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 2.9.03

Retaining wall details

Stem type	Propped cantilever
Stem height	h_{stem} = **4200** mm
Prop height	h_{prop} = **4200** mm
Stem thickness	t_{stem} = **350** mm
Angle to rear face of stem	α = **90** deg
Stem density	γ_{stem} = **25** kN/m^3
Toe length	l_{toe} = **1000** mm
Base thickness	t_{base} = **350** mm
Base density	γ_{base} = **25** kN/m^3
Height of retained soil	h_{ret} = **4200** mm
Angle of soil surface	β = **0** deg
Depth of cover	d_{cover} = **0** mm
Height of water	h_{water} = **3200** mm
Water density	γ_w = **9.8** kN/m^3

Retained soil properties

Soil type	Firm clay
Moist density	γ_{mr} = **18** kN/m^3
Saturated density	γ_{sr} = **18** kN/m^3
Characteristic effective shear resistance angle	$\phi'_{r.k}$ = **18** deg
Characteristic wall friction angle	$\delta_{r.k}$ = **9** deg

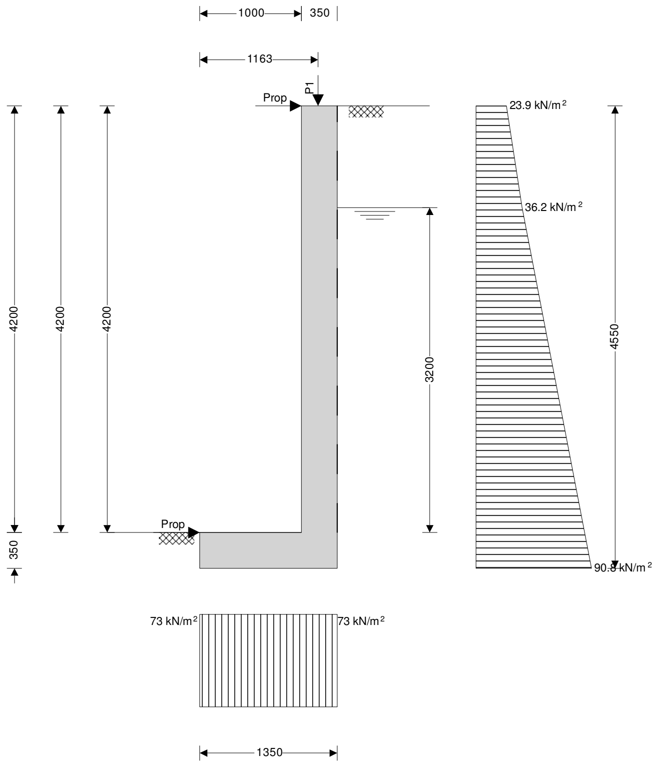
Base soil properties

Soil type	Firm clay
Soil density	γ_b = **18** 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	$P_{bearing}$ = **150** kN/m^2

Loading details

Permanent surcharge load	$Surcharge_G$ = **30** kN/m^2
Variable surcharge load	$Surcharge_Q$ = **5** kN/m^2
Vertical line load at 1163 mm	P_{G1} = **50** kN/m

Tekla Tedds P&M	Project 35 Templewood Avenue				Job no. 28585	
	Calcs for Typical basement retaining wall				Start page no./Revision 2	
	Calcs by MG	Calcs date 23/06/2020	Checked by	Checked date	Approved by	Approved date



General arrangement

Calculate retaining wall geometry

Base length $l_{base} = l_{toe} + t_{stem} = \mathbf{1350}$ mm

Saturated soil height $h_{sat} = h_{water} + d_{cover} = \mathbf{3200}$ mm

Moist soil height $h_{moist} = h_{ret} - h_{water} = \mathbf{1000}$ mm

Length of surcharge load $l_{sur} = l_{heel} = \mathbf{0}$ mm

- Distance to vertical component $x_{sur\_v} = l_{base} - l_{heel} / 2 = \mathbf{1350}$ mm

Effective height of wall $h_{eff} = h_{base} + d_{cover} + h_{ret} = \mathbf{4550}$ mm

