

Project 17 REGIS PARK ROAD, READING, RG6 7AD		Job no.	
Calcs for RETAINING WALL DESIGN		Start page no./Revision 1	
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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

Tedds calculation version 2.9.22

Analysis summary

Design summary

Overall design utilisation 0.958

Overall design status Pass

Description	Unit	Capacity	Applied	F o S	Result
Overturning stability	kNm/m	9.2	8.8	1.043	PASS
Bearing pressure	kN/m ²	100	74.7	1.338	PASS

Design summary

Description	Unit	Provided	Required	Utilisation	Result
Shear resistance	kN/m	81.2	13.8	0.170	PASS
Base top face - Flexural reinforcement	mm ² /m	392.7	228.0	0.581	PASS
Base bottom face - Flexural reinforcement	mm ² /m	392.7	228.0	0.581	PASS
Base - Shear resistance	kN/m	81.2	13.8	0.170	PASS
Min. transverse stem reinf.	mm ² /m	392.7	77.5	0.197	PASS
Min. transverse base reinf.	mm ² /m	392.7	78.5	0.200	PASS

Retaining wall details

Stem type	Cantilever
Stem height	$h_{\text{stem}} = 1250$ mm
Stem thickness	$t_{\text{stem}} = 215$ mm
Angle to rear face of stem	$\alpha = 90$ deg
Stem density	$\gamma_{\text{stem}} = 25$ kN/m ³
Toe length	$l_{\text{toe}} = 300$ mm
Heel length	$l_{\text{heel}} = 300$ mm
Base thickness	$t_{\text{base}} = 200$ mm
Base density	$\gamma_{\text{base}} = 25$ kN/m ³
Height of retained soil	$h_{\text{ret}} = 1150$ mm
Angle of soil surface	$\beta = 5$ deg
Depth of cover	$d_{\text{cover}} = 100$ mm
Depth of excavation	$d_{\text{exc}} = 100$ mm

Retained soil properties

Soil type	Stiff clay
Moist density	$\gamma_{\text{mr}} = 19$ kN/m ³
Saturated density	$\gamma_{\text{sr}} = 19$ kN/m ³
Characteristic effective shear resistance angle	$\phi'_{r,k} = 18$ deg
Characteristic wall friction angle	$\delta_{r,k} = 9$ deg

Base soil properties

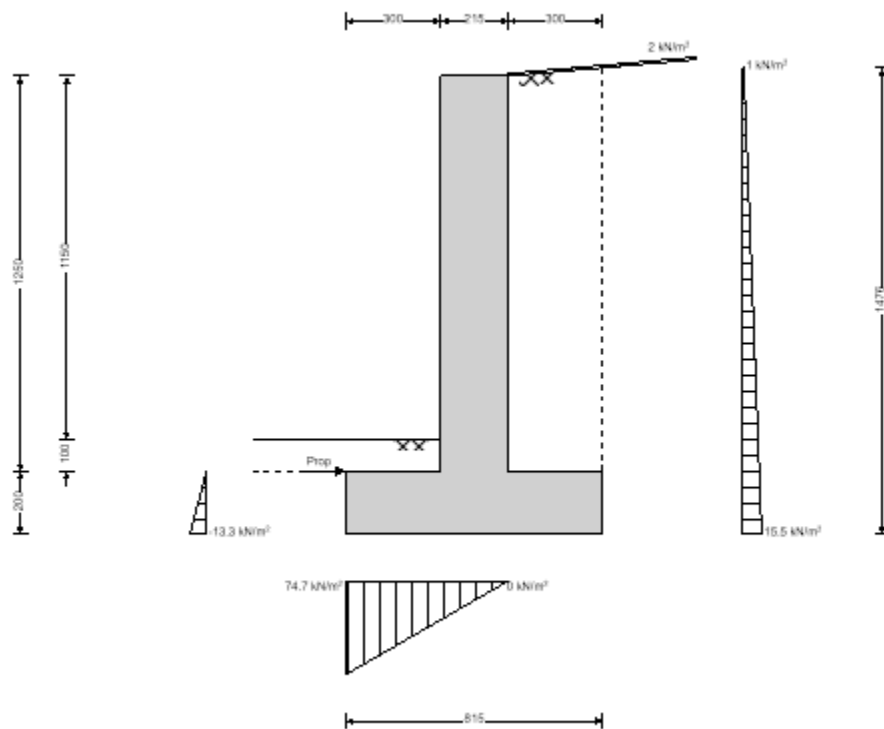
Soil type	Stiff clay
Soil density	$\gamma_b = 19$ kN/m ³
Characteristic effective shear resistance angle	$\phi'_{b,k} = 18$ deg
Characteristic wall friction angle	$\delta_{b,k} = 9$ deg
Characteristic base friction angle	$\delta_{bb,k} = 12$ deg
Presumed bearing capacity	$P_{\text{bearing}} = 100$ kN/m ²

