MASS CONCRETE RETAINING WALL FOR GARDEN AREA

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 0.984

Overall design status Pass

Description	Unit	Capacity	Applied	F o S	Result
Sliding stability	kN/m	10.6	10.4	1.016	PASS
Overturning stability	kNm/m	44.6	6.5	6.826	PASS
Bearing pressure	kN/m^2	54.7	29.9	1.825	PASS

Retaining wall details

Stem type Cantilever

Stem height h_{stem} = **1000** mm

Stem thickness t_{stem} = **700** mm

Angle to rear face of stem α = **90** deg

Stem density γ_{stem} = **24** kN/m^3

Toe length l_{toe} = **200** mm

Heel length l_{heel} = **900** mm

Base thickness t_{base} = **250** mm

Base density γ_{base} = **24** kN/m^3

Height of retained soil h_{ret} = **900** mm

Angle of soil surface β = **22.5** deg

Depth of cover d_{cover} = **100** mm

Depth of excavation d_{exc} = **100** mm

Retained soil properties

Soil type Very dense rock fill

Moist density γ_{mr} = **17.5** kN/m^3

Saturated density γ_{sr} = **21** kN/m^3

Characteristic effective shear resistance angle $\phi'_{r.k}$ = **42** deg

Characteristic wall friction angle $\delta_{r.k}$ = **21** deg

Base soil properties

Soil type Firm clay

Soil density γ_b = **18** kN/m^3

Characteristic cohesion $c'_{b.k}$ = **0** kN/m^2

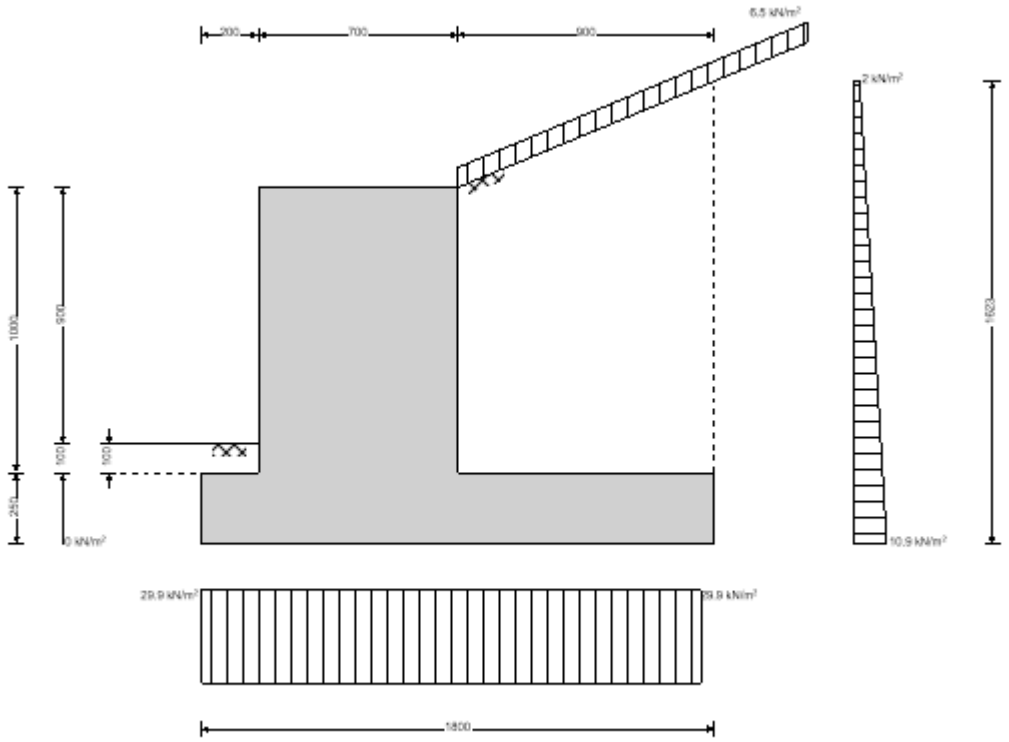
Characteristic effective shear resistance angle $\phi'_{b.k}$ = **24** deg