- Distance to horizontal component $x_{sur\_h} = h_{eff} / 2 = \mathbf{2275}$ mm

Area of wall stem $A_{stem} = h_{stem} \times t_{stem} = \mathbf{1.47}$ m^2

- Distance to vertical component $x_{stem} = l_{toe} + t_{stem} / 2 = \mathbf{1175}$ mm

Area of wall base $A_{base} = l_{base} \times t_{base} = \mathbf{0.473}$ m^2

- Distance to vertical component $x_{base} = l_{base} / 2 = \mathbf{675}$ mm

Using Coulomb theory

At rest pressure coefficient $K_0 = 1 - \sin(\phi'_{r.k}) = \mathbf{0.691}$

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 $F_{stem} = A_{stem} \times \gamma_{stem} = \mathbf{36.8}$ kN/m

Wall base $F_{base} = A_{base} \times \gamma_{base} = \mathbf{11.8}$ kN/m

Line loads $F_{P\_v} = P_{G1} = \mathbf{50}$ kN/m

Total $F_{total\_v} = F_{stem} + F_{base} + F_{water\_v} + F_{P\_v}$ = **98.6** kN/m

Horizontal forces on wall

Surcharge load $F_{sur\_h} = K_0 \times \cos(\delta_{r.d}) \times (Surcharge_G + Surcharge_Q) \times h_{eff}$ = **108.7** kN/m

Saturated retained soil $F_{sat\_h} = K_0 \times \cos(\delta_{r.d}) \times (\gamma_{sr}' - \gamma_w') \times (h_{sat} + h_{base})^2 / 2$ = **35.2** kN/m

Water $F_{water\_h} = \gamma_w' \times (h_{water} + d_{cover} + h_{base})^2 / 2$ = **61.8** kN/m

Moist retained soil $F_{moist\_h} = K_0 \times \cos(\delta_{r.d}) \times \gamma_{mr}' \times ((h_{eff} - h_{sat} - h_{base})^2 / 2 + (h_{eff} - h_{sat} - h_{base}) \times (h_{sat} + h_{base}))$ = **49.8** kN/m

Base soil $F_{pass\_h} = -K_P \times \cos(\delta_{b.d}) \times \gamma_b' \times (d_{cover} + h_{base})^2 / 2$ = **-2.6** kN/m

Total $F_{total\_h} = F_{sat\_h} + F_{moist\_h} + F_{pass\_h} + F_{water\_h} + F_{sur\_h}$ = **252.9** kN/m

Moments on wall

Wall stem $M_{stem} = F_{stem} \times x_{stem}$ = **43.2** kNm/m

Wall base $M_{base} = F_{base} \times x_{base}$ = **8** kNm/m

Surcharge load $M_{sur} = -F_{sur\_h} \times x_{sur\_h}$ = **-247.3** kNm/m

Line loads $M_P = P_{G1} \times p_1$ = **58.2** kNm/m

Saturated retained soil $M_{sat} = -F_{sat\_h} \times x_{sat\_h}$ = **-41.7** kNm/m

Water $M_{water} = -F_{water\_h} \times x_{water\_h}$ = **-73.1** kNm/m

Moist retained soil $M_{moist} = -F_{moist\_h} \times x_{moist\_h}$ = **-101.3** kNm/m

Total $M_{total} = M_{stem} + M_{base} + M_{sat} + M_{moist} + M_{water} + M_{sur} + M_P$ = **-354** kNm/m

Check bearing pressure

Propping force to stem $F_{prop\_stem} = (F_{total\_v} \times l_{base} / 2 - M_{total}) / (h_{prop} + t_{base})$ = **92.4** kN/m

Propping force to base $F_{prop\_base} = F_{total\_h} - F_{prop\_stem}$ = **160.5** kN/m

Moment from propping force $M_{prop} = F_{prop\_stem} \times (h_{prop} + t_{base})$ = **420.6** kNm/m

Distance to reaction $\bar{x} = (M_{total} + M_{prop}) / F_{total\_v}$ = **675** mm

Eccentricity of reaction $e = \bar{x} - l_{base} / 2$ = **0** mm

Loaded length of base $l_{load} = l_{base}$ = **1350** mm

Bearing pressure at toe $q_{toe} = F_{total\_v} / l_{base} \times (1 - 6 \times e / l_{base})$ = **73** kN/m²

