

 PHG Consulting Engineers Ltd 107 Cowbridge Road East Cardiff CF11 9AG	Project Harvey Crescent, Abervon, Port Talbot				Job no. 2336	
	Calcs for 1.2m Cavity Fill Retaining Wall				Start page no./Revision 1	
	Calcs by WW	Calcs date 22/03/2024	Checked by PHG	Checked date 25/03/2024	Approved by PHG	Approved date 25/03/2024

RETAINING WALL ANALYSIS

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

Tedds calculation version 2.9.17

Analysis summary

Design summary

Overall design utilisation 0.841

Overall design status Pass

Description	Unit	Capacity	Applied	F o S	Result
Sliding stability	kN/m	19.9	11.8	1.683	PASS
Overturning stability	kNm/m	42.4	10.4	4.061	PASS
Bearing pressure	kN/m ²	50	42	1.190	PASS

Design summary

Description	Unit	Provided	Required	Utilisation	Result
Shear resistance	kN/m	10.3	111.2	0.093	PASS
Min. transverse stem reinf.	mm ² /m	251.3	75.0	0.298	PASS
Base top face - Flexural reinforcement	mm ² /m	785.4	352.4	0.449	PASS
Base bottom face - Flexural reinforcement	mm ² /m	785.4	316.5	0.403	PASS
Base - Shear resistance	kN/m	111.2	10.3	0.093	PASS
Min. transverse base reinf. (t)	mm ² /m	251.3	157.1	0.625	PASS

Retaining wall details

Stem type	Cantilever			
Stem height	$h_{\text{stem}} = \mathbf{1500}$ mm			
Stem thickness	$t_{\text{stem}} = \mathbf{425}$ mm			
Angle to rear face of stem	$\alpha = \mathbf{90}$ deg			
Stem density	$\gamma_{\text{stem}} = \mathbf{25}$ kN/m ³			
Toe length	$l_{\text{toe}} = \mathbf{250}$ mm			
Heel length	$l_{\text{heel}} = \mathbf{900}$ mm			
Base thickness	$t_{\text{base}} = \mathbf{300}$ mm			
Base density	$\gamma_{\text{base}} = \mathbf{25}$ kN/m ³			
Height of retained soil	$h_{\text{ret}} = \mathbf{1200}$ mm	Angle of soil surface	$\beta = \mathbf{7}$ deg	
Depth of cover	$d_{\text{cover}} = \mathbf{225}$ mm			
Depth of excavation	$d_{\text{exc}} = \mathbf{225}$ mm			

Retained soil properties

Soil type	Dense rock fill				
Moist density	$\gamma_{\text{mr}} = 16.9$ kN/m ³				
Saturated density	$\gamma_{\text{sr}} = 20.6$ kN/m ³				
Characteristic effective shear resistance angle	$\phi'_{\text{r.k}} = 36$ deg				
Characteristic wall friction angle	$\delta_{\text{r.k}} = 18$ deg				

Base soil properties

Soil type	Firm clay				
Soil density	$\gamma_{\text{b}} = 18$ kN/m ³				
Characteristic effective shear resistance angle	$\phi'_{\text{b.k}} = 24$ deg				
Characteristic wall friction angle	$\delta_{\text{b.k}} = 12$ deg				
Characteristic base friction angle	$\delta_{\text{bb.k}} = 24$ deg				
Presumed bearing capacity	$P_{\text{bearing}} = 50$ kN/m ²				



PHG Consulting Engineers Ltd
107 Cowbridge Road East
Cardiff
CF11 9AG

Project

Harvey Crescent, Abervon, Port Talbot

Job no.