Characteristic wall friction angle $\delta_{b.k}$ = **9** deg

Characteristic base friction angle $\delta_{bb.k}$ = **16** deg

Loading details

Variable surcharge load $Surcharge_Q$ = **5** kN/m^2



General arrangement - sketch pressures relate to bearing check

Calculate retaining wall geometry

Base length	$l_{base} = l_{toe} + t_{stem} + l_{heel}$ = **1800** mm
Moist soil height	$h_{moist} = h_{soil}$ = **1000** mm
Length of surcharge load	$l_{sur} = l_{heel}$ = **900** mm
- Distance to vertical component	$x_{sur_v} = l_{base} - l_{heel} / 2$ = **1350** mm
Effective height of wall	$h_{eff} = h_{base} + d_{cover} + h_{ret} + l_{sur} \times \tan(\beta)$ = **1623** mm
- Distance to horizontal component	$x_{sur_h} = h_{eff} / 2$ = **811** mm
Area of wall stem	$A_{stem} = h_{stem} \times t_{stem}$ = **0.7** m^2
- Distance to vertical component	$x_{stem} = l_{toe} + t_{stem} / 2$ = **550** mm
Area of wall base	$A_{base} = l_{base} \times t_{base}$ = **0.45** m^2
- Distance to vertical component	$x_{base} = l_{base} / 2$ = **900** mm
Area of moist soil	$A_{moist} = h_{moist} \times l_{heel} + \tan(\beta) \times l_{heel}^2 / 2$ = **1.068** m^2
- Distance to vertical component	$x_{moist_v} = l_{base} - (h_{moist} \times l_{heel}^2 / 2 + \tan(\beta) \times l_{heel}^3 / 6) / A_{moist}$ = **1374** mm
- Distance to horizontal component	$x_{moist_h} = h_{eff} / 3$ = **541** mm
Area of base soil	$A_{pass} = d_{cover} \times l_{toe}$ = **0.02** m^2
- Distance to vertical component	$x_{pass_v} = l_{base} - (d_{cover} \times l_{toe} \times (l_{base} - l_{toe} / 2)) / A_{pass}$ = **100** mm
- Distance to horizontal component	$x_{pass_h} = (d_{cover} + h_{base}) / 3$ = **117** mm

Design approach 1

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

Partial factor set	A1
Permanent unfavourable action	γ_G = **1.350**

Permanent favourable action	γ_{Gf} = **1.000**
Variable unfavourable action	γ_{Q} = **1.500**
Variable favourable action	γ_{Qf} = **0.000**

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	γ_{γ} = **1.00**

Retained soil properties

Design moist density	$\gamma_{mr}' = \gamma_{mr} / \gamma_{\gamma}$ = **17.5** kN/m^3
Design saturated density	$\gamma_{sr}' = \gamma_{sr} / \gamma_{\gamma}$ = **21** kN/m^3
Design effective shear resistance angle	$\phi'_{r.d} = \text{atan}(\tan(\phi'_{r.k}) / \gamma_{\phi'})$ = **42** deg
Design wall friction angle	$\delta_{r.d} = \text{atan}(\tan(\delta_{r.k}) / \gamma_{\phi'})$ = **21** deg

Base soil properties

Design soil density	$\gamma_{b}' = \gamma_{b} / \gamma_{\gamma}$ = **18** kN/m^3
Design effective shear resistance angle	$\phi'_{b.d} = \text{atan}(\tan(\phi'_{b.k}) / \gamma_{\phi'})$ = **24** deg
Design wall friction angle	$\delta_{b.d} = \text{atan}(\tan(\delta_{b.k}) / \gamma_{\phi'})$ = **9** deg
Design base friction angle	$\delta_{bb.d} = \text{atan}(\tan(\delta_{bb.k}) / \gamma_{\phi'})$ = **16** deg
Design effective cohesion	$c'_{b.d} = c'_{b.k} / \gamma_{c'}$ = **0** kN/m^2