Bearing pressure at heel $q_{heel} = F_{total\_v} / l_{base} \times (1 + 6 \times e / l_{base})$ = **73** kN/m²

Factor of safety $FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel})$ = **2.055**

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

Tedds calculation version 2.9.03

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

Concrete strength class C32/40

Characteristic compressive cylinder strength f_{ck} = **32** N/mm²

Characteristic compressive cube strength $f_{ck,cube}$ = **40** N/mm²

Mean value of compressive cylinder strength $f_{cm} = f_{ck} + 8\ N/mm^2$ = **40** N/mm²

Mean value of axial tensile strength $f_{ctm} = 0.3\ N/mm^2 \times (f_{ck} / 1\ N/mm^2)^{2/3}$ = **3.0** N/mm²

5% fractile of axial tensile strength $f_{ctk,0.05} = 0.7 \times f_{ctm}$ = **2.1** N/mm²

Secant modulus of elasticity of concrete $E_{cm} = 22\ kN/mm^2 \times (f_{cm} / 10\ N/mm^2)^{0.3}$ = **33346** N/mm²

Partial factor for concrete - Table 2.1N γ_C = **1.50**

Compressive strength coefficient - cl.3.1.6(1) α_{cc} = **0.85**

Design compressive concrete strength - exp.3.15 $f_{cd} = \alpha_{cc} \times f_{ck} / \gamma_C$ = **18.1** N/mm²

Maximum aggregate size h_{agg} = **20** mm

Reinforcement details

Characteristic yield strength of reinforcement f_{yk} = **500** N/mm^2

Modulus of elasticity of reinforcement E_s = **200000** N/mm^2

Partial factor for reinforcing steel - Table 2.1N γ_S = **1.15**

Design yield strength of reinforcement $f_{yd} = f_{yk} / \gamma_S$ = **435** N/mm^2

