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PREAMBLE

- 1. The calculations that follow form part only of the overall application submitted for Building Control Approval and are based upon drawings prepared by others. Dimensions used in calculations have been scaled/obtained from such drawings.
- 2. The purpose of the calculations is to justify the use of identified structural members as shown on plans, or to determine minimum sizes necessary to comply with relevant Standards where sizes have either not been shown on plans or have proved to be undersized. Should sizes calculated conflict with those shown on plans the most structurally beneficial shall be adopted and it is the responsibility of the drawing originator to amend plans as appropriate.
- 3. The calculations are in respect only of those structural elements to which they specifically refer. No responsibility or liability is therefore accepted in respect of any other element or part of the building.
- 4. The contractor is to take all necessary precautions to ensure the safety of the building and its stability during all stages of the proposed works.
- 5. Any alterations to the drawings or any on site discrepancies or changes affected on site during construction should be notified to the Structural Engineer in writing, with specific instructions to accommodate the changes made as such changes could materially affect the sizes of the structural members that have been designed, approved and adopted on plans.
- 6. In any event, all work shall be made available for inspection by, and shall be to the entire satisfaction of, the Local Authority Building Control Inspector or other Approved Inspector.
- 7. No work appertaining to the plans should be carried out until the plans and calculations have been examined by the appropriate Local/Statutory Authority and formal written approval obtained. Any works carried before such approval is obtained, either for the original Application or revised information, is done solely at the Contractor's/Owners own risk. No works relating to these calculations should be carried out if 'Conditional Approval Subject to Calculations' is granted by the Local Authority.
- 8. No site visits are to be made by the Engineer during the course of construction unless specifically requested in writing.

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GENERAL NOTES

- 1. For setting out dimensions and general construction details, see Architect's Drawings. Any Engineer's sketch or drawings must not be scaled.
- 2. Contractor to check all dimensions and levels prior to commencing any construction or fabrication.
- 3. Any sketch, drawing or specification is to be read in conjunction with all other sketches, drawings or specifications relating to the project.
- 4. Where site or adjoining building details are at variance with issued details the Engineer is to be informed immediately in writing.
- 5. The contractor is to ensure the stability of each element and the whole building until the construction is complete.
- 6. All designs, connections, workmanship and materials are to comply with current Building Regulations, relevant British Standards, Codes of Practice, Manufacturers recommendations and Engineer details.
- 7. No structural members are to be cut, notched or jointed unless specified.
- 8. Proprietary structural elements, fixings or admixtures may only be used with Engineer's approval and to manufacturers' recommendations.
- 9. Unless noted otherwise, all connections (including laps and anchorage of any reinforcement in concrete) shall mobilize the full structural capacity of the member.
- 10. All boiled connections of steelwork shall have a minimum of 2 bolts.
- 11. All structural connections of timber to be formed using double-sided timber connectors and bolts with large washers.
- 12. No holes of any size to be formed in structural members unless specified by the Engineer or approval by him in writing.

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LOADING (kN/m ²)							
LOADING (kN/m ²) The following loading is ge PITCHED ROOF:	enerally con Tiles	sidered in the	design of s	structural ele 0.55	<u>ments.</u>		

			1.30	
FLAT ROOF:	Chipping's and Bitumen	0.20		
	Three Layers Felt		0.10	
	Boarding, Joists	0.29		
	Insulation		0.05	
	Plasterboard & Skim		0.18	
	IMPOSED		<u>0.75</u>	
			1.55	
LOFT / CEILING:	Joists / Boarding		0 12	
	Insulation		0.03	
	Plasterboard and Skim	0.18		
	IMPOSED		0.25	
			0.58	
FLOOR:	Boarding		0.13	
	Joists		0.17	
	Plasterboard and Skim	0.20		
	IMPOSED		<u>1.50</u>	
			2.00	
STUD WALL:	Studs and Noggins		0.09	
	Insulation		0.03	
	Plasterboard and Skim	0.36		
			0.48	
	Drieke		0.45	
TOOMIN BRICK WALL:	Bricks Blactor and Skim x 2		2.15	
	Flaster and Skill X Z		2.85	
			2.05	
215mm BRICK WALL:	Bricks		4.30	
	Render, Plaster and Skim		<u>0.70</u>	
			5.00	
CAVITY WALL:	102 Brick		2.15	
 -	125 Block + Insulation		0.58	
	Plaster and Skim		0.35	
			3.08	
GLASS BRICK WALL:	102 Brick		2.45	
	50 Brick		1.2	

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BASEMENT RETAINING WALL & SLAB DESIGN

BASEMENT SLAB

Loading:

Self-weight = $0.15x25kN/m^3 = 3.75kN/m^2$

Screed/Insulation = 0.075mx23kN/m³ = 1.73kN/m²

Variable load due to imposed loading on the slab surface = 1.5kN/m²

Variable load due to uplift pressure from the water (assuming 3m of waterhead) = 10kN/m³ x 3m = 30kN/m²

Span moment due to gravity loads = (1.35 x 5.48 + 1.5x1.5) x 2.5²/8 = 7.53kNm/m

Span moment due to uplift pressure = $(1.35x5.48 - 1.5x30) \times 2.5^2/8$ (conservatively ignore imposed load) = -29.37kNm/m Maximum Shear Force = 37.6kN x 2.5/2 = 47.0kN

RC SLAB DESIGN

In accordance with EN1992-1-1:2004 incorporating corrigendum January 2008 and the UK national annex



Basement Infill Slab

Short span direction

Short span direction

h = **150** mm

l_x = **2500** mm

l_y = **2500** mm

Two way spanning with restrained edges

Four edges continuous (interior panel)

kN/m²

Slab definition

Slab reference name; Type of slab; Overall slab depth; Shorter effective span of panel; Longer effective span of panel; Support conditions; Top outer layer of reinforcement; Bottom outer layer of reinforcement;

Loading

Characteristic permanent action;	G _k = 5.5 kN/m ²
Characteristic variable action;	Q _k = 28.5 kN/m ²
Partial factor for permanent action;	γ _G = 1.35
Partial factor for variable action;	γ _Q = 1.50
Quasi-permanent value of variable action;	ψ2 = 0.30
Design ultimate load;	$\textbf{q} = \gamma_G \times G_k + \gamma_Q \times Q_k = \textbf{50.1} \text{ kN/m}^2$
Quasi-permanent load;	$q_{\text{SLS}} = 1.0 \times G_k + \psi_2 \times Q_k = \textbf{14.0 kN}$

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Concrete properties							
Concrete strength class;		C25/30					
Characteristic cylinder strength;		f _{ck} = 25 N/	mm ²				
Partial factor (Table 2.1N);		γc = 1.50					
Compressive strength factor (cl.	3.1.6);	αcc = 0.85					
Design compressive strength (c	l. 3.1.6);	f _{cd} = 14.2	N/mm²				
Mean axial tensile strength (Tab	ole 3.1);	$f_{ctm} = 0.30$	$N/mm^2\times (f_{ck}$	/ 1 N/mm ²) ^{2/3} =	2.6 N/mm ²		
Maximum aggregate size;		d _g = 20 m	m				
Reinforcement properties							
Characteristic yield strength;		f _{yk} = 500 N	√mm²				
Partial factor (Table 2.1N);		γs = 1.15					
Design yield strength (fig. 3.8);		$f_{yd} = f_{yk} / \gamma_{yd}$	s = 434.8 N/m	nm²			
Concrete cover to reinforcem	ent						
Nominal cover to outer top reinf	orcement;	c _{nom_t} = 30	mm				
Nominal cover to outer bottom r	einforcement;	Cnom_b = 50	0 mm				
Fire resistance period to top of s	slab;	R _{top} = 30 r	min				
Fire resistance period to bottom	of slab;	R _{btm} = 30	min				
Axia distance to top reinft (Table	∋ 5.8);	a _{fi_t} = 10 n	nm				
Axia distance to bottom reinft (T	able 5.8);	a _{fi_b} = 10 r	nm				
Min. top cover requirement with	regard to bond	; C _{min,b_t} = 1	0 mm				
Min. btm cover requirement with	regard to bond	l; C _{min,b_b} = 1	0 mm				
Reinforcement fabrication;		Not subje	ect to QA sys	stem			
Cover allowance for deviation;		Δc_{dev} = 10	mm				
Min. required nominal cover to t	op reinft;	Cnom_t_min =	= 20.0 mm				
Min. required nominal cover to b	oottom reinft;	Cnom_b_min	= 20.0 mm				
			PASS - The	re is sufficient	cover to the top	o reinforcement	
		PA	SS - There is	sufficient cov	ver to the botton	n reinforcement	

