12 Pilgrim's Lane 2210419 Stage 2 Report – P1

A Proposed Structural Drawings and Preliminary Calculations

# elliottwood

engineering a better **society** 

A Elliott Wood Partnership Ltd



This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.

Do not scale from this drawing.

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June 2022

PDu



P1 28/06/22 PDu DBa Preliminary rev date by chk description scale (s) 1:100

date June 2022





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P1 28/06/22 PDu DBa Preliminary scale (s) date rev date by chk description 1:100 June 2022

10 Pilgrim's Lane

### ------ Steel beam Vertical X bracing Joist span Steel column Steel column below Crank in steelwork Steel moment connection or continuity RC Column / Wall

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Project

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Drawing status Status Revision Preliminary S2 P1 Project no. Originator Zone Level Type Role drg no. 2210419-EWP-ZZ-02-SK-S-1040



P1 28/06/22 PDu DBa Preliminary scale (s) date

rev date by chk description

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June 2022

10 Pilgrim's Lane

## Joist span Steel column Steel column below $\times$ Crank in steelwork Steel moment connection or continuity RC Column / Wall <sup>Project</sup> 12 Pilgrim's Lane

Steel beam

Vertical X bracing

![](_page_5_Picture_8.jpeg)

![](_page_5_Picture_9.jpeg)

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Drawing status Status Revision Preliminary S2 P1 Project no. Originator Zone Level Type Role drg no. 2210419-EWP-ZZ-03-SK-S-1050

elliott <b>wood</b>	Project	12 Pilgri	m's Lane		Job no. 2210	0419
55 Whitfield Street London	Calcs for Prelin	minary Underpin	Toe and Prop S	Sizing	Start page no./Re	vision 1
W11 4AH	Calcs by PDu	Calcs date 30/06/2022	Checked by DBa	Checked date 29/06/2022	Approved by DBa	Approved date 29/06/2022

#### RETAINING WALL ANALYSIS

In accordance with EN1997-1:2004 incorporating Corrigendum dated February 2009 and the UK National Annex incorporating Corrigendum No.1

Retaining wall details	
Stem type	Propped cantilever
Stem height	h <sub>stem</sub> <b>= 3600</b> mm
Prop height	h <sub>prop</sub> = <b>3000</b> mm
Stem thickness	t <sub>stem</sub> = <b>325</b> mm
Angle to rear face of stem	α <b>= 90</b> deg
Stem density	γ <sub>stem</sub> = <b>25</b> kN/m <sup>3</sup>
Toe length	l <sub>toe</sub> = <b>1500</b> mm
Base thickness	t <sub>base</sub> = <b>400</b> mm
Base density	γ <sub>base</sub> = <b>25</b> kN/m <sup>3</sup>
Height of retained soil	h <sub>ret</sub> = <b>3600</b> mm
Angle of soil surface	$\beta = 0 \deg$
Depth of cover	d <sub>cover</sub> = <b>0</b> mm
Height of water	h <sub>water</sub> = <b>2300</b> mm
Water density	γ <sub>w</sub> = <b>9.8</b> kN/m <sup>3</sup>
Retained soil properties	
Soil type	Firm clay
Moist density	γ <sub>mr</sub> = <b>18</b> kN/m <sup>3</sup>
Saturated density	γ <sub>sr</sub> = <b>18</b> kN/m <sup>3</sup>
Characteristic effective shear resistance angle	φ' <sub>r.k</sub> = <b>20</b> deg
Characteristic wall friction angle	$\delta_{r.k}$ = 10 deg
Base soil properties	
Soil type	Stiff clay
Soil density	γ <sub>b</sub> = <b>19</b> kN/m <sup>3</sup>
Characteristic effective shear resistance angle	φ' <sub>b.k</sub> = <b>24</b> deg
Characteristic wall friction angle	δ <sub>b.k</sub> = <b>12</b> deg
Characteristic base friction angle	δ <sub>bb.k</sub> = <b>12</b> deg
Presumed bearing capacity	P <sub>bearing</sub> = <b>125</b> kN/m <sup>2</sup>
Loading details	
Permanent surcharge load	Surcharge <sub>G</sub> = <b>5</b> kN/m <sup>2</sup>
Variable surcharge load	Surcharge <sub>Q</sub> = <b>5</b> kN/m <sup>2</sup>
Vertical line load at 1650 mm	P <sub>G1</sub> = <b>50</b> kN/m
	P <sub>Q1</sub> = <b>15</b> kN/m

elliott <b>wood</b>	Project	12 Pilgri	m's Lane		Job no. 2210	0419
55 Whitfield Street London	Calcs for Prelin	minary Underpir	Toe and Prop S	Sizing	Start page no./Re	evision 2
W1I 4AH	Calcs by PDu	Calcs date 30/06/2022	Checked by DBa	Checked date 29/06/2022	Approved by DBa	Approved date 29/06/2022

![](_page_7_Figure_1.jpeg)

Calculate	retaining	wall	geometry
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Base length	I <sub>base</sub> = I <sub>toe</sub> + t <sub>stem</sub> = <b>1825</b> mm
Saturated soil height	h <sub>sat</sub> = h <sub>water</sub> + d <sub>cover</sub> = <b>2300</b> mm
Moist soil height	h <sub>moist</sub> = h <sub>ret</sub> - h <sub>water</sub> = <b>1300</b> mm
Length of surcharge load	I <sub>sur</sub> = I <sub>heel</sub> = <b>0</b> mm
- Distance to vertical component	$x_{sur_v} = I_{base} - I_{heel} / 2 = 1825 \text{ mm}$
Effective height of wall	h <sub>eff</sub> = h <sub>base</sub> + d <sub>cover</sub> + h <sub>ret</sub> = <b>4000</b> mm
- Distance to horizontal component	x <sub>sur_h</sub> = h <sub>eff</sub> / 2 = <b>2000</b> mm
Area of wall stem	A <sub>stem</sub> = h <sub>stem</sub> × t <sub>stem</sub> = <b>1.17</b> m <sup>2</sup>
- Distance to vertical component	x <sub>stem</sub> = I <sub>toe</sub> + t <sub>stem</sub> / 2 = <b>1663</b> mm
Area of wall base	$A_{\text{base}} = I_{\text{base}} \times t_{\text{base}} = 0.73 \text{ m}^2$
- Distance to vertical component	x <sub>base</sub> = I <sub>base</sub> / 2 = <b>913</b> mm
Using Coulomb theory	
Active pressure coefficient	$K_{A} = \sin(\alpha + \phi'_{r,k})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,k}) \times [1 + \sqrt{[\sin(\phi'_{r,k} + \delta_{r,k})} \times \sin(\phi'_{r,k}) \times (\phi'_{r,k}) \times (\phi'_{\mathsf$
	- $\beta$ ) / (sin( $\alpha$ - $\delta_{r,k}$ ) × sin( $\alpha$ + $\beta$ ))]] <sup>2</sup> ) = <b>0.447</b>
Passive pressure coefficient	$K_P = sin(90 - \phi'_{b.k})^2 / (sin(90 + \delta_{b.k}) \times [1 - \sqrt{sin(\phi'_{b.k} + \delta_{b.k})} \times sin(\phi'_{b.k}) / (sin(\phi'_{b.k} + \delta_{b.k})) $
	(sin(90 + δ <sub>b.k</sub> ))]] <sup>2</sup> ) = <b>3.337</b>
Bearing pressure check	
Vertical forces on wall	
Wall stem	F <sub>stem</sub> = A <sub>stem</sub> × γ <sub>stem</sub> = <b>29.3</b> kN/m
Wall base	$F_{base} = A_{base} \times \gamma_{base} = 18.3 \text{ kN/m}$

elliottwood	Project Job no. 12 Pilgrim's Lane 2210419					0419
55 Whitfield Street	Calcs for Start page no./Revis					vision
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	PDu	30/06/2022	DBa	29/06/2022	DBa	29/06/2022
Line loads		$F_{P_{v}} = P_{G1} +$	• P <sub>01</sub> = <b>65</b> kN/m			
Total		F <sub>total_v</sub> = F <sub>ste</sub>	m + F <sub>base</sub> + F <sub>P_v</sub> -	+ F <sub>water_v</sub> = <b>112.5</b>	kN/m	
Horizontal forces on wall						
Surcharge load		$F_{sur_h} = K_A >$	$c\cos(\delta_{r.k}) \times (Surc$	charge <sub>G</sub> + Surch	arge <sub>Q</sub> ) × h <sub>eff</sub> =	<b>17.6</b> kN/m
Saturated retained soil		$F_{sat_h} = K_A \times$	$\cos(\delta_{r.k}) \times (\gamma_{sr} - $	$\gamma_w$ ) × (h <sub>sat</sub> + h <sub>base</sub>	) <sup>2</sup> / 2 = <b>13.1</b> kl	N/m
Water		$F_{water_h} = \gamma_w$	× (h <sub>water</sub> + d <sub>cover</sub> -	+ h <sub>base</sub> )² / 2 = <b>35</b>	. <b>8</b> kN/m	
Moist retained soil		F <sub>moist_h</sub> = K <sub>A</sub>	$\times \cos(\delta_{r.k}) \times \gamma_{mr}$	× ((h <sub>eff</sub> - h <sub>sat</sub> - h <sub>ba</sub>	<sub>ase</sub> ) <sup>2</sup> / 2 + (h <sub>eff</sub> -	h <sub>sat</sub> - h <sub>base</sub> ) ×
		(h <sub>sat</sub> + h <sub>base</sub> )	) = <b>34.5</b> kN/m			
Base soil	$F_{pass_h} = -K_P \times cos(\delta_{b.k}) \times \gamma_b \times (d_{cover} + h_{base})^2 / 2 = -5 \text{ kN/m}$					
Total	F <sub>total_h</sub> = F <sub>sur_h</sub> + F <sub>sat_h</sub> + F <sub>water_h</sub> + F <sub>moist_h</sub> + F <sub>pass_h</sub> = <b>96</b> kN/m					n
Moments on wall						
Wall stem	M <sub>stem</sub> = F <sub>stem</sub> × x <sub>stem</sub> = <b>48.6</b> kNm/m					
Wall base	M <sub>base</sub> = F <sub>base</sub> × x <sub>base</sub> = <b>16.7</b> kNm/m					
Surcharge load	M <sub>sur</sub> = -F <sub>sur_h</sub> × x <sub>sur_h</sub> = - <b>35.2</b> kNm/m					
Line loads		M <sub>P</sub> = (P <sub>G1</sub> +	P <sub>Q1</sub> ) × p <sub>1</sub> = <b>107</b> .	. <b>3</b> kNm/m		
Saturated retained soil		M <sub>sat</sub> = -F <sub>sat_l</sub>	h × Xsat_h = -11.8	kNm/m		
Water		M <sub>water</sub> = -F <sub>wa</sub>	ater_h × Xwater_h = -;	<b>32.2</b> kNm/m		
Moist retained soil		M <sub>moist</sub> = -F <sub>mo</sub>	pist_h × Xmoist_h = -	5 <b>8.5</b> kNm/m		
Total		M <sub>total</sub> = M <sub>sten</sub>	n + M <sub>base</sub> + M <sub>sur</sub> +	- M <sub>P</sub> + M <sub>sat</sub> + M <sub>wa</sub>	ater + M <sub>moist</sub> = 34	<b>4.8</b> kNm/m
Check bearing pressure						
Propping force to stem		F <sub>prop_stem</sub> = (	$F_{total_v} \times I_{base} / 2$ ·	- M <sub>total</sub> ) / (h <sub>prop</sub> + t	t <sub>base</sub> ) = <b>19.9</b> kN	l/m
Propping force to base		F <sub>prop_base</sub> = F	F <sub>total_h</sub> - F <sub>prop_stem</sub>	= <b>76.1</b> kN/m		
Moment from propping force		$M_{prop} = F_{prop}$	$_{_{stem}} \times (h_{prop} + t_{ba})$	<sub>ase</sub> ) = <b>67.8</b> kNm/r	n	
Distance to reaction	$\overline{\mathbf{x}} = (\mathbf{M}_{\text{total}} + \mathbf{M}_{\text{prop}}) / \mathbf{F}_{\text{total}_v} = 913 \text{ mm}$					
Eccentricity of reaction		$e = \overline{x} - I_{base}$	/ 2 = <b>0</b> mm			
Loaded length of base		I <sub>load</sub> = I <sub>base</sub> =	<b>1825</b> mm			
Bearing pressure at toe		$q_{toe} = F_{total_v}$	/ $I_{base} \times$ (1 - 6 $\times$	e / I <sub>base</sub> ) = <b>61.6</b> k	N/m <sup>2</sup>	
Bearing pressure at heel		$q_{heel} = F_{total}$	$_v$ / I <sub>base</sub> × (1 + 6 >	<pre>&lt; e / I<sub>base</sub>) = 61.6</pre>	kN/m²	
Factor of safety		$FoS_{bp} = P_{be}$	<sub>aring</sub> / max(q <sub>toe</sub> , q	<sub>heel</sub> ) = <b>2.028</b>		
	PASS - AI	lowable bearing	g pressure exc	eeds maximum	applied bear	ing pressure