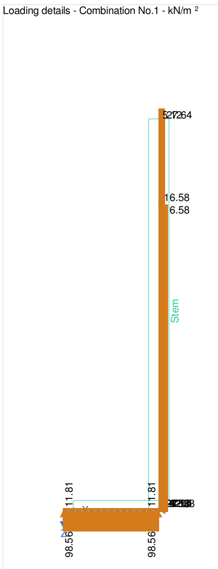
Cover to reinforcement

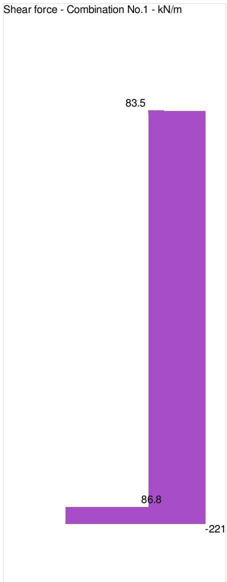
Front face of stem c_{sf} = **25** mm

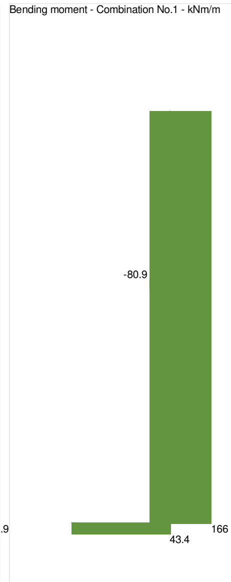
Rear face of stem c_{sr} = **75** mm

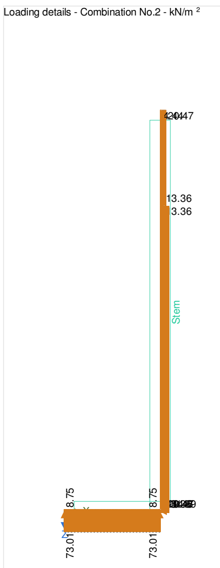
Top face of base c_{bt} = **25** mm

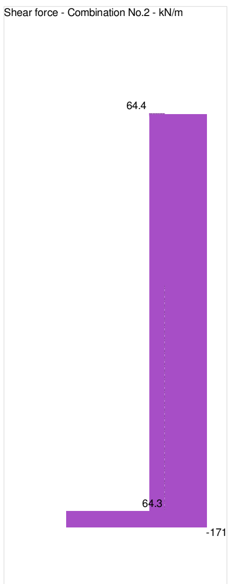
Bottom face of base c_{bb} = **50** mm

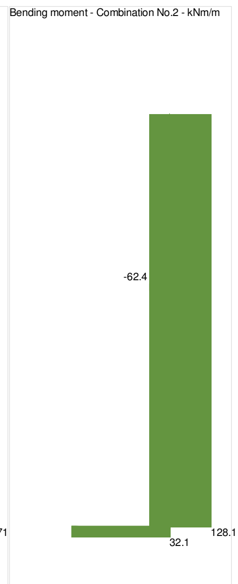












Check stem design at 2456 mm

Depth of section: h = **350** mm

Rectangular section in flexure - Section 6.1

Design bending moment combination 1	M = **80.9** kNm/m
Depth to tension reinforcement	$d = h - c_{sf} - \phi_{sx} - \phi_{sfM} / 2$ = **297** mm
	$K = M / (d^2 \times f_{ck})$ = **0.029**
	K' = **0.207**

K' > K - No compression reinforcement is required

Lever arm	$z = \min(0.5 + 0.5 \times (1 - 3.53 \times K)^{0.5}, 0.95) \times d$ = **282** mm
Depth of neutral axis	$x = 2.5 \times (d – z)$ = **37** mm
Area of tension reinforcement required	$A_{sfM.req} = M / (f_{yd} \times z)$ = **659** mm²/m
Tension reinforcement provided	16 dia.bars @ 150 c/c
Area of tension reinforcement provided	$A_{sfM.prov} = \pi \times \phi_{sfM}^2 / (4 \times s_{sfM})$ = **1340** mm²/m
Minimum area of reinforcement - exp.9.1N	$A_{sfM.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d$ = **467** mm²/m
Maximum area of reinforcement - cl.9.2.1.1(3)	$A_{sfM.max} = 0.04 \times h$ = **14000** mm²/m
	$\max(A_{sfM.req}, A_{sfM.min}) / A_{sfM.prov}$ = **0.492**

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

Deflection control - Section 7.4

Reference reinforcement ratio	$\rho_0 = \sqrt{(f_{ck} / 1\ N/mm^2)} / 1000$ = **0.006**
Required tension reinforcement ratio	$\rho = A_{sfM.req} / d$ = **0.002**
Required compression reinforcement ratio	$\rho' = A_{sfM.2.req} / d_2$ = **0.000**
Structural system factor - Table 7.4N	K_b = **1**
Reinforcement factor - exp.7.17	$K_s = \min(500\ N/mm^2 / (f_{yk} \times A_{sfM.req} / A_{sfM.prov}), 1.5)$ = **1.5**
Limiting span to depth ratio - exp.7.16.a	$\min(K_s \times K_b \times [11 + 1.5 \times \sqrt{(f_{ck} / 1\ N/mm^2)} \times \rho_0 / \rho + 3.2 \times \sqrt{(f_{ck} / 1\ N/mm^2)} \times (\rho_0 / \rho - 1)^{3/2}], 40 \times K_b)$ = **40**
Actual span to depth ratio	h_{prop} / d = **14.1**

PASS - Span to depth ratio is less than deflection control limit

Crack control - Section 7.3

Limiting crack width	w_{max} = **0.3** mm
Variable load factor - EN1990 – Table A1.1	ψ_2 = **0.6**
Serviceability bending moment	M_{sls} = **57.8** kNm/m
Tensile stress in reinforcement	$\sigma_s = M_{sls} / (A_{sfM.prov} \times z)$ = **152.7** N/mm²
Load duration	Long term
Load duration factor	k_t = **0.4**
Effective area of concrete in tension	$A_{c.eff} = \min(2.5 \times (h - d), (h – x) / 3, h / 2)$ = **104292** mm²/m
Mean value of concrete tensile strength	$f_{ct.eff} = f_{ctm}$ = **3.0** N/mm²
Reinforcement ratio	$\rho_{p.eff} = A_{sfM.prov} / A_{c.eff}$ = **0.013**
Modular ratio	$\alpha_e = E_s / E_{cm}$ = **5.998**
Bond property coefficient	k_1 = **0.8**
Strain distribution coefficient	k_2 = **0.5**
	k_3 = **3.4**
	k_4 = **0.425**
Maximum crack spacing - exp.7.11	$s_{r.max} = k_3 \times c_{sf} + k_1 \times k_2 \times k_4 \times \phi_{sfM} / \rho_{p.eff}$ = **297** 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 = **0.136** mm