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Loading details

Variable surcharge load

Surcharge_q = 2 kN/m²



General arrangement - sketch pressures relate to bearing check

Calculate retaining wall geometry

Base length

$$l_{base} = l_{toe} + t_{stem} + l_{heel} = \mathbf{815 \text{ mm}}$$

Moist soil height

$$h_{moist} = h_{soil} = \mathbf{1250 \text{ mm}}$$

Length of surcharge load

$$l_{sur} = l_{heel} = \mathbf{300 \text{ mm}}$$

- Distance to vertical component

$$x_{sur_v} = l_{base} - l_{heel} / 2 = \mathbf{665 \text{ mm}}$$

Effective height of wall

$$h_{eff} = h_{base} + d_{cover} + h_{ret} + l_{sur} \times \tan(\beta) = \mathbf{1476 \text{ mm}}$$

- Distance to horizontal component

$$x_{sur_h} = h_{eff} / 2 = \mathbf{738 \text{ mm}}$$

Area of wall stem

$$A_{stem} = h_{stem} \times t_{stem} = \mathbf{0.269 \text{ m}^2}$$

- Distance to vertical component

$$x_{stem} = l_{toe} + t_{stem} / 2 = \mathbf{407 \text{ mm}}$$

Area of wall base

$$A_{base} = l_{base} \times t_{base} = \mathbf{0.163 \text{ m}^2}$$

- Distance to vertical component

$$x_{base} = l_{base} / 2 = \mathbf{407 \text{ mm}}$$

Area of moist soil

$$A_{moist} = h_{moist} \times l_{heel} + \tan(\beta) \times l_{heel}^2 / 2 = \mathbf{0.379 \text{ m}^2}$$

- Distance to vertical component

$$x_{moist_v} = l_{base} - (h_{moist} \times l_{heel}^2 / 2 + \tan(\beta) \times l_{heel}^3 / 6) / A_{moist} = \mathbf{666 \text{ mm}}$$

- Distance to horizontal component

$$x_{moist_h} = h_{eff} / 3 = \mathbf{492 \text{ mm}}$$

Area of base soil

$$A_{pass} = d_{cover} \times l_{toe} = \mathbf{0.03 \text{ m}^2}$$

- Distance to vertical component

$$x_{pass_v} = l_{base} - (d_{cover} \times l_{toe} \times (l_{base} - l_{toe} / 2)) / A_{pass} = \mathbf{150 \text{ mm}}$$

- Distance to horizontal component

$$x_{pass_h} = (d_{cover} + h_{base}) / 3 = \mathbf{100 \text{ mm}}$$

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Using Coulomb theory

Active pressure coefficient

$$K_A = \sin(\alpha + \phi'_{r,k})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,k}) \times [1 + \sqrt{[\sin(\phi'_{r,k} + \delta_{r,k}) \times \sin(\phi'_{r,k} - \beta) / (\sin(\alpha - \delta_{r,k}) \times \sin(\alpha + \beta))]}])^2 = \mathbf{0.524}$$

Passive pressure coefficient

$$K_P = \sin(90 - \phi'_{b,k})^2 / (\sin(90 + \delta_{b,k}) \times [1 - \sqrt{[\sin(\phi'_{b,k} + \delta_{b,k}) \times \sin(\phi'_{b,k} / (\sin(90 + \delta_{b,k}))]}])^2 = \mathbf{2.359}$$

Bearing pressure check

Vertical forces on wall

Wall stem

$$F_{stem} = A_{stem} \times \gamma_{stem} = \mathbf{6.7 \text{ kN/m}}$$

Wall base

$$F_{base} = A_{base} \times \gamma_{base} = \mathbf{4.1 \text{ kN/m}}$$

Surcharge load

$$F_{sur_v} = \text{Surcharge}_Q \times l_{heel} = \mathbf{0.6 \text{ kN/m}}$$

Moist retained soil

$$F_{moist_v} = A_{moist} \times \gamma_{mr} = \mathbf{7.2 \text{ kN/m}}$$

Base soil

$$F_{pass_v} = A_{pass} \times \gamma_b = \mathbf{0.6 \text{ kN/m}}$$

Total

$$F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{pass_v} = \mathbf{19.2 \text{ kN/m}}$$