#### **RETAINING WALL DESIGN**

In accordance with EN1992-1-1:2004 incorporating Corrigendum dated January 2008 and the UK National Annex incorporating National Amendment No.1

Concrete details - Table 3.1 - Strength	and deformation characted	eristics for concrete
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Concrete strength class	C30/37
Characteristic compressive cylinder strength	f <sub>ck</sub> = <b>30</b> N/mm <sup>2</sup>
Characteristic compressive cube strength	f <sub>ck,cube</sub> = <b>37</b> N/mm <sup>2</sup>
Mean value of compressive cylinder strength	f <sub>cm</sub> = f <sub>ck</sub> + 8 N/mm <sup>2</sup> = <b>38</b> N/mm <sup>2</sup>
Mean value of axial tensile strength	$f_{ctm}$ = 0.3 N/mm <sup>2</sup> × ( $f_{ck}$ / 1 N/mm <sup>2</sup> ) <sup>2/3</sup> = <b>2.9</b> N/mm <sup>2</sup>
5% fractile of axial tensile strength	$f_{ctk,0.05} = 0.7 \times f_{ctm} = 2.0 \text{ N/mm}^2$
Secant modulus of elasticity of concrete	$E_{cm}$ = 22 kN/mm <sup>2</sup> × (f <sub>cm</sub> / 10 N/mm <sup>2</sup> ) <sup>0.3</sup> = <b>32837</b> N/mm <sup>2</sup>
Partial factor for concrete - Table 2.1N	γc = <b>1.50</b>
Compressive strength coefficient - cl.3.1.6(1)	α <sub>cc</sub> = <b>0.85</b>

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Design compressive concrete s	trength - exp.3.	15 $f_{cd} = \alpha_{cc} \times f_{c}$	<sub>k</sub> / γc = <b>17.0</b> N/m	1m²				
Maximum aggregate size		h <sub>agg</sub> = <b>20</b> m	m					
Ultimate strain - Table 3.1		ε <sub>cu2</sub> = <b>0.003</b>	5					
Shortening strain - Table 3.1		ε <sub>cu3</sub> = <b>0.003</b>	5					
Effective compression zone heig	ght factor	$\lambda = 0.80$						
Effective strength factor		η = <b>1.00</b>						
Jending coefficient k₁		K <sub>1</sub> = <b>0.40</b>	K <sub>1</sub> = <b>0.40</b>					
Bending coefficient k2		K <sub>2</sub> = 1.00 ×	$K_2 = 1.00 \times (0.6 + 0.0014/\epsilon_{cu2}) = 1.00$					
Bending coefficient k <sub>3</sub>		K <sub>3</sub> = <b>0.40</b>	K <sub>3</sub> = <b>0.40</b>					
Bending coefficient k4		$K_4 = 1.00 \times$	$K_4 = 1.00 \times (0.6 + 0.0014 / \epsilon_{cu2}) = 1.00$					
Reinforcement details								
Characteristic yield strength of r	einforcement	f <sub>yk</sub> = <b>500</b> N/	mm²					
Modulus of elasticity of reinforce	ement	E <sub>s</sub> = <b>20000</b>	E <sub>s</sub> = <b>200000</b> N/mm <sup>2</sup>					
Partial factor for reinforcing stee	el - Table 2.1N	γs = <b>1.15</b>	γs = <b>1.15</b>					
Design yield strength of reinford	ement	$f_{yd} = f_{yk} / \gamma_S$	f <sub>yd</sub> = f <sub>yk</sub> / γs = <b>435</b> N/mm <sup>2</sup>					
Cover to reinforcement								
Front face of stem	e of stem		c <sub>sf</sub> = <b>40</b> mm					
Rear face of stem	c <sub>sr</sub> = <b>50</b> mm							
Top face of base	c <sub>bt</sub> = <b>50</b> mm							
			-					

![](_page_9_Figure_1.jpeg)

elliottwood	Project				Job no.	
		12 Pilgri	m's Lane		221	0419
55 Whitfield Street	Calcs for				Start page no./R	evision
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	·	•				

![](_page_10_Figure_1.jpeg)

h = <b>325</b> mm
M = <b>18.8</b> kNm/m
d = h - c <sub>sf</sub> - φ <sub>sx</sub> - φ <sub>sfM</sub> / 2 = <b>267</b> mm
$K = M / (d^2 \times f_{ck}) = 0.009$
$K' = (2 \times \eta \times \alpha_{cc} / \gamma_{C}) \times (1 - \lambda \times (\delta - K_1) / (2 \times K_2)) \times (\lambda \times (\delta - K_1) / (2 \times K_2))$
K' = <b>0.207</b>
K' > K - No compression reinforcement is required
z = min(0.5 + 0.5 × (1 - 2 × K / ( $\eta \times \alpha_{cc}$ / $\gamma_c$ )) <sup>0.5</sup> , 0.95) × d = <b>254</b> mm
x = 2.5 × (d – z) = <b>33</b> mm
$A_{sfM.req} = M / (f_{yd} \times z) = 170 \text{ mm}^2/\text{m}$
12 dia.bars @ 200 c/c
$A_{sfM,prov} = \pi \times \phi_{sfM}^2 / (4 \times s_{sfM}) = 565 \text{ mm}^2/\text{m}$
$A_{sfM.min} = max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d = 402 \text{ mm}^2/\text{m}$
A <sub>sfM.max</sub> = 0.04 × h = <b>13000</b> mm <sup>2</sup> /m
max(A <sub>sfM.req</sub> , A <sub>sfM.min</sub> ) / A <sub>sfM.prov</sub> = <b>0.711</b>

#### PASS - Area of reinforcement provided is greater than area of reinforcement required

Library item: Rectangular single output

Deflection control - Section 7.4	
Reference reinforcement ratio	$\rho_0 = \sqrt{(f_{ck} / 1 \text{ N/mm}^2) / 1000} = 0.005$
Required tension reinforcement ratio	$\rho = A_{sfM.req} / d = 0.001$
Required compression reinforcement ratio	ρ' = A <sub>sfM.2.req</sub> / d <sub>2</sub> = <b>0.000</b>
Structural system factor - Table 7.4N	K <sub>b</sub> = 1
Reinforcement factor - exp.7.17	$K_s = min(500 \text{ N/mm}^2 / (f_{yk} \times A_{sfM.req} / A_{sfM.prov}), 1.5) = 1.5$
Limiting span to depth ratio - exp.7.16.a	$min(K_s \times K_b \times [11 + 1.5 \times \sqrt{(f_{ck} / 1 N/mm^2)} \times \rho_0 / \rho + 3.2 \times \sqrt{(f_{ck} / 1 N/mm^2)})$
	N/mm <sup>2</sup> ) × ( $\rho_0$ / $\rho$ - 1) <sup>3/2</sup> ], 40 × K <sub>b</sub> ) = <b>40</b>
Actual span to depth ratio	h <sub>prop</sub> / d = <b>11.2</b>
	PASS - Span to depth ratio is less than deflection control limit