Using Coulomb theory

Active pressure coefficient

$$K_A = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times [1 + \sqrt{[\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))]]^2}) = \mathbf{0.235}$$

Passive pressure coefficient

$$K_P = \sin(90 - \phi'_{b.d})^2 / (\sin(90 + \delta_{b.d}) \times [1 - \sqrt{[\sin(\phi'_{b.d} + \delta_{b.d}) \times \sin(\phi'_{b.d}) / (\sin(90 + \delta_{b.d}))]]^2}) = \mathbf{3.049}$$

Sliding check

Vertical forces on wall

Wall stem	$F_{stem} = \gamma_{Gf} \times A_{stem} \times \gamma_{stem}$ = **16.8** kN/m
Wall base	$F_{base} = \gamma_{Gf} \times A_{base} \times \gamma_{base}$ = **10.8** kN/m
Moist retained soil	$F_{moist_v} = \gamma_{Gf} \times A_{moist} \times \gamma_{mr}'$ = **18.7** kN/m
Total	$F_{total_v} = F_{stem} + F_{base} + F_{moist_v}$ = **46.3** kN/m

Horizontal forces on wall

Surcharge load	$F_{sur_h} = K_A \times \cos(\delta_{r.d}) \times \gamma_Q \times \text{Surcharge}_Q \times h_{eff}$ = **2.7** kN/m
Moist retained soil	$F_{moist_h} = \gamma_G \times K_A \times \cos(\delta_{r.d}) \times \gamma_{mr}' \times h_{eff}^2 / 2$ = **6.8** kN/m
Total	$F_{total_h} = F_{sur_h} + F_{moist_h}$ = **9.5** kN/m

Check stability against sliding

Base soil resistance	F_{exc_h} = **0** kN/m
Base friction	$F_{friction} = F_{total_v} \times \tan(\delta_{bb.d})$ = **13.3** kN/m
Resistance to sliding	$F_{rest} = F_{exc_h} + F_{friction}$ = **13.3** kN/m
Factor of safety	$FoS_{sl} = F_{rest} / F_{total_h}$ = **1.399**

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Wall stem — $F_{stem} = \gamma_{Gf} \times A_{stem} \times \gamma_{stem} =$ **16.8** kN/m

Wall base — $F_{base} = \gamma_{Gf} \times A_{base} \times \gamma_{base} =$ **10.8** kN/m

Moist retained soil — $F_{moist_v} = \gamma_{Gf} \times A_{moist} \times \gamma_{mr}' =$ **18.7** kN/m

Total — $F_{total_v} = F_{stem} + F_{base} + F_{moist_v} =$ **46.3** kN/m

Horizontal forces on wall

Surcharge load — $F_{sur_h} = K_A \times \cos(\delta_{r.d}) \times \gamma_Q \times \text{Surcharge}_Q \times h_{eff} =$ **2.7** kN/m

Moist retained soil — $F_{moist_h} = \gamma_G \times K_A \times \cos(\delta_{r.d}) \times \gamma_{mr}' \times h_{eff}^2 / 2 =$ **6.8** kN/m

Total — $F_{total_h} = F_{sur_h} + F_{moist_h} =$ **9.5** kN/m

Overturning moments on wall

Surcharge load — $M_{sur_OT} = F_{sur_h} \times x_{sur_h} =$ **2.2** kNm/m

Moist retained soil — $M_{moist_OT} = F_{moist_h} \times x_{moist_h} =$ **3.7** kNm/m

Total — $M_{total_OT} = M_{sur_OT} + M_{moist_OT} =$ **5.9** kNm/m

Restoring moments on wall

Wall stem — $M_{stem_R} = F_{stem} \times x_{stem} =$ **9.2** kNm/m

Wall base — $M_{base_R} = F_{base} \times x_{base} =$ **9.7** kNm/m

Moist retained soil — $M_{moist_R} = F_{moist_v} \times x_{moist_v} =$ **25.7** kNm/m