Horizontal forces on wall

Surcharge load

$$F_{sur_h} = K_A \times \cos(\delta_{r,k}) \times \text{Surcharge}_Q \times h_{eff} = \mathbf{1.5 \text{ kN/m}}$$

Moist retained soil

$$F_{moist_h} = K_A \times \cos(\delta_{r,k}) \times \gamma_{mr} \times h_{eff}^2 / 2 = \mathbf{10.7 \text{ kN/m}}$$

Base soil

$$F_{pass_h} = -K_P \times \cos(\delta_{b,k}) \times \gamma_b \times (d_{cover} + h_{base})^2 / 2 = \mathbf{-2 \text{ kN/m}}$$

Total

$$F_{total_h} = F_{sur_h} + F_{moist_h} + F_{pass_h} = \mathbf{10.2 \text{ kN/m}}$$

Moments on wall

Wall stem

$$M_{stem} = F_{stem} \times X_{stem} = \mathbf{2.7 \text{ kNm/m}}$$

Wall base

$$M_{base} = F_{base} \times X_{base} = \mathbf{1.7 \text{ kNm/m}}$$

Surcharge load

$$M_{sur} = F_{sur_v} \times X_{sur_v} - F_{sur_h} \times X_{sur_h} = \mathbf{-0.7 \text{ kNm/m}}$$

Moist retained soil

$$M_{moist} = F_{moist_v} \times X_{moist_v} - F_{moist_h} \times X_{moist_h} = \mathbf{-0.5 \text{ kNm/m}}$$

Base soil

$$M_{pass} = F_{pass_v} \times X_{pass_v} = \mathbf{0.1 \text{ kNm/m}}$$

Total

$$M_{total} = M_{stem} + M_{base} + M_{sur} + M_{moist} + M_{pass} = \mathbf{3.3 \text{ kNm/m}}$$

Check bearing pressure

Propping force

$$F_{prop_base} = F_{total_h} = \mathbf{10.2 \text{ kN/m}}$$

Distance to reaction

$$\bar{x} = M_{total} / F_{total_v} = \mathbf{171 \text{ mm}}$$

Eccentricity of reaction

$$e = \bar{x} - l_{base} / 2 = \mathbf{-237 \text{ mm}}$$

Loaded length of base

$$l_{load} = 3 \times \bar{x} = \mathbf{513 \text{ mm}}$$

Bearing pressure at toe

$$q_{toe} = 2 \times F_{total_v} / l_{load} = \mathbf{74.7 \text{ kN/m}^2}$$

Bearing pressure at heel

$$q_{heel} = \mathbf{0 \text{ kN/m}^2}$$

Factor of safety

$$FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel}) = \mathbf{1.338}$$

PASS - Allowable bearing pressure exceeds maximum applied bearing 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 and EN1996-1-1:2005 incorporating Corrigenda dated February 2006 and July 2009 and the UK National Annex

Tedds calculation version 2.9.22

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

Concrete strength class

$$\mathbf{C32/40}$$

Characteristic compressive cylinder strength

$$f_{ck} = \mathbf{32 \text{ N/mm}^2}$$

Characteristic compressive cube strength

$$f_{ck,cube} = \mathbf{40 \text{ N/mm}^2}$$

Mean value of compressive cylinder strength

$$f_{cm} = f_{ck} + 8 \text{ N/mm}^2 = \mathbf{40 \text{ N/mm}^2}$$

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Mean value of axial tensile strength	$f_{ctm} = 0.3 \text{ N/mm}^2 \times (f_{ck} / 1 \text{ N/mm}^2)^{2/3} = \mathbf{3.0 \text{ N/mm}^2}$
5% fractile of axial tensile strength	$f_{ctk,0.05} = 0.7 \times f_{ctm} = \mathbf{2.1 \text{ N/mm}^2}$
Secant modulus of elasticity of concrete	$E_{cm} = 22 \text{ kN/mm}^2 \times (f_{cm} / 10 \text{ N/mm}^2)^{0.3} = \mathbf{33346 \text{ N/mm}^2}$
Partial factor for concrete - Table 2.1N	$\gamma_C = \mathbf{1.50}$
Compressive strength coefficient - cl.3.1.6(1)	$\alpha_{cc} = \mathbf{0.85}$
Design compressive concrete strength - exp.3.15	$f_{cd} = \alpha_{cc} \times f_{ck} / \gamma_C = \mathbf{18.1 \text{ N/mm}^2}$
Maximum aggregate size	$h_{agg} = \mathbf{20 \text{ mm}}$
Ultimate strain - Table 3.1	$\epsilon_{cu2} = \mathbf{0.0035}$
Shortening strain - Table 3.1	$\epsilon_{cu3} = \mathbf{0.0035}$
Effective compression zone height factor	$\lambda = \mathbf{0.80}$
Effective strength factor	$\eta = \mathbf{1.00}$
Bending coefficient k_1	$K_1 = \mathbf{0.40}$
Bending coefficient k_2	$K_2 = 1.00 \times (0.6 + 0.0014/\epsilon_{cu2}) = \mathbf{1.00}$
Bending coefficient k_3	$K_3 = \mathbf{0.40}$
Bending coefficient k_4	$K_4 = 1.00 \times (0.6 + 0.0014/\epsilon_{cu2}) = \mathbf{1.00}$