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55 Whitfield Street	Calcs for				Start page no./Revision	
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W1I 4AH	Calcs by PDu	Calcs date 30/06/2022	Checked by DBa	Checked date 29/06/2022	Approved by DBa	Approved date 29/06/2022
Crack control - Section 7.3						
Limiting crack width		w <sub>max</sub> = <b>0.3</b> r	mm			
Variable load factor - EN1990 - 7	Table A1.1	ψ2 <b>= 0.6</b>				
Serviceability bending moment		M <sub>sls</sub> = <b>13.3</b>	kNm/m			
Tensile stress in reinforcement		$\sigma_{s}$ = M <sub>sls</sub> / (A	A <sub>sfM.prov</sub> × z) = 9	<b>92.8</b> N/mm <sup>2</sup>		
Load duration		Long term				
Load duration factor		k <sub>t</sub> = <b>0.4</b>				
Effective area of concrete in tens	ion	A <sub>c.eff</sub> = min( A <sub>c.eff</sub> = <b>9720</b>	2.5 × (h - d), (ł <b>)8</b> mm²/m	1 - x) / 3, h / 2)		
Mean value of concrete tensile st	trength	f <sub>ct.eff</sub> = f <sub>ctm</sub> =	<b>2.9</b> N/mm <sup>2</sup>			
Reinforcement ratio		$\rho_{p.eff} = A_{sfM,p}$	orov / A <sub>c.eff</sub> = <b>0.0</b>	06		
Modular ratio		$\alpha_{e} = E_{s} / E_{c}$	m = <b>6.091</b>			
Bond property coefficient		k <sub>1</sub> = <b>0.8</b>				
Strain distribution coefficient		k <sub>2</sub> = <b>0.5</b>				
		k <sub>3</sub> = <b>3.4</b>				
		k <sub>4</sub> = <b>0.425</b>				
Maximum crack spacing - exp.7.	11	$s_{r.max} = k_3 \times$	$\textbf{c}_{sf}\textbf{+}\textbf{k}_1\times\textbf{k}_2\times$	$k_4 \times \phi_{sfM}$ / $\rho_{p.eff}$ = 4	<b>87</b> mm	
Maximum crack width - exp.7.8	7.8 $w_{k} = s_{r.max} \times max(\sigma_{s} - k_{t} \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_{e} \times \rho_{p.eff}), 0.6 \times \sigma_{s}$			$6 \times \sigma_s) / E_s$		
		w <sub>k</sub> = <b>0.135</b>	mm			
		$w_k / w_{max} =$	0.451			
		PASS	- Maximum cı	rack width is les	s than limitin	g crack widtl
Check stem design at base of	stem					
Depth of section		h = <b>325</b> mn	n			
Rectangular section in flexure	- Section 6.1					
Design bending moment combination	ation 1	M = <b>40.5</b> ki	Nm/m			
Depth to tension reinforcement		d = h - c <sub>sr</sub> -	φ <sub>sr</sub> / 2 <b>= 267</b> m	im		
		$K = M / (d^2)$	× f <sub>ck</sub> ) = <b>0.019</b>			
		K' = (2 × η : K' = <b>0.207</b>	× α <sub>cc</sub> /γc)×(1 - λ	$\times$ ( $\delta$ - K <sub>1</sub> )/(2 $\times$ K <sub>2</sub> )	))×(λ × (δ - K <sub>1</sub> )	/(2 × K <sub>2</sub> ))
			K' > K -	No compression	n reinforceme	nt is required
Lever arm		z = min(0.5	+ 0.5 × (1 - 2	$ imes$ K / ( $\eta$ $ imes$ $lpha_{ ext{cc}}$ / $\gamma_{ ext{C}}$ )	) <sup>0.5</sup> , 0.95) × d =	= <b>254</b> mm
Depth of neutral axis		x = 2.5 × (d	− z) <b>= 33</b> mm			
Area of tension reinforcement red	quired	$A_{sr.req} = M /$	(f <sub>yd</sub> × z) = <b>367</b>	mm²/m		
Tension reinforcement provided		16 dia.bars	@ 100 c/c			
Area of tension reinforcement pro	sion reinforcement provided $A_{sr,prov} = \pi \times \phi_{sr}^2 / (4 \times s_{sr}) = 2011 \text{ mm}^2/\text{m}$					
Minimum area of reinforcement -	exp.9.1N	A <sub>sr.min</sub> = ma	$x(0.26 \times f_{ctm} / f_{y})$	<sub>yk</sub> , 0.0013) × d = 4	<b>102</b> mm²/m	
Maximum area of reinforcement	- cl.9.2.1.1(3)	) A <sub>sr.max</sub> = 0.04 × h = <b>13000</b> mm²/m				
		max(A <sub>sr.req</sub> ,	Asr.min) / Asr.prov	= 0.2		
F	PASS - Area o	f reinforcement	provided is g	<b>ireater than area</b> Li	of reinforcer	<b>ment required</b> Igular single outpu
Deflection control - Section 7.4	L .					•
Reference reinforcement ratio		$ ho_0 = \sqrt{f_{ck}} / 1$	I N/mm²) / 100	0 = <b>0.005</b>		
Required tension reinforcement r	atio	$\rho = A_{sr.req} / c$	d = 0.001			
Required compression reinforcer	nent ratio	$\rho$ ' = A <sub>sr.2.req</sub>	/ d <sub>2</sub> = <b>0.000</b>			
uctural system factor - Table 7.4N K <sub>b</sub> = <b>1</b>						

Reinforcement factor - exp.7.17

 $K_{s} = min(500 \text{ N/mm}^{2} / (f_{yk} \times A_{sr.req} / A_{sr.prov}), 1.5) = 1.5$ 

elliottwood	Project	Job no.				10419
55 Whitfield Street London	Calcs for Preli	iminary Underpir	n Toe and Prop	Start page no./F	7	
W11 4AH	Calcs by PDu	Calcs date 30/06/2022	Checked by DBa	Checked date 29/06/2022	Approved by DBa	Approved date 29/06/2022
Limiting span to depth ratio - exc		min(K <sub>s</sub> × K		(f <sub>ck</sub> / 1 N/mm²) ×	$\rho_0 / \rho + 3.2 \times$	√(f <sub>ck</sub> / 1
		$N/mm^2) \times ($	$(0, 1)^{3/2}$ 40	、 × Κ <sub>b</sub> ) = <b>40</b>		,
Actual span to depth ratio		b / d = 1	19 19			
		PASS	- Snan to denti	h ratio is less th	nan deflectio	n control limit
		1400	opun to uopti			
Crack control - Section 7.3						
Limiting crack width		$W_{max} = 0.3$	mm			
Variable load factor - EN1990 –	Table A1.1	ψ2 <b>= 0.6</b>				
Serviceability bending moment		M <sub>sls</sub> = <b>28.8</b>	kNm/m			
Tensile stress in reinforcement		$\sigma_{s}$ = M <sub>sls</sub> / (	$A_{sr.prov} \times z$ ) = 56.	<b>5</b> N/mm²		
Load duration		Long term				
Load duration factor		kt = <b>0.4</b>				
Effective area of concrete in tens	sion	A <sub>c.eff</sub> = min(	$2.5 \times$ (h - d), (h	- x) / 3, h / 2)		
		A <sub>c.eff</sub> = <b>972</b>	<b>08</b> mm²/m			
Mean value of concrete tensile s	trength	$f_{ct.eff} = f_{ctm} =$	<b>2.9</b> N/mm <sup>2</sup>			
Reinforcement ratio		$\rho_{p.eff} = A_{sr.pr}$	ov / A <sub>c.eff</sub> = <b>0.021</b>			
Modular ratio		$\alpha_{e} = E_{s} / E_{c}$	m = <b>6.091</b>			
Bond property coefficient		k₁ = <b>0.8</b>				
Strain distribution coefficient		k <sub>2</sub> = 0.5				
		k <sub>3</sub> = <b>3.4</b>				
		k <sub>4</sub> = 0.425				
Maximum crack spacing - exp.7.	.11	$s_{r.max} = k_3 \times$	$c_{sr}$ + $k_1 \times k_2 \times k_3$	4 × φsr / ρp.eff <b>= 30</b>	<b>)2</b> mm	
Maximum crack width - exp.7.8	w <sub>k</sub> = s <sub>r.max</sub> >	$\propto \max(\sigma_{s} - k_{t} \times (1$	$f_{\rm ct.eff} /  ho_{ m p.eff})  imes$ (1 +	$\cdot \alpha_{e} \times \rho_{p.eff}$ ), 0.	$6  imes \sigma_s$ ) / Es	
		w <sub>k</sub> = <b>0.051</b>	mm			
		w <sub>k</sub> / w <sub>max</sub> =	0.17			
		PASS	- Maximum cra	ck width is les	s than limitin	ng crack width
Rectangular section in shear -	Section 6.2					
Design shear force		V = 78.7 kM	N/m			
		$C_{Rd,c} = 0.18$	8 / γc = <b>0.120</b>			
		k = min(1 +	· √(200 mm / d),	2) = <b>1.865</b>		
Longitudinal reinforcement ratio		$\rho_{\rm I} = \min(A_{\rm st})$	prov / d. 0.02) = 0	0.008		
5		$V_{min} = 0.035$	5 N <sup>1/2</sup> /mm × k <sup>3/2</sup>	× f <sub>ck</sub> <sup>0.5</sup> = 0.488 N	/mm <sup>2</sup>	
Design shear resistance - eyo 6	2a & 6 2h	V <sub>Rdo</sub> = max	$r(C_{\text{Ed}} \times k \times (100))$	$N^2/mm^4 \times \alpha \times f$	$(1/3 V_{min}) \times d$	
	28 0 0.20				ck), vmin) ^ u	
		$V_{Rd.c} - 109$				
			).400 S. Dosian cho	ar rocistanco o	vaade daeid	an choor forco
		FA3	o - Designi sile	ai resistance ez	10000 ACCEUS (1851)	n snear iorce
Check stem design at prop						
Depth of section		h = <b>325</b> mr	n			
Rectangular section in flexure	- Section 6.1					
Design bending moment combin	ation 1	M = <b>1.5</b> kN	m/m			
Depth to tension reinforcement		d = h - c <sub>sr</sub> -	φ <sub>sr1</sub> / 2 <b>= 267</b> m	m		
		K = M / (d²	× f <sub>ck</sub> ) = 0.001			
		K' = (2 × n	× αcc/γc)×(1 - λ >	< (δ - K1)/(2 × K2)	))×(λ × (δ - Κ <sub>1</sub> )	)/(2 × K <sub>2</sub> ))
		K' = 0.207		· · · · · · · · · · · · · · · · · · ·		-//
			K' > K - N	o compression	reinforceme	ent is reauired
Lever arm		z = min(0.5)	+ 0.5 × (1 - 2 ×	$K / (n \times \alpha_{cc} / v_c)$	) <sup>0.5</sup> , 0.95) × d	= <b>254</b> mm
		(0.0		, (	, ,, . u	

elliott <b>wood</b>	Project	12 Pilgri	m's Lane		Job no. 221	0419		
55 Whitfield Street	Calcs for	Calcs for			Start page no./Revision			
	Preli	minary Underpir	Toe and Prop	Sizing		8		
V 11 7/11	Calcs by PDu	Calcs date 30/06/2022	Checked by DBa	Checked date 29/06/2022	Approved by DBa	Approved date 29/06/2022		
Depth of neutral axis		x = 2.5 × (d	– z) = <b>33</b> mm					
Area of tension reinforcement	required	A <sub>sr1.req</sub> = M /	/ (f <sub>yd</sub> × z) = <b>14</b> m	nm²/m				
Tension reinforcement provide	ed	16 dia.bars	@ 100 c/c					
Area of tension reinforcement	provided	$A_{sr1.prov} = \pi$	$\times \phi_{sr1}^2$ / (4 $\times s_{sr1}^2$ )	) = <b>2011</b> mm²/m				
Minimum area of reinforcemer	nt - exp.9.1N	A <sub>sr1.min</sub> = ma	$ax(0.26 \times f_{ctm} / f_y)$	<sub>rk</sub> , 0.0013) × d = 4	<b>402</b> mm²/m			
Maximum area of reinforceme	nt - cl.9.2.1.1(3)	$A_{sr1.max} = 0.0$	04 × h = <b>13000</b>	mm²/m				
		max(A <sub>sr1.req</sub> ,	, A <sub>sr1.min</sub> ) / A <sub>sr1.pro</sub>	<sub>bv</sub> = <b>0.2</b>				
	PASS - Area of	f reinforcement	provided is gr	eater than area	of reinforcer	nent required		
				Lit	orary item: Rectar	gular single output		
<b>Deflection control - Section</b>	7.4							
Reference reinforcement ratio		ρ₀ = √(f <sub>ck</sub> / 1	N/mm <sup>2</sup> ) / 1000	= 0.005				
Required tension reinforcement	nt ratio	ho = A <sub>sr1.req</sub> /	d = <b>0.000</b>					
Required compression reinfor	cement ratio	$\rho' = A_{sr1.2.req}$	/ d <sub>2</sub> = <b>0.000</b>					
Structural system factor - Tabl	e 7.4N	K <sub>b</sub> = <b>0.4</b>						
Reinforcement factor - exp.7.1	7	K₅ = min(50	00 N/mm² / (f <sub>yk</sub> ×	Asr1.req / Asr1.prov)	, 1.5) <b>= 1.5</b>			
Limiting span to depth ratio - e	exp.7.16.a	$min(K_s \times K_b)$	× [11 + 1.5 × √	(f <sub>ck</sub> / 1 N/mm <sup>2</sup> ) ×	ρ₀ / ρ + 3.2 ×	√(f <sub>ck</sub> / 1		
		$N/mm^2) \times (p$	ο <sub>0</sub> / ρ - 1) <sup>3/2</sup> ], 40	× K <sub>b</sub> ) = <b>16</b>				
Actual span to depth ratio		$(h_{\text{stem}} - h_{\text{prop}}) / d = 2.2$						
		PASS	- Span to deptl	h ratio is less th	an deflection	n control limit		
Crack control - Section 7.3								
Limiting crack width		w <sub>max</sub> = 0.3 r	nm					
Variable load factor - FN1990	– Table A1.1	$w_{12} = 0.6$						
Serviceability bending momen	t	φ₂ 0.0 M <sub>els</sub> = 0.9 kl	Nm/m					
Tensile stress in reinforcemen	t	$\sigma_{s} = M_{sls} / (A)$	$A_{sr1 prov} \times 7) = 1.8$	<b>8</b> N/mm <sup>2</sup>				
Load duration	-	Long term						
Load duration factor		k <sub>t</sub> = <b>0.4</b>						
Effective area of concrete in te	ension	A <sub>c.eff</sub> = min(	2.5 × (h - d), (h	- x) / 3, h / 2)				
		A <sub>c.eff</sub> = 9720	<b>)8</b> mm²/m	, , ,				
Mean value of concrete tensile	e strength	$f_{ct.eff} = f_{ctm} =$	<b>2.9</b> N/mm <sup>2</sup>					
Reinforcement ratio	-	$\rho_{p.eff} = A_{sr1.p}$	rov / Ac.eff = <b>0.02</b>	1				
Modular ratio		$\alpha_{e} = E_{s} / E_{cr}$	m = <b>6.091</b>					
Bond property coefficient		k <sub>1</sub> = <b>0.8</b>						
Strain distribution coefficient		k <sub>2</sub> = <b>0.5</b>						
		k <sub>3</sub> = <b>3.4</b>						
		k <sub>4</sub> = <b>0.425</b>						
Maximum crack spacing - exp	.7.11	$s_{r.max} = k_3 \times$	$c_{sr} \textbf{+} \textbf{k}_1 \times \textbf{k}_2 \times \textbf{k}$	$_4  imes \phi_{sr1}$ / $\rho_{p.eff}$ = 3	02 mm			
Maximum crack width - exp.7.8	8	w <sub>k</sub> = s <sub>r.max</sub> ×	max( $\sigma_{s} - k_{t} \times (1)$	$f_{ct.eff}$ / $ ho_{p.eff}$ $ imes$ (1 +	$\alpha_{e} \times \rho_{p.eff}$ ), 0.	$6  imes \sigma_s$ ) / Es		
		w <sub>k</sub> = <b>0.002</b>	mm					
		$w_k / w_{max} = 0$	0.005					
		PASS	- Maximum cra	ack width is less	s than limitin	g crack width		
Rectangular section in shea	r - Section 6.2							
Design shear force		V = <b>27.1</b> kN	l/m					
		C <sub>Rd,c</sub> = 0.18	3 / γc = <b>0.120</b>					
		k = min(1 +	√(200 mm / d),	2) = <b>1.865</b>				
		•	,,					
Longitudinal reinforcement rat	io	ρι = min(A <sub>sr</sub>	1.prov / d, 0.02) =	0.008				