Total — $M_{total_R} = M_{stem_R} + M_{base_R} + M_{moist_R} =$ **44.6** kNm/m

Check stability against overturning

Factor of safety — $FoS_{ot} = M_{total_R} / M_{total_OT} =$ **7.624**

PASS - Maximum restoring moment is greater than overturning moment

Bearing pressure check

Vertical forces on wall

Wall stem — $F_{stem} = \gamma_G \times A_{stem} \times \gamma_{stem} =$ **22.7** kN/m

Wall base — $F_{base} = \gamma_G \times A_{base} \times \gamma_{base} =$ **14.6** kN/m

Surcharge load — $F_{sur_v} = \gamma_Q \times \text{Surcharge}_Q \times l_{heel} =$ **6.8** kN/m

Moist retained soil — $F_{moist_v} = \gamma_G \times A_{moist} \times \gamma_{mr}' =$ **25.2** kN/m

Base soil — $F_{pass_v} = \gamma_G \times A_{pass} \times \gamma_b' =$ **0.5** kN/m

Total — $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{pass_v} =$ **69.7** kN/m

Horizontal forces on wall

Surcharge load — $F_{sur_h} = K_A \times \cos(\delta_{r.d}) \times \gamma_Q \times \text{Surcharge}_Q \times h_{eff} =$ **2.7** kN/m

Moist retained soil — $F_{moist_h} = \gamma_G \times K_A \times \cos(\delta_{r.d}) \times \gamma_{mr}' \times h_{eff}^2 / 2 =$ **6.8** kN/m

Total — $F_{total_h} = \max(F_{sur_h} + F_{moist_h} - F_{total_v} \times \tan(\delta_{bb.d}), 0\text{ kN/m}) =$ **0** kN/m

Moments on wall

Wall stem — $M_{stem} = F_{stem} \times x_{stem} =$ **12.5** kNm/m

Wall base — $M_{base} = F_{base} \times x_{base} =$ **13.1** kNm/m

Surcharge load — $M_{sur} = F_{sur_v} \times x_{sur_v} - F_{sur_h} \times x_{sur_h} =$ **6.9** kNm/m

Moist retained soil — $M_{moist} = F_{moist_v} \times x_{moist_v} - F_{moist_h} \times x_{moist_h} =$ **31** kNm/m

Base soil — $M_{pass} = F_{pass_v} \times x_{pass_v} =$ **0** kNm/m

Total — $M_{total} = M_{stem} + M_{base} + M_{sur} + M_{moist} + M_{pass} =$ **63.6** kNm/m

Check bearing pressure

Distance to reaction — $\bar{x} = M_{total} / F_{total_v} =$ **912** mm

Eccentricity of reaction	$e = \bar{x} - l_{base} / 2 =$ **12** mm
Loaded length of base	$l_{load} = 2 \times (l_{base} - \bar{x}) =$ **1777** mm
Bearing pressure at toe	$q_{toe} =$ **0** kN/m^2
Bearing pressure at heel	$q_{heel} = F_{total_v} / l_{load} =$ **39.2** kN/m^2
Effective overburden pressure	$q = (t_{base} + d_{cover}) \times \gamma_b' =$ **6.3** kN/m^2
Design effective overburden pressure	$q' = q / \gamma_\gamma =$ **6.3** kN/m^2
Bearing resistance factors	$N_q = Exp(\pi \times \tan(\phi'_{b.d})) \times (\tan(45 \text{ deg} + \phi'_{b.d} / 2))^2 =$ **9.603**
	$N_c = (N_q - 1) \times \cot(\phi'_{b.d}) =$ **19.324**
	$N_\gamma = 2 \times (N_q - 1) \times \tan(\phi'_{b.d}) =$ **7.661**
Foundation shape factors	$s_q = 1$
	$s_\gamma = 1$
	$s_c = 1$
Load inclination factors	$H = F_{sur_h} + F_{moist_h} =$ **9.5** kN/m
	$V = F_{total_v} =$ **69.7** kN/m
	$m = 2$
	$i_q = [1 - H / (V + l_{load} \times c'_{b.d} \times \cot(\phi'_{b.d}))]^m =$ **0.746**
	$i_\gamma = [1 - H / (V + l_{load} \times c'_{b.d} \times \cot(\phi'_{b.d}))]^{(m+1)} =$ **0.645**
	$i_c = i_q - (1 - i_q) / (N_c \times \tan(\phi'_{b.d})) =$ **0.717**
Net ultimate bearing capacity	
	$n_f = c'_{b.d} \times N_c \times s_c \times i_c + q' \times N_q \times s_q \times i_q + 0.5 \times \gamma_b' \times l_{load} \times N_\gamma \times s_\gamma \times i_\gamma =$ **124.2** kN/m^2
Factor of safety	$FoS_{bp} = n_f / \max(q_{toe}, q_{heel}) =$ **3.164**
	PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