2336

Calcs for

1.2m Cavity Fill Retaining Wall

Start page no./Revision

2

Calcs by

WW

Calcs date

22/03/2024

Checked by

PHG

Checked date

25/03/2024

Approved by

PHG

Approved date

25/03/2024

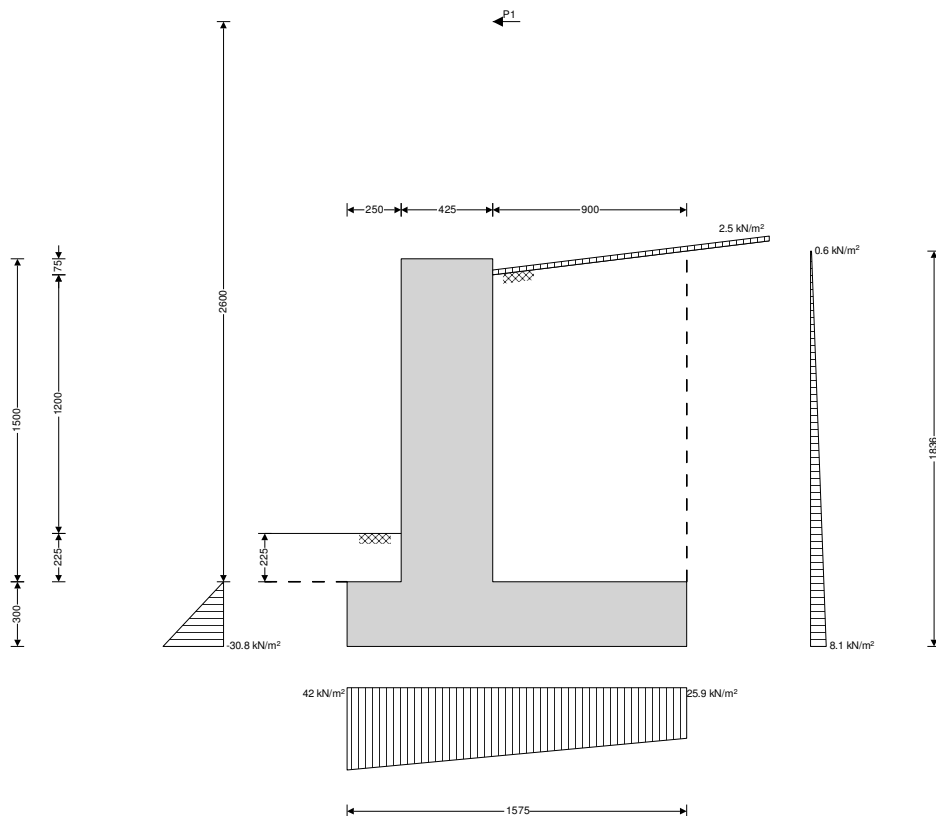
Loading details

Variable surcharge load

Surcharge_Q = **2.5 kN/m²**

Horizontal line load at 2600 mm

P_{Q1} = **0.7 kN/m**



General arrangement - sketch pressures relate to bearing check

Calculate retaining wall geometry

Base length $l_{\text{base}} = 1575 \text{ mm}$
Moist soil height $h_{\text{moist}} = 1425 \text{ mm}$
Length of surcharge load $l_{\text{sur}} = 900 \text{ mm}$
Vertical distance $x_{\text{sur}_v} = 1125 \text{ mm}$
Effective height of wall $h_{\text{eff}} = 1836 \text{ mm}$
Horizontal distance $x_{\text{sur}_h} = 918 \text{ mm}$
Area of wall stem $A_{\text{stem}} = 0.638 \text{ m}^2$
Area of wall base $A_{\text{base}} = 0.473 \text{ m}^2$
Area of moist soil $A_{\text{moist}} = 1.332 \text{ m}^2$
Area of base soil $A_{\text{pass}} = 0.056 \text{ m}^2$

Vertical distance $x_{\text{stem}} = 463 \text{ mm}$
Vertical distance $x_{\text{base}} = 788 \text{ mm}$
Vertical distance $x_{\text{moist}_v} = 1131 \text{ mm}$
Horizontal distance $x_{\text{moist}_h} = 612 \text{ mm}$
Vertical distance $x_{\text{pass}_v} = 125 \text{ mm}$
Horizontal distance $x_{\text{pass}_h} = 175 \text{ mm}$

Using Coulomb theory

Active pressure coefficient $K_A = 0.254$

Passive pressure coefficient $K_P = 3.337$

Bearing pressure check

Vertical forces on wall

Total $F_{\text{total}_v} = F_{\text{stem}} + F_{\text{base}} + F_{\text{sur}_v} + F_{\text{moist}_v} + F_{\text{pass}_v} = 53.5 \text{ kN/m}$