elliott <b>wood</b>	Project	Project Job no. 12 Pilgrim's Lane 2210419				
55 Whitfield Street	Calcs for	Calcs for Start page				Revision
	Prel	iminary Underpi	n Toe and Pro	p Sizing		9
WTT 4AH	Calcs by PDu	Calcs date 30/06/2022	Checked by DBa	Checked date 29/06/2022	Approved by DBa	Approved date 29/06/2022
Design shear resistance - ex	p.6.2a & 6.2b	V <sub>Rd.c</sub> = max V <sub>Rd.c</sub> = <b>169</b>	(C <sub>Rd.c</sub> × k × (۱۱ kN/m	00 N²/mm <sup>4</sup> × ρι × f	<sub>ck</sub> ) <sup>1/3</sup> , V <sub>min</sub> ) × d	
		$V / V_{Rd.c} = 0$	0.160			
		PAS	SS - Design sh	ear resistance e	xceeds desi	gn shear force
Horizontal reinforcement p	arallel to face of	stem - Section	9.6			
Minimum area of reinforcement	ent – cl.9.6.3(1)	A <sub>sx.req</sub> = ma	$ax(0.25 \times A_{sr.pro})$	v, $0.001 \times t_{stem}$ = 4	<b>503</b> mm²/m	
Maximum spacing of reinford	cement – cl.9.6.3(2	$s_{sx_max} = 40$	<b>)0</b> mm			
Transverse reinforcement pr	ovided	12 dia.bars	s @ 200 c/c			
Area of transverse reinforcer	nent provided	$A_{sx.prov} = \pi$	$\times \phi_{sx}^2 / (4 \times s_{sx})^2$	) = <b>565</b> mm²/m		
	PASS - Area o	f reinforcemen	t provided is g	greater than area	of reinforce	ment required
Check base design at toe						
Depth of section		h = <b>400</b> mr	n			
Rectangular section in flex	ure - Section 6.1					
Design bending moment con	nbination 1	M = <b>79.8</b> k	Nm/m			
Depth to tension reinforceme	ent	d = h - c <sub>bb</sub> -	- φ <sub>bb</sub> / 2 = <b>317</b> ι	mm		
		$K = M / (d^2)$	$\times f_{ck}$ ) = 0.026			
		K' = (2 × n	$\times \alpha_{cc}/\gamma_{c} \times (1 - \lambda)$	× (δ - K1)/(2 × K2)	))×(λ × (δ - K1	)/(2 × K <sub>2</sub> ))
		K' = 0.207		(*** (*********************************	,)	/(_ // 2/)
			K' > K -	No compression	reinforcem	ent is required
Lever arm		z = min(0.5	5 + 0.5 × (1 - 2	$\times$ K / (n $\times \alpha_{cc}$ / $\gamma_{c}$ )	) <sup>0.5</sup> . 0.95) × d	- = 301 mm
Depth of neutral axis		$x = 2.5 \times (0)$	(1 - 7) = 40  mm		, , ,	
Area of tension reinforcemer	tension reinforcement required $\Delta u = 2.5 \times (u - 2) = 610 \text{ mm}^2/\text{m}$					
Tension reinforcement provid	ded	16 dia bars	s @ 100 c/c	,, ,		
Area of tension reinforcemer	nt provided	$A_{bb prov} = \pi$	$\times d_{hh}^2 / (4 \times s_{hh})^2$	) = <b>2011</b> mm <sup>2</sup> /m		
Minimum area of reinforcem	ent - exp 9 1N	$A_{\rm bb,min} = m_{\rm i}$	ax(0.26 × form /	$f_{\rm W} = 0.0013$ × d = 4	<b>477</b> mm²/m	
Maximum area of reinforcem	ent = cl 9 2 1 1(3)	$A_{\rm bb,max} = 0$	$0.4 \times h = 16000$	$n_{\rm mm^2/m}$	•••••	
	iont - 01.3.2.1.1(3)	$max(\Delta_{hh})$	Διμ	= 0 303		
	PASS - Area o		, ADD.min) / ADD.pr t provided is (	ov – 0.505 preater than area	of reinforce	ment required
				Li	brary item: Recta	ngular single output
Crack control - Section 7.3						
Limiting crack width		w <sub>max</sub> = <b>0.3</b>	mm			
Variable load factor - EN199	0 – Table A1.1	ψ <sub>2</sub> = <b>0.6</b>				
Serviceability bending mome	ent	M <sub>sls</sub> = <b>58.1</b>	kNm/m			
Tensile stress in reinforceme	ent	$\sigma_{s}$ = M <sub>sls</sub> / (	$A_{bb.prov} \times z) = 9$	<b>6</b> N/mm <sup>2</sup>		
Load duration		Long term				
Load duration factor		k <sub>t</sub> = <b>0.4</b>				
Effective area of concrete in	tension	A <sub>c.eff</sub> = min	(2.5 × (h - d), (	h - x) / 3, h / 2)		
		A <sub>c.eff</sub> = <b>120</b>	<b>125</b> mm²/m			
Mean value of concrete tens	ile strength	f <sub>ct.eff</sub> = f <sub>ctm</sub> =	<b>2.9</b> N/mm <sup>2</sup>			
Reinforcement ratio		$\rho_{p.eff} = A_{bb.p}$	rov / A <sub>c.eff</sub> = <b>0.0</b>	17		
Modular ratio		$\alpha_{e} = E_{s} / E_{o}$	cm = 6.091			
Bond property coefficient		k <sub>1</sub> = <b>0.8</b>				
Strain distribution coefficient		k <sub>2</sub> = <b>0.5</b>				
		k <sub>3</sub> = <b>3.4</b>				
		k <sub>4</sub> = <b>0.425</b>				
Maximum crack spacing - ex	p.7.11	$s_{r.max} = k_3 \times$	$c_{bb}$ + $k_1 \times k_2 \times k_2$	$k_4 \times \phi_{bb} / \rho_{p,eff} = 4$	<b>18</b> mm	

elliottwood	Project				Job no.	
		12 Pilgri	m's Lane		2210419	
55 Whitfield Street	Calcs for				Start page no./Revision	
	Prelim	ninary Underpir	n Toe and Prop	o Sizing		10
	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	FDu	30/00/2022	DDa	29/00/2022	DDa	29/00/2022
Maximum crack width - exp.7	.8	W <sub>k</sub> = S <sub>r.max</sub> ×	× max(σ <sub>s</sub> – k <sub>t</sub> ×	$(f_{ct,eff} / \rho_{p,eff}) \times (1 +$	$-\alpha_{e} \times \rho_{p,eff}$ , 0.	.6 × σs) / Es
		w <sub>k</sub> = <b>0.12</b> n	nm	( ) [) (	p.p,, -	
		w <sub>k</sub> / w <sub>max</sub> =	0.401			
		PASS	- Maximum c	rack width is les	s than limitin	ng crack width
Rectangular section in she	ar - Section 6.2					
Design shear force		V = 106.4 k	κN/m			
		$C_{Rd,c} = 0.18$	3 / γc = <b>0.120</b>			
		k = min(1 +	√(200 mm / d	), 2) = <b>1.794</b>		
Longitudinal reinforcement ra	itio	ρι = min(A <sub>bi</sub>	<sub>o.prov</sub> / d, 0.02) :	= 0.006		
		v <sub>min</sub> = 0.035	$5 \text{ N}^{1/2}/\text{mm} \times \text{k}^{3/2}$	<sup>2</sup> × f <sub>ck</sub> <sup>0.5</sup> = <b>0.461</b> N	l/mm²	
Design shear resistance - ex	o.6.2a & 6.2b	V <sub>Rd.c</sub> = max	$(C_{Rd.c} \times k \times (10))$	$00 \text{ N}^2/\text{mm}^4 \times \rho_\text{I} \times f_0$	ck) <sup>1/3</sup> , Vmin) $\times$ d	
		V <sub>Rd.c</sub> = <b>182</b> .	. <b>2</b> kN/m			
		$V / V_{Rd.c} = 0$	).584			
		PAS	S - Design sh	ear resistance e	xceeds desig	n shear force
Secondary transverse reinf	orcement to base ·	Section 9.3				
Minimum area of reinforceme	ent – cl.9.3.1.1(2)	$A_{bx.req} = 0.2$	$\times A_{bb,prov} = 40$	<b>2</b> mm²/m		
Maximum spacing of reinforc	ement – cl.9.3.1.1(3	5) s <sub>bx_max</sub> = <b>45</b>	0 mm			
I ransverse reinforcement pro		12 dia.bars	@ 200 c/c			
Area of transverse reinforcen	nent provided	$A_{bx,prov} = \pi$	× φ <sub>bx</sub> ∠ / (4 × S <sub>bx</sub>	) = 565 mm²/m		
	PASS - Area of I	reinforcement	provided is g	greater than area	of reinforce	ment requirea
		40-▶  ◀▶	<b>4</b> −50			
	12 c horizo para	dia.bars @ 200 c/c Intal reinforcement Ilel to face of stem				
	12 0	dia.bars @ 200 c/c				
		1 1				
		1 1				
	12 0	dia.bars @ 200 c/c	— 12 dia.bars @ 200 c/c			
	12 0	dia.bars @ 200 c/c	16 dia.bars @ 100 c/c			
	12 dia 150	a.uais @ 200 C/C	50 ±			
	Ť   [					
	16 dia	a.bars @ 100 c/c	<b>↑</b> 75			

