>55</b> mm²/m		
Reinforcement provided		12 mm dia.ba	ars @ 150 mr	n centres			
Area of reinforcement provideo	t	As_stem_prov = 7	<b>54</b> mm²/m				
		PASS - Rein	forcement pr	ovided at the	retaining wall st	tem is adequ	
Check shear resistance at w	all stem						
Design shear stress		$v_{stem} = V_{stem} / (b \times d_{stem}) = 0.102 \text{ N/mm}^2$					
Allowable shear stress		v <sub>adm</sub> = min(0.8 × √(f <sub>cu</sub> / 1 N/mm²), 5) × 1 N/mm² = <b>5.000</b> N/mm²					
		PASS	- Design she	ear stress is l	ess than maximu	ım shear str	
From BS8110:Part 1:1997 - 1	able 3.8						
Design concrete shear stress		Vc_stem = <b>0.497</b>	N/mm <sup>2</sup>				
			Vst	tem < Vc_stem - I	lo shear reinford	ement requi	
Check retaining wall deflecti	on						
Check retaining wall deflecti Basic span/effective depth rational statements and the statement of the statem		ratio <sub>bas</sub> = <b>7</b>					
•		ratio <sub>bas</sub> = 7 $f_s = 2 \times f_y \times A_s$	s_stem_req / (3 $\times$ /	As_stem_prov) = 2	2 <b>01.2</b> N/mm²		
Basic span/effective depth ration		$f_s = 2 \times f_y \times A_s$		,		),2) = <b>2.00</b>	
Basic span/effective depth rational Design service stress	o factor <sub>tens</sub> = min(0.5	$f_s = 2 \times f_y \times A_s$	$^{2} - f_{s})/(120 \times (0$	0.9 N/mm <sup>2</sup> + (		),2) = <b>2.00</b>	
Basic span/effective depth ration Design service stress Modification factor	o factor <sub>tens</sub> = min(0.5 ratio	$f_s = 2 \times f_y \times A_s$ 55 + (477 N/mm <sup>2</sup>	$^2$ - f <sub>s</sub> )/(120 × (0 Dbas × factor <sub>tens</sub>	0.9 N/mm <sup>2</sup> + (		),2) = <b>2.00</b>	



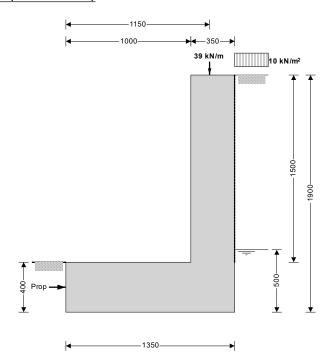
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Architecture for London.	Retary wall Desry	Start page no./Re	vision
	Client	Calcs by	Calcs date

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		all (h= 3.a.)	1/43)	12.9	
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and a new Daught of the Alice of David Connection of David		(9.1/2) (1.0,1.5		4.55 6.	
	$- n \alpha j $	(9.1/2) (0.83		<u>3.78</u> <u>34.88</u>	
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et him	tar level = 1.an	(B.G.L) Ass	amed		51 vrg*u*g\$100_0;11(71-01)-g\$1-vf} cdg=v41/cdcmdfe(-)_{1}0-afferg1v4gamgCouncespron
<u>* Wall 13</u>					
7	Land:-			Dend Live	
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		(5.4/2) (1.0		2.7 4.0	
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				2.7 4.0	
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* 5	Eurchano - 100	41122		W. 171 10.0	
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Architecture for London.	Section Wall 12				Sheet no./rev. 1	
Tor London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	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

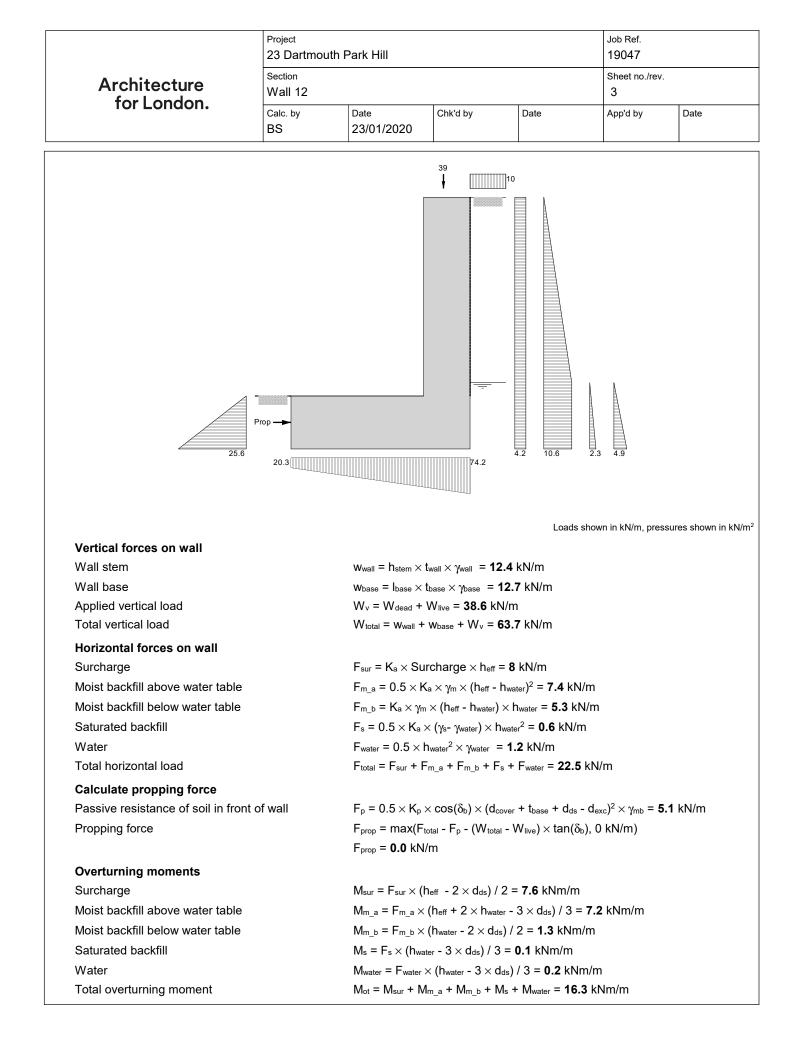
Cantilever propped at base h<sub>stem</sub> = **1500** mm t<sub>wall</sub> = 350 mm I<sub>toe</sub> = **1000** mm I<sub>heel</sub> = 0 mm Ibase = Itoe + Iheel + twall = 1350 mm t<sub>base</sub> = **400** mm d<sub>ds</sub> = **0** mm I<sub>ds</sub> = **900** mm t<sub>ds</sub> = **400** mm  $h_{wall} = h_{stem} + t_{base} + d_{ds} = 1900 \text{ mm}$ d<sub>cover</sub> = **0** mm  $d_{exc} = 0 mm$ h<sub>water</sub> = **500** mm  $h_{sat} = max(h_{water} - t_{base} - d_{ds}, 0 mm) = 100 mm$ γ<sub>wall</sub> = 23.6 kN/m<sup>3</sup>  $\gamma_{\text{base}} = 23.6 \text{ kN/m}^3$ α = **90.0** deg

## $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 1900 \text{ mm}$

 $\beta$  = **0.0** deg

M = 1.5

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for London.	Calc. by BS	Date 23/01/2020	Chk'd by	App'd by	Date		
Moist density of retained mater	ial	γm = <b>18.0</b> kN/r	n <sup>3</sup>				
Saturated density of retained m	naterial	γ <sub>s</sub> = <b>21.0</b> kN/r	n <sup>3</sup>				
Design shear strength		∳' = <b>24.2</b> deg					
Angle of wall friction		$\delta$ = <b>0.0</b> deg					
Base material details							
Moist density		γ <sub>mb</sub> = <b>18.0</b> kN	/m³				
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>110</b>	kN/m²				
Based on Kerisel & Absi - 'Ao	ctive and passive	earth pressure	tables'				
Active pressure coefficient for	or retained materi	al					
Slope angle ratio		$r_a = \beta / \phi' = 0.$	00				
Wall friction ratio		$r_{b} = \delta / \phi' = 0.0$	00				
Active pressure coefficient for r	retained material	Ka = <b>0.419</b>					
Passive pressure coefficient	for base material						
Slope angle ratio		r <sub>a</sub> = 0 deg / φ'	o = 0.00				
Wall friction ratio		$r_b = \delta_b / \phi'_b = 0.77$					
Passive pressure coefficient fo	r base material	K <sub>p</sub> = <b>3.754</b>					
At-rest pressure							
At-rest pressure for retained m	aterial	$K_0 = 1 - sin(\phi$	') = <b>0.590</b>				
Loading details							
Surcharge load on plan		Surcharge = '	10.0 kN/m²				
Applied vertical dead load on w	vall	W <sub>dead</sub> = <b>34.9</b>	κN/m				
Applied vertical live load on wa	11	W <sub>live</sub> = <b>3.7</b> kN	/m				
Position of applied vertical load	l on wall	l <sub>load</sub> = <b>1150</b> m					
Applied horizontal dead load of		F <sub>dead</sub> = <b>0.0</b> kN					
Applied horizontal live load on		F <sub>live</sub> = <b>0.0</b> kN/	m				
Height of applied horizontal loa	id on wall	h <sub>load</sub> = <b>0</b> mm					



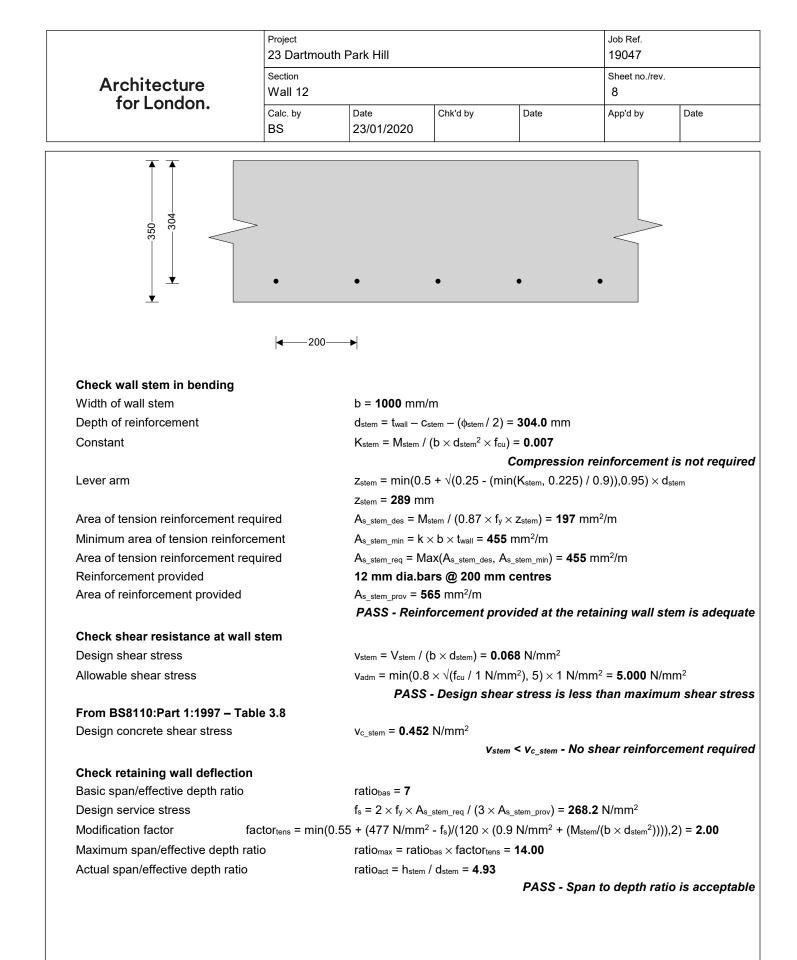
	Project 23 Dartmouth Park Hill					
Architecture for London.	Section Wall 12		Sheet no./rev. 4			
Tor London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date