Reinforcement details

Characteristic yield strength of reinforcement	$f_{yk} = \mathbf{500 \text{ N/mm}^2}$
Modulus of elasticity of reinforcement	$E_s = \mathbf{200000 \text{ N/mm}^2}$
Partial factor for reinforcing steel - Table 2.1N	$\gamma_S = \mathbf{1.15}$
Design yield strength of reinforcement	$f_{yd} = f_{yk} / \gamma_S = \mathbf{435 \text{ N/mm}^2}$

Cover to reinforcement

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

Masonry details - Section 3.1

Masonry type	Aggregate concrete - Group 1
Normalised mean compressive strength	$f_b = \mathbf{7.3 \text{ N/mm}^2}$
Characteristic flexural strength - cl.6.3.4(1)	$f_{xk} = \mathbf{0 \text{ N/mm}^2}$
Initial shear strength - Table NA.5	$f_{vko} = \mathbf{0.3 \text{ N/mm}^2}$

Mortar details - Section 3.2

Mortar type	Thin layer - M6, prescribed mix
Compressive strength of mortar	$f_m = \mathbf{6 \text{ N/mm}^2}$

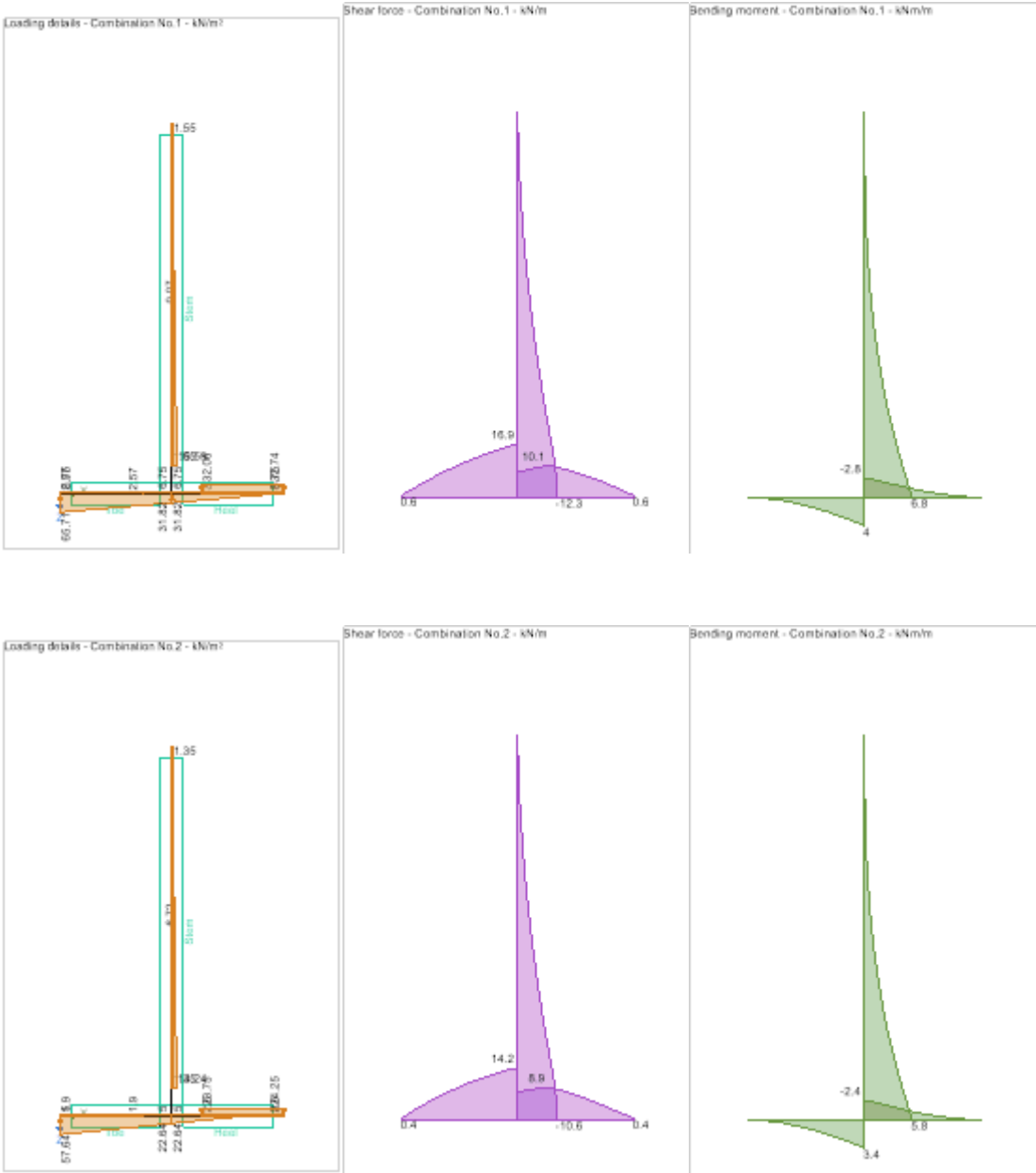
Ultimate limit states - Table NA.1

Class of execution control	1
Category of manufacture control	1
Partial factor for direct or flexural compression	$\gamma_{Mc} = \mathbf{2.0}$
Partial factor for flexural tension	$\gamma_{Mt} = \mathbf{2.3}$
Partial factor for shear	$\gamma_{Mv} = \mathbf{2.0}$

Characteristic strengths of concrete infill - Table 3.2

Concrete infill strength class	C25/30
Characteristic compressive strength	$f_{ck,infill} = \mathbf{25 \text{ N/mm}^2}$
Characteristic shear strength	$f_{cvk,infill} = \mathbf{0.45 \text{ N/mm}^2}$
Design shear strength	$f_{cvd,infill} = f_{cvk,infill} / \gamma_{Mv} = \mathbf{0.225 \text{ N/mm}^2}$