12 dia.bars @ 200 c/c transverse reinforcement in base

Reinforcement details

elliott <b>wood</b>	Project				Job no.	
		12 Pilgrii	m's Lane		2210	0419
55 Whitfield Street	Calcs for				Start page no./Re	evision
	Prelir	ninary Underpin	Toe and Prop S	Sizing	11	
W11 4AH	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	PDu	30/06/2022	DBa	29/06/2022	DBa	29/06/2022

elliott <b>wood</b>	Project 12 Pilgrim's Lane				Job no. 2210	0419
55 Whitfield Street London	Calcs for Preliminary Retaining Wall				Start page no./Revision 1	
W11 4AH	Calcs by PDu	Calcs date 30/06/2022	Checked by DBa	Checked date 29/06/2022	Approved by DBa	Approved date 29/06/2022

#### RETAINING WALL ANALYSIS

In accordance with EN1997-1:2004 incorporating Corrigendum dated February 2009 and the UK National Annex incorporating Corrigendum No.1

Retaining wall details	
Stem type	Propped cantilever
Stem height	h <sub>stem</sub> = <b>3600</b> mm
Prop height	h <sub>prop</sub> = <b>3000</b> mm
Stem thickness	t <sub>stem</sub> = <b>250</b> mm
Angle to rear face of stem	α = <b>90</b> deg
Stem density	γ <sub>stem</sub> <b>= 25</b> kN/m <sup>3</sup>
Toe length	l <sub>toe</sub> = <b>1500</b> mm
Base thickness	t <sub>base</sub> = <b>400</b> mm
Base density	γ <sub>base</sub> = <b>25</b> kN/m <sup>3</sup>
Height of retained soil	h <sub>ret</sub> = <b>3600</b> mm
Angle of soil surface	$\beta = 0 \operatorname{deg}$
Depth of cover	d <sub>cover</sub> = 0 mm
Height of water	h <sub>water</sub> = <b>2300</b> mm
Water density	γ <sub>w</sub> = <b>9.8</b> kN/m <sup>3</sup>
Retained soil properties	
Soil type	Firm clay
Moist density	γ <sub>mr</sub> = <b>18</b> kN/m <sup>3</sup>
Saturated density	γ <sub>sr</sub> = <b>18</b> kN/m <sup>3</sup>
Characteristic effective shear resistance angle	φ'r.k = <b>20</b> deg
Characteristic wall friction angle	δ <sub>r.k</sub> = <b>10</b> deg
Base soil properties	
Soil type	Stiff clay
Soil density	γ <sub>b</sub> = <b>19</b> kN/m <sup>3</sup>
Characteristic effective shear resistance angle	φ' <sub>b.k</sub> = <b>24</b> deg
Characteristic wall friction angle	δ <sub>b.k</sub> = <b>12</b> deg
Characteristic base friction angle	δ <sub>bb.k</sub> = <b>12</b> deg
Presumed bearing capacity	P <sub>bearing</sub> = <b>125</b> kN/m <sup>2</sup>
Loading details	
Permanent surcharge load	Surcharge <sub>G</sub> = 25 kN/m <sup>2</sup>
Variable surcharge load	Surcharge <sub>Q</sub> = <b>25</b> kN/m <sup>2</sup>
Vertical line load at 1650 mm	P <sub>G1</sub> = <b>50</b> kN/m
	P <sub>Q1</sub> = <b>15</b> kN/m

elliott <b>wood</b>	Project	12 Pilgri	m's Lane		Job no. 2210	0419
55 Whitfield Street London	Calcs for Preliminary Retaining Wall				Start page no./Revision 2	
W1T 4AH	Calcs by PDu	Calcs date 30/06/2022	Checked by DBa	Checked date 29/06/2022	Approved by DBa	Approved date 29/06/2022

![](_page_18_Figure_1.jpeg)

Wall stem Wall base

$$\label{eq:Fstem} \begin{split} \mathsf{F}_{stem} &= \mathsf{A}_{stem} \times \gamma_{stem} = \textbf{22.5 kN/m} \\ \mathsf{F}_{base} &= \mathsf{A}_{base} \times \gamma_{base} = \textbf{17.5 kN/m} \end{split}$$

elliott <b>wood</b>	Project Job no 12 Pilgrim's Lane					0419	
55 Whitfield Street London	Calcs for	Preliminary R	Retaining Wall		Start page no./Revision 3		
W1T 4AH	Calcs by PDu	Calcs date     Checked by     Checked date     Approved by       Du     30/06/2022     DBa     29/06/2022     DBa					
Line loads		F <sub>P_v</sub> = P <sub>G1</sub> +	• P <sub>Q1</sub> = <b>65</b> kN/m	1			
Total		F <sub>total_v</sub> = F <sub>ste</sub>	m + F <sub>base</sub> + F <sub>P_v</sub>	+ F <sub>water_v</sub> = <b>105</b> k	:N/m		
Horizontal forces on wall							
Surcharge load		$F_{sur_h} = K_A >$	$c\cos(\delta_{r.k}) \times (Su)$	rcharge <sub>G</sub> + Surch	arge <sub>Q</sub> ) × h <sub>eff</sub> =	<b>88</b> kN/m	
Saturated retained soil		$F_{sat_h} = K_A \times$	$(\cos(\delta_{r.k}) \times (\gamma_{sr}))$	- $\gamma_w$ ) × (h <sub>sat</sub> + h <sub>base</sub>	∍)² / 2 <b>= 13.1</b> k	N/m	
Water		$F_{water_h} = \gamma_w$	× (h <sub>water</sub> + d <sub>cover</sub>	+ h <sub>base</sub> ) <sup>2</sup> / 2 = <b>35</b>	<b>.8</b> kN/m		
Moist retained soil		F <sub>moist_h</sub> = K <sub>A</sub>	$\times \cos(\delta_{r.k}) \times \gamma_{m}$	r  imes ((h <sub>eff</sub> - h <sub>sat</sub> - h <sub>ba</sub>	<sub>ase</sub> ) <sup>2</sup> / 2 + (h <sub>eff</sub> -	h <sub>sat</sub> - h <sub>base</sub> ) ×	
		(h <sub>sat</sub> + h <sub>base</sub> )	) = <b>34.5</b> kN/m				
Base soil	$F_{pass_h} = -K_P \times cos(\delta_{b,k}) \times \gamma_b \times (d_{cover} + h_{base})^2 / 2 = -5 \text{ kN/m}$						
Total		F <sub>total_h</sub> = F <sub>sur_h</sub> + F <sub>sat_h</sub> + F <sub>water_h</sub> + F <sub>moist_h</sub> + F <sub>pass_h</sub> = <b>166.4</b> kN/m					
Moments on wall							
Wall stem	M <sub>stem</sub> = F <sub>stem</sub> × x <sub>stem</sub> = <b>36.6</b> kNm/m						
Wall base	M <sub>base</sub> = F <sub>base</sub> × x <sub>base</sub> = <b>15.3</b> kNm/m						
Surcharge load		$M_{sur} = -F_{sur}$	h × X <sub>sur_h</sub> = -176	kNm/m			
Line loads		M <sub>P</sub> = (P <sub>G1</sub> +	P <sub>Q1</sub> ) × p <sub>1</sub> = <b>10</b> 7	<b>7.3</b> kNm/m			
Saturated retained soil		M <sub>sat</sub> = -F <sub>sat_t</sub>	h × <b>X</b> sat_h = <b>-11.8</b>	kNm/m			
Water		M <sub>water</sub> = -F <sub>wa</sub>	ater_h × Xwater_h =	<b>-32.2</b> kNm/m			
Moist retained soil		$M_{moist} = -F_{mo}$	$p_{\text{bist}_h} \times \mathbf{x}_{\text{moist}_h} = \mathbf{x}_{\text{moist}_h}$	<b>-58.5</b> kNm/m			
Total		M <sub>total</sub> = M <sub>sten</sub>	n + M <sub>base</sub> + M <sub>sur</sub>	+ M <sub>P</sub> + M <sub>sat</sub> + M <sub>w</sub>	ater + M <sub>moist</sub> = -	<b>119.4</b> kNm/m	
Check bearing pressure							
Propping force to stem		F <sub>prop_stem</sub> = (	$F_{total_v} \times I_{base} / 2$	- M <sub>total</sub> ) / (h <sub>prop</sub> +	t <sub>base</sub> ) = <b>62.1</b> kN	l/m	
Propping force to base		F <sub>prop_base</sub> = F	- total_h - Fprop_stem	n = <b>104.3</b> kN/m			
Moment from propping force		$M_{prop} = F_{prop}$	stem × (h <sub>prop</sub> + t <sub>i</sub>	<sub>base</sub> ) = <b>211.2</b> kNm	ı/m		
Distance to reaction		$\overline{\mathbf{x}} = (\mathbf{M}_{\text{total}} + \mathbf{M}_{\text{prop}}) / F_{\text{total}_v} = 875 \text{ mm}$					
Eccentricity of reaction		$e = \overline{x} - I_{base}$	, / 2 = <b>0</b> mm				
Loaded length of base		I <sub>load</sub> = I <sub>base</sub> =	<b>1750</b> mm				
Bearing pressure at toe	$q_{toe} = F_{total_v} / I_{base} \times (1 - 6 \times e / I_{base}) = 60 \text{ kN/m}^2$						
Bearing pressure at heel		$q_{\text{heel}} = F_{\text{total}}$	<sub>v</sub> / $I_{base} \times (1 + 6)$	× e / I <sub>base</sub> ) = <b>60</b> k	N/m²		
Factor of safety		$FoS_{bp} = P_{be}$	<sub>aring</sub> / max(q <sub>toe</sub> , o	q <sub>heel</sub> ) = <b>2.083</b>			
	PASS -	Allowable bearing	g pressure exc	ceeds maximum	applied bear	ing pressure	

#### **RETAINING WALL DESIGN**

In accordance with EN1992-1-1:2004 incorporating Corrigendum dated January 2008 and the UK National Annex incorporating National Amendment No.1

Concrete details - Table 3.1 - Strength and deformation chara	acteristics for concrete
---	--------------------------