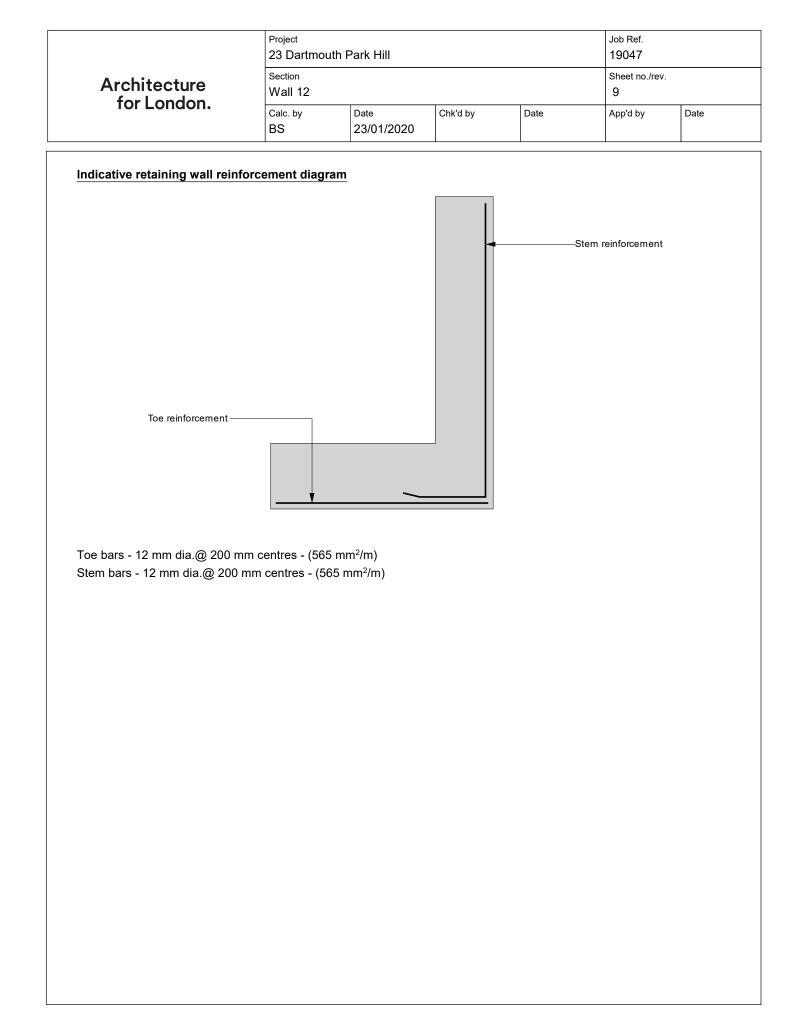
Restoring moments	
Wall stem	$M_{wall}$ = $w_{wall} \times (I_{toe} + t_{wall} / 2)$ = <b>14.6</b> kNm/m
Wall base	M <sub>base</sub> = w <sub>base</sub> × I <sub>base</sub> / 2 = <b>8.6</b> kNm/m
Design vertical load	$M_v = W_v \times I_{load} = 44.4 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_v = 67.6 \text{ kNm/m}$
Check bearing pressure	
Total moment for bearing	M <sub>total</sub> = M <sub>rest</sub> - M <sub>ot</sub> = <b>51.2</b> kNm/m
Total vertical reaction	R = W <sub>total</sub> = <b>63.7</b> kN/m
Distance to reaction	x <sub>bar</sub> = M <sub>total</sub> / R = <b>803</b> mm
Eccentricity of reaction	e = abs((I <sub>base</sub> / 2) - x <sub>bar</sub> ) = <b>128</b> mm
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 20.3 \text{ kN/m}^2$
Bearing pressure at heel	$p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 74.2 \text{ kN/m}^2$
	PASS - Maximum bearing pressure is less than allowable bearing pressure

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	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date			
RETAINING WALL DESIGN (I	BS 8002:1994 <u>)</u>								
Ultimate limit state load facto	ors				TEDDS calcul	ation version 1.2			
Dead load factor		γ <sub>f_d</sub> = <b>1.4</b>							
Live load factor		γ <sub>f_1</sub> = <b>1.6</b>							
Earth and water pressure facto	or	γ <sub>f_e</sub> = <b>1.4</b>							
Factored vertical forces on w	vall								
Wall stem		W <sub>wall</sub> f=γfd×	$h_{stem}  imes t_{wall}  imes \gamma_{w}$	<sub>vall</sub> = <b>17.3</b> kN/m	ı				
Wall base			-	/base = <b>17.8</b> kN/					
Applied vertical load		_ · -		/ <sub>live</sub> = <b>54.8</b> kN/n					
Total vertical load		_ · -	_f + W <sub>base_f</sub> + W						
Factored horizontal at-rest for	orces on wall								
Surcharge	-	$F_{sur_{f}} = \gamma_{f_{l}} \times K$	‰ × Surcharge	e × h <sub>eff</sub> <b>= 17.9</b> kl	N/m				
Moist backfill above water table	e	$F_{m\_a\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times \gamma_m \times (h_{eff} - h_{water})^2 = 14.6 \text{ kN/m}$							
Moist backfill below water table	e	$F_{m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = \textbf{10.4 kN}/m$							
Saturated backfill		$F_{s_f} = \gamma_{f_e} \times 0.5 \times K_0 \times (\gamma_{s} - \gamma_{water}) \times h_{water}^2 = 1.2 \text{ kN/m}$							
Water		$F_{water_f} = \gamma_{f_e} \times 0.5 \times h_{water}^2 \times \gamma_{water} = 1.7 \text{ kN/m}$							
Total horizontal load		$F_{total_f} = F_{sur_f} + F_{m_a_f} + F_{m_b_f} + F_{s_f} + F_{water_f} = 45.8 \text{ kN/m}$							
Calculate propping force									
Passive resistance of soil in fro	ont of wall	$F_{p_f} = \gamma_{f_e} \times 0.$	$5  imes K_p  imes \cos(\delta$	$(d_{cover} + t_{ba})$	se + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup> ×	γ <sub>mb</sub> = <b>7.2</b> kN			
Propping force		$F_{prop_f} = max(F_{prop_f} = 10.3)$	•	$N_{total_f}$ - $\gamma_{f_I}  imes W$	$_{ m live}) imes$ tan( $\delta_{ m b}$ ), 0 k	N/m)			
Factored overturning momer	nts								
Surcharge		$M_{sur_f} = F_{sur_f}$	$\times$ (h <sub>eff</sub> - 2 $\times$ d <sub>ds</sub>	s) / 2 = <b>17</b> kNm	/m				
Moist backfill above water table	е	$M_{m\_a\_f} = F_{m\_a\_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 14.1 \text{ kNm/m}$							
Moist backfill below water table	e	$M_{m_b_f} = F_{m_b_f} \times (h_{water} - 2 \times d_{ds}) / 2 = 2.6 \text{ kNm/m}$							
Saturated backfill		$M_{s_f} = F_{s_f} \times (I)$	$n_{water}$ - $3  imes d_{ds}$ )	/ 3 = <b>0.2</b> kNm/	m				
Water		$M_{water_f} = F_{water_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 0.3 \text{ kNm/m}$							
Total overturning moment		$M_{ot_f} = M_{sur_f} + M_{m_a_f} + M_{m_b_f} + M_{s_f} + M_{water_f} = 34.2 \text{ kNm/m}$							
Restoring moments									
Wall stem		$M_{wall_f} = w_{wall_f}$	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	2) = <b>20.4</b> kNm/ı	m				
Wall base		$M_{base_f} = w_{base_f} \times I_{base} / 2 = 12 \text{ kNm/m}$							
Design vertical load		$M_{v_f} = W_{v_f} \times I_{load} = 63 \text{ kNm/m}$							
Total restoring moment		M <sub>rest_f</sub> = M <sub>wall_f</sub>	f + M <sub>base_f</sub> + M <sub>v</sub>	<sub>/_f</sub> = <b>95.5</b> kNm/i	m				
Factored bearing pressure									
Total moment for bearing			f - Mot_f = 61.2	kNm/m					
Total vertical reaction		R <sub>f</sub> = W <sub>total_f</sub> = <b>90.0</b> kN/m							
Distance to reaction		$x_{bar_f} = M_{total_f} / R_f = 681 \text{ mm}$							
Eccentricity of reaction		e <sub>f</sub> = abs((I <sub>base</sub>	$/2) - x_{bar_f}) = 0$						
				Dooction	acts within mid	dla third of			