$w_k / w_{max} = \mathbf{0.453}$

PASS - Maximum crack width is less than limiting crack width

Check stem design at base of stem

Depth of section — $h = \mathbf{350}$ mm

Rectangular section in flexure - Section 6.1

Design bending moment combination 1 — $M = \mathbf{166}$ kNm/m

Depth to tension reinforcement — $d = h - c_{sr} - \phi_{sr} / 2 = \mathbf{263}$ mm

$K = M / (d^2 \times f_{ck}) = \mathbf{0.075}$

$K' = \mathbf{0.207}$

K' > K - No compression reinforcement is required

Lever arm — $z = \min(0.5 + 0.5 \times (1 - 3.53 \times K)^{0.5}, 0.95) \times d = \mathbf{244}$ mm

Depth of neutral axis — $x = 2.5 \times (d - z) = \mathbf{47}$ mm

Area of tension reinforcement required — $A_{sr.req} = M / (f_{yd} \times z) = \mathbf{1566}$ mm²/m

Tension reinforcement provided — 25 dia.bars @ 75 c/c

Area of tension reinforcement provided — $A_{sr.prov} = \pi \times \phi_{sr}^2 / (4 \times s_{sr}) = \mathbf{6545}$ mm²/m

Minimum area of reinforcement - exp.9.1N — $A_{sr.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d = \mathbf{413}$ mm²/m

Maximum area of reinforcement - cl.9.2.1.1(3) — $A_{sr.max} = 0.04 \times h = \mathbf{14000}$ mm²/m

$\max(A_{sr.req}, A_{sr.min}) / A_{sr.prov} = \mathbf{0.239}$

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

Deflection control - Section 7.4

Reference reinforcement ratio — $\rho_0 = \sqrt{(f_{ck} / 1\ N/mm^2)} / 1000 = \mathbf{0.006}$

Required tension reinforcement ratio — $\rho = A_{sr.req} / d = \mathbf{0.006}$

Required compression reinforcement ratio — $\rho' = A_{sr.2.req} / d_2 = \mathbf{0.000}$

Structural system factor - Table 7.4N — $K_b = \mathbf{1}$

Reinforcement factor - exp.7.17 — $K_s = \min(500\ N/mm^2 / (f_{yk} \times A_{sr.req} / A_{sr.prov}), 1.5) = \mathbf{1.5}$

Limiting span to depth ratio - exp.7.16.b — $\min(K_s \times K_b \times [11 + 1.5 \times \sqrt{(f_{ck} / 1\ N/mm^2)} \times \rho_0 / (\rho - \rho') + \sqrt{(f_{ck} / 1\ N/mm^2)} \times \sqrt{(\rho' / \rho_0)} / 12], 40 \times K_b) = \mathbf{28.6}$

Actual span to depth ratio — $h_{prop} / d = \mathbf{16}$

PASS - Span to depth ratio is less than deflection control limit

Crack control - Section 7.3

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

Variable load factor - EN1990 – Table A1.1 — $\psi_2 = \mathbf{0.6}$

Serviceability bending moment — $M_{sls} = \mathbf{119.1}$ kNm/m

Tensile stress in reinforcement — $\sigma_s = M_{sls} / (A_{sr.prov} \times z) = \mathbf{74.7}$ N/mm²

Load duration — Long term

Load duration factor — $k_t = \mathbf{0.4}$

Effective area of concrete in tension — $A_{c.eff} = \min(2.5 \times (h - d), (h - x) / 3, h / 2) = \mathbf{101015}$ mm²/m