Concrete strength class	C30/37
Characteristic compressive cylinder strength	f <sub>ck</sub> = <b>30</b> N/mm <sup>2</sup>
Characteristic compressive cube strength	f <sub>ck,cube</sub> = <b>37</b> N/mm <sup>2</sup>
Mean value of compressive cylinder strength	f <sub>cm</sub> = f <sub>ck</sub> + 8 N/mm <sup>2</sup> = <b>38</b> N/mm <sup>2</sup>
Mean value of axial tensile strength	$f_{ctm}$ = 0.3 N/mm <sup>2</sup> × ( $f_{ck}$ / 1 N/mm <sup>2</sup> ) <sup>2/3</sup> = <b>2.9</b> N/mm <sup>2</sup>
5% fractile of axial tensile strength	$f_{ctk,0.05}$ = 0.7 × $f_{ctm}$ = <b>2.0</b> N/mm <sup>2</sup>
Secant modulus of elasticity of concrete	$E_{cm}$ = 22 kN/mm <sup>2</sup> × (f <sub>cm</sub> / 10 N/mm <sup>2</sup> ) <sup>0.3</sup> = <b>32837</b> N/mm <sup>2</sup>
Partial factor for concrete - Table 2.1N	γc = <b>1.50</b>
Compressive strength coefficient - cl.3.1.6(1)	α <sub>cc</sub> = <b>0.85</b>

elliottwooo	Project	Project 12 Pilgrim's Lane				Job no. 2210419		
55 Whitfield Street	Calcs for				Start page no./Revision			
London		Preliminary F	Retaining Wall			4		
W1T 4AH	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved da		
	PDu	30/06/2022	DBa	29/06/2022	DBa	29/06/20		
Design compressive concret	e strenath - exp.3.	15 $f_{cd} = \alpha_{cc} \times f_{cd}$	ck / γc = <b>17.0</b> Ν	/mm <sup>2</sup>				
Maximum aggregate size		h <sub>agg</sub> = <b>20</b> m	im					
Ultimate strain - Table 3.1		ε <sub>cu2</sub> = 0.003	35					
Shortening strain - Table 3.1		ε <sub>cu3</sub> = <b>0.003</b>	35					
Effective compression zone	height factor	$\lambda = 0.80$						
Effective strength factor		η = <b>1.00</b>						
Bending coefficient k1		K <sub>1</sub> = <b>0.40</b>						
Bending coefficient k2		$K_2 = 1.00 \times (0.6 + 0.0014 / \epsilon_{cu2}) = 1.00$						
Bending coefficient k <sub>3</sub>		K <sub>3</sub> = <b>0.40</b>	K <sub>3</sub> = <b>0.40</b>					
Bending coefficient k <sub>4</sub>		K <sub>4</sub> = 1.00 ×	(0.6 + 0.0014	′ε <sub>cu2</sub> ) <b>=1.00</b>				
Reinforcement details								
Characteristic yield strength	of reinforcement	f <sub>yk</sub> = <b>500</b> N/	/mm²					
Modulus of elasticity of reinfo	orcement	E <sub>s</sub> = <b>20000</b>	<b>0</b> N/mm <sup>2</sup>					
Partial factor for reinforcing	steel - Table 2.1N	γs <b>= 1.15</b>						
Design yield strength of rein	forcement	$f_{yd}$ = $f_{yk}$ / $\gamma_S$	= <b>435</b> N/mm <sup>2</sup>					
Cover to reinforcement								
Front face of stem		c <sub>sf</sub> = <b>40</b> mn	า					
Rear face of stem		c <sub>sr</sub> = <b>50</b> mn	n					
Top face of base		c <sub>bt</sub> = <b>50</b> mn	n					
Bottom face of base		c <sub>bb</sub> = <b>75</b> mr	n					

![](_page_20_Figure_1.jpeg)

elliott <b>wood</b>	Project 12 Pilgrim's Lane				Job no. 2210419	
55 Whitfield Street London	Calcs for Preliminary Retaining Wall				Start page no./Revision 5	
W1T 4AH	Calcs by PDu	Calcs date 30/06/2022	Checked by DBa	Checked date 29/06/2022	Approved by DBa	Approved date 29/06/2022

![](_page_21_Figure_1.jpeg)

Check stem design at 1734 mm	
Depth of section	h = <b>250</b> mm
Rectangular section in flexure - Section 6.1	
Design bending moment combination 1	M = <b>32.7</b> kNm/m
Depth to tension reinforcement	$d = h - c_{sf} - \phi_{sx} - \phi_{sfM} / 2 = 192 \text{ mm}$
	$K = M / (d^2 \times f_{ck}) = 0.030$
	$K' = (2 \times \eta \times \alpha_{cc} / \gamma_{C}) \times (1 - \lambda \times (\delta - K_{1}) / (2 \times K_{2})) \times (\lambda \times (\delta - K_{1}) / (2 \times K_{2}))$
	K' = 0.207
	K' > K - No compression reinforcement is required
Lever arm	z = min(0.5 + 0.5 × (1 - 2 × K / ( $\eta \times \alpha_{cc}$ / $\gamma_{C}$ )) <sup>0.5</sup> , 0.95) × d = <b>182</b> mm
Depth of neutral axis	x = 2.5 × (d − z) = <b>24</b> mm
Area of tension reinforcement required	$A_{sfM.req} = M / (f_{yd} \times z) = 413 mm2/m$
Tension reinforcement provided	12 dia.bars @ 200 c/c
Area of tension reinforcement provided	$A_{sfM,prov} = \pi \times \phi_{sfM}^2 / (4 \times s_{sfM}) = 565 \text{ mm}^2/\text{m}$
Minimum area of reinforcement - exp.9.1N	$A_{sfM.min} = max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d = 289 \text{ mm}^2/\text{m}$
Maximum area of reinforcement - cl.9.2.1.1(3)	$A_{sfM.max} = 0.04 \times h = 10000 \text{ mm}^2/\text{m}$
	max(A <sub>sfM.req</sub> , A <sub>sfM.min</sub> ) / A <sub>sfM.prov</sub> = <b>0.73</b>

PASS - Area of reinforcement provided is greater than area of reinforcement required

Library item: Rectangular single output

Deflection control - Section 7.4	
Reference reinforcement ratio	$\rho_0 = \sqrt{(f_{ck} / 1 \text{ N/mm}^2) / 1000} = 0.005$
Required tension reinforcement ratio	$\rho = A_{sfM.req} / d = 0.002$
Required compression reinforcement ratio	ρ' = A <sub>sfM.2.req</sub> / d <sub>2</sub> = <b>0.000</b>
Structural system factor - Table 7.4N	K <sub>b</sub> = 1
Reinforcement factor - exp.7.17	$K_s = min(500 \text{ N/mm}^2 / (f_{yk} \times A_{sfM.req} / A_{sfM.prov}), 1.5) = 1.37$
Limiting span to depth ratio - exp.7.16.a	$min(K_s \times K_b \times [11 + 1.5 \times \sqrt{(f_{ck} / 1 N/mm^2)} \times \rho_0 / \rho + 3.2 \times \sqrt{(f_{ck} / 1 N/mm^2)})$
	N/mm <sup>2</sup> ) × ( $\rho_0$ / $\rho$ - 1) <sup>3/2</sup> ], 40 × K <sub>b</sub> ) = <b>40</b>
Actual span to depth ratio	h <sub>prop</sub> / d = <b>15.6</b>
	PASS - Span to depth ratio is less than deflection control limit

	12 Pilgrim's Lane 2210419					10419		
55 Whitfield Street	alcs for				Start page no./I	Revision		
London		Preliminary F	Retaining Wall			6		
W1T 4AH	alcs by	Calcs date	Checked by	Checked date	Approved by	Approved d		
	PDu	30/06/2022	DBa	29/06/2022	DBa	29/06/20		
Crack control - Section 7.3								
Limiting crack width		w <sub>max</sub> = <b>0.3</b> I	mm					
Variable load factor - EN1990 – Ta	able A1.1	ψ <sub>2</sub> = <b>0.6</b>						
Serviceability bending moment		M <sub>sls</sub> = <b>21.1</b>	kNm/m					
Tensile stress in reinforcement		$\sigma_{s}$ = M <sub>sls</sub> / (	$A_{sfM.prov} \times z) = 2$	<b>204.8</b> N/mm <sup>2</sup>				
Load duration		Long term						
Load duration factor		kt = <b>0.4</b>						
Effective area of concrete in tension	on	A <sub>c.eff</sub> = min(	(2.5 × (h - d), (l	h - x) / 3, h / 2)				
		A <sub>c.eff</sub> = <b>753</b>	<b>33</b> mm²/m					
Mean value of concrete tensile stre	ength	$f_{ct.eff} = f_{ctm} =$	<b>2.9</b> N/mm <sup>2</sup>					
Reinforcement ratio		$\rho_{p.eff} = A_{sfM,j}$	prov / A <sub>c.eff</sub> = <b>0.0</b>	08				
Modular ratio		$\alpha_{e} = E_{s} / E_{c}$	m = 6.091					
Bond property coefficient		k <sub>1</sub> = <b>0.8</b>						
Strain distribution coefficient		k <sub>2</sub> = <b>0.5</b>						
		k <sub>3</sub> = <b>3.4</b>						
		k <sub>4</sub> = <b>0.425</b>						
Maximum crack spacing - exp.7.17	$s_{r.max} = k_3 \times$	$c_{sf} + k_1 \times k_2 \times k_2$	$k_4 \times \varphi_{sfM} \ / \ \rho_{p.eff} = 4$	<b>108</b> mm				
Maximum crack width - exp.7.8		$W_k = S_{r.max} >$	$<$ max( $\sigma_s$ – k <sub>t</sub> $\times$	(f <sub>ct.eff</sub> / $\rho_{p.eff}$ ) × (1 +	+ α <sub>e</sub> × ρ <sub>p.eff</sub> ), 0	$.6 \times \sigma_s) / E_s$		
		w <sub>k</sub> = <b>0.251</b>	mm					
		$w_k / w_{max} =$	0.835					
		PASS	- Maximum c	rack width is les	s than limitir	ng crack wi		
Check stem design at base of st	tem							
Depth of section		h = <b>250</b> mr	n					
Rectangular section in flexure -	Section 6.1							
Design bending moment combinat	tion 1	M = <b>66.4</b> kl	Nm/m					
Depth to tension reinforcement		d = h - c <sub>sr</sub> -	$\phi_{sr}$ / 2 = <b>192</b> m	าท				
		K = M / (d²	× f <sub>ck</sub> ) = <b>0.060</b>					
		K' = (2 × η	× α <sub>cc</sub> /γc)×(1 - λ	$\lambda \times (\delta - K_1)/(2 \times K_2)$	))×(λ × (δ - K <sub>1</sub>	)/(2 × K <sub>2</sub> ))		
		K' = <b>0.207</b>						
Lovor arm		$z = \min(0.5)$	<b>~ ~ ~ ~</b>	K / (m x q / yo)		– 191 mm		
		z = 1111(0.5)	(1 - 2) = 27 mm	$\times$ K / (II $\times$ Ucc / $\gamma$ C)	)**, 0.93) × u	- 101 11111		
Area of tanaian nainfanaanant nam	بالمع ما	X - 2.5 × (0	(f - 2) - 21 (((((					
Area or tension reinforcement requ	urea	Asr.req = IVI /	$(1yd \times Z) = 843$	11111-/111				
Area of tension roinforcement area	vided	To uld. Dats ( $(100 \text{ G})^2$						
Minimum area of roinforcement		Asr.prov – $\pi$ >	×ψsr /(4+×Ssr)	- <b>2011</b> 11111-/111	280 mm <sup>2/m</sup>			
Maximum area of reinforcement - e	-xh.a. III			$y_{\rm K}$ , 0.0013) × a = 2	203      -/[[]			
waximum area or reinforcement -	0.9.2.1.1(3)	$A_{sr.max} = 0.0$	µ4 × ח = 10000 ∧	- 0 440				
D	ASS - Aros o	max(Asr.req,	Asr.min) / Asr.prov	/ - U.419 proator than area	of reinforce	ment room		
F7		, rennorcenieni		Li	brary item: Recta	ngular single o		
Deflection control - Section 7.4								
Reference reinforcement ratio		$ ho_0 = \sqrt{f_{ck}} / 2$	1 N/mm²) / 100	00 = <b>0.005</b>				
Required tension reinforcement ra	itio	$\rho = A_{sr,req} / $	d = <b>0.004</b>					
Required compression reinforcem	ent ratio	ρ' = A <sub>sr.2.rea</sub>	/ d <sub>2</sub> = <b>0.000</b>					