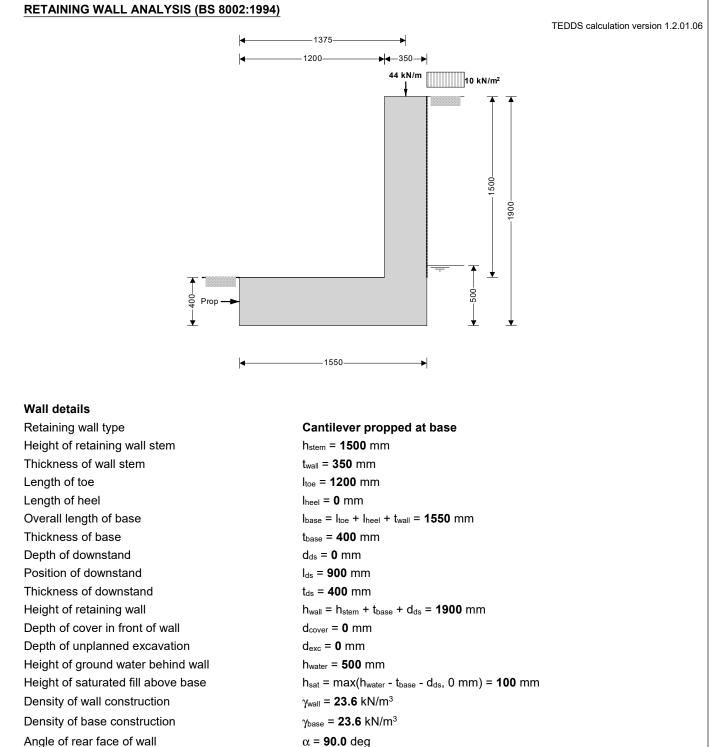
	Project 23 Dartmo	uth Park Hill	Job Ref. 19047						
Architecture for London.	Section Wall 12				Sheet no./rev. 6				
TOI LONGON.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date			
Bearing pressure at heel		p <sub>heel_f</sub> = (R <sub>f</sub> / I <sub>b</sub>	$_{ase})$ + (6 $\times$ R <sub>f</sub> >	< e <sub>f</sub> / I <sub>base</sub> <sup>2</sup> ) = 68	<b>3.3</b> kN/m <sup>2</sup>				
Rate of change of base reaction	'n	rate = (p <sub>toe_f</sub> -	p <sub>heel_f</sub> ) / I <sub>base</sub> =	-2.42 kN/m <sup>2</sup> /m	I				
Bearing pressure at stem / toe		p <sub>stem_toe_f</sub> = ma	ax(p <sub>heel_f</sub> + (rat	$e  imes (I_{heel} + t_{wall}))$	, 0 kN/m²) = <b>67.</b> 4	kN/m²			
Bearing pressure at mid stem		p <sub>stem_mid_f</sub> = ma	ax(p <sub>heel_f</sub> + (rat	$ ext{te}  imes (I_{ ext{heel}} +  ext{twall})$	2)), 0 kN/m²) = 0	67.9 kN/m²			
Bearing pressure at stem / heel		$p_{stem\_heel\_f} = m$	ax(p <sub>heel_f</sub> + (ra	te $\times$ I <sub>heel</sub> ), 0 kN/	′m²) = <b>68.3</b> kN/m	2			
Design of reinforced concret	e retaining wal	l toe (BS 8002:199	<u>4)</u>						
Material properties									
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mm	2						
Characteristic strength of reinfo	orcement	f <sub>y</sub> = <b>500</b> N/mn	1 <sup>2</sup>						
Base details									
Minimum area of reinforcemen	t	k = <b>0.13</b> %							
Cover to reinforcement in toe		c <sub>toe</sub> = <b>30</b> mm							
Calculate shear for toe desig	n								
Shear from bearing pressure		$V_{toe\_bear} = (p_{toe\_f} + p_{stem\_toe\_f}) \times I_{toe} / 2 = 66.2 \text{ kN/m}$							
Shear from weight of base		$V_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times I_{toe} \times t_{base} =$ <b>13.2</b> kN/m							
Total shear for toe design		$V_{toe} = V_{toe\_bear}$	- V <sub>toe_wt_base</sub> =	<b>53</b> kN/m					
Calculate moment for toe dea	sign								
Moment from bearing pressure	•	M <sub>toe_bear</sub> = (2 >	<pre>toe_f + pstem_i</pre>	$_{\rm mid_f})  imes (I_{ m toe} + t_{ m wa})$	∥ / 2)² / 6 <b>= 45.5</b>	«Nm/m			
Moment from weight of base		$M_{toe\_wt\_base} = (\gamma_{f\_d} \times \gamma_{base} \times t_{base} \times (I_{toe} + t_{wall} / 2)^2 / 2) = 9.1 \text{ kNm/m}$							
Total moment for toe design		M <sub>toe</sub> = M <sub>toe_bear</sub> - M <sub>toe_wt_base</sub> = <b>36.4</b> kNm/m							
364	•	•	•	•	•				
<u>+</u>									
<u> </u>	◀───200								
Check toe in bending	<b> ←</b> 200	I	m						
Width of toe	<b> ⊲</b> 200	b = <b>1000</b> mm/		364 0 mm					
Width of toe Depth of reinforcement	<b> ⊲</b> 200	b = <b>1000</b> mm/ d <sub>toe</sub> = t <sub>base</sub> – ci	<sub>oe</sub> – (φ <sub>toe</sub> / 2) =						
Width of toe	<b> 4</b> ——200	b = <b>1000</b> mm/	<sub>oe</sub> – (φ <sub>toe</sub> / 2) =	= 0.007	n reinforcemen	t is not reau			
Width of toe Depth of reinforcement	<b> ←</b> 200	b = <b>1000</b> mm/ d <sub>toe</sub> = t <sub>base</sub> – cr K <sub>toe</sub> = M <sub>toe</sub> / (b	$\phi_{oe} - (\phi_{toe} / 2) =$ $\phi \times d_{toe}^2 \times f_{cu} =$	= 0.007 Compressio	<i>n reinforcemen</i> 0.9)),0.95) × dt₀c	-			
Width of toe Depth of reinforcement Constant	<b> 4</b> ——200	b = <b>1000</b> mm/ d <sub>toe</sub> = t <sub>base</sub> – cr K <sub>toe</sub> = M <sub>toe</sub> / (b	$d_{\text{oe}} - (\phi_{\text{toe}} / 2) = 0$ $d_{\text{toe}} + \sqrt{(0.25 - (mi))}$	= 0.007 Compressio	<b>n reinforcemen</b> 0.9)),0.95) × d <sub>toe</sub>	-			
Width of toe Depth of reinforcement Constant	1	b = <b>1000</b> mm/ $d_{toe} = t_{base} - c_t$ $K_{toe} = M_{toe} / (b_t)$ $z_{toe} = min(0.5)$ $z_{toe} = 346 mm$	$d_{\text{oe}} - (\phi_{\text{toe}} / 2) = 0$ $d_{\text{toe}}^2 \times f_{\text{cu}} = 0$ $d_{\text{toe}}^2 \times f_{\text{cu}} = 0$ $d_{\text{toe}}^2 + \sqrt{(0.25 - (\text{min}))^2}$	= 0.007 Compressio	$0.9)), 0.95)  imes d_{tot}$	-			
Width of toe Depth of reinforcement Constant Lever arm	required	b = <b>1000</b> mm/ $d_{toe} = t_{base} - c_t$ $K_{toe} = M_{toe} / (b_t)$ $z_{toe} = min(0.5)$ $z_{toe} = 346 mm$	$b_{oe} - (\phi_{toe} / 2) =$ $b \times d_{toe}^2 \times f_{cu} =$ $+ \sqrt{(0.25 - (min))}$ $b_{oe} / (0.87 \times f_y \times f_y)$	= <b>0.007</b> <i>Compressio</i> in(K <sub>toe</sub> , 0.225) / z z <sub>toe</sub> ) = <b>242</b> mn	$0.9)), 0.95)  imes d_{tot}$	-			

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Reinforcement provided		12 mm dia.b	ars @ 200 mi	n centres					
Area of reinforcement provideo		A <sub>s_toe_prov</sub> = 56 PASS - Re		provided at th	e retaining wal	l toe is adequ			
Check shear resistance at to	e								
Design shear stress		$v_{toe} = V_{toe} / (b$	× d <sub>toe</sub> ) = <b>0.14</b>	6 N/mm²					
Allowable shear stress		v <sub>adm</sub> = min(0.8	8×√(f <sub>cu</sub> / 1 N/	mm²), 5) × 1 N/	mm² = <b>5.000</b> N/	mm²			
		PASS	- Design she	ear stress is le	ss than maxim	um shear str			
From BS8110:Part 1:1997 - T	able 3.8								
Design concrete shear stress		v <sub>c_toe</sub> = <b>0.407</b>	N/mm <sup>2</sup>						
				$v_{toe} < v_{c_{toe}} - N$	o shear reinfor	cement requi			
Design of reinforced concret	e retaining wal	l stem (BS 8002:1	994 <u>)</u>						
Material properties									
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mm	1 <sup>2</sup>						
Characteristic strength of reinforcement		f <sub>y</sub> = <b>500</b> N/mr	n²						
Wall details									
Minimum area of reinforcemen	t	k = <b>0.13</b> %							
Cover to reinforcement in stem		c <sub>stem</sub> = <b>40</b> mm							
Cover to reinforcement in wall		c <sub>wall</sub> = <b>30</b> mm							
Factored horizontal at-rest for	orces on stem								
Surcharge		$F_{s\_sur\_f} = \gamma_{f\_l} \times$	K <sub>0</sub> × Surcharg	${\sf ge}  imes ({\sf h}_{\sf eff}$ - ${\sf t}_{\sf base}$ -	- d <sub>ds</sub> ) = <b>14.2</b> kN/ı	m			
Moist backfill above water table	<b>;</b>	$F_{s_m_a_f} = 0.5$	$ imes \gamma_{f_e}  imes K_0  imes \gamma_r$	$_{ m n}  imes$ (h <sub>eff</sub> - t <sub>base</sub> - d	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>14.6</b>	kN/m			
Moist backfill below water table		$F_{s_m_b_f} = \gamma_{f_e}$	$\times$ K <sub>0</sub> $\times$ $\gamma_m$ $\times$ (he	eff - t <sub>base</sub> - d <sub>ds</sub> - h	<sub>sat</sub> ) × h <sub>sat</sub> = <b>2.1</b> k	N/m			
Saturated backfill		$F_{s s f} = 0.5 \times T$	$\gamma_{\rm fe} \times K_0 \times (\gamma_{\rm s} -$	$\gamma_{water}$ ) × $h_{sat}^2$ = (	<b>)</b> kN/m				
Water				< h <sub>sat</sub> <sup>2</sup> <b>= 0.1</b> kN/					
Calculate shear for stem des	ign								
Shear at base of stem	•	V <sub>stem</sub> = F <sub>s_sur_f</sub>	f + Fs_m_a_f + F	s_m_b_f + Fs_s_f +	Fs_water_f - Fprop_f	= <b>20.6</b> kN/m			
Calculate moment for stem d	esign								
Surcharge		$M_{s\_sur} = F_{s\_sur}$	$_{f} \times (h_{stem} + t_{bas})$	<sub>se</sub> ) / 2 = <b>13.5</b> kN	lm/m				
Moist backfill above water table	)	$M_{s_m_a} = F_{s_m_a}$	$_{a_f} \times (2 \times h_{sat} \cdot$	+ h <sub>eff</sub> - d <sub>ds</sub> + t <sub>base</sub>	₀ / 2) / 3 = <b>11.2</b> k	kNm/m			
Moist backfill below water table		$M_{s_m_b} = F_{s_m}$	$_{b_f} \times h_{sat} / 2 =$	<b>0.1</b> kNm/m					
Saturated backfill		$M_{s_s} = F_{s_s_f} \times$	: h <sub>sat</sub> / 3 <b>= 0</b> kN	lm/m					
Water		$M_{s_water} = F_{s_w}$	<sub>rater_f</sub> × h <sub>sat</sub> / 3 :	= <b>0</b> kNm/m					
Total moment for stem design		M <sub>stem</sub> = M <sub>s_sur</sub>							





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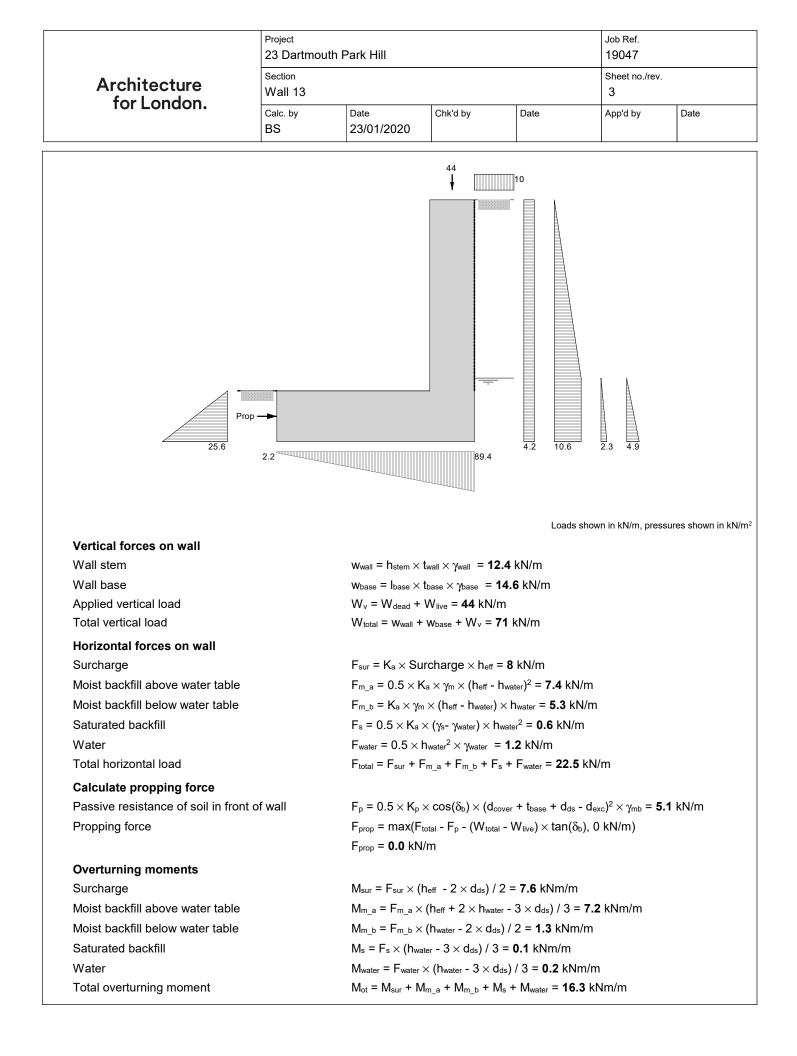