Mean value of concrete tensile strength — $f_{ct.eff} = f_{ctm} = \mathbf{3.0}$ N/mm²

Reinforcement ratio — $\rho_{p.eff} = A_{sr.prov} / A_{c.eff} = \mathbf{0.065}$

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 — $s_{r.max} = k_3 \times c_{sr} + k_1 \times k_2 \times k_4 \times \phi_{sr} / \rho_{p.eff} = \mathbf{321}$ 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 = **0.078** mm

w_k / w_{max} = **0.26**

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force — V = **221.9** kN/m

$C_{Rd,c} = 0.18 / \gamma_C$ = **0.120**

$k = \min(1 + \sqrt{(200\text{ mm} / d)}, 2)$ = **1.873**

Longitudinal reinforcement ratio — $\rho_l = \min(A_{sr.prov} / d, 0.02)$ = **0.020**

$v_{min} = 0.035\ N^{1/2}/mm \times k^{3/2} \times f_{ck}^{0.5}$ = **0.507** N/mm²

Design shear resistance - exp.6.2a & 6.2b — $V_{Rd.c} = \max(C_{Rd.c} \times k \times (100\ N^2/mm^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$

$V_{Rd.c}$ = **236** kN/m

$V / V_{Rd.c}$ = **0.940**

PASS - Design shear resistance exceeds design shear force

Check stem design at prop

Depth of section — h = **350** mm

Rectangular section in shear - Section 6.2

Design shear force — V = **83.5** kN/m

$C_{Rd,c} = 0.18 / \gamma_C$ = **0.120**

$k = \min(1 + \sqrt{(200\text{ mm} / d)}, 2)$ = **1.873**

Longitudinal reinforcement ratio — $\rho_l = \min(A_{sr1.prov} / d, 0.02)$ = **0.003**

$v_{min} = 0.035\ N^{1/2}/mm \times k^{3/2} \times f_{ck}^{0.5}$ = **0.507** N/mm²

Design shear resistance - exp.6.2a & 6.2b — $V_{Rd.c} = \max(C_{Rd.c} \times k \times (100\ N^2/mm^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$

$V_{Rd.c}$ = **133.2** kN/m

$V / V_{Rd.c}$ = **0.627**

PASS - Design shear resistance exceeds design shear force

Horizontal reinforcement parallel to face of stem - Section 9.6

Minimum area of reinforcement – cl.9.6.3(1) — $A_{sx.req} = \max(0.25 \times A_{sr.prov}, 0.001 \times t_{stem})$ = **1636** mm²/m

Maximum spacing of reinforcement – cl.9.6.3(2) — s_{sx_max} = **400** mm

Transverse reinforcement provided — 20 dia.bars @ 150 c/c

Area of transverse reinforcement provided — $A_{sx.prov} = \pi \times \phi_{sx}^2 / (4 \times s_{sx})$ = **2094** mm²/m

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

Check base design at toe

Depth of section — h = **350** mm

Rectangular section in flexure - Section 6.1

Design bending moment combination 1 — M = **43.4** kNm/m

Depth to tension reinforcement — $d = h - c_{bb} - \phi_{bb} / 2$ = **292** mm

$K = M / (d^2 \times f_{ck})$ = **0.016**

K' = **0.207**

K' > K - No compression reinforcement is required

Lever arm — $z = \min(0.5 + 0.5 \times (1 - 3.53 \times K)^{0.5}, 0.95) \times d$ = **277** mm

Depth of neutral axis — $x = 2.5 \times (d - z)$ = **37** mm

Area of tension reinforcement required — $A_{bb.req} = M / (f_{yd} \times z)$ = **360** mm²/m

Tension reinforcement provided — 16 dia.bars @ 150 c/c

Area of tension reinforcement provided — $A_{bb.prov} = \pi \times \phi_{bb}^2 / (4 \times s_{bb})$ = **1340** mm²/m

Minimum area of reinforcement - exp.9.1N $A_{bb.min} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d =$ **459** mm²/m

Maximum area of reinforcement - cl.9.2.1.1(3) $A_{bb.max} = 0.04 \times h =$ **14000** mm²/m