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Check stem design at base of stem

Depth of section t = 215 mm

Hollow wall details

Face shell thickness t_{shell} = 35 mm

Web shell thickness t_{web} = 35 mm

Masonry characteristics

Compressive strength constants - Table NA.4 K = 0.900

Characteristic compressive strength - cl.3.6.1.2(1) f_k = K × f_b^{0.85} × (1 N/mm²)^{0.15} = 4.876 N/mm²

Design compressive strength f_d = min(f_k, f_{ck,infill}) / γ_{Mc} = 2.438 N/mm²

Design flexural strength f_{xd} = f_{xk} / γ_{Mt} = 0 N/mm²

Height of masonry h_{wt} = h_{stem} = 1250 mm

Compressive axial force combination 1 F_x = γ_{Gf} × γ_{stem} × h_{wt} × t = 6.7 kN/m

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Moment combination 1

$$M_x = \gamma_{Gf} \times \gamma_{stem} \times h_{wt} \times t^2 / 2 = \mathbf{0.7 \text{ kNm/m}}$$

Eccentricity of axial load

$$e = \max(\text{abs}(t / 2 - M_x / F_x), 0.05 \times t) = \mathbf{10.8 \text{ mm}}$$

Capacity reduction factor - exp.6.4

$$\Phi = 1 - 2 \times e / t = \mathbf{0.9}$$

Design vertical resistance - exp.6.2

$$N_{Rd} = \Phi \times t \times f_d = \mathbf{471.8 \text{ kN/m}}$$

Design vertical compressive stress

$$\sigma_d = \min(F_x / t, 0.15 \times N_{Rd} / t) = \mathbf{0.031 \text{ N/mm}^2}$$

Apparent design flexural strength - exp.6.16

$$f_{xd,app} = f_{xd} + \sigma_d = \mathbf{0.031 \text{ N/mm}^2}$$

Limit of charact. shear strength - exp. 3.1

$$f_{vk,lim} = 0.065 \times f_b = \mathbf{0.475 \text{ N/mm}^2}$$

Characteristic shear strength - exp.3.5

$$f_{vk} = \min(f_{vko} + 0.4 \times \sigma_d, f_{vk,lim}) = \mathbf{0.313 \text{ N/mm}^2}$$