 $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 1900 \text{ mm}$ 

Angle of soil surface behind wall $\beta = 0.0 \text{ deg}$ 

Effective height at virtual back of wall

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for London.	Wall 13		- 1		2			
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Retained material details								
Mobilisation factor		M = 1.5						
Moist density of retained materia	al	γ <sub>m</sub> = <b>18.0</b> kN/r	m <sup>3</sup>					
Saturated density of retained ma		γ <sub>s</sub> = <b>21.0</b> kN/n						
Design shear strength		φ' = <b>24.2</b> deg						
Angle of wall friction		δ = <b>0.0</b> deg						
Base material details								
Moist density		γ <sub>mb</sub> = <b>18.0</b> kN/	/m³					
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>110</b> kN/m <sup>2</sup>						
Based on Kerisel & Absi - 'Ac	tive and passiv	e earth pressure	tables'					
Active pressure coefficient fo	r retained mate	rial						
Slope angle ratio		$r_a = \beta / \phi' = 0.$	00					
Wall friction ratio		$r_b = \delta / \phi' = 0.0$	00					
Active pressure coefficient for re	etained material	K <sub>a</sub> = <b>0.419</b>						
Passive pressure coefficient f	or base materia	al						
Slope angle ratio		r <sub>a</sub> = 0 deg / φ'ι	o = 0.00					
Wall friction ratio		$r_{\rm b} = \delta_{\rm b} / \phi'_{\rm b} = 0.77$						
Passive pressure coefficient for	base material	K <sub>p</sub> = <b>3.754</b>						
At-rest pressure								
At-rest pressure for retained ma	terial	K₀ = 1 – sin(φ	') = <b>0.590</b>					
Loading details								
Surcharge load on plan		Surcharge = '						
Applied vertical dead load on wa		W <sub>dead</sub> = <b>25.9</b> kN/m						
Applied vertical live load on wall		W <sub>live</sub> = <b>18.0</b> kl						
Position of applied vertical load		l <sub>load</sub> = 1375 m						
Applied horizontal dead load on		F <sub>dead</sub> = <b>0.0</b> kN						
Applied horizontal live load on w Height of applied horizontal load		F <sub>live</sub> = <b>0.0</b> kN/i h <sub>load</sub> = <b>0</b> mm	11					



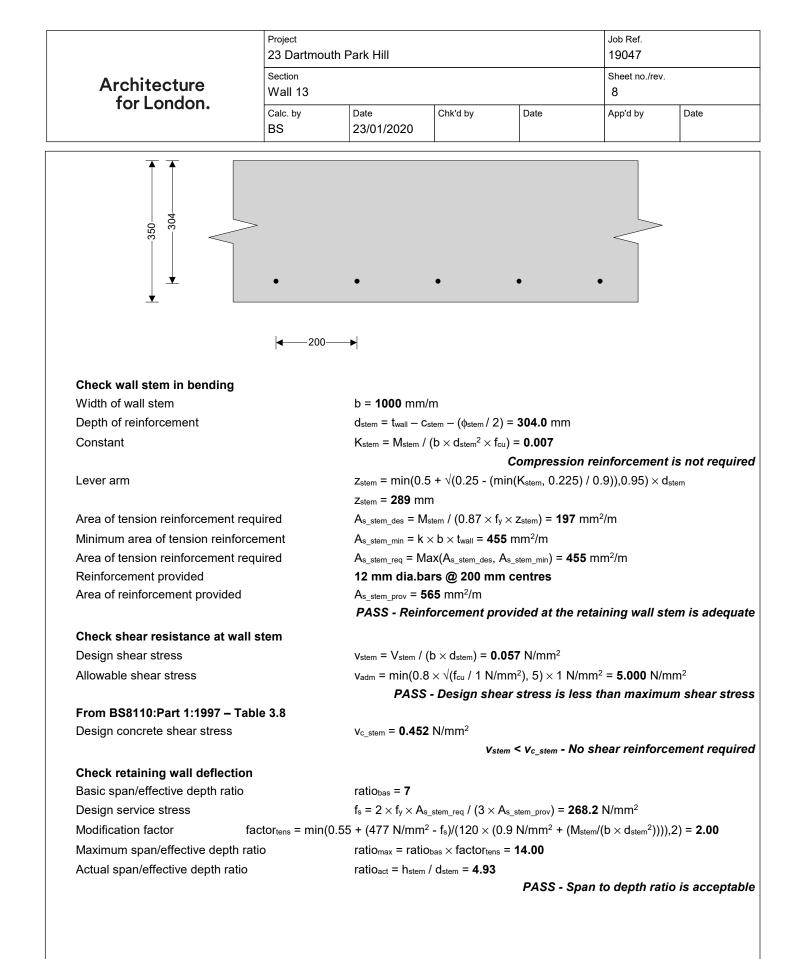
	Project 23 Dartmouth Park Hill					
Architecture for London.	Section Wall 13					
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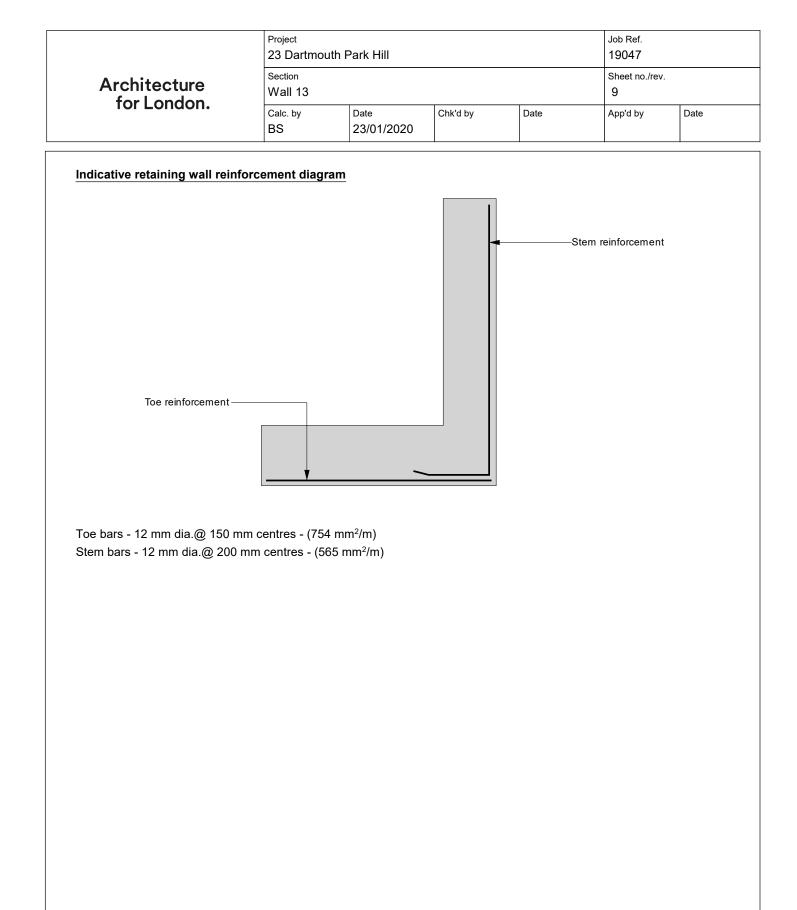
Restoring moments	
Wall stem	$M_{wall} = w_{wall} \times (I_{toe} + t_{wall} / 2) = 17 \text{ kNm/m}$
Wall base	$M_{base}$ = $w_{base} \times I_{base}$ / 2 = <b>11.3</b> kNm/m
Design vertical load	$M_v = W_v \times I_{load} = 60.5 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_v = 88.8 \text{ kNm/m}$
Check bearing pressure	
Total moment for bearing	M <sub>total</sub> = M <sub>rest</sub> - M <sub>ot</sub> = <b>72.5</b> kNm/m
Total vertical reaction	R = W <sub>total</sub> = <b>71.0</b> kN/m
Distance to reaction	x <sub>bar</sub> = M <sub>total</sub> / R = <b>1021</b> mm
Eccentricity of reaction	e = abs((I <sub>base</sub> / 2) - x <sub>bar</sub> ) = <b>246</b> mm
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 2.2 \text{ kN/m}^2$
Bearing pressure at heel	$p_{heel} = (R / I_{base}) + (6 \times R \times e / I_{base}^2) = 89.4 \text{ kN/m}^2$
	PASS - Maximum bearing pressure is less than allowable bearing pressure

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RETAINING WALL DESIGN (I	BS 8002:1994 <u>)</u>					ation version 1.2			
Ultimate limit state load facto	ors								
Dead load factor		$\gamma_{f_d} = 1.4$							
Live load factor		γ <sub>f_l</sub> = <b>1.6</b>							
Earth and water pressure facto	or	γ <sub>f_e</sub> = <b>1.4</b>							
Factored vertical forces on w	vall								
Wall stem		W <sub>wall</sub> f=γfd×	$h_{stem}  imes t_{wall}  imes \gamma_{v}$	wall = <b>17.3</b> kN/n	n				
Wall base		_ · · -		/base = <b>20.5</b> kN/					
Applied vertical load		_ · · -		/ <sub>live</sub> = <b>65.2</b> kN/n					
Total vertical load		- •-	• –	/ <sub>v_f</sub> = <b>103</b> kN/m					
Factored horizontal at-rest for	orces on wall								
Surcharge		Fsur f = ∿f L × K	o × Surcharge	e × h <sub>eff</sub> = <b>17₋9</b> k	N/m				
Moist backfill above water table	<u>م</u>	$F_{sur_f} = \gamma_{f_l} \times K_0 \times Surcharge \times h_{eff} = 17.9 \text{ kN/m}$ $F_m = f = \gamma_{f e} \times 0.5 \times K_0 \times \gamma_m \times (h_{eff} - h_{water})^2 = 14.6 \text{ kN/m}$							
Moist backfill below water table		$F_{m b f} = \gamma_{f e} \times K_0 \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 10.4 \text{ kN/m}$							
Saturated backfill		$F_{s_{1}f} = \gamma_{t_{e}} \times 0.5 \times K_{0} \times (\gamma_{s} - \gamma_{water}) \times h_{water}^{2} = 1.2 \text{ kN/m}$							
Water		Fwater f = $\gamma_f e \times 0.5 \times hwater^2 \times \gamma_water = 1.7 \text{ kN/m}$							
Total horizontal load				$b_{f} + F_{s_{f}} + F_{water}$					
			· · · · · · · · · · · · · · · · · · ·						
Calculate propping force Passive resistance of soil in fro	opt of wall	$F_{\rm ext} = \gamma_{\rm ext} \times 0$	$5 \times \mathbf{k} \times \cos(\delta)$	$(d_{1}) \times (d_{2}) + t_{1}$	$_{ m se}$ + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup> ×				
Propping force			F <sub>total_f</sub> - F <sub>p_f</sub> - (\	, ,	$_{\text{live}}$ × tan( $\delta_{\text{b}}$ ), 0 k	•			
Factored overturning momen	nts	1 K_2 2 2 2							
Surcharge		M <sub>sur f</sub> = F <sub>sur f</sub> ;	× (h <sub>eff</sub> - 2 × d <sub>d</sub>	<sub>s</sub> ) / 2 = <b>17</b> kNm	/m				
Moist backfill above water table	e	$M_{m,a_f} = F_{m,a_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 14.1 \text{ kNm/m}$							
Moist backfill below water table		$M_{m_b_f} = F_{m_b_f} \times (h_{water} - 2 \times d_{ds}) / 2 = 2.6 \text{ kNm/m}$							
Saturated backfill			•	/ 3 = <b>0.2</b> kNm/					
Water		$M_{water_f} = F_{water_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 0.3 \text{ kNm/m}$							
Total overturning moment		$M_{ot_{f}} = M_{sur_{f}} + M_{m_{a_{f}}} + M_{m_{b_{f}}} + M_{s_{f}} + M_{water_{f}} = 34.2 \text{ kNm/m}$							
Restoring moments									
Wall stem		$M_{wall f} = W_{wall f}$	$\times$ (I <sub>toe</sub> + t <sub>wall</sub> / 2	2) = <b>23.9</b> kNm/i	m				
Wall base		$M_{\text{base f}} = w_{\text{base f}} \times I_{\text{base}} / 2 = 15.9 \text{ kNm/m}$							
Design vertical load		-	l <sub>load</sub> = <b>89.6</b> kNi						
Total restoring moment				<sub>f</sub> = <b>129.3</b> kNm	ı/m				
Factored bearing pressure									
Total moment for bearing		M <sub>total_f</sub> = M <sub>rest</sub>	_f - Mot_f = 95.1	kNm/m					
Total vertical reaction		R <sub>f</sub> = W <sub>total_f</sub> =							
Distance to reaction	$x_{bar_f} = M_{total_f} / R_f = 924 \text{ mm}$								
Distance to reaction									
Eccentricity of reaction		e <sub>f</sub> = abs((I <sub>base</sub>	/ 2) - x <sub>bar_f</sub> ) =		acts within mid				