$\max(A_{bb.req}, A_{bb.min}) / A_{bb.prov} =$ **0.343**

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

Crack control - Section 7.3

Limiting crack width $w_{max} =$ **0.3** mm

Variable load factor - EN1990 – Table A1.1 $\psi_2 =$ **0.6**

Serviceability bending moment $M_{sls} =$ **32.1** kNm/m

Tensile stress in reinforcement $\sigma_s = M_{sls} / (A_{bb.prov} \times z) =$ **86.4** N/mm²

Load duration Long term

Load duration factor $k_t =$ **0.4**

Effective area of concrete in tension $A_{c.eff} = \min(2.5 \times (h - d), (h – x) / 3, h / 2) =$ **104500** mm²/m

Mean value of concrete tensile strength $f_{ct.eff} = f_{ctm} =$ **3.0** N/mm²

Reinforcement ratio $\rho_{p.eff} = A_{bb.prov} / A_{c.eff} =$ **0.013**

Modular ratio $\alpha_e = E_s / E_{cm} =$ **5.998**

Bond property coefficient $k_1 =$ **0.8**

Strain distribution coefficient $k_2 =$ **0.5**

$k_3 =$ **3.4**

$k_4 =$ **0.425**

Maximum crack spacing - exp.7.11 $s_{r.max} = k_3 \times c_{bb} + k_1 \times k_2 \times k_4 \times \phi_{bb} / \rho_{p.eff} =$ **382** mm

Maximum crack width - exp.7.8 $w_k = s_{r.max} \times \max(\sigma_s – k_t \times (f_{ct.eff} / \rho_{p.eff}) \times (1 + \alpha_e \times \rho_{p.eff}), 0.6 \times \sigma_s) / E_s$

$w_k =$ **0.099** mm

$w_k / w_{max} =$ **0.33**

PASS - Maximum crack width is less than limiting crack width

Rectangular section in shear - Section 6.2

Design shear force $V =$ **86.8** kN/m

$C_{Rd,c} = 0.18 / \gamma_C =$ **0.120**

$k = \min(1 + \sqrt{(200 \text{ mm} / d)}, 2) =$ **1.828**

Longitudinal reinforcement ratio $\rho_l = \min(A_{bb.prov} / d, 0.02) =$ **0.005**

$v_{min} = 0.035 \text{ N}^{1/2}/\text{mm} \times k^{3/2} \times f_{ck}^{0.5} =$ **0.489** N/mm²

Design shear resistance - exp.6.2a & 6.2b $V_{Rd.c} = \max(C_{Rd.c} \times k \times (100 \text{ N}^2/\text{mm}^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) \times d$

$V_{Rd.c} =$ **156.8** kN/m

$V / V_{Rd.c} =$ **0.553**

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) $A_{bx.req} = 0.2 \times A_{bt.prov} =$ **654** mm²/m

Maximum spacing of reinforcement – cl.9.3.1.1(3) $s_{bx\_max} =$ **450** mm

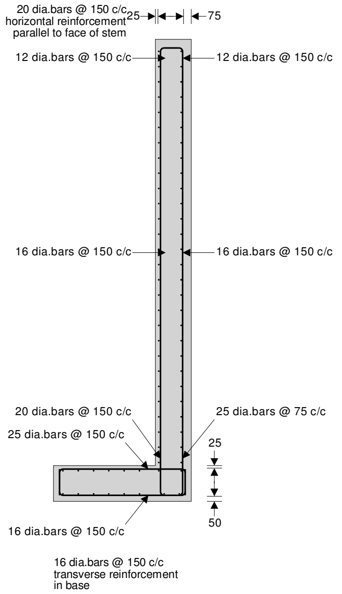
Transverse reinforcement provided 16 dia.bars @ 150 c/c

Area of transverse reinforcement provided $A_{bx.prov} = \pi \times \phi_{bx}^2 / (4 \times s_{bx}) =$ **1340** mm²/m

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

P&M

Project				Job no.	
35 Templewood Avenue				28585	
Calcs for				Start page no./Revision	
Typical basement retaining wall				9	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
MG	23/06/2020				



Reinforcement details