 PHG Consulting Engineers Ltd 107 Cowbridge Road East Cardiff CF11 9AG	Project Harvey Crescent, Abervon, Port Talbot				Job no. 2336	
	Calcs for 1.2m Cavity Fill Retaining Wall				Start page no./Revision 3	
	Calcs by WW	Calcs date 22/03/2024	Checked by PHG	Checked date 25/03/2024	Approved by PHG	Approved date 25/03/2024

Horizontal forces on wall

Total $F_{\text{total}_h} = \max(F_{\text{sur}_h} + F_{P_h} + F_{\text{moist}_h} + F_{\text{pass}_h} - F_{\text{total}_v} \times \tan(\delta_{\text{bb},k}), 0 \text{ kN/m}) = 0 \text{ kN/m}$

Moments on wall

Total $M_{\text{total}} = M_{\text{stem}} + M_{\text{base}} + M_{\text{sur}} + M_P + M_{\text{moist}} + M_{\text{pass}} = 38.8 \text{ kNm/m}$

Check bearing pressure

Bearing pressure at toe $q_{\text{toe}} = 42 \text{ kN/m}^2$ Bearing pressure at heel $q_{\text{heel}} = 25.9 \text{ kN/m}^2$

Factor of safety $\text{FoS}_{\text{bp}} = 1.19$

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

Design approach 1

Partial factors on actions - Table A.3 - Combination 1

Partial factor set A1

Permanent unfavourable action $\gamma_G = 1.35$ Permanent favourable action $\gamma_{Gf} = 1.00$

Variable unfavourable action $\gamma_Q = 1.50$ Variable favourable action $\gamma_{Qf} = 0.00$

Partial factors for soil parameters – Table A.4 - Combination 1

Soil parameter set M1

Angle of shearing resistance $\gamma_{\phi'} = 1.00$ Effective cohesion $\gamma_{c'} = 1.00$

Weight density $\gamma_r = 1.00$

Retained soil properties

Design moist density $\gamma_{mr}' = 16.9 \text{ kN/m}^3$ Design saturated density $\gamma_{sr}' = 20.6 \text{ kN/m}^3$

Des. eff. shear resist. angle $\phi'_{r,d} = 36 \text{ deg}$ Design wall friction angle $\delta_{r,d} = 18 \text{ deg}$

Base soil properties

Design soil density $\gamma_b' = 18 \text{ kN/m}^3$ Des. eff. shear resist. angle $\phi'_{b,d} = 24 \text{ deg}$

Design wall friction angle $\delta_{b,d} = 12 \text{ deg}$ Design base friction angle $\delta_{bb,d} = 24 \text{ deg}$

Design effective cohesion $c'_{b,d} = 0 \text{ kN/m}^2$

Using Coulomb theory

Active pressure coefficient $K_A = 0.254$ Passive pressure coefficient $K_P = 3.337$

Sliding check

Vertical forces on wall

Total $F_{\text{total}_v} = F_{\text{stem}} + F_{\text{base}} + F_{\text{moist}_v} = 50.2 \text{ kN/m}$

Horizontal forces on wall

Total $F_{\text{total}_h} = F_{\text{sur}_h} + F_{P_h} + F_{\text{moist}_h} = 12.1 \text{ kN/m}$

Check stability against sliding

Resistance to sliding $F_{\text{rest}} = 25 \text{ kN/m}$ Factor of safety $\text{FoS}_{\text{sl}} = 2.073$

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Total $F_{\text{total}_v} = F_{\text{stem}} + F_{\text{base}} + F_{\text{moist}_v} = 50.2 \text{ kN/m}$

Horizontal forces on wall

Total $F_{\text{total}_h} = F_{\text{sur}_h} + F_{P_h} + F_{\text{moist}_h} + F_{\text{exc}_h} = 9.4 \text{ kN/m}$

Overturning moments on wall

Total $M_{\text{total}_OT} = M_{\text{sur}_OT} + M_{P_OT} + M_{\text{moist}_OT} = 10.4 \text{ kNm/m}$