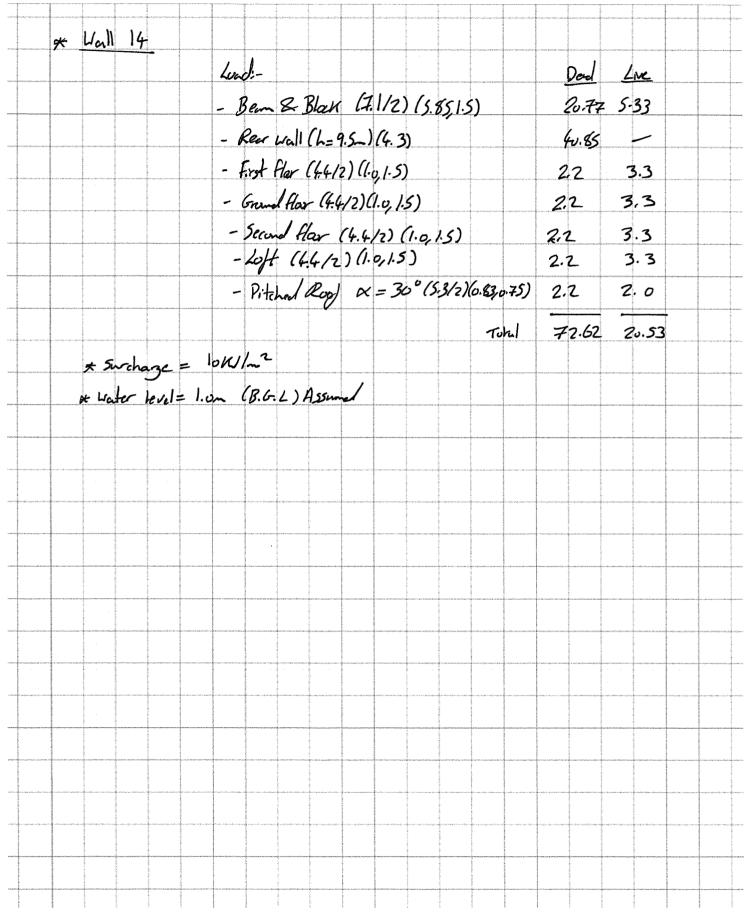
	Project 23 Dartmou	uth Park Hill	Job Ref. 19047						
Architecture	Section								
for London.	Wall 13				6				
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Bearing pressure at heel		·	, ,	< e <sub>f</sub> / I <sub>base</sub> <sup>2</sup> ) = <b>10</b>					
Rate of change of base reaction	ı			-49.30 kN/m²/i		_			
Bearing pressure at stem / toe					), 0 kN/m²) = <b>87.4</b>				
Bearing pressure at mid stem					(2)), 0 kN/m <sup>2</sup> ) = 9				
Bearing pressure at stem / heel		$p_{stem\_heel\_f} = m$	ax(p <sub>heel_f</sub> + (ra	$te \times I_{heel}$ ), 0 kN/	/m²) = <b>104.7</b> kN/r	m²			
Design of reinforced concrete	e retaining wall	toe (BS 8002:199	<u>4)</u>						
Material properties									
Characteristic strength of concr	ete	f <sub>cu</sub> = <b>40</b> N/mm	1 <sup>2</sup>						
Characteristic strength of reinfo	rcement	f <sub>y</sub> = <b>500</b> N/mn	1 <sup>2</sup>						
Base details									
Minimum area of reinforcement		k = <b>0.13</b> %							
Cover to reinforcement in toe		c <sub>toe</sub> = <b>30</b> mm							
Calculate shear for toe design	ı								
Shear from bearing pressure		V <sub>toe_bear</sub> = (p <sub>toe</sub>	e_f + p <sub>stem_toe_f</sub> )	× I <sub>toe</sub> / 2 = <b>69.4</b>	kN/m				
Shear from weight of base		$V_{toe\_wt\_base} = \gamma_{f}$	$V_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times I_{toe} \times t_{base} = 15.9 \text{ kN/m}$						
Total shear for toe design		V <sub>toe</sub> = V <sub>toe_bear</sub>	- V <sub>toe_wt_base</sub> =	<b>53.5</b> kN/m					
Calculate moment for toe des	ign								
Moment from bearing pressure	-	M <sub>toe_bear</sub> = (2 >	<pre>toe_f + pstem_i</pre>	$_{\rm mid_f})  imes (I_{ m toe} + t_{ m wa})$	ul / 2) <sup>2</sup> / 6 = <b>48.1</b>	kNm/m			
Moment from weight of base		M <sub>toe_wt_base</sub> = (*	$\gamma_{f_d}  imes \gamma_{ ext{base}}  imes \mathbf{t}_{ ext{base}}$	$_{ m ase}  imes ({ m I}_{ m toe}$ + ${ m t}_{ m wall}$ /	2) <sup>2</sup> / 2) = <b>12.5</b> ki	Nm/m			
Total moment for toe design		M <sub>toe</sub> = M <sub>toe_bea</sub>							
400	•	• •	·		•				
Check toe in bending	<b> </b> 150►	1							
Width of toe		b = <b>1000</b> mm	/m						
			$d_{\text{toe}} = t_{\text{base}} - c_{\text{toe}} - (\phi_{\text{toe}} / 2) = 364.0 \text{ mm}$						
Depth of reinforcement	•		$K_{\text{toe}} = M_{\text{toe}} / (b \times d_{\text{toe}}^2 \times f_{\text{cu}}) = 0.007$						
			/						
Depth of reinforcement				Compressio	n reinforcemen	t is not requ			
Depth of reinforcement		z <sub>toe</sub> = min(0.5 z <sub>toe</sub> = <b>346</b> mm		-	n reinforcemen ( 0.9)),0.95) × d <sub>toe</sub>	-			
Depth of reinforcement Constant	equired	z <sub>toe</sub> = <b>346</b> mm	1	-	( 0.9)),0.95) × d <sub>toe</sub>	-			
Depth of reinforcement Constant Lever arm	-	z <sub>toe</sub> = <b>346</b> mm	1 <sub>be</sub> / (0.87 × f <sub>y</sub> ×	in(K <sub>toe</sub> , 0.225) / z z <sub>toe</sub> ) = <b>236</b> mn	( 0.9)),0.95) × d <sub>toe</sub>	-			

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Reinforcement provided		12 mm dia.b	ars @ 150 mr	n centres					
Area of reinforcement provideo	I	A <sub>s_toe_prov</sub> = ۲۶ PASS - Re		provided at th	e retaining wal	l toe is adequ			
Check shear resistance at to	e								
Design shear stress		$v_{toe} = V_{toe} / (b$	× d <sub>toe</sub> ) = <b>0.14</b>	<b>7</b> N/mm²					
Allowable shear stress		v <sub>adm</sub> = min(0.8	B×√(f <sub>cu</sub> / 1 N/	mm²), 5) × 1 N/	/mm² = <b>5.000</b> N/	mm <sup>2</sup>			
		PASS	- Design she	ear stress is le	ess than maxim	um shear str			
From BS8110:Part 1:1997 – 1	able 3.8								
Design concrete shear stress		v <sub>c_toe</sub> = <b>0.448</b>	N/mm <sup>2</sup>						
				$v_{toe} < v_{c_{toe}} - N$	o shear reinfor	cement requi			
Design of reinforced concret	e retaining wal	l stem (BS 8002:1	994 <u>)</u>						
Material properties									
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mm	1 <sup>2</sup>						
Characteristic strength of reinforcement		f <sub>y</sub> = <b>500</b> N/mr	n²						
Wall details									
Minimum area of reinforcemen	t	k = <b>0.13</b> %							
Cover to reinforcement in stem		c <sub>stem</sub> = <b>40</b> mm							
Cover to reinforcement in wall		c <sub>wall</sub> = <b>30</b> mm							
Factored horizontal at-rest for	orces on stem								
Surcharge		$F_{s\_sur\_f} = \gamma_{f\_l} \times$	K <sub>0</sub> × Surcharg	${\sf ge}  imes ({\sf h}_{\sf eff}$ - ${\sf t}_{\sf base}$ -	- d <sub>ds</sub> ) = <b>14.2</b> kN/ı	n			
Moist backfill above water table	e	F <sub>s_m_a_f</sub> = 0.5	$ imes \gamma_{f_e}  imes K_0  imes \gamma_{n}$	$_{ m n}  imes$ (h <sub>eff</sub> - t <sub>base</sub> - o	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>14.6</b>	kN/m			
Moist backfill below water table	;	$F_{s_m_b_f} = \gamma_{f_e}$	$ imes K_0  imes \gamma_{m}  imes (h_{e})$	eff - t <sub>base</sub> - d <sub>ds</sub> - h	<sub>sat</sub> ) × h <sub>sat</sub> = <b>2.1</b> k	N/m			
Saturated backfill		$F_{s_s_f} = 0.5 \times 7$	$\gamma_{f_e} \times K_0 \times (\gamma_{s})$	$\gamma_{water}$ ) × $h_{sat}^2$ = (	<b>)</b> kN/m				
Water				< h <sub>sat</sub> <sup>2</sup> = <b>0.1</b> kN/					
Calculate shear for stem des	ign								
Shear at base of stem	.3	V <sub>stem</sub> = F <sub>s_sur_f</sub>	+ Fs_m_a_f + F	s_m_b_f + Fs_s_f +	Fs_water_f - Fprop_f	= <b>17.3</b> kN/m			
Calculate moment for stem d	lesign								
Surcharge		$M_{s_{sur}} = F_{s_{sur}}$	$_{f} \times (h_{stem} + t_{bas})$	<sub>se</sub> ) / 2 = <b>13.5</b> kN	lm/m				
Moist backfill above water table	e	M <sub>s_m_a</sub> = F <sub>s_m_</sub>	$_{a_f} \times (2 \times h_{sat} \cdot$	+ h <sub>eff</sub> - d <sub>ds</sub> + t <sub>bas</sub>	e / 2) / 3 = <b>11.2</b> k	«Nm/m			
Moist backfill below water table	)		_b_f × h <sub>sat</sub> / 2 =						
Saturated backfill			: h <sub>sat</sub> / 3 <b>= 0</b> kN						
Water			<sub>ater_f</sub> × h <sub>sat</sub> / 3 =						