Reinforcement design at midspan in short span direction (cl.6.1)

βsx_p = 0.0240
$M_{x_p} = \beta_{sx_p} \times q \times I_x^2 = 7.5 \text{ kNm/m}$
A393 mesh
A _{sx_p} = 393 mm²/m
$d_{x_p} = h - c_{nom_b} - \phi_{x_p} / 2 = 95.0 \text{ mm}$
$K = M_{x_p} / (b \times d_{x_p}^2 \times f_{ck}) = 0.033$
δ = 1.0
K' = $0.598 \times \delta - 0.18 \times \delta^2 - 0.21 = 0.208$
K < K' - Compression reinforcement is not required
z = min(0.95 × d _{x_p} , d _{x_p} /2 × (1 + (1 - $3.53 \times K)^{0.5}$)) = 90.2 mm

 $A_{sx_p} = M_{x_p} / (f_{yd} \times z) = 192 \text{ mm}^2/\text{m}$

 $A_{sx_p_req} = max(A_{sx_p_m}, A_{sx_p_min}) = 192 \text{ mm}^2/\text{m}$

Area of reinforcement required for bending; Minimum area of reinforcement required; Area of reinforcement required;

Check reinforcement spacing

Reinforcement service stress; Maximum allowable spacing (Table 7.3N); Actual bar spacing; $\sigma_{sx_p} = (f_{yk} / \gamma_S) \times min((A_{sx_p_m}/A_{sx_p}), 1.0) \times q_{SLS} / q = 59.3 \text{ N/mm}^2$ $s_{max_x_p} = 300 \text{ mm}$ $s_{x_p} = 200 \text{ mm}$

 $A_{sx_p_min} = max(0.26 \times (f_{ctm}/f_{yk}) \times b \times d_{x_p}, 0.0013 \times b \times d_{x_p}) = \textbf{127} \text{ mm}^2/\text{m}$

PASS - Area of reinforcement provided exceeds area required

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			PAS	S - The reinfo	rcement spacing	g is acceptable
Reinforcement design at mids	pan in long	span direction (c	l.6.1)			
Bending moment coefficient;		β _{sy_p} = 0.0 2	240			
Design bending moment;		$M_{y_p} = \beta_{sy_p}$	$p \times q \times l_x^2 = 7.$. 5 kNm/m		
Reinforcement provided;		A393 mes	ן גענייני אין אין אין אין אין אין אין אין אין אי			
Area provided;		$A_{sy_p} = 393$	3 mm²/m			
Effective depth to tension reinfo	rcement;	$d_{y_p} = h - c$	nom_b = φx_p = φ	_{by_p} / 2 = 85.0 m	im	
K factor;		$K = M_{y_p}$	$(b \times d_{y_p^2} \times t_{ck})$	() = 0.042		
Redistribution ratio;		$\delta = 1.0$	a a (a a'	2		
K' factor;		K' = 0.598	× ð - 0.18 × ð	² - 0.21 = 0.20	\$ 	·
			K < K' -			is not required
Lever arm;		z = min(0.5)	95 × 0y_p, 0y_p/	$2 \times (1 + (1 - 3))$	$53 \times (1000) = 80.7$	mm
Area of reinforcement required f	or bending;	$A_{sy_p_m} = N$	/ly_p / (Tyd × Z) =	= 214 mm²/m	0.0040 1	
Minimum area of reinforcement	requirea;	$A_{sy_p_min} =$	$\max(0.26 \times (10))$	ctm/Tyk) × D × Qy_	p, U.UU13×D×dy_p) = 113 mm²/m
Area of reinforcement required,		Asy_p_req =	Παχ(Asy_p_m, F	Asy_p_min) = 214		s area required
		FAS			i ovided exceed	s alea leguileu
Check reinforcement spacing		15				2 N/
Reinforcement service stress;		$\sigma_{sy_p} = (f_{yk})$	/ γs) × min((As	sy_p_m/Asy_p), 1.0	$(0) \times q_{SLS} / q = 66$.3 N/mm²
Maximum allowable spacing (1a	adie 7.3N);	$S_{max_y_p} = 3$	500 mm			
Actual bar spacing,		Sy_p = 200	PAS	S - The reinfo	rcement snacin	n is accentable
Poinforcoment design at cont		ort in chart onen	direction (al	6 1)	oomon opaam	
Reimorcement design at cont	inuous supp		arrection (ci	.0.1)		
Design bonding moment:		psx_n – 0.0.	$x a x l^2 = 0$	7 kNm/m		
Beinforcement provided:		$Mix_n - psx_$	n × y × ix – 3. n + 10 mm dia	a bare at 200 n	nm centres	
Area provided		$A_{sx,n} = 78f$	S mm ² /m	a. bars at 200 h		
Effective depth to tension reinfo	rcement:	$d_{x,n} = h - c$	$\sin \phi t = \phi t n / 2$	= 115.0 mm		
K factor:	loomont,	$K = M_{X,n} / J$	$(b \times d_{x n^2} \times f_{ck})$) = 0.029		
Redistribution ratio:		$\delta = 1.0$,		
K' factor:		K' = 0.598	$\times \delta$ - 0.18 $\times \delta^{3}$	² - 0.21 = 0.20 8	3	
,			K < K' -	Compression	n reinforcement	is not required
Lever arm;		z = min(0.9	95 × dx n, dx n/	/2 × (1 + (1 - 3.	53×K) ^{0.5})) = 109. 2	2 mm
Area of reinforcement required f	or bending;	$A_{sx_n_m} = N$	/l _{x_n} / (f _{yd} × z) =	= 205 mm²/m		
Minimum area of reinforcement	required;	A _{sx_n_min} =	$max(0.26 \times (f_{c}))$	$_{\rm ctm}/f_{\rm yk}) imes b imes d_{\rm x}$	_n, 0.0013×b×d _{x_n}) = 153 mm²/m
Area of reinforcement required;	•	A _{sx_n_req} =	max(A _{sx_n_m} , A	A _{sx_n_min}) = 205	mm²/m	
		PASS	S - Area of rei	inforcement p	rovided exceed	s area required
Check reinforcement spacing						
Reinforcement service stress;		$\sigma_{sx n} = (f_{yk}$	/ γs) × min((As	sx n m/Asx n), 1.(0) × q _{SLS} / q = 31 .	. 7 N/mm²
Maximum allowable spacing (Ta	able 7.3N);	Smax_x_n = 3	300 mm		<i>·</i> · · ·	
Actual bar spacing;		s _{x_n} = 100	mm			
			PAS	S - The reinfo	rcement spacing	g is acceptable
Reinforcement design at cont	inuous supp	ort in long span	direction (cl.	6.1)		
Bending moment coefficient;		β _{sy_n} = 0.03	320			
Design bending moment;		$M_{y_n} = \beta_{sy}$	$_{n} \times q \times l_{x}^{2} = 10$	0.0 kNm/m		
Reinforcement provided;		A393 mes	n + 10 mm dia	a. bars at 200 n	nm centres	

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Area provided;		A _{sy_n} = 786	mm²/m			
Effective depth to tension reinfor	cement;	d _{y_n} = h - c	nom_t - \$x_n - \$y_1	n / 2 = 105.0 mm		
K factor;		$K = M_{y_n} / ($	$b \times d_{y_n^2} \times f_{ck}$	= 0.036		
Redistribution ratio;		δ = 1.0				
K' factor;		K' = 0.598	$\times \delta$ - 0.18 $\times \delta^2$	- 0.21 = 0.208		
			K < K' - (Compression rei	nforcement i	s not require
Lever arm;		z = min(0.9	$0.05 \times d_{y_n}, d_{y_n}/2$	× (1 + (1 - 3.53×k	() ^{0.5})) = 99.7 r	nm
Area of reinforcement required for	or bending;	$A_{sy_n_m} = N$	$I_{y_n} / (f_{yd} \times z) =$	231 mm²/m		
Minimum area of reinforcement	equired;	A _{sy_n_min} = I	max($0.26 \times (f_{ctr})$	$_{n}/f_{yk}$) × b × d _{y_n} , 0.	0013×b×d _{y_n})	= 140 mm²/m
Area of reinforcement required;		$A_{sy_n_{req}} = r$	max(A _{sy_n_m} , A _s	y_n_min) = 231 mm	²/m	
		PASS	- Area of rein	forcement provi	ded exceeds	area require
Check reinforcement spacing						
Reinforcement service stress;		$\sigma_{sy n} = (f_{yk})$	/ γs) × min((A _{sv}	n m/Asy n), 1.0) × (q _{SLS} / q = 35.8	8 N/mm ²
Maximum allowable spacing (Table 7.3N);		$S_{max_y_n} = 3$	00 mm			
Actual bar spacing;		s _{y_n} = 100 i	mm			
			PASS	- The reinforcen	nent spacing	is acceptabl
Shear capacity check at short	span contin	uous support				
Shear force;	-	$V_{x_n} = q \times I$	_x / 2 = 62.7 kN/	'n		
Effective depth factor (cl. 6.2.2);		k = min(2.0), 1 + (200 mm	/ d _{x_n}) ^{0.5}) = 2.000		
Reinforcement ratio;		ρι = min(0 .0	02, A _{sx_n} / (b ×)	dx_n)) = 0.0068		
Minimum shear resistance (Exp.	6.3N);	V_{Rd,c_min} = 0.035 N/mm ² × k ^{1.5} × (f _{ck} / 1 N/mm ²) ^{0.5} × b × d _{x_n}				
		$V_{Rd,c_min} = $	56.9 kN/m			
Shear resistance (Exp. 6.2a);	V _{Rd,c_x_n} = ma	ax(V _{Rd,c_min} , (0.18 N	$1/mm^2 / \gamma_c$) × k	$ imes$ (100 $ imes$ $ ho_{l}$ $ imes$ (f _{ck} /	1 N/mm²)) ^{0.333}	$^{3} \times b \times d_{x_n}$)
		$V_{Rd,c_x_n} = $	71.0 kN/m			
				PASS - S	Shear capaci	ty is adequate
Shear capacity check at long	span continu	ous support				
Shear force;		$V_{y_n} = q \times I$	_x / 2 = 62.7 kN/	'n		
Effective depth factor (cl. 6.2.2);		k = min(2.0), 1 + (200 mm	$/ d_{y_n})^{0.5}) = 2.000$		
Reinforcement ratio;		ρι = min(0.0	D2, A_{sy_n} / (b ×)	dy_n)) = 0.0075		
Minimum shear resistance (Exp.	6.3N);	$V_{Rd,c_min} = 0$	0.035 N/mm ² ×	$k^{1.5} \times (f_{ck} / 1 N/m)$	$m^2)^{0.5} \times b \times d_y$	_n
		$V_{Rd,c_min} = $	52.0 kN/m			
Shear resistance (Exp. 6.2a);	V _{Rd,c_y_n} = ma	ax(V _{Rd,c_min} , (0.18 N	$1/mm^2 / \gamma_c) \times k$	\times (100 \times ρ_{l} \times (f _{ck} /	1 N/mm ²)) ^{0.333}	$^{3} \times b \times d_{y_n}$)
		$V_{Rd,c_y_n} = 0$	66.8 kN/m			
				PASS - S	snear capaci	ty is adequat
Basic span-to-depth deflection	1 ratio check	c (cl. 7.4.2)				
Reference reinforcement ratio;		ρ0 = (f _{ck} / 1	N/mm ²) ^{0.5} / 10	00 = 0.0050		
Required tension reinforcement	ratio;	ρ = max(0.	0035, A _{sx_p_req} /	$(b \times d_{x_p}) = 0.00$	35	
Required compression reinforce	ment ratio;	$\rho' = A_{scx_p_r}$	$req / (b \times d_{x_p}) =$	0.0000		
Stuctural system factor (Table 7	4N);	K _δ = 1.5				
Basic limit span-to-depth ratio;	ratio _{lim_x_bas} =	$K_{\delta} \times [11 + 1.5 \times (f_{ck})]$	′1 N/mm²) ^{0.5} ×ρα	p/ρ + 3.2×(fck/1 N/r	mm²) ^{0.5} ×(ρ₀/ρ	-1) ^{1.5}]
(Exp. 7.16);		ratio _{lim_x_bas}	s = 39.31			
	ratio _{lim_x} = mii	$n(40 \times K_{\delta}, min(1.5))$, (500 N/mm²/f _y	/k)×(A _{sx_p} /A _{sx_p_m})) × ratio _{lim_x_ba}	_s) = 58.96
Mod span-to-depth ratio limit;						
Mod span-to-depth ratio limit; Actual span-to-eff. depth ratio;		ratio _{act_x} =	l _x / d _{x_p} = 26.32			

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Reinforcement sketch

The following sketch is indicative only. Note that additional reinforcement may be required in accordance with clauses 9.2.1.2, 9.2.1.4 and 9.2.1.5 of EN 1992-1-1:2004 to meet detailing rules.



BASEMENT RETAINING WALLS:

CASE 1: FRONT RETAINING WALL ANALYSIS AND DESIGN

ASSUMPTIONS & PARAMETERS:

The retaining wall design is based on the parameters obtained from geotechnical report carried out by 'Chelmer Consultancy Services' reference GENV/5839. The following design parameters are used: Retained Height (assuming existing foundations 200mm below ground level) = 3.8m

Concrete Strength: C32/40

Wall is designed as propped at the base in the permanent condition – prop being offered by the basement slab Water table is assumed at 1.0m below ground level based on the worst case scenario

Soil Type: London Clay Formation

Bearing Capacity: 125kN/m²

Loading:

Permanent Loads Allow for slab permanent load on the wall's toe = 10.5kN/m

Variable Loads <u>Total Variable Load UDL = 15.20kN/m</u> Allow for slab variable load on the wall's toe = 2.8kN/m

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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;	Cantilever
Stem height;	h _{stem} = 3400 mm
Stem thickness;	t _{stem} = 400 mm
Angle to rear face of stem;	α = 90 deg
Stem density;	γ_{stem} = 25 kN/m ³
Toe length;	I _{toe} = 1500 mm
Heel length;	I _{heel} = 300 mm
Base thickness;	t _{base} = 400 mm
Key position;	p _{key} = 1500 mm
Key depth;	d _{key} = 500 mm
Key thickness;	t _{key} = 400 mm
Base density;	γ_{base} = 25 kN/m ³
Height of retained soil;	h _{ret} = 3400 mm
Angle of soil surface;	$\beta = 0 \text{ deg}$
Depth of cover;	d _{cover} = 0 mm
Height of water;	h _{water} = 2400 mm
Water density;	γw = 9.8 kN/m ³
Retained soil properties	
Soil type;	Organic clay
Moist density;	γmr = 15 kN/m ³
Saturated density;	γsr = 15 kN/m ³
Characteristic effective shear resistance angle;	∮' r.k = 18 deg
Characteristic wall friction angle;	$\delta_{r.k}$ = 9 deg
Base soil properties	
Soil type;	Organic clay
Soil density;	γь = 15 kN/m ³
Characteristic effective shear resistance angle;	φ' _{b.k} = 18 deg
Characteristic wall friction angle;	δ _{b.k} = 9 deg
Characteristic base friction angle;	δ _{bb.k} = 12 deg
Presumed bearing capacity;	P _{bearing} = 125 kN/m ²
- · · ·	5

Loading details

Vertical line load at 0 mm;	
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;

P_{G1} = **10.5** kN/m P_{Q1} = **2.8** kN/m



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- Distance to horizontal compo	nent;	$x_{moist_h} = (h)$	$moist imes (t_{base} + h_{base})$	_{sat} + h _{moist} / 3) / 2	2 + (h _{sat} + h _{base})	\times ((h _{sat} +				
		h _{base})/2 - d	_{key})) / (h _{sat} + h _{ba}	se + h _{moist} / 2) =	1411 mm					
- Distance to horizontal compo	nent above key;	x _{moist_h_a} =	$(h_{moist} imes (t_{base} +$	h _{sat} + h _{moist} / 3)	/ 2 + (h _{sat} + t _{base}	e)²/2) / (h _{sat} +				
		t _{base} + h _{mois}	.t / 2) = 1663 mi	n						
Using Coulomb theory										
Active pressure coefficient;		$K_A = sin(\alpha)$	+ $\phi'_{r,k}$) ² / (sin(α)	$p^2 \times sin(\alpha - \delta_{r,k}) >$	< [1 + √[sin(o' _{r.k}	+ δ _{r.k}) ×				
		sin(φ'r.κ - β)	$/(\sin(\alpha - \delta_{r,k}) \times$	$\sin(\alpha + \beta))$	= 0.483	,				
Passive pressure coefficient:		$K_P = \sin(90)$	$(4^{1})^{2} / (\sin(9)^{2})^{2}$	0 + δ _{b k}) × [1 - √	$[\sin(\phi'_{bk} + \delta_{bk})]$	× sin(d'hk)/				
		(sin(90 + δ	(2.359)	•••••••	[(+	2(+ 2)				
Bearing pressure check										
Vertical forces on wall										
Wall stem;		F _{stem} = A _{ste}	$m \times \gamma_{stem} = 34 \text{ k}$	N/m						
Wall base;		F _{base} = A _{bas}	se $\times \gamma_{\text{base}} = 27 \text{ k}$	N/m						
Line loads;	e loads;			l/m						
Saturated retained soil;		$F_{sat_v} = A_{sat} \times (\gamma_{sr'} - \gamma_{w'}) = 3.7 \text{ kN/m}$								
Water;		F _{water_v} = A _{water} × γ _w ' = 7.1 kN/m								
Moist retained soil;		F _{moist_v} = A	moist × γmr ' = 4.5	kN/m						
Total;		F _{total_v} = F _s	F _{total_v} = F _{stem} + F _{base} + F _{sat_v} + F _{moist_v} + F _{water_v} + F _{P_v} = 89.6 kN/m							
Horizontal forces on wall	Horizontal forces on wall									
Saturated retained soil:		Fsath = KA	× $\cos(\delta_{r,d})$ × (γ_{sl}	.' - νw') × (h _{sat} + t	$(base)^2 / 2 = 9.7$	N/m				
Water:		$F_{water} = h = h$	$v' \times (h_{water} + d_{cov})$	$(er + t_{base})^2 / 2 =$	38.5 kN/m					
Moist retained soil:		$F_{moist h} = K$	$A \times COS(\delta_r d) \times V$	mr' × ((heff - heat -	$(h_{hase})^2 / 2 + (h_{hase})^2$	off - heat - hhase)				
		\times (h _{eat} + t _{ba}	(0.1) = 23.6 kN/m							
Base soil		$F_{\text{mass}} = -K$		 /h' × (daavar + bha	$(a)^2/2 = -142$	«N/m				
Total:		$F_{total, h} = F_{a}$	$r + F_{\text{moist } h} + F_{\text{moist } h} + 1$	Enase h + Ewster h	$s_{s} h + F_{water} h = 57.6 \text{ kN/m}$					
				pass_ii · i watei_ii						
Moments on Wall		–								
VVall stem;		M _{stem} = F _{ste}	$m \times X_{stem} = 57.8$	kNm/m						
Wall base;		M _{base} = F _{ba}	$se \times X_{base} = 32.7$	′ kNm/m						
Saturated retained soil;		M _{sat} = F _{sat} _	$v \times \mathbf{X}_{sat_v} - \mathbf{F}_{sat_h}$	× x _{sat_h} = 1.8 kN	Nm/m					
Water;		M _{water} = F _w	ater_v × Xwater_v -	$F_{water_{h}} \times X_{water_{h}}$	n = -8.6 kNm/m					
Moist retained soil;		M _{moist} = F _m	oist_v \times Xmoist_v -	F_{moist} h × Xmoist_h	= -24.1 kNm/m	l				
Total;		$M_{total} = M_{ste}$	em + M _{base} + M _{sa}	at + M _{moist} + M _{wat}	_{ter} + M _P = 59.6	<nm m<="" td=""></nm>				
Check bearing pressure										
Propping force;		F _{prop_base} =	F _{total_h} = 57.6 k	N/m						
Distance to reaction;		$\overline{\mathbf{x}} = \mathbf{M}_{\text{total}}$	′ F _{total_v} = 666 m	im						
Eccentricity of reaction;		$e = \overline{x} - I_{bas}$	_{se} / 2 = -434 mn	ו						
Loaded length of base;		I_{load} = 3 ×	x = 1997 mm							
Bearing pressure at toe;		q_{toe} = 2 × F	total_v / Iload = 89	.7 kN/m²						
Bearing pressure at heel;		q _{heel} = 0 kN	I/m ²							
Factor of safety;		$FoS_{bp} = P_b$	_{earing} / max(q _{toe} ,	q _{heel}) = 1.393						
	PASS - A	llowable bearii	ng pressure ex	ceeds maximu	ım applied bea	aring pressure				

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ASSUMPTIONS & PARAMETERS:

The retaining wall design is based on the parameters obtained from geotechnical report carried out by 'Chelmer Consultancy Services' reference GENV/5839. The following design parameters are used: Retained Height (assuming existing foundations 200mm below ground level) = 3.8m Concrete Strength: C32/40 Wall is designed as propped at the base in the permanent condition – prop being offered by the basement slab Water table is assumed at 1.0m below ground level based on the worst case scenario Soil Type: London Clay Formation Bearing Capacity: 125kN/m² Loading: Permanent Loads Ground floor wall - 343mm (13.5") wall (3.50m height) = 23kN/m³ x 3.50m x 0.343m = 27.62kN/m Walls for first floor and above – 229mm (9") (9.00m height) = 23kN/m³ x 9.00m x 0.229m = 47.40kN/m

Walls for first floor and above -229mm (9") (9.00m height) $= 23kN/m^2 \times 3.50m \times 0.343m - 27.02kN/m^2$ Floor loads $= 0.75kN/m^2 \times 4.50m/2 \times 4$ (no. of floors) = 6.75kN/mRoof load $= 0.80kN/m^2 \times 4.50m/2 = 1.8kN/m^2$

<u>Total Permanent Load UDL = 83.60kN/m</u> <u>Allow for slab permanent load on the wall's toe = 10.5kN/m</u>

Variable Loads

Floor loads = 1.50kN/m² x 4.50m/2 x 4 (no. of floors) = 13.50kN/m Roof load = 0.75kN/m² x 4.50m/2 = 1.69kN/m

Total Variable Load UDL = 15.20kN/m Allow for slab variable load on the wall's toe = 2.8kN/m

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;	Cantilever
Stem height;	h _{stem} = 3400 mm
Stem thickness;	t _{stem} = 400 mm
Angle to rear face of stem;	α = 90 deg
Stem density;	$\gamma_{\text{stem}} = 25 \text{ kN/m}^3$
Toe length;	I _{toe} = 1500 mm
Base thickness;	t _{base} = 400 mm
Base density;	$\gamma_{\text{base}} = 25 \text{ kN/m}^3$
Height of retained soil;	h _{ret} = 3400 mm
Angle of soil surface;	$\beta = 0 \deg$
Depth of cover;	d _{cover} = 0 mm
Height of water;	h _{water} = 2800 mm
Water density;	γw = 9.8 kN/m ³
Retained soil properties	
Soil type;	Organic clay

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Maint density		- 45 14	1/223				
Moist density;		$\gamma_{\rm mr} = 15$ KM	v/m°				
Saturated density;		$\gamma_{\rm sr} = 15 \rm KIN$	/m ³				
Characteristic effective shear re	sistance angle;	φ'r.k = 18 de	eg				
Characteristic wall friction angle	3	δ _{r.k} = 9 deg)				
Base soil properties							
Soil type;		Organic cla	ау				
Soil density;		γ _b = 15 kN/	/m ³				
Characteristic effective shear re	sistance angle;	φ' _{b.k} = 18 d	eg				
Characteristic wall friction angle	:	δ _{b k} = 9 deo	2				
Characteristic base friction and	ب	$\delta_{bb} k = 12 c$	lea				
Presumed bearing capacity:	-,	$P_{\text{hearing}} = 1^{\circ}$	25 kN/m ²				
Loading details		c .					
Variable surcharge load;		Surcharge	g = 1.5 kN/m ²				
Vertical line load at 1700 mm;		P _{G1} = 83.6	kN/m				
;		Pq1 = 15.2	kN/m				
Vertical line load at 0 mm;	P _{G2} = 10.5	kN/m					
;		P _{Q2} = 2.8 k	κN/m				
		1500					
	F	1500	▶ ≪-400-▶				
	H	1700	→				
*	Ŧ			- 1 ^{0.7 kN/m²}	*		
				5 kN/m ²			
				I A			
- 3400	- 3400				8		
					8		
	Prop.						
400	·						
<u>↓</u>	44.3 kN/m ²						
	106.3 kN/m²[β7.5 kN/m ²				
	◄ 1900►						
	General arrangement						
Calculate retaining wall geom	etry						
Base length;		$I_{base} = I_{toe} +$	• t _{stem} = 1900 n	nm			
Saturated soil height;		h _{sat} = h _{water}	+ d _{cover} = 280	0 mm			
Moist soil height;		h _{moist} = h _{ret}	- h _{water} = 600	mm			
Length of surcharge load;		I _{sur} = I _{heel} =	0 mm				
L							

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Ī	Distance to vertical company	.4.		- L	1	000 mm								
	- Distance to ventical component	IL,		$X_{sur_v} = I_{base}$	z = 1 heel $/ Z = 1$	- 2800 mm								
	- Distance to horizontal compor	ent [.]		$Y_{aut} = h_{aut}$	/ 2 = 1900 m	- 3600 mm								
	Area of wall stem:	icint,		$\Delta_{stem} = h_{eff}$	7 Z − 1300 m m × tatam = 1 3	6 m ²								
	- Distance to vertical componer	nt.		$X_{stem} = I_{top}$	$+ t_{stem} / 2 = 17$	700 mm								
	Area of wall base	,		Abase = Ibase	$x t_{base} = 0.76$	5 m ²								
	- Distance to vertical componer	nt:		Xbase = Ibase	/ 2 = 950 mn	n								
	Using Coulomb theory	;		1.5400 1.5400										
				$\mathbf{K}_{\mathbf{A}} = \sin(\alpha)$	+ $d_{1}^{2}/(ein)^{2}$	$(\alpha)^2 \times \sin(\alpha - \delta_{-1}) \times$	[1 + √[sin(a'-,	- 8-1-) ×						
	Active pressure coemclent,			$RA = Sin(\alpha)$	$(\sin(\alpha - \delta_{rk}))$	$(\alpha + \beta)$ $(\alpha + \beta)$	ι · ν <u>ι</u> οπι(ψτ.κ · Λ 483	Ur.kj ×						
	Passive pressure coefficient:			$K_{\rm D} = \sin(9)$) - d's s) ² / (sin	/ × 3ii((α + β))]]) = √ i(90 + δ _{5 μ}) × [1 - √[s	sin(ժեր + ծրր) չ	sin(d'_k) /						
				(sin(90 + &	$(311)^{-1} (\psi_{D,K}) = 2.35$	GOO F OD.K) ∧ [1 - v[3	σιι(ψ <u>σ.κ</u> · O <u>σ.</u> κ) ^	σιι(ψ b.κ) /						
					U.K))]]) — 2.00									
	Bearing pressure check													
	Vertical forces on wall													
	Wall stem;		F _{stem} = A _{ste}	m × γ _{stem} = 34	kN/m									
	Wall base;			$F_{base} = A_{base} \times \gamma_{base} = 19 \text{ kN/m}$										
	Line loads;			$F_{P_v} = P_{G1} + P_{Q1} + P_{G2} + P_{Q2} = 112.1 \text{ kN/m}$										
	l otal;	$ \Box_{total_v} = \Box_{stem} + \Box_{base} + \Box_{water_v} + \Box_{P_v} = 105.1 \text{ KN/M} $												
	Horizontal forces on wall													
	Surcharge load;	Surcharge load;				$F_{sur_h} = K_A \times cos(\delta_{r.d}) \times Surcharge_Q \times h_{eff} = 2.7 \text{ kN/m}$								
	Saturated retained soil;		$F_{sat_h} = K_A \times cos(\delta_{r.d}) \times (\gamma_{sr'} - \gamma_{w'}) \times (h_{sat} + h_{base})^2 / 2 = 12.7 \text{ kN/m}$											
	Water;		$F_{water_h} = \gamma_w' \times (h_{water} + d_{cover} + h_{base})^2 / 2 = 50.2 \text{ kN/m}$											
	Moist retained soil;		$F_{\text{moist}_h} = K_A \times \cos(\delta_{r.d}) \times \gamma_{mr'} \times ((h_{eff} - h_{sat} - h_{base})^2 / 2 + (h_{eff} - h_{sat} - h_{base}) \times (h_{sat} + h_{base})) = 15 \text{ kN/m}$											
	Base soll;			$F_{\text{pass}_h} = -K_P \times \text{COS}(\delta_{\text{b.d.}}) \times \gamma_b \times (\text{d}_{\text{cover}} + \text{h}_{\text{base}})^2 / 2 = -2.8 \text{ kN/m}$										
	i otai;		Ftotal_h = Fsat_h + Fmoist_h + Fpass_h + Fwater_h + Fsur_h = 77.9 kN/m											
	Moments on wall													
	Wall stem;		M _{stem} = F _{stem} × x _{stem} = 57.8 kNm/m											
	Wall base;			M _{base} = F _{ba}	$se \times x_{base} = 18$	3.1 kNm/m								
	Surcharge load;		$M_{sur} = -F_{sur_h} \times x_{sur_h} = -5.2 \text{ kNm/m}$											
	Line loads;		$M_P = (P_{G1} + P_{Q1}) \times p_1 + (P_{G2} + P_{Q2}) \times p_2 = 168 \text{ kNm/m}$											
	Saturated retained soil;			Msat = - Fsat	_h × Xsat_h = -1	3.5 kNm/m								
	vvater;			Mwater = -Fv	water_h × Xwater_	h = -53.6 KNM/M								
	Total:			$IVI_{moist} = -F_r$	noist_h × Xmoist_l	h = -26.4 KIN (ff)/ff	т N4 т N4	145 2 kNm/m						
				IVItotal - IVIste	em T Wbase T N	/Isat + IVImoist + IVIwater	+ IVI _{SUR} + IVIP -	143.2 KINIII/III						
	Check bearing pressure			-		1.5.17								
	Propping force;			Fprop_base =	$F_{total_h} = 77.9$	KIN/M								
				$\mathbf{X} = \mathbf{IV}_{\text{total}}$	$F_{total_v} = 8/9$	- mm								
	Eccentricity of reaction,			e = x - Ibas	= 1900 mm	11								
						6 × 0 / 1) - 100 ($\frac{1}{2}$ kN/m ²							
	Bearing pressure at loe,				v / Ibase < (1 - 1)	$b \wedge c / base = 100.$	5 kN/m^2							
	Factor of safety			$F_0S_{hn} = P_h$	r_v increase $< (1)$	$(0 \land 0) = 1.176$								
	r dotor or baroty,	PASS	- A	llowable bearin		exceeds maximum	n applied bea	rina pressure						
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CASE 3: REAR PARTY WALL RETAINING WALL ANALYSIS AND DESIGN

ASSUMPTIONS & PARAMETERS:

The retaining wall design is based on the parameters obtained from geotechnical report carried out by 'Chelmer Consultancy Services' reference GENV/5839. The following design parameters are used: Retained Height (assuming existing foundations 200mm below ground level) = 3.3m Concrete Strength: C32/40 Wall is designed as propped at the base in the permanent condition – prop being offered by the basement slab Water table is assumed at 1.0m below ground level based on the worst case scenario Soil Type: London Clay Formation Bearing Capacity: 125kN/m² Loading:

Permanent Loads

Ground floor wall - 343mm (13.5") wall (3.00m height) = $23kN/m^3 \times 3.00m \times 0.343m = 23.67kN/m$ Walls for first floor and above - 229mm (9") (5.50m height) = $23kN/m^3 \times 5.50m \times 0.229m = 28.97kN/m$ Floor loads = $0.75kN/m^2 \times 4.50m/2 \times 3$ (no. of floors) = 5.06kN/m

<u>Total Permanent Load UDL = 57.70kN/m</u> <u>Allow for slab permanent load on the wall's toe = 10.5kN/m</u>

Variable Loads

Floor loads = 1.50kN/m² x 4.50m/2 x 3 (no. of floors) = 10.13kN/m

<u>Total Variable Load UDL = 10.13kN/m</u> <u>Allow for slab variable load on the wall's toe = 2.8kN/m</u>

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;	Cantilever
Stem height;	h _{stem} = 2900 mm
Stem thickness;	t _{stem} = 400 mm
Angle to rear face of stem;	α = 90 deg
Stem density;	γ_{stem} = 25 kN/m ³
Toe length;	I _{toe} = 1200 mm
Base thickness;	t _{base} = 400 mm
Base density;	γ _{base} = 25 kN/m ³
Height of retained soil;	h _{ret} = 2900 mm
Angle of soil surface;	$\beta = 0 \deg$
Depth of cover;	d _{cover} = 0 mm
Height of water;	h _{water} = 2300 mm



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	Saturated soil height;			h _{sat} = h _{water}	+ d _{cover} = 2300 i	mm								
	Moist soil height;			$h_{moist} = h_{ret}$	- h _{water} = 600 mr	n								
	Retained surface length;			$I_{sur} = I_{heel} =$	0 mm									
	Effective height of wall;			h _{eff} = h _{base} ·	+ d_{cover} + h_{ret} = 3	300 mm								
	Area of wall stem;			A _{stem} = h _{ster}	m × t _{stem} = 1.16 n	n²								
	- Distance to vertical componer	nt;		$X_{stem} = I_{toe} +$	- t _{stem} / 2 = 1400	mm								
	Area of wall base;			$A_{base} = I_{base}$	× t _{base} = 0.64 m	2								
	- Distance to vertical componer	nt;		$\mathbf{x}_{\text{base}} = \mathbf{I}_{\text{base}}$	/ 2 = 800 mm									
	Using Coulomb theory													
	Active pressure coefficient;			$K_A = sin(\alpha)$	+ $\phi'_{r.k}$) ² / (sin(α) ²	$\times \sin(\alpha - \delta_{r.k}) \times [$	1 + √[sin(∳' r.k +	$\delta_{r.k}$) ×						
				sin(φ'r.k - β)	/ (sin(α - $\delta_{r.k}$) × :	$sin(\alpha + \beta))]]^2) = 0$.483							
	Passive pressure coefficient;			K _P = sin(90	- φ' _{b.k})² / (sin(90) + δ _{b.k}) × [1 - √[si	n(φ' _{b.k} + δ _{b.k}) ×	sin(ф' _{b.k}) /						
				(sin(90 + δt	_{b.k}))]] ²) = 2.359									
	Bearing pressure check	Bearing pressure check												
	Vortical forces on wall													
	Wall stom:	- 20 kN	l/m											
					$r_{stem} - r_{stem} \times \gamma_{stem} = 23 KIN/III$									
	lino loads:													
	Lille loads,		$F_{\text{rotal}} = F_{\text{star}} + F_{\text{hass}} + F_{\text{wotar}} + F_{\text{p}} = 126.1 \text{ kN/m}$											
				i total_v - i st	er_v • T P_v - 120.									
	Horizontal forces on wall													
	Saturated retained soil;			$F_{sat_h} = K_A$	$\times \cos(\delta r.d) \times (\gamma sr')$	$-\gamma_{w}') \times (h_{sat} + h_{ba})$	_{lase})² / 2 = 9 kN/m							
	Water;			$F_{water_h} = \gamma_w$	$J' \times (h_{water} + d_{cove})$	$(r + h_{base})^2 / 2 = 3$	= 35.8 kN/m - h _{base}) ² / 2 + (h _{eff} - h _{sat} - h _{base})							
	Moist retained soil;			F _{moist_h} = K	$A imes COS(\delta_{r.d}) imes \gamma_{m}$	r' × ((h _{eff} - h _{sat} - h								
				\times (h _{sat} + h _{ba}	_{ase})) = 12.9 kN/m	ו								
	Base soil;			F _{pass_h} = -K	$P \times COS(\delta_{b.d}) \times \gamma_{b}$	$d' \times (d_{cover} + h_{base})$	² / 2 = -2.8 kN	/m						
	Total;			$F_{total_h} = F_{sa}$	$at_h + F_{moist_h} + F_{f}$	_{pass_h} + F _{water_h} =	54.9 kN/m							
	Moments on wall													
	Wall stem;			M _{stem} = F _{ste}	m × x _{stem} = 40.6	kNm/m								
	Wall base;			$M_{base} = F_{bas}$	$_{se} \times x_{base}$ = 12.8	kNm/m								
	Line loads;			M _P = (P _{G1} +	+ P_{Q1}) × p_1 + (P_G	₆₂ + P _{Q2}) × p ₂ = 9	5 kNm/m							
	Saturated retained soil;			$M_{sat} = -F_{sat}$	_h × x _{sat_h} = -8.1	kNm/m								
	Water;			M _{water} = -F _w	vater_h × Xwater_h =	-32.2 kNm/m								
	Moist retained soil;			M _{moist} = -F _m	noist_h × Xmoist_h =	-19.4 kNm/m								
	Total;			M _{total} = M _{ste}	m + M _{base} + M _{sat}	+ M _{moist} + M _{water}	+ M⊳ = 88.7 kľ	Nm/m						
	Check bearing pressure													
	Propping force;			Fprop base =	Ftotal h = 54.9 kN	l/m								
	Distance to reaction;			$\overline{x} = M_{total}$	F _{total v} = 703 mr	n								
	Eccentricity of reaction:			$e = \overline{x} - b_{as}$	e / 2 = -97 mm									
	Loaded length of base:			l _{load} = l _{base} =	= 1600 mm									
	Bearing pressure at toe:			q _{toe} = F _{total}	v / I _{base} × (1 - 6 ×	e / I _{base}) = 107.5	kN/m ²							
	Bearing pressure at heel:			g _{heel} = F _{total}	$_{\rm v}$ / $l_{\rm base}$ × (1 + 6	× e / I _{base}) = 50.2	kN/m ²							
	Factor of safety:			$F_{0}S_{hn} = P_{hearing} / max(q_{hea}, q_{heal}) = 1.163$										
	· · · · · · · · · · · · · · · · · · ·	PASS -	All	owable bearin	ig pressure exc	ceeds maximum	applied bear	ing pressure						

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CASE 4: REAR GARDEN RETAINING SIDE (FENCE) WALL ANALYSIS AND DESIGN

ASSUMPTIONS & PARAMETERS:

The retaining wall design is based on the parameters obtained from geotechnical report carried out by 'Chelmer Consultancy Services' reference GENV/5839. The following design parameters are used: Retained Height (assuming existing foundations 200mm below ground level) = 3.3m Concrete Strength: C32/40 Wall is designed as propped at the base in the permanent condition – prop being offered by the basement slab Water table is assumed at 1.0m below ground level based on the worst case scenario Soil Type: London Clay Formation Bearing Capacity: 125kN/m²

Loading:

Permanent Loads

Ground floor wall - 229mm (9") (5.50m height) = 23kN/m³ x 5.50m x 0.229m = 29.00kN/m <u>Total Permanent Load UDL = 29.00kN/m</u> <u>Allow for slab permanent load on the wall's toe = 10.5kN/m</u>

Variable Loads

Allow for slab variable load on the wall's toe = 2.8kN/m

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;	Cantilever
Stem height;	h _{stem} = 2900 mm
Stem thickness;	t _{stem} = 400 mm
Angle to rear face of stem;	α = 90 deg
Stem density;	γ _{stem} = 25 kN/m ³
Toe length;	l _{toe} = 1500 mm
Base thickness;	t _{base} = 400 mm
Base density;	γ _{base} = 25 kN/m ³
Height of retained soil;	h _{ret} = 2900 mm
Angle of soil surface;	β = 0 deg
Depth of cover;	d _{cover} = 0 mm
Height of water;	h _{water} = 2300 mm
Water density;	γw = 9.8 kN/m ³
Retained soil properties	
Soil type;	Organic clay
Moist density;	γ _{mr} = 15 kN/m ³
Saturated density;	γsr = 15 kN/m ³
Characteristic effective shear resistance angle;	φ'r.k = 18 deg

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Characteristic wall friction angle	;	δ _{r.k} = 9 deg	1			
Base soil properties						
Soil type:		Organic cla	av			
Soil density:		$w_{\rm b} = 15 \rm k M$	/m ³			
Characteristic effective shear re	sistance angle:	/b = 18 d				
Characteristic well friction angle		$\varphi_{D,k} = 0 d\alpha$	cy			
	,					
	e,	$o_{bb.k} = 120$				
Presumed bearing capacity;		Pbearing = 1	25 KIN/M ²			
Loading details						
Vertical line load at 1550 mm;		P _{G1} = 29 k	N/m			
Vertical line load at 0 mm;		P _{G2} = 10.5	kN/m			
. ,		P _{Q2} = 2.8 k	:N/m			
	 	1500	_ ▶ ∢_400_ >			
	 	1550	→			
	*			- 1 ^{0 kN/m²}	*	
				- 4.3 kN/m ²		
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000 000	**:					
<u>★</u>				37.5 kN/m ²	.★	
	103.3 kN/m ²		0 kN/m ²			
	 •	1900	→			
	Ger	neral arrangement				
		Ū				
Calculate retaining wall geom	etry					
Base length;		$I_{base} = I_{toe} +$	t _{stem} = 1900 mr	n		
Saturated soil height;		h _{sat} = h _{water}	+ d _{cover} = 2300	mm		
Moist soil height;	Moist soil height; $h_{moist} = h_{ret} - h_{water} = 600 \text{ mm}$					
Retained surface length;	Retained surface length; $I_{sur} = I_{heel} = 0 \text{ mm}$					
Effective height of wall;	Effective height of wall; $h_{eff} = h_{base} + d_{cover} + h_{ret} = 3300 \text{ mm}$					
Area of wall stem;		A _{stem} = h _{ste}	m × t _{stem} = 1.16 ı	m²		
- Distance to vertical componer	- Distance to vertical component; $x_{stem} = I_{toe} + t_{stem} / 2 = 1700 \text{ mm}$					
Area of wall base; $A_{\text{base}} = I_{\text{base}} \times t_{\text{base}} = 0.76 \text{ m}^2$						
- Distance to vertical componer	nt;	x _{base} = I _{base}	/ 2 = 950 mm			

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Using Coulomb theory						
Active pressure coefficient;		$K_A = sin(\alpha)$	+ φ' _{r.k})² / (sin	$(\alpha)^2 \times \sin(\alpha - \delta_{r.k})$	× [1 + √[sin(¢'r.	k + δr.k) ×
		sin(φ'r.k - β) / (sin (α - δr.i	$(\alpha + \beta))]]^2)$	= 0.483	
Passive pressure coefficient;		K _P = sin(9	Ο - φ' _{b.k})² / (si	n(90 + δ _{b.k}) × [1 - γ	√[sin(φ' _{b.k} + δ _{b.k}) × sin(ф' _{b.k}) /
		(sin(90 + δ	b.k))]] ²) = 2.3	59		
Bearing pressure check						
Vertical forces on wall						
Wall stem;		F _{stem} = A _{ste}	$m \times \gamma_{stem} = 29$	9 kN/m		
Wall base;		F _{base} = A _{ba}	se × γ _{base} = 1	9 kN/m		
Line loads;		$F_{P_v} = P_{G1}$	+ P _{G2} + P _{Q2}	= 42.3 kN/m		
Total;	F _{total_v} = F _{stem} + F _{base} + F _{water_v} + F _{P_v} = 90.3 kN/m					
Horizontal forces on wall						
Saturated retained soil;		F _{sat_h} = K _A	\times cos($\delta_{r.d}$) \times	$(\gamma_{sr}' - \gamma_w') \times (h_{sat} +$	h _{base}) ² / 2 = 9 k	κN/m
Water;	$F_{water_h} = \gamma_w' \times (h_{water} + d_{cover} + h_{base})^2 / 2 = 35.8 \text{ kN/m}$					
Moist retained soil;	$F_{moist_h} = K_A \times cos(\delta_{r.d}) \times \gamma_{mr'} \times ((h_{eff} - h_{sat} - h_{base})^2 / 2 + (h_{eff} - h_{sat} - h_{base})$					
		imes (h _{sat} + h _t	_{ase})) = 12.9 k	N/m		
Base soil;	F_{pass_h} = -K _P × cos($\delta_{b.d}$) × γ_b ' × (d _{cover} + h _{base}) ² / 2 = -2.8 kN/m			kN/m		
Total;	F _{total_h} = F _{sat_h} + F _{moist_h} + F _{pass_h} + F _{water_h} = 54.9 kN/m					
Moments on wall						
Wall stem;		M _{stem} = F _{st}	$em \times X_{stem} = 4$	9.3 kNm/m		
Wall base;		M _{base} = F _b	$x_{base} \times x_{base} = 1$	8.1 kNm/m		
Line loads;		$M_P = P_{G1}$	< p ₁ + (P _{G2} +	P _{Q2}) × p ₂ = 45 kNr	m/m	
Saturated retained soil;		$M_{sat} = -F_{sa}$	t_h × X _{sat_h} = -	8.1 kNm/m		
Water;		M _{water} = -F	water_h $ imes$ Xwater	_ _h = -32.2 kNm/m		
Moist retained soil;	M _{moist} = -F _{moist_h} × x _{moist_h} = -19.4 kNm/m					
Total;	M _{total} = M _{stem} + M _{base} + M _{sat} + M _{moist} + M _{water} + M _P = 52.6 kNm/m				kNm/m	
Check bearing pressure						
Propping force;		F _{prop_base} =	F _{total_h} = 54.	9 kN/m		
Distance to reaction;	$\overline{\mathbf{x}}$ = M _{total} / F _{total_v} = 583 mm					
Eccentricity of reaction;	e = x - I _{base} / 2 = -367 mm					
Loaded length of base;		I_{load} = 3 $ imes$	x = 1748 mr	n		
Bearing pressure at toe;		q_{toe} = 2 \times I	= _{total_v} / I _{load} =	103.3 kN/m ²		
Bearing pressure at heel;		q _{heel} = 0 kl	N/m ²			
Factor of safety;		FoS _{bp} = P	_{bearing} / max(q	toe, q _{heel}) = 1.21		
	PASS	- Allowable beari	ng pressure	exceeds maxim	um applied be	earing pressure

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CASE 5: REAR GARDEN RETAINING BACK WALL ANALYSIS AND DESIGN

ASSUMPTIONS & PARAMETERS:

The retaining wall design is based on the parameters obtained from geotechnical report carried out by 'Chelmer Consultancy Services' reference GENV/5839. The following design parameters are used: Retained Height (assuming existing foundations 200mm below ground level) = 3.4m

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Concrete Strength: C32/40

Wall is designed as propped at the base in the permanent condition – prop being offered by the basement slab Water table is assumed at 1.0m below ground level based on the worst case scenario Soil Type: London Clay Formation

Bearing Capacity: 125kN/m²

Loading:

Permanent Loads

Allow for slab permanent load on the wall's toe = 10.5kN/m

Variable Loads

<u>Allow for slab variable load on the wall's toe = 2.80kN/m Surcharge load = 1.50kN/m²</u>

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;	Cantilever
Stem height;	h _{stem} = 3000 mm
Stem thickness;	t _{stem} = 400 mm
Angle to rear face of stem;	α = 90 deg
Stem density;	γ _{stem} = 25 kN/m ³
Toe length;	I _{toe} = 1500 mm
Heel length;	I _{heel} = 200 mm
Base thickness;	t _{base} = 400 mm
Key position;	p _{key} = 1500 mm
Key depth;	d _{key} = 500 mm
Key thickness;	t _{key} = 400 mm
Base density;	$\gamma_{\text{base}} = 25 \text{ kN/m}^3$
Height of retained soil;	h _{ret} = 3000 mm
Angle of soil surface;	$\beta = 0 \deg$
Depth of cover;	d _{cover} = 0 mm
Height of water;	h _{water} = 2400 mm
Water density;	γw = 9.8 kN/m ³
Retained soil properties	
Soil type;	Organic clay
Moist density;	γ _{mr} = 15 kN/m ³
Saturated density;	γsr = 15 kN/m ³
Characteristic effective shear resistance angle;	∲' r.k = 18 deg
Characteristic wall friction angle;	δ _{r.k} = 9 deg
Base soil properties	
Soil type;	Organic clay
Soil density;	γ _b = 15 kN/m ³
Characteristic effective shear resistance angle;	φ' _{b.k} = 18 deg
Characteristic wall friction angle;	δ _{b.k} = 9 deg



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- Distance to horizontal compon	ent [.]	$x_{sat h} = (h_{sa})$	$h + h_{base}) / 3 - d_k$	ev = 600 mm					
- Distance to horizontal compon	ent above kev:	$X_{sat h} = (h)$	$t_{\text{lsat}} + t_{\text{base}} / 3 = 1$	933 mm					
Area of water;	,,	$A_{water} = h_{sat}$	t × I _{heel} = 0.48 m	2					
- Distance to vertical component	t;	$x_{water v} = I_{ba}$	ase - ($h_{sat} \times I_{heel}^2$)	/ 2) / A _{sat} = 2000 r	nm				
- Distance to horizontal compon	ent;	$X_{water h} = (h)$	Isat + h _{base}) / 3 -	d _{key} = 600 mm					
- Distance to horizontal compon	ent above key;	x _{water_h_a} =	(h _{sat} + t _{base}) / 3 =	= 933 mm					
Area of moist soil;		A _{moist} = h _{mo}	oist × Iheel = 0.12	m²					
- Distance to vertical component	t;	$\mathbf{x}_{\text{moist}_v} = \mathbf{I}_{\text{base}}$	ase - (hmoist × Iheel	² / 2) / A _{moist} = 200)0 mm				
- Distance to horizontal compon	ent;	x _{moist_h} = (h	$t_{moist} imes (t_{base} + h_s)$	_{at} + h _{moist} / 3) / 2 +	· (h _{sat} + h _{base}) :	× ((h _{sat} +			
		h _{base})/2 - d _i	_{key})) / (h _{sat} + h _{bas}	_{se} + h _{moist} / 2) = 13	04 mm				
- Distance to horizontal compon	ent above key;	Xmoist_h_a =	$(h_{moist} \times (t_{base} + $	h _{sat} + h _{moist} / 3) / 2	+ (h _{sat} + t _{base})	² /2) / (h _{sat} +			
		t _{base} + h _{mois}	_{.t} / 2) = 1555 mn	n					
Using Coulomb theory									
Active pressure coefficient;		$K_A = sin(\alpha)$	+ $\phi'_{r.k}$) ² / (sin(α) ²	$^{2} \times sin(\alpha - \delta_{r.k}) \times [^{2}$	1 + √[sin(థ' _{r.k} +	· δr.k) ×			
		sin(φ'r.k - β)	/ (sin(α - $\delta_{r.k}$) ×	$sin(\alpha + \beta))]]^2) = 0$.483				
Passive pressure coefficient;		K _P = sin(90) - φ' _{b.k})² / (sin(9	0 + δ _{b.k}) × [1 - √[si	n(φ' _{b.k} + δ _{b.k}) ×	sin(¢' _{b.k}) /			
		(sin(90 + δ	b.k))]] ²) = 2.359						
Bearing pressure check									
Vertical forces on wall									
Wall stem.		Fotom = Acto	$m \times v_{atom} = 30 \text{ k}$	N/m					
Wall base:		$F_{base} = A_{base}$	$m \times \gamma stem = 26 km$	N/m					
Surcharge load:		$F_{sur} = Sur$	$F_{sur v} = Surcharge_Q \times I_{heel} = 0.3 \text{ kN/m}$						
Line loads:		$F_{P_V} = P_{G1}$	+ Po1 = 13.3 kN	l/m					
Saturated retained soil:		F _{sat} v = A _{sa}	$t \times (\gamma_{sr}' - \gamma_{w}') = 2$.5 kN/m					
Water;		$F_{water v} = A$	water × γw' = 4.7 k	۸۷/m					
Moist retained soil:		$F_{moist v} = A$	$F_{moist_v} = A_{moist} \times \gamma_{mr'} = 1.8 \text{ kN/m}$						
Total;		$F_{total_v} = F_{stem} + F_{base} + F_{sat_v} + F_{moist_v} + F_{water_v} + F_{sur_v} + F_{P_v} = 78.6$							
		kN/m				-			
Horizontal forces on wall									
Surcharge load:		Fsur h = KA	× cos(δrd) × Su	$rcharge_{O} \times (h_{eff} - c)$	d _{kev}) = 2.4 kN/r	m			
Saturated retained soil:		Fsat h = KA	× $\cos(\delta_{r,d})$ × (γ_{sr}	$(-\gamma_w') \times (h_{sat} + t_{bas})$) ² / 2 = 9.7 kN	√/m			
Water;		$F_{\text{water h}} = \gamma_{\text{w}}' \times (h_{\text{water}} + d_{\text{cover}} + t_{\text{base}})^2 / 2 = 38.5 \text{ kN/m}$							
Moist retained soil;		$F_{moist h} = K$	$A \times COS(\delta_{r.d}) \times \gamma_n$	$nr' \times ((h_{eff} - h_{sat} - h_{t}))$	$(h_{eff})^2 / 2 + (h_{eff})^2$	- h _{sat} - h _{base})			
,		\times (h _{sat} + t _{ba}	_{se})) = 13.3 kN/m	1	(0.1	cat baccy			
Base soil;	$F_{\text{nass } h} = -K_P \times \cos(\delta_{h,d}) \times \gamma_h' \times (d_{\text{naver}} + h_{\text{hase}})^2 / 2 = -14.2 \text{ kN/m}$				N/m				
Total;		$F_{total_h} = F_{sat_h} + F_{moist_h} + F_{pass_h} + F_{water_h} + F_{sur_h} = 49.8 \text{ kN/m}$							
Moments on wall			_	_					
Wall stem:		Mstem = Fetz	em × Xstem = 51 k	Nm/m					
Wall base;			$M_{\text{base}} = F_{\text{base}} \times x_{\text{base}} = 30.6 \text{ kNm/m}$						
Surcharge load:		M _{sur} = F _{sur}	$M_{sur} = F_{sur} \times x_{sur} \times - F_{sur} + x_{sur} = -2.9 \text{ kNm/m}$						
Saturated retained soil:		$M_{sat} = F_{sat} \times X_{sat} \times - F_{sat} \times X_{sat} \times = -0.8 \text{ kNm/m}$							
Water;		M _{water} = F _w	ter v × Xwater v - Fwater h × Xwater h = -13.7 kNm/m						
Maint ratained sail:		$M_{\text{moist}} = F_{\text{moist}} \times X_{\text{moist}} + F_{\text{moist}} + X_{\text{moist}} + \mathbf{h} = -13.8 \text{ kNm/m}$							
Total				<u>-</u>					

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Check bearing pressure	
Propping force;	F _{prop_base} = F _{total_h} = 49.8 kN/m
Distance to reaction;	$\overline{\mathbf{x}} = \mathbf{M}_{\text{total}} / \mathbf{F}_{\text{total}_{\mathbf{v}}} = 641 \text{ mm}$
Eccentricity of reaction;	e = x - I _{base} / 2 = -409 mm
Loaded length of base;	$I_{load} = 3 \times \overline{x} = 1922 \text{ mm}$
Bearing pressure at toe;	$q_{toe} = 2 \times F_{total_v} / I_{load} = 81.8 \text{ kN/m}^2$
Bearing pressure at heel;	$q_{heel} = 0 \text{ kN/m}^2$
Factor of safety;	$FoS_{bp} = P_{bearing} / max(q_{toe}, q_{heel}) = 1.529$
	PASS - Allowable bearing pressure exceeds maximum applied bearing pressure