Design approach 1

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

Partial factor set	A2
Permanent unfavourable action	$\gamma_G =$ **1.000**
Permanent favourable action	$\gamma_{Gf} =$ **1.000**
Variable unfavourable action	$\gamma_Q =$ **1.300**
Variable favourable action	$\gamma_{Qf} =$ **0.000**

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

Soil parameter set	M2
Angle of shearing resistance	$\gamma_{\phi'} =$ **1.25**
Effective cohesion	$\gamma_{c'} =$ **1.25**
Weight density	$\gamma_\gamma =$ **1.00**

Retained soil properties

Design moist density	$\gamma_{mr}' = \gamma_{mr} / \gamma_\gamma =$ **17.5** kN/m^3
Design saturated density	$\gamma_{sr}' = \gamma_{sr} / \gamma_\gamma =$ **21** kN/m^3
Design effective shear resistance angle	$\phi'_{r.d} = atan(\tan(\phi'_{r.k}) / \gamma_{\phi'}) =$ **35.8** deg
Design wall friction angle	$\delta_{r.d} = atan(\tan(\delta_{r.k}) / \gamma_{\phi'}) =$ **17.1** deg

Base soil properties

Design soil density	$\gamma_b' = \gamma_b / \gamma_\gamma =$ **18** kN/m^3
Design effective shear resistance angle	$\phi'_{b.d} = atan(\tan(\phi'_{b.k}) / \gamma_{\phi'}) =$ **19.6** deg
Design wall friction angle	$\delta_{b.d} = atan(\tan(\delta_{b.k}) / \gamma_{\phi'}) =$ **7.2** deg
Design base friction angle	$\delta_{bb.d} = atan(\tan(\delta_{bb.k}) / \gamma_{\phi'}) =$ **12.9** deg

Design effective cohesion $c'_{b.d} = c'_{b.k} / \gamma_{c'} = \mathbf{0}$ kN/m²

Using Coulomb theory

Active pressure coefficient $K_A = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times [1 + \sqrt{[\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))]]^2}) = \mathbf{0.325}$

Passive pressure coefficient $K_P = \sin(90 - \phi'_{b.d})^2 / (\sin(90 + \delta_{b.d}) \times [1 - \sqrt{[\sin(\phi'_{b.d} + \delta_{b.d}) \times \sin(\phi'_{b.d}) / (\sin(90 + \delta_{b.d}))]]^2}) = \mathbf{2.409}$

Sliding check

Vertical forces on wall

Wall stem $F_{stem} = \gamma_{Gf} \times A_{stem} \times \gamma_{stem} = \mathbf{16.8}$ kN/m

Wall base $F_{base} = \gamma_{Gf} \times A_{base} \times \gamma_{base} = \mathbf{10.8}$ kN/m

Moist retained soil $F_{moist_v} = \gamma_{Gf} \times A_{moist} \times \gamma_{mr}' = \mathbf{18.7}$ kN/m