 $K_b = 1$ 

 $K_{s} = min(500 \text{ N/mm}^{2} / (f_{yk} \times A_{sr.req} / A_{sr.prov}), \ 1.5) = \textbf{1.5}$ 

Structural system factor - Table 7.4N

Reinforcement factor - exp.7.17

elliottwood	Project Job no.					
_		12 Pilgr	im's Lane		221	0419
55 Whitfield Street C London	Calcs for	Preliminary F	Retaining Wall		Start page no./Re	evision 7
W1T 4AH	Calcs by PDu	Calcs date 30/06/2022	Checked by DBa	Checked date 29/06/2022	Approved by DBa	Approved date 29/06/2022
Limiting span to depth ratio - exp.	.7.16.a	min(K₅ × Kı	₀ × [11 + 1.5 × √(	[f <sub>ck</sub> / 1 N/mm <sup>2</sup> ) ×	ρ₀ / ρ + 3.2 × ኀ	(f <sub>ck</sub> / 1
		N/mm²) × (	ρ₀ / ρ - 1) <sup>3/2</sup> ], 40	× K <sub>b</sub> ) = <b>35.1</b>		
Actual span to depth ratio		h <sub>prop</sub> / d = <b>1</b>	5.6			
		PASS	- Span to depth	n ratio is less th	an deflection	control limit
Crack control - Section 7.3						
Limiting crack width		w <sub>max</sub> = <b>0.3</b>	mm			
Variable load factor - EN1990 – T	able A1.1	ψ <sub>2</sub> = <b>0.6</b>				
Serviceability bending moment		M <sub>sls</sub> = <b>43.4</b>	kNm/m			
Tensile stress in reinforcement		$\sigma_{s}$ = M <sub>sls</sub> / (	A <sub>sr.prov</sub> × z) = <b>119</b>	<b>).1</b> N/mm <sup>2</sup>		
Load duration		Long term				
Load duration factor		k <sub>t</sub> = <b>0.4</b>				
Effective area of concrete in tensi	ion	A <sub>c.eff</sub> = min(	(2.5 × (h - d), (h - 49 mm²/m	- x) / 3, h / 2)		
Mean value of concrete tensile st	renath	$f_{c.eff} = f_{-t-r} =$	<b>2 9</b> N/mm <sup>2</sup>			
Reinforcement ratio	rongui	$O_{\rm R} = A_{\rm er} = A_{\rm er}$	$\Delta_{0.0} = 0.027$			
Modular ratio		pp.ell = Asr.pr	- 6 091			
Rond property coefficient		$u_e = E_s / E_c$	m – 0.091			
Strain distribution coefficient		$k_1 = 0.8$				
Strain distribution coefficient		k <sub>2</sub> = <b>3.4</b>				
		k <sub>4</sub> = 0.425				
Maximum crack spacing - exp.7.1	1	$s_{r,max} = k_3 \times$	$c_{sr} + k_1 \times k_2 \times k_2$	$4 \times \phi_{sr} / \rho_{p,eff} = 27$	<b>1</b> mm	
Maximum crack width - exp.7.8		Wk = Sr.max >	$\langle \max(\sigma_s - \mathbf{k}_t \times (\mathbf{f})) \rangle$	$_{\rm ct.eff}/\rho_{\rm p.eff}) \times (1 +$	$\alpha_{\rm e} \times \rho_{\rm p.eff}$ ). 0.6	$\delta \times \sigma_{\rm s}) / E_{\rm s}$
······································		w <sub>k</sub> = 0.097	mm		510 Pp.511, 515	
		$W_k / W_{max} =$	0.322			
		PASS	- Maximum cra	ck width is less	s than limiting	rack width
Rectangular section in shear -	Section 6.2					
Design shear force		∨ = 123.5 ∤	κN/m			
C C		C <sub>Rd,c</sub> = 0.18	3 / γc = <b>0.120</b>			
		k = min(1 +	- √(200 mm / d),	2) = <b>2.000</b>		
Longitudinal reinforcement ratio		$\rho_{\rm I} = \min(A_{\rm sl})$	(1, 1)	). 0.010		
5		$V_{min} = 0.03!$	$5 \text{ N}^{1/2}/\text{mm} \times \text{k}^{3/2}$	≺ f <sub>ck</sub> <sup>0.5</sup> = <b>0.542</b> N	/mm²	
Design shear resistance - exp.6.2	Pa & 6.2b	$V_{\text{Rd}c} = max$	$(C_{Rdc} \times \mathbf{k} \times (100))$	$N^2/mm^4 \times o \times f_c$	$(k)^{1/3}$ , $V_{min}$ × d	
g		V <sub>Rd c</sub> = <b>145</b>	.4 kN/m		, , , , , , <u>,</u>	
		$V / V_{Rd.c} = 0$	0.849			
		PAS	S - Design shea	ar resistance ex	ceeds desigr	n shear force
Check stem design at prop			-		-	
Depth of section		h = <b>250</b> mr	n			
Poctangular soction in flowure	Soction 6 4					
Design bending moment combine	tion 1	M = <b>6</b> kNm	/m			
Depth to tension reinforcement		$d = h - c_{m-1}$	 رفعت / ۲ = <b>197</b> mr	m		
		$K = M / (d^2)$	$y_{\text{sin}} = 0.005$			
		$k' = (2) + \frac{1}{2}$	$\sim 10 \text{ kg} = 0.000$	$(8 - \mathbf{K})/(2 - \mathbf{K})$	$(\lambda \times (S \times M))$	$(2 \vee \mathbf{k}_{2}))$
		r、 – (Ζ × η κ' – ο 207	$\times$ UccryCJ×(1 - $\wedge$ ×	$(0 - \pi_1)/(2 \times \pi_2)$	/^(∿ × (0 - №1)/	( <b>~</b> × 1\2 <i>))</i>
		rx – U.2U/	K' > K _ N	o compression	reinforcemer	nt is required
l ever arm		z = min/0 5	5+05×(1-2×	$K / (n \times \alpha_{co} / \gamma_{c})$	<sup>0.5</sup> 0 95) v d =	: 182 mm
		2 - mm(0.0	· · · · · · · · · · · · · · · · · · ·	$(1 \land (0 \land $	, 0.80) × u –	

elliottwooa			12 Pilgrim's Lane					
55 Whitfield Street London	Calcs for Start page Preliminary Retaining Wall		Start page no./I	Revision 8				
W1T 4AH	Calcs by	Calcs date Checked by Checked d			Approved by	by Approved		
	PDu	30/06/2022	DBa	29/06/2022	DBa	29/06/2		
Depth of neutral axis		x = 2.5 × (d	– z) = <b>24</b> mm					
Area of tension reinforceme	ent required	$A_{sr1.req} = M$	/ (f <sub>yd</sub> × z) = <b>76</b>	mm²/m				
Tension reinforcement prov	ided	16 dia.bars	@ 100 c/c					
Area of tension reinforceme	ent provided	$A_{sr1.prov} = \pi$	$\times \phi_{sr1}^2 / (4 \times s_{sr1})^2$	1) = <b>2011</b> mm²/m				
Minimum area of reinforcem	nent - exp.9.1N	A <sub>sr1.min</sub> = ma	$ax(0.26 \times f_{ctm} /$	$f_{yk}$ , 0.0013) × d =	<b>289</b> mm²/m			
Maximum area of reinforcer	nent - cl.9.2.1.1(3	) $A_{sr1.max} = 0.$	04 × h = <b>1000</b>	<b>)</b> mm²/m				
		max(A <sub>sr1.req</sub>	, A <sub>sr1.min</sub> ) / A <sub>sr1.p</sub>	prov = <b>0.144</b>				
	PASS - Area	of reinforcement	provided is g	reater than area	of reinforce	ment requ		
				Li	brary item: Recta	ngular single		
Deflection control - Section	on 7.4	115 1	NU 20 1 4 9 9					
Reference reinforcement ra	ແດ	$\rho_0 = \sqrt{t_{ck}} / 1$	N/mm <sup>2</sup> ) / 100	U = <b>U.005</b>				
Required tension reinforcen	nent ratio	$\rho = A_{sr1.req} / $	a = v.vv0					
Required compression reinf	orcement ratio	$\rho' = A_{sr1.2.req}$	/ d <sub>2</sub> = <b>0.000</b>					
Structural system factor - 1a	able 7.4N	K <sub>b</sub> = <b>0.4</b>	2.1.15					
Reinforcement factor - exp.	7.17	$K_s = min(50)$	00 N/mm² / (t <sub>yk</sub>	× Asr1.req / Asr1.prov	), 1.5) = <b>1.5</b>	1		
Limiting span to depth ratio	- exp.7.16.a	$min(K_s \times K_t)$	× [11 + 1.5 ×	√(f <sub>ck</sub> / 1 N/mm²) ×	ρ₀ / ρ + 3.2 ×	√(f <sub>ck</sub> / 1		
		N/mm²) × ( <sub>I</sub>	ο <sub>0</sub> / ρ - 1) <sup>3/2</sup> ], 40	0 × K <sub>b</sub> ) = <b>16</b>				
Actual span to depth ratio		(h <sub>stem</sub> - h <sub>prop</sub>	$(n_{\text{stem}} - n_{\text{prop}}) / d = 3.1$					
		PASS	- Span to dep	th ratio is less ti	nan deflectio	n control		
Crack control - Section 7.3	3							
Limiting crack width		$W_{max} = 0.3$ r	nm					
Variable load factor - EN19		$\psi_2 = 0.6$						
Serviceability bending mom	ent	$M_{sls} = 3.4 \text{ KNM/m}$						
	ent	σ <sub>s</sub> – IVIsis / (/	Asr1.prov × Z) – S	.4 N/IIIII-				
Load duration factor		k, = <b>0 4</b>						
Effective area of concrete in	tension	$A_{c,eff} = min($	$A_{a,aff} = \min(2.5 \times (h - d) (h - x) / 3 h / 2)$					
		$A_{c,eff} = 7533$	<b>33</b> mm²/m	,,, 0,, 2)				
Mean value of concrete tens	sile strength	$f_{ct.eff} = f_{ctm} =$	<b>2.9</b> N/mm <sup>2</sup>					
Reinforcement ratio	0	$\rho_{p.eff} = A_{sr1.p}$	rov / A <sub>c.eff</sub> = <b>0.0</b> 2	27				
Modular ratio		$\alpha_{e} = E_{s} / E_{c}$	m = <b>6.091</b>					
Bond property coefficient		k <sub>1</sub> = <b>0.8</b>						
Strain distribution coefficien	t	k <sub>2</sub> = <b>0.5</b>						
		k <sub>3</sub> = <b>3.4</b>						
		k <sub>4</sub> = <b>0.425</b>						
Maximum crack spacing - e	xp.7.11	$s_{r.max} = k_3 \times$	$c_{sr} \textbf{+} \textbf{k}_1 \times \textbf{k}_2 \times$	$k_4 \times \phi_{sr1} / \rho_{p.eff} = 2$	272 mm			
Maximum crack width - exp	.7.8	$W_k = S_{r.max} \times$	max( $\sigma_s - k_t \times$	$(f_{ct.eff} / \rho_{p.eff}) \times (1 +$	• α <sub>e</sub> × ρ <sub>p.eff</sub> ), 0	.6 × σs) / E		
		w <sub>k</sub> = <b>0.008</b>	mm					
		$W_k / W_{max} =$	0.026					
		PASS	- Maximum ci	rack width is les	s than limitir	ng crack v		
Rectangular section in sh	ear - Section 6.2							
Design shear force		V = 57.6 kM	l/m					
		$C_{Rd,c} = 0.18$	s / γc = <b>0.120</b>					
		k = min(1 +	√(200 mm / d	), 2) = <b>2.000</b>				
Longitudinal reinforcement	ratio	$\rho_{\rm l} = \min(A_{\rm sr})$	<sub>1.prov</sub> / d, 0.02)	= 0.010				
		v <sub>min</sub> = 0.035	$5 \text{ N}^{1/2}/\text{mm} \times \text{k}^{3/2}$	<sup>2</sup> × f <sub>ck</sub> <sup>0.5</sup> = <b>0.542</b> N	l/mm²			

elliott <b>wood</b>	Project	12 Pilar	m's Lane		Job no.	10419
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		Preliminary F	Retaining Wall		Start page no./	9
WIT 4AH	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	PDu	30/06/2022	DBa	29/06/2022	DBa	29/06/2022
Design shear resistance - exp	.6.2a & 6.2b	V <sub>Rd.c</sub> = max V <sub>Rd.c</sub> = <b>145</b> V / V <sub>Rd.c</sub> = (	:(C <sub>Rd.c</sub> × k × (10 .4 kN/m ).396	$100 \text{ N}^2/\text{mm}^4 \times \rho_1 \times \text{f}$	$_{\rm ck})^{1/3},{\sf V}_{\rm min}) imes {\sf d}$	
		PAS	S - Design sh	ear resistance e	xceeds desig	gn shear force
Horizontal reinforcement pa	rallel to face of s	tem - Section 9	9.6		_	
Minimum area of reinforcemen	nt – cl.9.6.3(1)	A <sub>sx.req</sub> = ma	x(0.25 × Asr.prov	v, 0.001 × t <sub>stem</sub> ) = $t$	503 mm²/m	
Maximum spacing of reinforce	ment – cl.9.6.3(2)	s <sub>sx_max</sub> = <b>40</b>	0 mm			
I ransverse reinforcement pro	vided	12 dia.bars	@ 200 c/c	2/		
Area of transverse reinforcem	ent provided	$A_{sx.prov} = \pi$	< φ <sub>sx</sub> ² / (4 × S <sub>sx</sub> )	) = <b>565</b> mm²/m		
	PASS - Area of	reinforcement	provided is g	reater than area	of reinforce	ment required
Check base design at toe						
Depth of section		h = <b>400</b> mr	n			
Rectangular section in flexu	re - Section 6.1					
Design bending moment coml	pination 1	M = <b>77.4</b> k	Nm/m			
Depth to tension reinforcemer	ıt	d = h - c <sub>bb</sub> -	- φ <sub>bb</sub> / 2 <b>= 317</b> r	nm		
		$K = M / (d^2)$	× f <sub>ck</sub> ) = <b>0.026</b>			
		K' = (2 × η	× α <sub>cc</sub> /γ <sub>C</sub> )×(1 - λ	$\times (\delta - K_1)/(2 \times K_2)$	))×(λ × (δ - K <sub>1</sub>	)/(2 × K <sub>2</sub> ))
		K' = <b>0.207</b>				
			K' > K -	No compression	reinforceme	ent is required
Lever arm		z = min(0.5	+ 0.5 × (1 - 2	× K / ( $\eta$ × $\alpha_{cc}$ / $\gamma_c$ )	) <sup>0.5</sup> , 0.95) × d	= <b>301</b> mm
Depth of neutral axis		x = 2.5 × (c	−z) = <b>40</b> mm			
Area of tension reinforcement	required	$A_{bb.req} = M$	$(f_{yd} \times z) = 591$	mm²/m		
Tension reinforcement provide	ed	16 dia.bars	@ 100 c/c			
Area of tension reinforcement	provided	$A_{bb.prov} = \pi$	$\times \phi_{bb}^2 / (4 \times s_{bb})$	) = <b>2011</b> mm²/m		
Minimum area of reinforcement	nt - exp.9.1N	A <sub>bb.min</sub> = ma	$ax(0.26 \times f_{ctm} / f_{ctm})$	$f_{yk}$ , 0.0013) × d = 4	<b>477</b> mm²/m	
Maximum area of reinforceme	nt - cl.9.2.1.1(3)	$A_{bb.max} = 0.$	04 × h = <b>16000</b>	<b>)</b> mm²/m		
		max(A <sub>bb.req</sub>	A <sub>bb.min</sub> ) / A <sub>bb.pro</sub>	<sub>pv</sub> = <b>0.294</b>		
	PASS - Area of	reinforcement	provided is g	reater than area	of reinforce	ment required
				Li	brary item: Recta	ngular single output
Crack control - Section 7.3						
	<b>T</b> 11 A4 4	$W_{max} = 0.3$	nm			
Variable load factor - EN1990		$\psi_2 = 0.6$	LeN line /ine			
Serviceability bending momen	۱L ۰	$ V _{sis} = 50.3$	KIN(T)/TT	$20 \text{ M/mm}^2$		
	it.	σ <sub>s</sub> – Misis / (	Abb.prov × Z) – 9	2.9 N/IIIII-		
Load duration factor						
Effective area of concrete in te	ansion	$A_{1} = min($	$2.5 \times (h_{-}d)$ (l	(x - x)/3 + (2)		
		Δ	<u>2.5 ^ (ii - u), (i</u> 125 mm²/m	1 - Aj / J, 11 / Z)		
Mean value of concrete tensile	e strength	$f_{\text{ct off}} = f_{\text{ctro}} =$	<b>2.9</b> N/mm <sup>2</sup>			
Reinforcement ratio	- sa sa gai	$O_{\text{D} \text{ eff}} = A_{\text{bb}}$	$r_{OV} / A_{c eff} = 0.01$	17		
Modular ratio		$\alpha_{\rm e} = F_{\rm e} / F_{\rm e}$	m = 6.091			
Bond property coefficient		k1 = 0.8				
Strain distribution coefficient		k <sub>2</sub> = 0.5				
		k <sub>3</sub> = <b>3.4</b>				
		k <sub>4</sub> = <b>0.425</b>				
Maximum crack spacing - exp	.7.11	$s_{r.max} = k_3 \times$	$c_{\text{bb}} \textbf{+} \textbf{k}_1 \times \textbf{k}_2 \times$	$k_4 \times \phi_{bb} \ / \ \rho_{p.eff} = \textbf{4}$	<b>18</b> mm	

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		12 Pilgri	m's Lane		22	10419
55 Whitfield Street London	Calcs for	Preliminary F	Start page no./Revision 10			
W1T 4AH	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	PDu	30/06/2022	DBa	29/06/2022	DBa	29/06/2022
Maximum crack width - exp.7	7.8	Wk = Sr.max ×	× max(σ <sub>s</sub> – k <sub>t</sub> ×	$(f_{ct.eff} / \rho_{p.eff}) \times (1 +$	$\alpha_{e} \times \rho_{p,eff}$ ). 0	.6 × σs) / Es
		w <sub>k</sub> = 0.116	mm	(1000) (1	ere percent, er	
		w <sub>k</sub> / w <sub>max</sub> =	0.388			
		PASS	- Maximum c	rack width is les	s than limitin	ng crack width
Rectangular section in she	ar - Section 6.2					
Design shear force		∨ = 103.2 k	κN/m			
		$C_{Rd,c} = 0.18$	8 / γc = <b>0.120</b>			
		k = min(1 +	√(200 mm / d	), 2) = <b>1.794</b>		
Longitudinal reinforcement ra	atio	ρι = min(A <sub>bl</sub>	<sub>o.prov</sub> / d, 0.02) :	= 0.006		
		v <sub>min</sub> = 0.035	$5 \text{ N}^{1/2}/\text{mm} \times \text{k}^{3/2}$	$^{2} \times f_{ck}^{0.5} = 0.461 \text{ N}$	/mm²	
Design shear resistance - ex	p.6.2a & 6.2b	V <sub>Rd.c</sub> = max	$(C_{Rd.c} \times k \times (10))$	00 N <sup>2</sup> /mm <sup>4</sup> × $\rho_l$ × for	ck) <sup>1/3</sup> , Vmin) $ imes$ d	
		V <sub>Rd.c</sub> = <b>182</b> .	. <b>2</b> kN/m			
		$V / V_{Rd.c} = 0$	).566			
		PAS	S - Design sh	ear resistance ex	xceeds desig	yn shear force
Secondary transverse rein	forcement to bas	se - Section 9.3		• 3/		
Minimum area of reinforceme	ent – cl.9.3.1.1(2)	$A_{bx.req} = 0.2$	$\times A_{bb,prov} = 40$	<b>2</b> mm²/m		
Maximum spacing of reinforce	cement – cl.9.3.1.	$1(3)$ S <sub>bx_max</sub> = <b>45</b>	<b>u</b> mm @ 200 do			
Area of transverse reinforcement pr			$(\frac{1}{2}) = \frac{2}{1} \frac{1}{1} $	$- \mathbf{E}\mathbf{E}\mathbf{E} \mathbf{m}^{2}/\mathbf{m}$		
Area of transverse reinforcer		Abx.prov - n	× ψ <sub>bx</sub> - / (4 × S <sub>bx</sub> ,	roator than area	of roinforco	mont roquiroo
	FASS - Alea	orrennorcement	provided is g	leater than area	orrennorce	inent required
		40-►	<b>4</b> −50			
		12 dia.bars @ 200 c/c horizontal reinforcement parallel to face of stem				
		12 dia.bars @ 200 c/c	— 16 dia.bars @ 100 c/c			
		11				
		11				
		12 dia.bars @ 200 c/c	— 12 dia.bars @ 200 c/c			
		11				
		12 dia.bars @ 200 c/c	16 dia.bars @ 100 c/c			
	150	12 Uld.Val S @ 200 C/C	50 ↓			
	τĮ		<u>↓</u>			
		16 dia bars @ 100 c/c	<b>↑</b> 75			

16 dia.bars @ 100 c/c 12 dia.bars @ 200 c/c transverse reinforcement in base

Reinforcement details

elliottwood	Project				Job no.	
		12 Pilgrii	2210419			
55 Whitfield Street	Calcs for	Calcs for			Start page no./Revision	
London	Preliminary Retaining Wall			11		
W1I 4AH	Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	PDu	30/06/2022	DBa	29/06/2022	DBa	29/06/2022