Design shear strength

$$f_{vd} = f_{vk} / \gamma_{Mv} = \mathbf{0.156 \text{ N/mm}^2}$$

Library item: Masonry characteristics output

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

Design bending moment combination 1

$$M = \mathbf{5.5 \text{ kNm/m}}$$

Tension reinforcement provided

$$10 \text{ dia.bars @ } 200 \text{ c/c}$$

Area of tension reinforcement provided

$$A_{sr,prov} = \pi \times \phi_{sr}^2 / (4 \times s_{sr}) = \mathbf{393 \text{ mm}^2/\text{m}}$$

Depth to tension reinforcement

$$d = \mathbf{155 \text{ mm}}$$

Minimum area of reinforcement - cl.8.2.3(1)

$$A_{sr,min} = 0.0005 \times d = \mathbf{78 \text{ mm}^2/\text{m}}$$

Lever arm - exp.6.23

$$z = d \times \min(1 - 0.5 \times A_{sr,prov} \times f_{yd} / (d \times f_d), 0.95) = \mathbf{120 \text{ mm}}$$

Moment of resistance - exp.6.22 and exp.6.24a

$$M_{Rd} = \min(A_{sr,prov} \times f_{yd} \times z, 0.4 \times f_d \times d^2) = \mathbf{20.5 \text{ kNm/m}}$$

$$M / M_{Rd} = \mathbf{0.270}$$

PASS - Moment of resistance exceeds applied design moment

Reinforced masonry members subjected to shear loading - Section 6.7

Design shear force

$$V = \mathbf{12.309 \text{ kN/m}}$$

Design shear resistance - exp.6.40

$$V_{Rd} = \min(f_{vd}, f_{cvd,infill}) \times d = \mathbf{24.219 \text{ kN/m}}$$

$$V / V_{Rd} = \mathbf{0.508}$$

PASS - Design shear resistance exceeds applied design shear force

Horizontal reinforcement parallel to face of stem

Minimum area of reinforcement - cl.8.2.3(4)

$$A_{sx,req} = 0.0005 \times d = \mathbf{78 \text{ mm}^2/\text{m}}$$

Transverse reinforcement provided

$$10 \text{ dia.bars @ } 200 \text{ c/c}$$

Area of transverse reinforcement provided

$$A_{sx,prov} = \pi \times \phi_{sx}^2 / (4 \times s_{sx}) = \mathbf{393 \text{ mm}^2/\text{m}}$$

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

Check base design at toe

Depth of section

$$h = \mathbf{200 \text{ mm}}$$

Rectangular section in flexure - Section 6.1

Design bending moment combination 1

$$M = \mathbf{2.3 \text{ kNm/m}}$$

Depth to tension reinforcement

$$d = h - C_{bb} - \phi_{bb} / 2 = \mathbf{145 \text{ mm}}$$

$$K = M / (d^2 \times f_{ck}) = \mathbf{0.003}$$

$$K' = (2 \times \eta \times \alpha_{cc} / \gamma_c) \times (1 - \lambda \times (\delta - K_1) / (2 \times K_2)) \times (\lambda \times (\delta - K_1) / (2 \times K_2))$$

$$K' = \mathbf{0.207}$$

K' > K - No compression reinforcement is required

Lever arm

$$z = \min(0.5 + 0.5 \times (1 - 2 \times K / (\eta \times \alpha_{cc} / \gamma_c))^{0.5}, 0.95) \times d = \mathbf{138 \text{ mm}}$$

Depth of neutral axis

$$x = 2.5 \times (d - z) = \mathbf{18 \text{ mm}}$$

Area of tension reinforcement required

$$A_{bb,req} = M / (f_{yd} \times z) = \mathbf{39 \text{ mm}^2/\text{m}}$$

Tension reinforcement provided

$$10 \text{ dia.bars @ } 200 \text{ c/c}$$

Area of tension reinforcement provided

$$A_{bb,prov} = \pi \times \phi_{bb}^2 / (4 \times s_{bb}) = \mathbf{393 \text{ mm}^2/\text{m}}$$

Minimum area of reinforcement - exp.9.1N

$$A_{bb,min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d = \mathbf{228 \text{ mm}^2/\text{m}}$$