 PHG Consulting Engineers Ltd 107 Cowbridge Road East Cardiff CF11 9AG	Project Harvey Crescent, Abervon, Port Talbot				Job no. 2336	
	Calcs for 1.2m Cavity Fill Retaining Wall				Start page no./Revision 4	
	Calcs by WW	Calcs date 22/03/2024	Checked by PHG	Checked date 25/03/2024	Approved by PHG	Approved date 25/03/2024

Restoring moments on wall

Total $M_{total_R} = M_{stem_R} + M_{base_R} + M_{moist_R} + M_{exc_R} = 42.4 \text{ kNm/m}$

Check stability against overturning

Factor of safety $FoS_{ot} = 4.061$

PASS - Maximum restoring moment is greater than overturning moment

Design approach 1

Partial factors on actions - Table A.3 - Combination 2

Partial factor set A2

Permanent unfavourable action $\gamma_G = 1.00$ Permanent favourable action $\gamma_{Gf} = 1.00$

Variable unfavourable action $\gamma_Q = 1.30$ Variable favourable action $\gamma_{Qf} = 0.00$

Partial factors for soil parameters – Table A.4 - Combination 2

Soil parameter set M2

Angle of shearing resistance $\gamma_\psi = 1.25$ Effective cohesion $\gamma_{c'} = 1.25$

Weight density $\gamma_\gamma = 1.00$

Retained soil properties

Design moist density $\gamma_{mr}' = 16.9 \text{ kN/m}^3$ Design saturated density $\gamma_{sr}' = 20.6 \text{ kN/m}^3$

Des.eff.shear resist.angle $\phi'_{r,d} = 30.2 \text{ deg}$ Design wall friction angle $\delta_{r,d} = 14.6 \text{ deg}$

Base soil properties

Design soil density $\gamma_b' = 18 \text{ kN/m}^3$ Des.eff.shear resist.angle $\phi'_{b,d} = 19.6 \text{ deg}$

Design wall friction angle $\delta_{b,d} = 9.7 \text{ deg}$ Design base friction angle $\delta_{bb,d} = 19.6 \text{ deg}$

Design effective cohesion $c'_{b,d} = 0 \text{ kN/m}^2$

Using Coulomb theory

Active pressure coefficient $K_A = 0.327$ Passive pressure coefficient $K_P = 2.567$

Sliding check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{moist_v} = 50.2 \text{ kN/m}$

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{P_h} + F_{moist_h} = 11.8 \text{ kN/m}$

Check stability against sliding

Resistance to sliding $F_{rest} = 19.9 \text{ kN/m}$ Factor of safety $FoS_{sl} = 1.683$

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{moist_v} = 50.2 \text{ kN/m}$

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{P_h} + F_{moist_h} + F_{exc_h} = 9.8 \text{ kN/m}$

Overturning moments on wall

Total $M_{total_OT} = M_{sur_OT} + M_{P_OT} + M_{moist_OT} = 10 \text{ kNm/m}$

Restoring moments on wall

Total $M_{total_R} = M_{stem_R} + M_{base_R} + M_{moist_R} + M_{exc_R} = 42.3 \text{ kNm/m}$

 PHG Consulting Engineers Ltd 107 Cowbridge Road East Cardiff CF11 9AG	Project Harvey Crescent, Abervon, Port Talbot				Job no. 2336	
	Calcs for 1.2m Cavity Fill Retaining Wall				Start page no./Revision 5	
	Calcs by WW	Calcs date 22/03/2024	Checked by PHG	Checked date 25/03/2024	Approved by PHG	Approved date 25/03/2024

Check stability against overturning

Factor of safety $FoS_{ot} = 4.219$

PASS - Maximum restoring moment is greater than overturning moment

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 and EN1996-1-1:2005 incorporating Corrigenda dated February 2006 and July 2009 and the UK National Annex

Tedds calculation version 2.9.17

Concrete details - Table 3.1 - Strength and deformation characteristics for concrete

Concrete strength class	C28/35		
Char.comp.cylinder strength	$f_{ck} = 28 \text{ N/mm}^2$	Mean axial tensile strength	$f_{ctm} = 2.8 \text{ N/mm}^2$
Secant modulus of elasticity	$E_{cm} = 32308 \text{ N/mm}^2$	Maximum aggregate size	$h_{agg} = 20 \text{ mm}$
Design comp.concrete strength		$f_{cd} = 15.9 \text{ N/mm}^2$	Partial factor $\gamma_c = 1.50$

Reinforcement details

Characteristic yield strength	$f_{yk} = 500 \text{ N/mm}^2$	Modulus of elasticity	$E_s = 200000 \text{ N/mm}^2$
Design yield strength	$f_{yd} = 435 \text{ N/mm}^2$	Partial factor	$\gamma_s = 1.15$

Cover to reinforcement

Top face of base	$C_{bt} = 50 \text{ mm}$	Bottom face of base	$C_{bb} = 75 \text{ mm}$
------------------	--------------------------	---------------------	--------------------------

Masonry details - Section 3.1

Masonry type	Aggregate concrete - Group 1		
Norm.mean comp.strength	$f_b = 10.4 \text{ N/mm}^2$	Char.flexural strength	$f_{xk} = 0 \text{ N/mm}^2$
Initial shear strength	$f_{vko} = 0.15 \text{ N/mm}^2$		

Mortar details - Section 3.2

Mortar type	General purpose - M6, prescribed mix	Comp.strength of mortar
	$f_m = 6 \text{ N/mm}^2$	

Ultimate limit states - Table NA.1

Execution control class	1	Manufacture control category	1
Partial factor for compression	$\gamma_{Mc} = 2.0$	Partial factor for tension	$\gamma_{Mt} = 2.3$
Partial factor for shear	$\gamma_{Mv} = 2.0$		

Characteristic strengths of concrete infill - Table 3.2

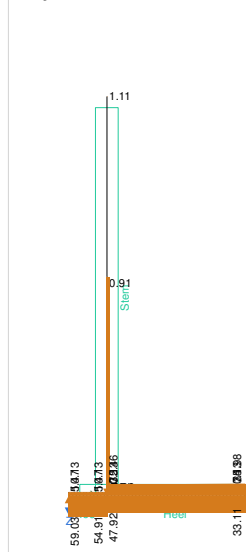
Concrete infill strength class	C28/35	Char.compressive strength	$f_{ck,infill} = 25 \text{ N/mm}^2$
Char.shear strength	$f_{cvk,infill} = 0.45 \text{ N/mm}^2$	Design shear strength	$f_{cvd,infill} = 0.225 \text{ N/mm}^2$



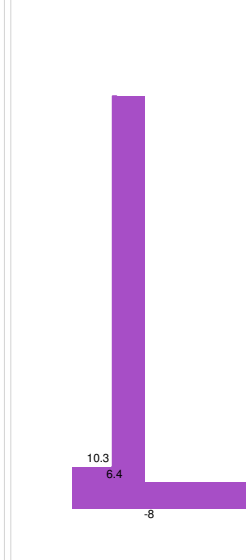
PHG Consulting Engineers Ltd
107 Cowbridge Road East
Cardiff
CF11 9AG

Project Harvey Crescent, Abervon, Port Talbot				Job no. 2336	
Calcs for 1.2m Cavity Fill Retaining Wall				Start page no./Revision 6	
Calcs by WW	Calcs date 22/03/2024	Checked by PHG	Checked date 25/03/2024	Approved by PHG	Approved date 25/03/2024

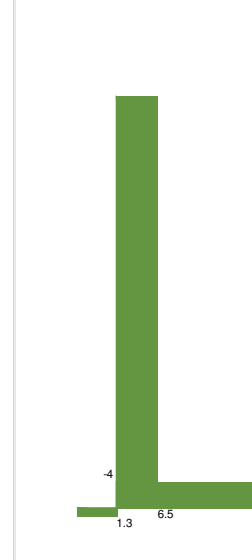
Loading details - Combination No.1 - kN/m²



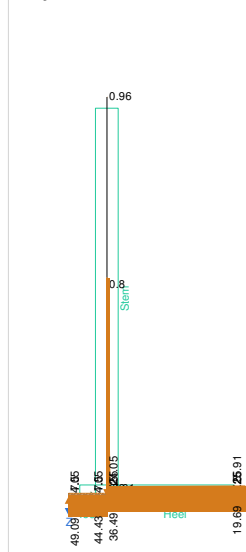
Shear force - Combination No.1 - kN/m



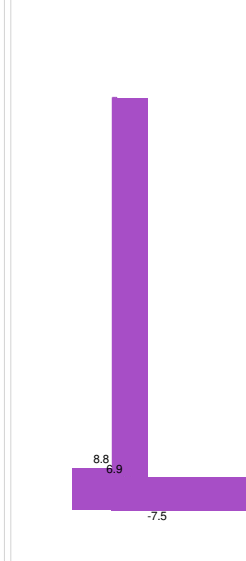
Bending moment - Combination No.1 - kNm/m



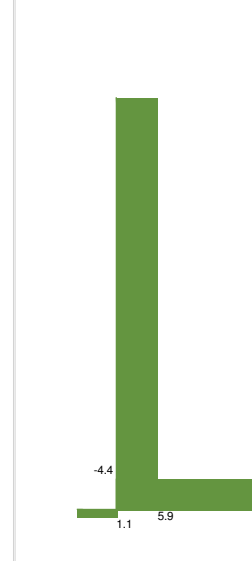
Loading details - Combination No.2 - kN/m²



Shear force - Combination No.2 - kN/m



Bending moment - Combination No.2 - kNm/m



Check stem design at base of stem

Depth of section $t = 425$ mm

Cavity wall details

Front leaf thickness $t_f = 102$ mm

Rear leaf thickness $t_r = 100$ mm

Masonry characteristics

Char.compressive strength $f_k = 4.85$ N/mm²

Design compressive strength $f_d = 2.425$ N/mm²

Design flexural strength $f_{xd} = 0$ N/mm²

Apparent design flex.strength $f_{xd,app} = 0.038$ N/mm²

Characteristic shear strength $f_{vk} = 0.165$ N/mm²

Design shear strength $f_{vd} = 0.083$ N/mm²

Reinforced masonry members subjected to bending, bending and axial loading, or axial loading - Section 6.6

Design bending moment $M = 6.5$ kNm/m

Moment of resistance $M_{Rd} = 21.8$ kNm/m

Tens.reinforcement provided 10 dia.bars @ 100 c/c

Tens.reinforcement provided $A_{sr,prov} = 785$ mm²/m

Min.area of reinforcement $A_{sr,min} = 75$ mm²/m

 PHG Consulting Engineers Ltd 107 Cowbridge Road East Cardiff CF11 9AG	Project Harvey Crescent, Abervon, Port Talbot				Job no. 2336	
	Calcs for 1.2m Cavity Fill Retaining Wall				Start page no./Revision 7	
	Calcs by WW	Calcs date 22/03/2024	Checked by PHG	Checked date 25/03/2024	Approved by PHG	Approved date 25/03/2024

PASS - Moment of resistance exceeds applied design moment

Reinforced masonry members subjected to shear loading - Section 6.7

Design shear force $V = 8 \text{ kN/m}$

Design shear resistance $V_{Rd} = 12.375 \text{ kN/m}$

PASS - Design shear resistance exceeds applied design shear force

Horizontal reinforcement parallel to face of stem

Min.area of reinforcement $A_{sx.req} = 75 \text{ mm}^2/\text{m}$

Trans.reinforcement provided Mesh - 8 dia.bars @ 200 c/c Trans.reinforcement provided $A_{sx.prov} = 251 \text{ mm}^2/\text{m}$
 $\pi \times \phi_{sx}^2 / (4 \times s_{sx})$

Check base design at toe

Depth of section $h = 300 \text{ mm}$

Rectangular section in flexure - Section 6.1

Design bending moment $M = 1.3 \text{ kNm/m}$ $K = 0.001$ $K' = 0.207$

$K' > K$ - No compression reinforcement is required

Tens.reinforcement required $A_{bb.req} = 14 \text{ mm}^2/\text{m}$

Tens.reinforcement provided Mesh B785 - 10 dia.bars @ 100 c/c

Tens.reinforcement

provided $A_{bb.prov} = 785 \text{ mm}^2/\text{m}$

Min.area of reinforcement $A_{bb.min} = 316 \text{ mm}^2/\text{m}$ Max.area of reinforcement $A_{bb.max} = 12000 \text{ mm}^2/\text{m}$

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

Library item: Rectangular single summary

Crack control - Section 7.3

Limiting crack width $w_{max} = 0.3 \text{ mm}$

Maximum crack width $w_k = 0.008 \text{ mm}$

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force $V = 10.3 \text{ kN/m}$

Rectangular section in shear - Section 6.2

Design shear force $V = 10.3 \text{ kN/m}$

Design shear resistance $V_{Rd.c} = 111.2 \text{ kN/m}$

PASS - Design shear resistance exceeds design shear force

Check base design at heel

Depth of section $h = 300 \text{ mm}$

Rectangular section in flexure - Section 6.1

Design bending moment $M = 4.4 \text{ kNm/m}$ $K = 0.003$ $K' = 0.207$

$K' > K$ - No compression reinforcement is required

Tens.reinforcement required $A_{bt.req} = 43 \text{ mm}^2/\text{m}$

Tens.reinforcement provided Mesh B785 - 10 dia.bars @ 100 c/c

Tens.reinforcement

provided $A_{bt.prov} = 785 \text{ mm}^2/\text{m}$

Min.area of reinforcement $A_{bt.min} = 352 \text{ mm}^2/\text{m}$ Max.area of reinforcement $A_{bt.max} = 12000 \text{ mm}^2/\text{m}$

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

Library item: Rectangular single summary

Crack control - Section 7.3

Limiting crack width $w_{max} = 0.3 \text{ mm}$

Maximum crack width $w_k = 0.013 \text{ mm}$

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force $V = 6.9 \text{ kN/m}$

 PHG Consulting Engineers Ltd 107 Cowbridge Road East Cardiff CF11 9AG	Project Harvey Crescent, Abervon, Port Talbot				Job no. 2336	
	Calcs for 1.2m Cavity Fill Retaining Wall				Start page no./Revision 8	
	Calcs by WW	Calcs date 22/03/2024	Checked by PHG	Checked date 25/03/2024	Approved by PHG	Approved date 25/03/2024

Rectangular section in shear - Section 6.2

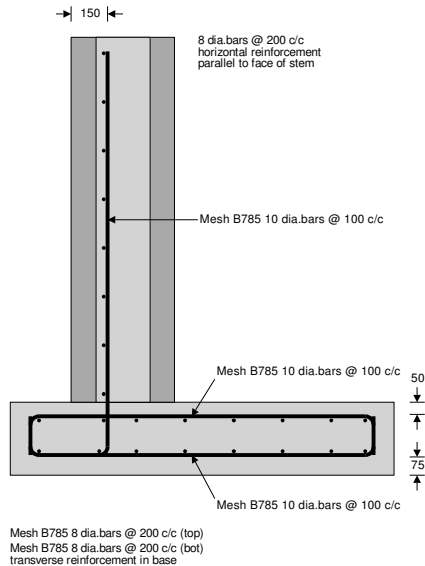
Design shear force $V = 6.9 \text{ kN/m}$ Design shear resistance $V_{Rd,c} = 119.2 \text{ kN/m}$
PASS - Design shear resistance exceeds design shear force

Secondary transverse reinforcement to base - Section 9.3

Min.area of reinforcement $A_{bx,req} = 157 \text{ mm}^2/\text{m}$ Max.spacing of reinforcement $S_{bx,max} = 450 \text{ mm}$
Trans.reinforcement provided Mesh - 8 dia.bars @ 200 c/c Trans.reinforcement provided $A_{bx,prov} = 251 \text{ mm}^2/\text{m}$
PASS - Area of reinforcement provided is greater than area of reinforcement required

Secondary transverse reinforcement to base - Section 9.3

Min.area of reinforcement $A_{bx,req} = 157 \text{ mm}^2/\text{m}$ Max.spacing of reinforcement $S_{bx,max} = 450 \text{ mm}$
Trans.reinforcement provided Mesh - 8 dia.bars @ 200 c/c Trans.reinforcement provided $A_{bx,prov} = 251 \text{ mm}^2/\text{m}$
PASS - Area of reinforcement provided is greater than area of reinforcement required



Reinforcement details