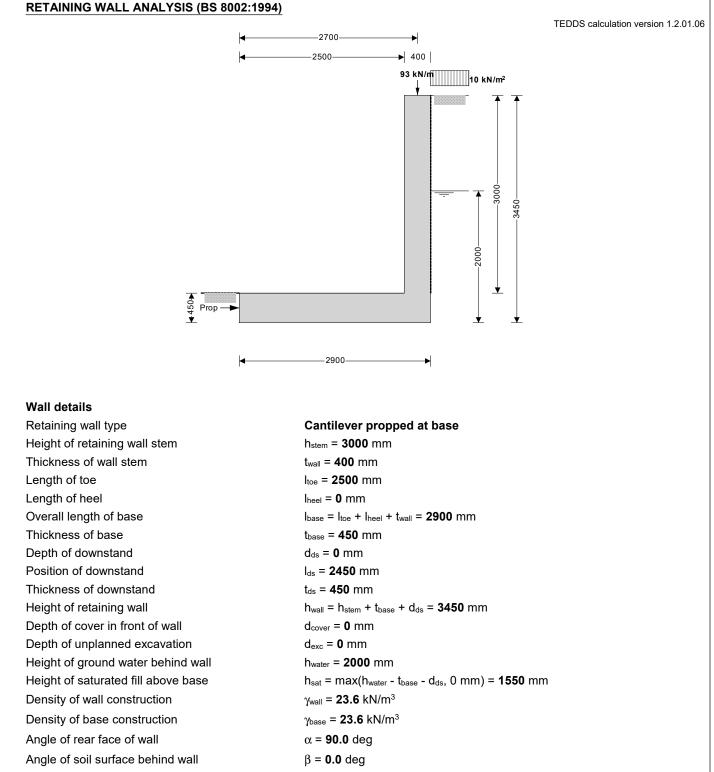




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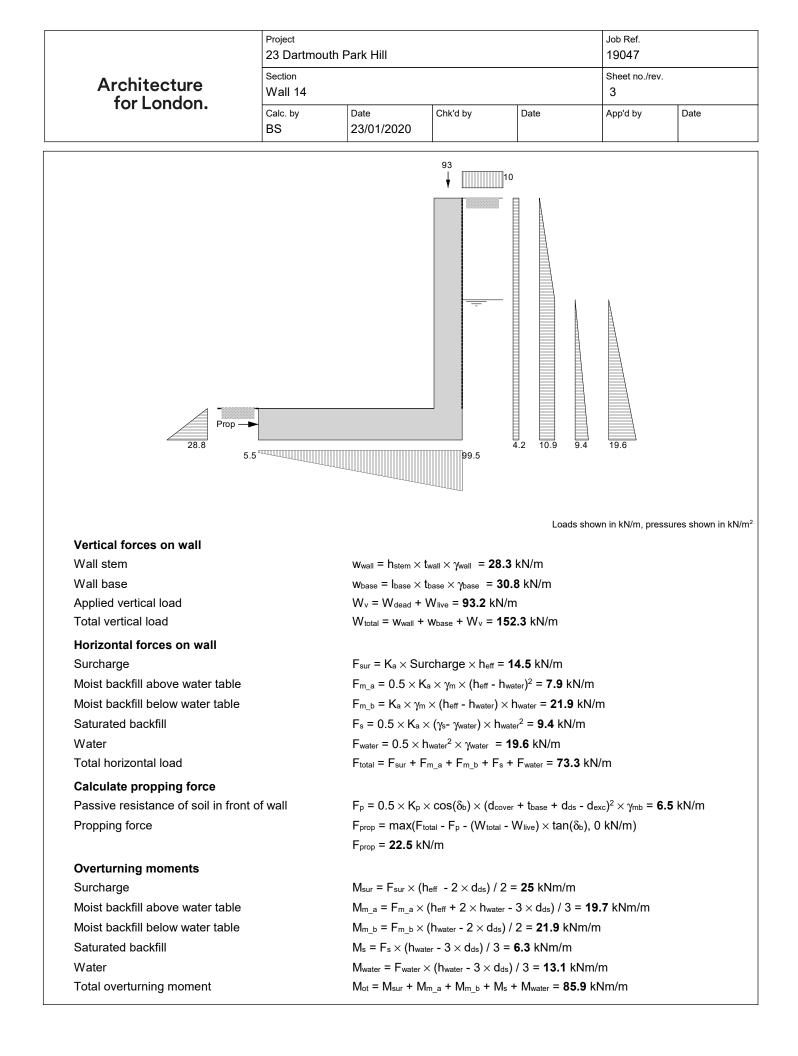




 $h_{eff} = h_{wall} + I_{heel} \times tan(\beta) = 3450 \text{ mm}$ 

Effective height at virtual back of wall

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for London.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date	
Retained material details							
Mobilisation factor		M = 1.5					
Moist density of retained mater	ial	γ <sub>m</sub> = <b>18.0</b> kN/r	m <sup>3</sup>				
Saturated density of retained m	aterial	γ <sub>s</sub> = <b>21.0</b> kN/n	n <sup>3</sup>				
Design shear strength		φ' = <b>24.2</b> deg					
Angle of wall friction		δ <b>= 0.0</b> deg					
Base material details							
Moist density		γ <sub>mb</sub> = <b>18.0</b> kN/	′m³				
Design shear strength		φ' <sub>b</sub> = <b>24.2</b> deg					
Design base friction		$\delta_{\rm b}$ = <b>18.6</b> deg					
Allowable bearing pressure		P <sub>bearing</sub> = <b>110</b> kN/m <sup>2</sup>					
Based on Kerisel & Absi - 'Ad	tive and passiv	e earth pressure	tables'				
Active pressure coefficient for	or retained mate	rial					
Slope angle ratio		$r_a = \beta / \phi' = 0.0$	00				
Wall friction ratio		$r_{\rm b} = \delta / \phi' = 0.0$					
Active pressure coefficient for r	etained material	K <sub>a</sub> = <b>0.419</b>					
Passive pressure coefficient	for base materia	al					
Slope angle ratio		r <sub>a</sub> = 0 deg / φ'ι	o = 0.00				
Wall friction ratio		$r_{\rm b} = \delta_{\rm b} / \phi'_{\rm b} = 0.77$					
Passive pressure coefficient fo	r base material	K <sub>p</sub> = <b>3.754</b>					
At-rest pressure							
At-rest pressure for retained ma	aterial	K₀ = 1 – sin(φ	') = <b>0.590</b>				
Loading details							
Surcharge load on plan		Surcharge = '	10.0 kN/m <sup>2</sup>				
Applied vertical dead load on w	all	W <sub>dead</sub> = <b>72.6</b> kN/m					
Applied vertical live load on wa	II	W <sub>live</sub> = <b>20.5</b> kN/m					
Position of applied vertical load	on wall	l <sub>load</sub> = <b>2700</b> m	m				
Applied horizontal dead load or	n wall	F <sub>dead</sub> = <b>0.0</b> kN	/m				
Applied horizontal live load on		F <sub>live</sub> = <b>0.0</b> kN/	m				
Height of applied horizontal loa	d on wall	h <sub>load</sub> <b>= 0</b> mm					



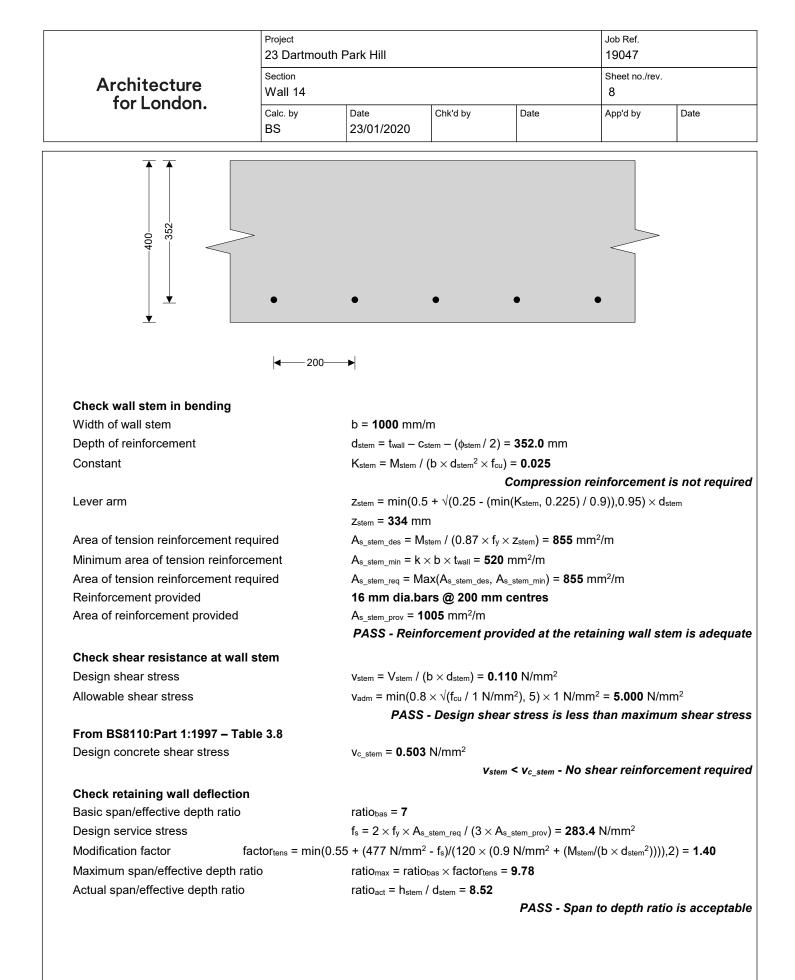
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				•		•	

Restoring moments	
Wall stem	$M_{wall}$ = $w_{wall} \times (I_{toe} + t_{wall} / 2)$ = <b>76.5</b> kNm/m
Wall base	M <sub>base</sub> = w <sub>base</sub> × I <sub>base</sub> / 2 = <b>44.7</b> kNm/m
Design vertical load	$M_v = W_v \times I_{load} = 251.5 \text{ kNm/m}$
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_v = 372.6 \text{ kNm/m}$
Check bearing pressure	
Total moment for bearing	M <sub>total</sub> = M <sub>rest</sub> - M <sub>ot</sub> = <b>286.7</b> kNm/m
Total vertical reaction	R = W <sub>total</sub> = <b>152.3</b> kN/m
Distance to reaction	x <sub>bar</sub> = M <sub>total</sub> / R = <b>1883</b> mm
Eccentricity of reaction	e = abs((I <sub>base</sub> / 2) - x <sub>bar</sub> ) = <b>433</b> mm
	Reaction acts within middle third of base
Bearing pressure at toe	$p_{toe} = (R / I_{base}) - (6 \times R \times e / I_{base}^2) = 5.5 \text{ kN/m}^2$
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

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RETAINING WALL DESIGN (I	BS 8002:1994 <u>)</u>						
Ultimate limit state load facto	ors				TEDDS calcula	ation version 1.2	
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 facto	or	γ <sub>=</sub> = <b>1.4</b>					
Factored vertical forces on w							
Wall stem		Wwall f = ∿f d ×	$h_{stem}  imes t_{wall}  imes v_{v}$	wall = <b>39.6</b> kN/n	n		
Wall base		_ · -	-	/base = <b>43.1</b> kN			
Applied vertical load			•	/ <sub>live</sub> = <b>134.5</b> kN/			
Total vertical load			• -	/ <sub>v_f</sub> = <b>217.3</b> kN/			
Factored horizontal at-rest for	orces on wall			_			
Surcharge		$F_{sur f} = \gamma_{f} \times K$	$x_0  imes$ Surcharge	e × h <sub>eff</sub> = <b>32.6</b> k	N/m		
Moist backfill above water table	e	_ · -	-	× (h <sub>eff</sub> - h <sub>water</sub> ) <sup>2</sup> =			
Moist backfill below water table	9	$F_{m b f} = \gamma_{f e} \times K_0 \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water} = 43.1 \text{ kN/m}$					
Saturated backfill		$F_{s f} = \gamma_{f e} \times 0.5 \times K_0 \times (\gamma_{s} - \gamma_{water}) \times h_{water}^2 = 18.5 \text{ kN/m}$					
Water		Fwater f = $\gamma_{f} e \times 0.5 \times hwater^2 \times \gamma_{Water}$ = <b>27.5</b> kN/m					
Total horizontal load		$F_{\text{total}_{f}} = F_{\text{sur}_{f}} + F_{\text{m}_{a}_{f}} + F_{\text{m}_{b}_{f}} + F_{\text{s}_{f}} + F_{\text{water}_{f}} = 137.3 \text{ kN/m}$					
Calculate propping force					_		
Passive resistance of soil in fro	ont of wall	$F_{p f} = \gamma_{f e} \times 0.$	$5 \times K_{D} \times \cos(\delta)$	$(d_{cover} + t_{ba})$	$_{\rm use}$ + d <sub>ds</sub> - d <sub>exc</sub> ) <sup>2</sup> ×	γ <sub>mb</sub> = <b>9.1</b> kN	
Propping force		· = • =	F <sub>total_f</sub> - F <sub>p_f</sub> - (\	, ,	$T_{live}) \times tan(\delta_b), 0 k$	•	
Factored overturning momen	nts						
Surcharge		M <sub>sur_f</sub> = F <sub>sur_f</sub> :	$\times$ (h <sub>eff</sub> - 2 $\times$ d <sub>ds</sub>	s) / 2 = <b>56.2</b> kN	m/m		
Moist backfill above water table	е	$M_{m\_a\_f}=F_{m\_a\_f}$	$_{\rm f} \times ({\rm h}_{\rm eff} + 2 \times {\rm h})$	Nwater - 3 × d <sub>ds</sub> ) /	3 = <b>38.8</b> kNm/m		
Moist backfill below water table	e	$M_{m_b_f} = F_{m_b_f} \times (h_{water} - 2 \times d_{ds}) / 2 = 43.1 \text{ kNm/m}$					
Saturated backfill		$M_{s_f} = F_{s_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 12.3 \text{ kNm/m}$					
Water		$M_{water_f} = F_{water_f} \times (h_{water} - 3 \times d_{ds}) / 3 = 18.3 \text{ kNm/m}$					
Total overturning moment		$M_{ot_{f}} = M_{sur_{f}} + M_{m_{a_{f}}} + M_{m_{b_{f}}} + M_{s_{f}} + M_{water_{f}} = 168.8 \text{ kNm/m}$					
Restoring moments							
Wall stem		$M_{wall_f} = w_{wall_f}$	imes (I <sub>toe</sub> + t <sub>wall</sub> / 2	2) = <b>107</b> kNm/r	n		
Wall base	$M_{base_f} = w_{base_f} \times I_{base} / 2 = 62.5 \text{ kNm/m}$						
Design vertical load	$M_{v_{-}f} = W_{v_{-}f} \times I_{load} = 363.2 \text{ kNm/m}$						
Total restoring moment		M <sub>rest_f</sub> = M <sub>wall_f</sub>	f + M <sub>base_f</sub> + M <sub>v</sub>	<sub>∕_f</sub> = <b>532.8</b> kNm	n/m		
Factored bearing pressure							
Total moment for bearing		M <sub>total_f</sub> = M <sub>rest_</sub>	_f - M <sub>ot_f</sub> = 364	kNm/m			
Total vertical reaction		$R_f = W_{total_f} =$	<b>217.3</b> kN/m				
Distance to reaction			/ R <sub>f</sub> = <b>1675</b> mi				
		$\alpha = \alpha h \alpha / l_{\rm b}$	$(2) \times (1-1)$	225 mm			
Eccentricity of reaction		e <sub>f</sub> = abs((I <sub>base</sub>	/ 2) - Xbar_t) - 4		acts within mid		

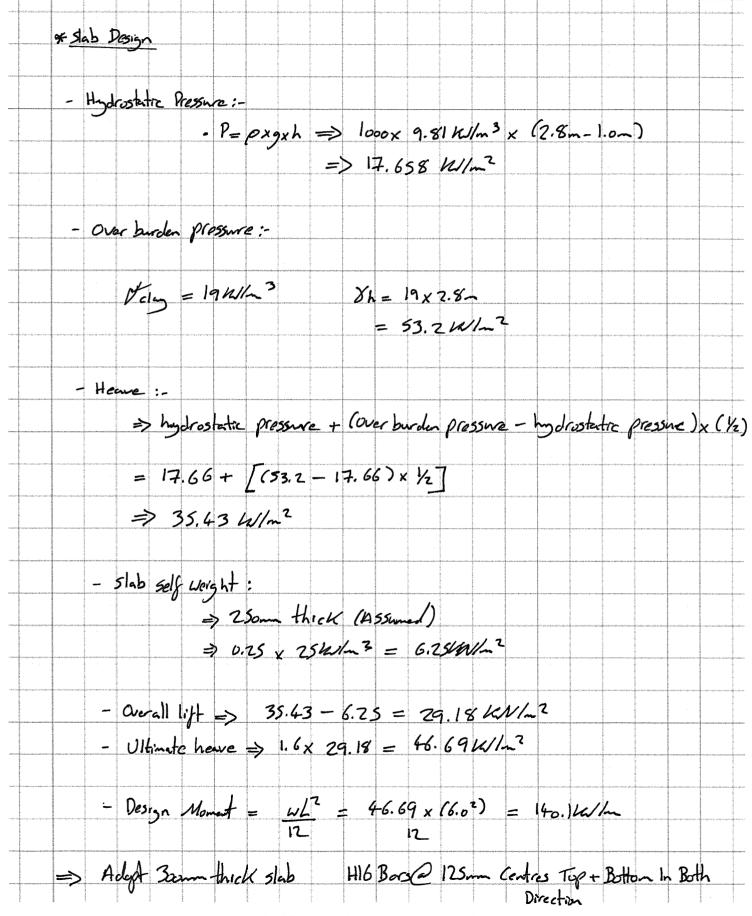
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Bearing pressure at heel		p <sub>heel_f</sub> = (R <sub>f</sub> / I <sub>b</sub>	$_{\text{base}}$ ) + (6 × R <sub>f</sub> >	< e <sub>f</sub> / I <sub>base</sub> <sup>2</sup> ) = <b>10</b>	<b>)9.8</b> kN/m <sup>2</sup>		
Rate of change of base reaction		rate = $(p_{toe_f} -$	p <sub>heel_f</sub> ) / I <sub>base</sub> =	-24.08 kN/m <sup>2</sup> /	m		
Bearing pressure at stem / toe					), 0 kN/m²) = <b>100</b> .		
Bearing pressure at mid stem		$p_{stem_mid_f} = ma$	ax(p <sub>heel_f</sub> + (rat	$te  imes (I_{heel} + t_{wall})$	/ 2)), 0 kN/m²) = 1	1 <b>05</b> kN/m²	
Bearing pressure at stem / heel		p <sub>stem_heel_f</sub> = m	ax(p <sub>heel_f</sub> + (ra	$te \times I_{heel}$ ), 0 kN/	/m²) = <b>109.8</b> kN/r	n <sup>2</sup>	
Design of reinforced concrete	retaining wall	toe (BS 8002:199	<u>4)</u>				
Material properties							
Characteristic strength of concre	ete	f <sub>cu</sub> = <b>40</b> N/mm	2				
Characteristic strength of reinfor	cement	f <sub>y</sub> = <b>500</b> N/mn	1 <sup>2</sup>				
Base details							
Minimum area of reinforcement		k = <b>0.13</b> %					
Cover to reinforcement in toe		c <sub>toe</sub> = <b>30</b> mm					
Calculate shear for toe design							
Shear from bearing pressure			,	× I <sub>toe</sub> / 2 = <b>175</b> .			
Shear from weight of base		$V_{toe\_wt\_base} = \gamma_{f\_d} \times \gamma_{base} \times I_{toe} \times t_{base} = 37.2 \text{ kN/m}$					
Total shear for toe design		$V_{toe} = V_{toe\_bear}$	- V <sub>toe_wt_base</sub> =	<b>138.1</b> kN/m			
Calculate moment for toe desi	gn						
Moment from bearing pressure					$(12)^2 / 6 = 224.8$		
Moment from weight of base Total moment for toe design				<sub>ase</sub> × (I <sub>toe</sub> + t <sub>wall</sub> / = <b>170.6</b> kNm/m	(2) <sup>2</sup> / 2) = <b>54.2</b> kM	Nm/m	
450	•	• •	•	• •	•		
	<b>∢</b> — 150—►						
Check toe in bending							
Width of toe		b = <b>1000</b> mm/	/m				
Depth of reinforcement		$d_{toe} = t_{base} - c_{t}$					
Constant		$K_{toe} = M_{toe} / (b)$	$\times d_{toe}^2 \times f_{cu}$ =				
		$z_{\text{toe}} = \min(0.5)$	+ √(0.25 - (m	-	n reinforcement (0.9)),0.95) × d <sub>toe</sub>	-	
Lever arm		z <sub>toe</sub> = <b>391</b> mm			,,,, ,		
Lever arm Area of tension reinforcement re	quired	z <sub>toe</sub> = <b>391</b> mm	1	z <sub>toe</sub> ) = <b>1002</b> m			

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Architecture for London.	Wall 14	Wall 14				
TOF LONGON.	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Area of tension reinforcement	required	$A_{s\_toe\_req} = Ma$	ax(As_toe_des, As	_toe_min) = <b>1002</b>	mm²/m	
Reinforcement provided			ars @ 150 mn	n centres		
Area of reinforcement provided	I	As_toe_prov = 13				
		PASS - Re	inforcement p	provided at the	e retaining wall	toe is adequ
Check shear resistance at to	e					
Design shear stress		$v_{toe} = V_{toe} / (b$	× d <sub>toe</sub> ) = <b>0.335</b>	5 N/mm²		
Allowable shear stress		v <sub>adm</sub> = min(0.8	8 × √(f <sub>cu</sub> / 1 N/r	mm²), 5) × 1 N/	mm² = <b>5.000</b> N/ı	mm²
		PASS	S - Design she	ar stress is le	ss than maxim	um shear str
From BS8110:Part 1:1997 – T	able 3.8					
Design concrete shear stress		v <sub>c_toe</sub> = 0.508	N/mm <sup>2</sup>			
				v <sub>toe</sub> < v <sub>c_toe</sub> - No	o shear reinford	cement requi
Design of reinforced concret	e retaining wal	l stem (BS 8002:1	994)			
Material properties						
Characteristic strength of conc	rete	f <sub>cu</sub> = <b>40</b> N/mn	n <sup>2</sup>			
Characteristic strength of reinfo		f <sub>y</sub> = <b>500</b> N/mr	m²			
enalue energine ingai en reinit						
-						
Wall details		·				
Wall details Minimum area of reinforcemen	t	k = <b>0.13</b> %				
Wall details	t	·	ı			
Wall details Minimum area of reinforcemen Cover to reinforcement in stem	t	k = 0.13 % c <sub>stem</sub> = 40 mm	ı			
Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall	t	k = 0.13 % c <sub>stem</sub> = 40 mm c <sub>wall</sub> = 30 mm	ı	$je  imes (h_{eff} - t_{base} -$	d <sub>ds</sub> ) = <b>28.3</b> kN/r	n
Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for	t brces on stem	k = 0.13 % c <sub>stem</sub> = 40 mm c <sub>wall</sub> = 30 mm F <sub>s_sur_f</sub> = γ <sub>f_l</sub> ×	n K₀ × Surcharg		d <sub>ds</sub> ) = <b>28.3</b> kN/r I <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b>	
Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge	t p <b>rces on stem</b>	k = 0.13 % c <sub>stem</sub> = 40 mm c <sub>wall</sub> = 30 mm F <sub>s_sur_f</sub> = γ <sub>f_l</sub> × F <sub>s_m_a_f</sub> = 0.5	n Ko×Surcharg ×γr_e×Ko×γm	$h \times (h_{eff} - t_{base} - c)$		kN/m
Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table	t p <b>rces on stem</b>	k = 0.13 % $c_{stem}$ = 40 mm $c_{wall}$ = 30 mm $F_{s\_sur\_f}$ = $\gamma_{f\_l} \times$ $F_{s\_m\_a\_f}$ = 0.5 $F_{s\_m\_b\_f}$ = $\gamma_{f\_e}$	n Ko × Surcharg × γr_e × Ko × γm × Ko × γm × (het	$h \times (h_{eff} - t_{base} - c)$	lds - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> sat) × h <sub>sat</sub> = <b>33.4</b>	kN/m
Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table	t p <b>rces on stem</b>	k = 0.13 % $c_{stem}$ = 40 mm $c_{wall}$ = 30 mm $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$	h K <sub>0</sub> × Surcharg × γ <sub>f_e</sub> × K <sub>0</sub> × γ <sub>m</sub> × K <sub>0</sub> × γ <sub>m</sub> × (h <sub>ef</sub> γ <sub>f_e</sub> × K <sub>0</sub> × (γ <sub>s</sub> - $^{-1}$	$h  imes (h_{eff} - t_{base} - c_{ff})$	l <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>1.1</b> kN/m	kN/m
Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water	t prces on stem	k = 0.13 % $c_{stem}$ = 40 mm $c_{wall}$ = 30 mm $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$	h K <sub>0</sub> × Surcharg × γ <sub>f_e</sub> × K <sub>0</sub> × γ <sub>m</sub> × K <sub>0</sub> × γ <sub>m</sub> × (h <sub>ef</sub> γ <sub>f_e</sub> × K <sub>0</sub> × (γ <sub>s</sub> - $^{-1}$	$h \times (h_{eff} - t_{base} - C_{ff})$ $ff - t_{base} - d_{ds} - h_{s}$ $\gamma_{water}) \times h_{sat}^2 = 1$	l <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>1.1</b> kN/m	kN/m
Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill	t prces on stem	k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$	h K <sub>0</sub> × Surcharg × γ <sub>f_e</sub> × K <sub>0</sub> × γ <sub>m</sub> × K <sub>0</sub> × γ <sub>m</sub> × (h <sub>et</sub> γ <sub>f_e</sub> × K <sub>0</sub> × (γ <sub>s</sub> - $\gamma$ 5 × γ <sub>f_e</sub> × γ <sub>water</sub> ×	$h \times (h_{eff} - t_{base} - C_{ff} - t_{base} - d_{ds} - h_{s}$ $ff - t_{base} - d_{ds} - h_{s}$ $\gamma_{water}) \times h_{sat}^2 = 1$ $h_{sat}^2 = 16.5 \text{ kN}$	l <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> <b>1.1</b> kN/m	kN/m kN/m
Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des	t prces on stem	k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$	h K <sub>0</sub> × Surcharg × γ <sub>f_e</sub> × K <sub>0</sub> × γ <sub>m</sub> × K <sub>0</sub> × γ <sub>m</sub> × (h <sub>et</sub> γ <sub>f_e</sub> × K <sub>0</sub> × (γ <sub>s</sub> - $\gamma$ 5 × γ <sub>f_e</sub> × γ <sub>water</sub> ×	$h \times (h_{eff} - t_{base} - C_{ff} - t_{base} - d_{ds} - h_{s}$ $ff - t_{base} - d_{ds} - h_{s}$ $\gamma_{water}) \times h_{sat}^2 = 1$ $h_{sat}^2 = 16.5 \text{ kN}$	d <sub>ds</sub> - h <sub>sat</sub> )² = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b> ∣ 1 <b>.1</b> kN/m I/m	kN/m kN/m
Wall details Minimum area of reinforcement Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem	t prces on stem	k = 0.13 % $c_{stem}$ = 40 mm $c_{wall}$ = 30 mm $F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$	$K_0 \times Surcharg \\ \times \gamma_{f_e} \times K_0 \times \gamma_m \\ \times K_0 \times \gamma_m \times (h_{el} \\ \gamma_{f_e} \times K_0 \times (\gamma_{s^-} \gamma_{s^-} \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times f + F_{s_m_a_f} + F_s$	$h \times (h_{eff} - t_{base} - C_{ff} - t_{base} - d_{ds} - h_{s}$ $ff - t_{base} - d_{ds} - h_{s}$ $\gamma_{water}) \times h_{sat}^2 = 1$ $h_{sat}^2 = 16.5 \text{ kN}$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b>   <b>1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m
Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des	t prces on stem e ign lesign	k = 0.13 % $C_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5 \times$ $V_{stem} = F_{s\_sur\_l}$ $M_{s\_sur} = F_{s\_sur\_l}$	$K_0 \times Surcharg  \times \gamma_{f_e} \times K_0 \times \gamma_m  \times K_0 \times \gamma_m \times (her  \gamma_{f_e} \times K_0 \times (\gamma_{s^-} - \gamma_{s^-})  \times \gamma_{f_e} \times \gamma_{water} \times  f + F_{s_m_a_f} + F_{s_f}  _f \times (h_{stem} + t_{base})$	$h \times (h_{eff} - t_{base} - C_{ds} - h_{s})$ $ff - t_{base} - d_{ds} - h_{s}$ $\gamma_{water}) \times h_{sat}^2 = 1$ $h_{sat}^2 = 16.5 \text{ kN}$ $h_{sm_b_f} + F_{s_s_f} + h_{s}$ $h_{sm_b_f} + 2 = 48.9 \text{ kN}$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b>   <b>1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub>	kN/m kN/m = <b>38.8</b> kN/m
Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge	t prces on stem e ign lesign	k = 0.13 % $c_{stem} = 40 \text{ mm}$ $c_{wall} = 30 \text{ mm}$ $F_{s\_sur\_f} = \gamma_{f\_l} \times$ $F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times$ $F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_1}$ $M_{s\_sur} = F_{s\_sur\_1}$	$K_0 \times Surcharg  \times \gamma_{f_e} \times K_0 \times \gamma_m  \times K_0 \times \gamma_m \times (h_{el}  \gamma_{f_e} \times K_0 \times (\gamma_{s} - \gamma_{s}  \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times  f + F_{s_m_a_f} + F_{s}  f + F_{s_m_a_f} + F_{s_{a_f}} + F_{s_{$	$f \times (h_{eff} - t_{base} - C_{ds} - h_{s}$ $f - t_{base} - d_{ds} - h_{s}$ $\gamma_{water}) \times h_{sat}^{2} = 1$ $f + h_{sat}^{2} = 16.5 \text{ kN}$ $f + F_{s_s_f} + F_{s_s_f} + h_{s}$ $(h_{eff} - d_{ds} + t_{base})$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b>   <b>1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub> m/m	kN/m kN/m = <b>38.8</b> kN/m
Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge Moist backfill above water table	t prces on stem e ign lesign	k = 0.13 % C <sub>stem</sub> = 40 mm C <sub>wall</sub> = 30 mm $F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_f}$ $M_{s\_sur} = F_{s\_sur\_f}$ $M_{s\_m\_a} = F_{s\_m\_m}$ $M_{s\_m\_a} = F_{s\_m\_m}$	$K_0 \times Surcharg \times \gamma_{f_e} \times K_0 \times \gamma_m \times (h_{ef} \times K_0 \times \gamma_m \times (h_{ef} \times f_e \times K_0 \times (\gamma_{s^-} + f_s) \times \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times f_f + F_{s_m_a_f} + F_{s_a_f} \times (h_{stem} + t_{base}) \times (f_s \times f_s) \times (f_s \times f_s) \times (f_s) \times (f_$	$h \times (h_{eff} - t_{base} - C_{ds} - h_{s}$ $ff - t_{base} - d_{ds} - h_{s}$ $g_{water}) \times h_{sat}^{2} = 1$ $(h_{sat}^{2} = 16.5 \text{ kN})$ $h_{s} - h_{s} - f + F_{s} - f + F_{s} - f + h_{s}$ $h_{e}) / 2 = 48.9 \text{ kN}$ $h_{eff} - d_{ds} + t_{base}$ $25.9 \text{ kNm/m}$	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b>   <b>1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub> m/m	kN/m kN/m = <b>38.8</b> kN/m
Wall details Minimum area of reinforcemen Cover to reinforcement in stem Cover to reinforcement in wall Factored horizontal at-rest for Surcharge Moist backfill above water table Moist backfill below water table Saturated backfill Water Calculate shear for stem des Shear at base of stem Calculate moment for stem des Surcharge Moist backfill above water table Moist backfill above water table	t prces on stem e ign lesign	k = 0.13 % C <sub>stem</sub> = 40 mm C <sub>wall</sub> = 30 mm $F_{s\_sur\_f} = \gamma_{f\_l} \times F_{s\_m\_a\_f} = 0.5$ $F_{s\_m\_b\_f} = \gamma_{f\_e}$ $F_{s\_s\_f} = 0.5 \times F_{s\_water\_f} = 0.5$ $V_{stem} = F_{s\_sur\_i}$ $M_{s\_sur} = F_{s\_sur\_i}$ $M_{s\_m\_a} = F_{s\_sur\_i}$ $M_{s\_m\_b} = F_{s\_m\_i}$ $M_{s\_m\_b} = F_{s\_m\_i}$	$K_0 \times Surcharg  \times \gamma_{f_e} \times K_0 \times \gamma_m  \times K_0 \times \gamma_m \times (h_{el}  \gamma_{f_e} \times K_0 \times (\gamma_{s} - \gamma_{s}  \gamma_{f_e} \times \gamma_{f_e} \times \gamma_{water} \times  f + F_{s_m_a_f} + F_{s}  f + F_{s_m_a_f} + F_{s_{a_f}} + F_{s_{$	$h \times (h_{eff} - t_{base} - C_{ds} - h_{s}$ $ff - t_{base} - d_{ds} - h_{s}$ $\gamma_{water}) \times h_{sat}^{2} = 1$ $h_{sat}^{2} = 16.5 \text{ kN}$ $h_{sm}b_{f} + F_{s_{s}f} + h_{s}$ $h_{e}) / 2 = 48.9 \text{ kN}$ $h_{eff} - d_{ds} + t_{base}$ 25.9 kNm/m	d <sub>ds</sub> - h <sub>sat</sub> ) <sup>2</sup> = <b>15.6</b> <sub>sat</sub> ) × h <sub>sat</sub> = <b>33.4</b>   <b>1.1</b> kN/m I/m F <sub>s_water_f</sub> - F <sub>prop_f</sub> m/m	kN/m kN/m = <b>38.8</b> kN/m



	Project 23 Dartmouth	n Park Hill			Job Ref. 19047	
Architecture for London.	Section Wall 14				Sheet no./rev. 9	
	Calc. by BS	Date 23/01/2020	Chk'd by	Date	App'd by	Date
Indicative retaining wall reinforc	ement diagrar	<u>n</u>				
Toe bars - 16 mm dia.@ 150 mm o Stem bars - 16 mm dia.@ 200 mm	centres - (1340			Stem rei	nforcement	

A	Project 23 Dartmouth Park Hill	Job no. <b>1904 7</b>	
Architecture for London.	Calcsfor Slab Design	Start page no.	/Revision
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SOLID	T DESIGN to BS 8110:2005 SLABS rom RCC11.xls v4.0 © 2006 - 2010 TCC
	Location Dartmouth Park Hill noment, M <u>140.1</u> kNm/m fcu <u>40</u> $\checkmark$ N/mm <sup>2</sup> $\gamma c = 1.50$ ßb <u>1.00</u> fy <u>500</u> N/mm <sup>2</sup> $\gamma s = 1.15$ span <u>6000</u> mm steel class <u>A</u> Height, h <u>300</u> mm Section location <u>CONTINUOUS SPAN</u> Bar Ø <u>16</u> mm Compression steel <u>NOMINAL</u> cover <u>50</u> mm to these bars (deflection control only)
OUTPUT (3.4.4.4) (3.4.4.4) (3.4.4.1) (Eqn 8) (Eqn 7) (Equation 9) (3.4.6.3)	ONE or TWO WAY SLABDartmouth Park HillCompression steel = NOMINAL 0.13% $d = 300 - 50 - 16/2 = 242.0 \text{ mm}$ K' = 0.156 > K = 0.060 ok $K' = 0.156 > K = 0.060 \text{ ok}$ $z = 242.0 [0.5 + (0.25 - 0.060 / 0.893)]^{1/2} = 224.7 < 0.95d = 229.9 \text{ mm}$ As = 140.10E6 /500 /224.5 x 1.15 = 1435 > min As = 390 mm²/mPROVIDE H16 @ 125 = 1608 mm²/m As increased by 0.2% for deflectionfs = 2/3 x 500 x 1435 /1608 /1.00 = 297.4 N/mm²Tens mod factor = 0.55 + (477 - 297.4) /120 /(0.9 + 2.392) = 1.005Comp mod factor = 1 + 0.130/(3 + 0.130) = 1.042Permissible L/d = 26.0 x 1.005 x 1.042 = 27.205Actual L/d = 6000 /242.0 = 24.793 ok

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