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Maximum area of reinforcement - cl.9.2.1.1(3)

$$A_{bb,max} = 0.04 \times h = \mathbf{8000 \text{ mm}^2/m}$$

$$\max(A_{bb,req}, A_{bb,min}) / A_{bb,prov} = \mathbf{0.581}$$

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

Library item: Rectangular single output

Crack control - Section 7.3

Limiting crack width

$$W_{max} = \mathbf{0.3 \text{ mm}}$$

Variable load factor - EN1990 – Table A1.1

$$\psi_2 = \mathbf{0.6}$$

Serviceability bending moment

$$M_{sls} = \mathbf{1.6 \text{ kNm/m}}$$

Tensile stress in reinforcement

$$\sigma_s = M_{sls} / (A_{bb,prov} \times z) = \mathbf{29.4 \text{ N/mm}^2}$$

Load duration

Long term

Load duration factor

$$k_t = \mathbf{0.4}$$

Effective area of concrete in tension

$$A_{c,eff} = \min(2.5 \times (h - d), (h - x) / 3, h / 2)$$

$$A_{c,eff} = \mathbf{60625 \text{ mm}^2/m}$$

Mean value of concrete tensile strength

$$f_{ct,eff} = f_{ctm} = \mathbf{3.0 \text{ N/mm}^2}$$

Reinforcement ratio

$$\rho_{p,eff} = A_{bb,prov} / A_{c,eff} = \mathbf{0.006}$$

Modular ratio

$$\alpha_e = E_s / E_{cm} = \mathbf{5.998}$$

Bond property coefficient

$$k_1 = \mathbf{0.8}$$

Strain distribution coefficient

$$k_2 = \mathbf{0.5}$$

$$k_3 = \mathbf{3.4}$$

$$k_4 = \mathbf{0.425}$$

Maximum crack spacing - exp.7.11

$$s_{r,max} = k_3 \times c_{bb} + k_1 \times k_2 \times k_4 \times \phi_{bb} / \rho_{p,eff} = \mathbf{432 \text{ mm}}$$

Maximum crack width - exp.7.8

$$w_k = s_{r,max} \times \max(\sigma_s - k_t \times (f_{ct,eff} / \rho_{p,eff}) \times (1 + \alpha_e \times \rho_{p,eff}), 0.6 \times \sigma_s) / E_s$$

$$w_k = \mathbf{0.038 \text{ mm}}$$

$$w_k / w_{max} = \mathbf{0.127}$$

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force

$$V = \mathbf{13.8 \text{ kN/m}}$$

$$C_{Rd,c} = 0.18 / \gamma_c = \mathbf{0.120}$$

$$k = \min(1 + \sqrt{(200 \text{ mm} / d)}, 2) = \mathbf{2.000}$$

Longitudinal reinforcement ratio

$$\rho_l = \min(A_{bb,prov} / d, 0.02) = \mathbf{0.003}$$

$$v_{min} = 0.035 \text{ N}^{1/2}/\text{mm} \times k^{3/2} \times f_{ck}^{0.5} = \mathbf{0.560 \text{ N/mm}^2}$$

Design shear resistance - exp.6.2a & 6.2b

$$V_{Rd,c} = \max(C_{Rd,c} \times k \times (100 \text{ N}^2/\text{mm}^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$$

$$V_{Rd,c} = \mathbf{81.2 \text{ kN/m}}$$

$$V / V_{Rd,c} = \mathbf{0.170}$$

PASS - Design shear resistance exceeds design shear force

Check base design at heel

Depth of section

$$h = \mathbf{200 \text{ mm}}$$

Rectangular section in flexure - Section 6.1

Design bending moment combination 1

$$M = \mathbf{1.8 \text{ kNm/m}}$$

Depth to tension reinforcement

$$d = h - c_{bt} - \phi_{bt} / 2 = \mathbf{145 \text{ mm}}$$

$$K = M / (d^2 \times f_{ck}) = \mathbf{0.003}$$

$$K' = (2 \times \eta \times \alpha_{cc} / \gamma_c) \times (1 - \lambda \times (\delta - K_1) / (2 \times K_2)) \times (\lambda \times (\delta - K_1) / (2 \times K_2))$$

$$K' = \mathbf{0.207}$$

K' > K - No compression reinforcement is required

Lever arm

$$z = \min(0.5 + 0.5 \times (1 - 2 \times K / (\eta \times \alpha_{cc} / \gamma_c))^{0.5}, 0.95) \times d = \mathbf{138 \text{ mm}}$$

Depth of neutral axis

$$x = 2.5 \times (d - z) = \mathbf{18 \text{ mm}}$$

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Area of tension reinforcement required

$$A_{bt.req} = M / (f_{yd} \times z) = \mathbf{30 \text{ mm}^2/m}$$

Tension reinforcement provided

$$10 \text{ dia.bars @ } 200 \text{ c/c}$$

Area of tension reinforcement provided

$$A_{bt.prov} = \pi \times \phi_{bt}^2 / (4 \times s_{bt}) = \mathbf{393 \text{ mm}^2/m}$$

Minimum area of reinforcement - exp.9.1N

$$A_{bt.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d = \mathbf{228 \text{ mm}^2/m}$$

Maximum area of reinforcement - cl.9.2.1.1(3)

$$A_{bt.max} = 0.04 \times h = \mathbf{8000 \text{ mm}^2/m}$$

$$\max(A_{bt.req}, A_{bt.min}) / A_{bt.prov} = \mathbf{0.581}$$

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

Library item: Rectangular single output

Crack control - Section 7.3

Limiting crack width

$$w_{max} = \mathbf{0.3 \text{ mm}}$$

Variable load factor - EN1990 – Table A1.1

$$\psi_2 = \mathbf{0.6}$$

Serviceability bending moment

$$M_{sls} = \mathbf{1.2 \text{ kNm/m}}$$

Tensile stress in reinforcement

$$\sigma_s = M_{sls} / (A_{bt.prov} \times z) = \mathbf{21.7 \text{ N/mm}^2}$$

Load duration

Long term

Load duration factor

$$k_t = \mathbf{0.4}$$

Effective area of concrete in tension

$$A_{c.eff} = \min(2.5 \times (h - d), (h - x) / 3, h / 2)$$

$$A_{c.eff} = \mathbf{60625 \text{ mm}^2/m}$$

Mean value of concrete tensile strength

$$f_{ct.eff} = f_{ctm} = \mathbf{3.0 \text{ N/mm}^2}$$

Reinforcement ratio

$$\rho_{p.eff} = A_{bt.prov} / A_{c.eff} = \mathbf{0.006}$$

Modular ratio

$$\alpha_e = E_s / E_{cm} = \mathbf{5.998}$$

Bond property coefficient

$$k_1 = \mathbf{0.8}$$

Strain distribution coefficient

$$k_2 = \mathbf{0.5}$$

$$k_3 = \mathbf{3.4}$$

$$k_4 = \mathbf{0.425}$$

Maximum crack spacing - exp.7.11

$$s_{r.max} = k_3 \times c_{bt} + k_1 \times k_2 \times k_4 \times \phi_{bt} / \rho_{p.eff} = \mathbf{432 \text{ mm}}$$

Maximum crack width - exp.7.8

$$w_k = s_{r.max} \times \max(\sigma_s - k_t \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_e \times \rho_{p.eff}), 0.6 \times \sigma_s) / E_s$$

$$w_k = \mathbf{0.028 \text{ mm}}$$

$$w_k / w_{max} = \mathbf{0.094}$$

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force

$$V = \mathbf{10.1 \text{ kN/m}}$$

$$C_{Rd,c} = 0.18 / \gamma_c = \mathbf{0.120}$$

$$k = \min(1 + \sqrt{(200 \text{ mm} / d)}, 2) = \mathbf{2.000}$$

Longitudinal reinforcement ratio

$$\rho_l = \min(A_{bt.prov} / d, 0.02) = \mathbf{0.003}$$

$$v_{min} = 0.035 \text{ N}^{1/2}/\text{mm} \times k^{3/2} \times f_{ck}^{0.5} = \mathbf{0.560 \text{ N/mm}^2}$$

Design shear resistance - exp.6.2a & 6.2b

$$V_{Rd,c} = \max(C_{Rd,c} \times k \times (100 \text{ N}^2/\text{mm}^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$$

$$V_{Rd,c} = \mathbf{81.2 \text{ kN/m}}$$

$$V / V_{Rd,c} = \mathbf{0.124}$$

PASS - Design shear resistance exceeds design shear force

Secondary transverse reinforcement to base - Section 9.3

Minimum area of reinforcement – cl.9.3.1.1(2)

$$A_{bx.req} = 0.2 \times A_{bb.prov} = \mathbf{79 \text{ mm}^2/m}$$

Maximum spacing of reinforcement – cl.9.3.1.1(3)

$$s_{bx_max} = \mathbf{450 \text{ mm}}$$

Transverse reinforcement provided

$$10 \text{ dia.bars @ } 200 \text{ c/c}$$

Area of transverse reinforcement provided

$$A_{bx.prov} = \pi \times \phi_{bx}^2 / (4 \times s_{bx}) = \mathbf{393 \text{ mm}^2/m}$$

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

Project 17 REGIS PARK ROAD, READING, RG6 7AD				Job no.	
Calcs for RETAINING WALL DESIGN				Start page no./Revision 9	
Calcs by RB	Calcs date 24/07/2025	Checked by	Checked date	Approved by	Approved date