Total $F_{total_v} = F_{stem} + F_{base} + F_{moist_v} = \mathbf{46.3}$ kN/m

Horizontal forces on wall

Surcharge load $F_{sur_h} = K_A \times \cos(\delta_{r.d}) \times \gamma_Q \times \text{Surcharge}_Q \times h_{eff} = \mathbf{3.3}$ kN/m

Moist retained soil $F_{moist_h} = \gamma_G \times K_A \times \cos(\delta_{r.d}) \times \gamma_{mr}' \times h_{eff}^2 / 2 = \mathbf{7.2}$ kN/m

Total $F_{total_h} = F_{sur_h} + F_{moist_h} = \mathbf{10.4}$ kN/m

Check stability against sliding

Base soil resistance $F_{exc_h} = \mathbf{0}$ kN/m

Base friction $F_{friction} = F_{total_v} \times \tan(\delta_{bb.d}) = \mathbf{10.6}$ kN/m

Resistance to sliding $F_{rest} = F_{exc_h} + F_{friction} = \mathbf{10.6}$ kN/m

Factor of safety $FoS_{sl} = F_{rest} / F_{total_h} = \mathbf{1.016}$

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Wall stem $F_{stem} = \gamma_{Gf} \times A_{stem} \times \gamma_{stem} = \mathbf{16.8}$ kN/m

Wall base $F_{base} = \gamma_{Gf} \times A_{base} \times \gamma_{base} = \mathbf{10.8}$ kN/m

Moist retained soil $F_{moist_v} = \gamma_{Gf} \times A_{moist} \times \gamma_{mr}' = \mathbf{18.7}$ kN/m

Total $F_{total_v} = F_{stem} + F_{base} + F_{moist_v} = \mathbf{46.3}$ kN/m

Horizontal forces on wall

Surcharge load $F_{sur_h} = K_A \times \cos(\delta_{r.d}) \times \gamma_Q \times \text{Surcharge}_Q \times h_{eff} = \mathbf{3.3}$ kN/m

Moist retained soil $F_{moist_h} = \gamma_G \times K_A \times \cos(\delta_{r.d}) \times \gamma_{mr}' \times h_{eff}^2 / 2 = \mathbf{7.2}$ kN/m

Total $F_{total_h} = F_{sur_h} + F_{moist_h} = \mathbf{10.4}$ kN/m

Overturning moments on wall

Surcharge load $M_{sur_OT} = F_{sur_h} \times x_{sur_h} = \mathbf{2.7}$ kNm/m

Moist retained soil $M_{moist_OT} = F_{moist_h} \times x_{moist_h} = \mathbf{3.9}$ kNm/m

Total $M_{total_OT} = M_{sur_OT} + M_{moist_OT} = \mathbf{6.5}$ kNm/m

Restoring moments on wall

Wall stem $M_{stem_R} = F_{stem} \times x_{stem} = \mathbf{9.2}$ kNm/m

Wall base $M_{base_R} = F_{base} \times x_{base} = \mathbf{9.7}$ kNm/m

Moist retained soil $M_{moist_R} = F_{moist_v} \times x_{moist_v} = \mathbf{25.7}$ kNm/m

Total $M_{total_R} = M_{stem_R} + M_{base_R} + M_{moist_R} = \mathbf{44.6}$ kNm/m

Check stability against overturning

Factor of safety $FoS_{ot} = M_{total_R} / M_{total_OT} = \mathbf{6.826}$

PASS - Maximum restoring moment is greater than overturning moment

Bearing pressure check

Vertical forces on wall

Wall stem	$F_{stem} = \gamma_G \times A_{stem} \times \gamma_{stem} =$ **16.8** kN/m
Wall base	$F_{base} = \gamma_G \times A_{base} \times \gamma_{base} =$ **10.8** kN/m
Surcharge load	$F_{sur_v} = \gamma_Q \times Surcharge_Q \times l_{heel} =$ **5.9** kN/m
Moist retained soil	$F_{moist_v} = \gamma_G \times A_{moist} \times \gamma_{mr}' =$ **18.7** kN/m
Base soil	$F_{pass_v} = \gamma_G \times A_{pass} \times \gamma_b' =$ **0.4** kN/m
Total	$F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{pass_v} =$ **52.5** kN/m

Horizontal forces on wall

Surcharge load	$F_{sur_h} = K_A \times \cos(\delta_{r.d}) \times \gamma_Q \times Surcharge_Q \times h_{eff} =$ **3.3** kN/m
Moist retained soil	$F_{moist_h} = \gamma_G \times K_A \times \cos(\delta_{r.d}) \times \gamma_{mr}' \times h_{eff}^2 / 2 =$ **7.2** kN/m
Total	$F_{total_h} = \max(F_{sur_h} + F_{moist_h} - F_{total_v} \times \tan(\delta_{bb.d}), 0\ kN/m) =$ **0** kN/m

Moments on wall

Wall stem	$M_{stem} = F_{stem} \times x_{stem} =$ **9.2** kNm/m
Wall base	$M_{base} = F_{base} \times x_{base} =$ **9.7** kNm/m
Surcharge load	$M_{sur} = F_{sur_v} \times x_{sur_v} - F_{sur_h} \times x_{sur_h} =$ **5.2** kNm/m
Moist retained soil	$M_{moist} = F_{moist_v} \times x_{moist_v} - F_{moist_h} \times x_{moist_h} =$ **21.8** kNm/m
Base soil	$M_{pass} = F_{pass_v} \times x_{pass_v} =$ **0** kNm/m
Total	$M_{total} = M_{stem} + M_{base} + M_{sur} + M_{moist} + M_{pass} =$ **46** kNm/m

Check bearing pressure

Distance to reaction	$\bar{x} = M_{total} / F_{total_v} =$ **877** mm
Eccentricity of reaction	$e = \bar{x} - l_{base} / 2 =$ **-23** mm
Loaded length of base	$l_{load} = 2 \times \bar{x} =$ **1753** mm
Bearing pressure at toe	$q_{toe} = F_{total_v} / l_{load} =$ **29.9** kN/m^2
Bearing pressure at heel	$q_{heel} =$ **0** kN/m^2
Effective overburden pressure	$q = (t_{base} + d_{cover}) \times \gamma_b' =$ **6.3** kN/m^2
Design effective overburden pressure	$q' = q / \gamma_\gamma =$ **6.3** kN/m^2
Bearing resistance factors	$N_q = Exp(\pi \times \tan(\phi'_{b.d})) \times (\tan(45\ deg + \phi'_{b.d} / 2))^2 =$ **6.154**
	$N_c = (N_q - 1) \times \cot(\phi'_{b.d}) =$ **14.47**
	$N_\gamma = 2 \times (N_q - 1) \times \tan(\phi'_{b.d}) =$ **3.671**
Foundation shape factors	$s_q = 1$
	$s_\gamma = 1$
	$s_c = 1$
Load inclination factors	$H = F_{sur_h} + F_{moist_h} =$ **10.4** kN/m
	$V = F_{total_v} =$ **52.5** kN/m
	$m = 2$
	$i_q = [1 - H / (V + l_{load} \times c'_{b.d} \times \cot(\phi'_{b.d}))]^m =$ **0.642**
	$i_\gamma = [1 - H / (V + l_{load} \times c'_{b.d} \times \cot(\phi'_{b.d}))]^{(m+1)} =$ **0.514**
	$i_c = i_q - (1 - i_q) / (N_c \times \tan(\phi'_{b.d})) =$ **0.572**
Net ultimate bearing capacity	
	$n_f = c'_{b.d} \times N_c \times s_c \times i_c + q' \times N_q \times s_q \times i_q + 0.5 \times \gamma_b' \times l_{load} \times N_\gamma \times s_\gamma \times i_\gamma =$ **54.7** kN/m^2
Factor of safety	$FoS_{bp} = n_f / \max(q_{toe}, q_{heel}) =$ **1.825**

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure