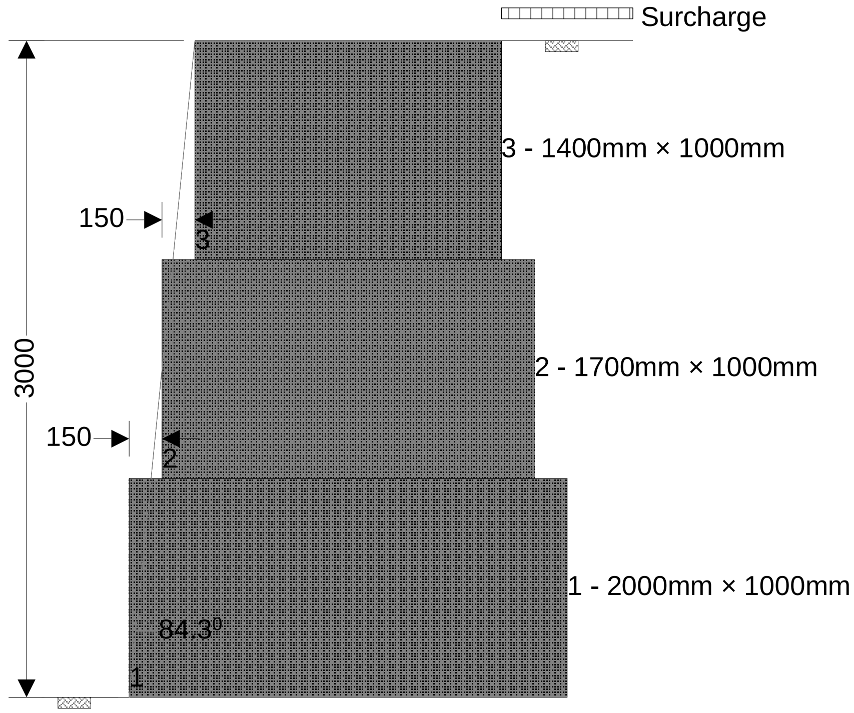
GABION RETAINING WALL ANLYSIS & DESIGN

In accordance with EN 1997-1:2004 - Code of Practice for Geotechnical design and the UK National Annex

Tedds calculation version 2.0.01



Wall geometry

Width of gabion 1	w_1 = **2000** mm
Height of gabion 1	h_1 = **1000** mm
Width of gabion 2	w_2 = **1700** mm
Height of gabion 2	h_2 = **1000** mm
Step to front face between courses 1 and 2	s_2 = **150** mm
Width of gabion 3	w_3 = **1400** mm
Height of gabion 3	h_3 = **1000** mm
Step to front face between courses 2 and 3	s_3 = **150** mm
Wall inclination	ε = **0** deg

Gabion properties

Unit weight of fill	γ_d = **16.0** kN/m^3
Friction between gabions	$\delta_{bg.k}$ = **35.0** deg

Loading

Permanent surcharge	$p_{o,G}$ = **5** kN/m^2

Soil properties

Slope of retained soil	β = **0.0** deg
Characteristic effective shearing resistance angle	$\phi'_{r.k}$ = **30.0** deg
Characteristic saturated density of retained soil	γ_{sr} = **21.0** kN/m^3
Coefficient for wall friction	$k_{membrane}$ = **0.75**
Wall friction angle	$\delta_{r.k}$ = **22.5** deg
Characteristic base friction angle	$\delta_{bb.k}$ = **30.0** deg

Bearing capacity of founding soil — $q = \mathbf{100}$ kN/m^2

Wall geometry

Horizontal distance to centre of gravity gabion 1	$x_{g1} = w_1 / 2 = \mathbf{1000}$ mm
Vertical distance to centre of gravity gabion 1	$y_{g1} = h_1 / 2 = \mathbf{500}$ mm
Weight of gabion 1	$W_{g1} = \gamma_d \times w_1 \times h_1 = \mathbf{32.0}$ kN/m
Horizontal distance to centre of gravity gabion 2	$x_{g2} = w_2 / 2 + s_2 = \mathbf{1000}$ mm
Vertical distance to centre of gravity gabion 2	$y_{g2} = h_2 / 2 + h_1 = \mathbf{1500}$ mm
Weight of gabion 2	$W_{g2} = \gamma_d \times w_2 \times h_2 = \mathbf{27.2}$ kN/m
Horizontal distance to centre of gravity gabion 3	$x_{g3} = w_3 / 2 + s_2 + s_3 = \mathbf{1000}$ mm
Vertical distance to centre of gravity gabion 3	$y_{g3} = h_3 / 2 + h_1 + h_2 = \mathbf{2500}$ mm
Weight of gabion 3	$W_{g3} = \gamma_d \times w_3 \times h_3 = \mathbf{22.4}$ kN/m
Weight of entire gabion	$W_g = W_{g1} + W_{g2} + W_{g3} = \mathbf{81.6}$ kN/m
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g1} \times x_{g1}) + (W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3})) / W_g = \mathbf{1000}$ mm
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g1} \times y_{g1}) + (W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3})) / W_g = \mathbf{1382}$ mm
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{1000}$ mm
Vertical change in height due to wall inclination	$H_f = y_{g3} + h_3/2 - ((y_{g3} + h_3/2) \times \cos(\varepsilon) - (x_{g3} + w_3/2) \times \sin(\varepsilon)) = \mathbf{0}$ mm

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90\text{deg} - \text{Atan}((w_1 - (x_{g3} + (w_3 / 2))) / (y_{g3} + h_3 / 2)) + \varepsilon = \mathbf{84.3}$ deg
Effective face angle	$\theta = \text{Atan}((y_{g3} + (h_3 / 2)) / ((x_{g3} - (w_3 / 2)))) - \varepsilon = \mathbf{84.3}$ deg
Effective height of wall	$H = (y_{g3} + h_3 / 2) + (w_1 \times \sin(\varepsilon)) - H_f = \mathbf{3000}$ mm
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g3} + h_3 / 2) \times \cos(\varepsilon) - (x_{g3} - (w_3 / 2)) \times \sin(\varepsilon)) = \mathbf{3000}$mm
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r.k})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.k}) \times (1 + \surd(\sin(\phi'_{r.k} + \delta_{r.k}) \times \sin(\phi'_{r.k} - \beta) / (\sin(\alpha - \delta_{r.k}) \times \sin(\alpha + \beta))))^2) = \mathbf{0.340}$
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{sr} \times H^2 = \mathbf{32.2}$ kN/m

Pressure at base

Horizontal forces

Retained soil	$F_{soil\_h,q} = P_{a,soil} \times \cos(90 - \alpha + \delta_{r.k}) = \mathbf{28.3}$ kN/m
Height of soil thrust resolved vertically	$d_{h,soil} = H / 3 - w_1 \times \sin(\varepsilon) = \mathbf{1000}$ mm
Surcharge	$F_{surch\_h,q} = p_{o,G} \times K_a \times H \times \cos(90 - \alpha + \delta_{r.k}) = \mathbf{4.5}$ kN/m
Height of surcharge thrust resolved vertically	$d_{h,surch} = H / 2 - w_1 \times \sin(\varepsilon) = \mathbf{1500}$ mm

Vertical forces

Gabion weight	$F_{gabion\_v,q} = W_g = \mathbf{81.6}$ kN/m
Retained soil	$F_{soil\_v,q} = P_{a,soil} \times \sin(90 - \alpha + \delta_{r.k}) = \mathbf{15.2}$ kN/m
Horizontal dist to where soil thrust acts	$b_{v,soil} = w_1 \times \cos(\varepsilon) - (H / 3) / \tan(\alpha) = \mathbf{1900}$ mm
Surcharge	$F_{surch\_v,q} = p_{o,G} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.k}) = \mathbf{2.4}$ kN/m
Horizontal dist to where surcharge thrust acts	$b_{v,surch} = w_1 \times \cos(\varepsilon) - (H / 2) / \tan(\alpha) = \mathbf{1850}$ mm
Total horizontal unfactored force	$T_q = F_{soil\_h,q} + F_{surch\_h,q} = \mathbf{32.8}$ kN/m
Total vertical unfactored force	$N_q = F_{gabion\_v,q} + F_{soil\_v,q} + F_{surch\_v,q} = \mathbf{99.2}$ kN/m
Force normal to base	$N_s = N_q \times \cos(\varepsilon) + T_q \times \sin(\varepsilon) = \mathbf{99.2}$ kN/m
Total unfactored overturning force	$M_{o,q} = F_{soil\_h,q} \times d_{h,soil} + F_{surch\_h,q} \times d_{h,surch} = \mathbf{35.1}$ kNm/m
Total unfactored restoring force	$M_{R,q} = F_{gabion\_v,q} \times X_g + F_{soil\_v,q} \times b_{v,soil} + F_{surch\_v,q} \times b_{v,surch} = \mathbf{115.0}$ kNm/m
Eccentricity	$e = w_1 / 2 - (M_{R,q} - M_{o,q}) / N_s = \mathbf{195}$ mm

Reaction acts within middle third of base

Pressure at toe $\sigma_{toe} = N_s / w_1 \times (1 + (6 \times e / w_1)) = \mathbf{78.6}$ kN/m^2

Pressure at heel $\sigma_{heel} = N_s / w_1 \times (1 - (6 \times e / w_1)) = \mathbf{20.6}$ kN/m^2

Factor of safety $FoS_Q = q / \max(\sigma_{toe}, \sigma_{heel}) = \mathbf{1.272}$

Allowable factor of safety $FoS_{Q\_allow} = \mathbf{1.000}$

PASS - Design FoS for allowable bearing pressure exceeds min allowable pressure to base

Design approach 1

Partial factors on actions - Section A.3.1 - Combination 1

Action factor set A1

Permanent unfavourable action $\gamma_G = \mathbf{1.35}$

Permanent favourable action $\gamma_{G,f} = \mathbf{1.00}$

Variable unfavourable action $\gamma_Q = \mathbf{1.50}$

Variable favourable action $\gamma_{Q,f} = \mathbf{0.00}$

Partial factors for soil parameters - Section A.3.2 - Combination 1

Soil factor set M1

Angle of shearing resistance $\gamma_{\phi'} = \mathbf{1.00}$

Weight density $\gamma_\gamma = \mathbf{1.00}$

Design soil properties

Design effective shearing resistance angle $\phi'_{r.d} = \text{Atan}(\tan(\phi'_{r.k}) / \gamma_{\phi'}) = \mathbf{30.0}$ deg

Design saturated density of retained soil $\gamma_{s.d} = \gamma_{sr} / \gamma_\gamma = \mathbf{21.0}$ kN/m^3

Design wall friction angle $\delta_{r.d} = \min(\text{atan}(\tan(\delta_{r.k}) / \gamma_{\phi'}), \phi'_{r.d} \times k_{membrane}) = \mathbf{22.5}$ deg

Design base friction angle $\delta_{bb.d} = \text{Atan}(\tan(\delta_{bb.k}) / \gamma_{\phi'}) = \mathbf{30.0}$ deg

Design friction between gabions $\delta_{bg.d} = \text{Atan}(\tan(\delta_{bg.k}) / \gamma_{\phi'}) = \mathbf{35.0}$ deg

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{}(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))))^2) = \mathbf{0.340}$

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2 = \mathbf{32.2}$ kN/m

Horizontal forces

Retained soil $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d}) = \mathbf{38.3}$ kN/m

Surcharge $F_{surch\_h} = p_{o,G} \times \gamma_G \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d}) = \mathbf{6.1}$ kN/m

Vertical forces

Gabion weight $F_{gabion\_v,f} = \gamma_{G,f} \times W_g = \mathbf{81.6}$ kN/m

Retained soil $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d}) = \mathbf{15.2}$ kN/m

Surcharge $F_{surch\_v,f} = p_{o,G} \times \gamma_{G,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d}) = \mathbf{2.4}$ kN/m

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch} = \mathbf{47.4}$ kNm/m

Restoring moment $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch} = \mathbf{115.0}$ kNm/m

Factor of safety $FoS_M = M_R / M_o = \mathbf{2.426}$

Allowable factor of safety $FoS_{M\_allow} = \mathbf{1.000}$

PASS - Design FOS for overturning exceeds min allowable FOS for overturning

Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force $T = F_{soil\_h} + F_{surch\_h} = \mathbf{44.3}$ kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f} = \mathbf{99.2}$ kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = \mathbf{44.3}$ kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bb.d}) = \mathbf{57.3}$ kN/m

Factor of safety $FoS_S = F_R / F_f =$ **1.292**

Allowable factor of safety $FoS_{S\_allow} =$ **1.000**

PASS - Design FOS for sliding exceeds min allowable FOS for sliding

Check overturning and sliding between courses 1 and 2

Wall geometry

Horizontal distance to centre of gravity gabion 2 $x_{g2} = w_2 / 2 =$ **850** mm

Vertical distance to centre of gravity gabion 2 $y_{g2} = h_2 / 2 =$ **500** mm

Weight of gabion 2 $W_{g2} = \gamma_d \times w_2 \times h_2 =$ **27.2** kN/m

Horizontal distance to centre of gravity gabion 3 $x_{g3} = w_3 / 2 + s_3 =$ **850** mm

Vertical distance to centre of gravity gabion 3 $y_{g3} = h_3 / 2 + h_2 =$ **1500** mm

Weight of gabion 3 $W_{g3} = \gamma_d \times w_3 \times h_3 =$ **22.4** kN/m

Weight of entire gabion $W_g = W_{g2} + W_{g3} =$ **49.6** kN/m

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3})) / W_g =$ **850** mm

Vert distance to centre of gravity entire gabion $y_g = ((W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3})) / W_g =$ **952** mm

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) =$ **850** mm

Vertical change in height due to wall inclination $H_f = y_{g3} + h_3/2 - ((y_{g3} + h_3/2) \times \cos(\varepsilon) - (x_{g3} + w_3/2) \times \sin(\varepsilon)) =$ **0** mm

Design dimensions

Effective angle of rear plane of wall $\alpha = 90deg - Atan((w_2 - (x_{g3} + (w_3 / 2))) / (y_{g3} + h_3 / 2)) + \varepsilon =$ **85.7** deg

Effective face angle $\theta = Atan((y_{g3} + (h_3 / 2)) / ((x_{g3} - (w_3 / 2)))) - \varepsilon =$ **85.7** deg

Effective height of wall $H = (y_{g3} + h_3 / 2) + (w_2 \times \sin(\varepsilon)) - H_f =$ **2000** mm

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g3} + h_3 / 2) \times \cos(\varepsilon) - (x_{g3} - (w_3 / 2)) \times \sin(\varepsilon)) =$ **2000**mm

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{}(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))))^2) =$ **0.329**

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2 =$ **13.8** kN/m

Horizontal forces

Retained soil $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d}) =$ **16.6** kN/m

Surcharge $F_{surch\_h} = p_{o,G} \times \gamma_G \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d}) =$ **4.0** kN/m

Vertical forces

Gabion weight $F_{gabion\_v,f} = \gamma_{G,f} \times W_g =$ **49.6** kN/m

Retained soil $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d}) =$ **6.2** kN/m

Surcharge $F_{surch\_v,f} = p_{o,G} \times \gamma_{G,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d}) =$ **1.5** kN/m

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch} =$ **15.1** kNm/m

Restoring moment $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch} =$ **54.8** kNm/m

Factor of safety $FoS_M = M_R / M_o =$ **3.641**

Allowable factor of safety $FoS_{M\_allow} =$ **1.000**

PASS - Design FOS for overturning exceeds min allowable FOS for overturning

Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force $T = F_{soil\_h} + F_{surch\_h} =$ **20.6** kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f} =$ **57.3** kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) =$ **20.6** kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d}) =$ **40.1** kN/m

Factor of safety $FoS_S = F_R / F_f =$ **1.947**

Allowable factor of safety FoS_{S_allow} = **1.000**

PASS - Design FOS for sliding exceeds min allowable FOS for sliding

Check overturning and sliding between courses 2 and 3

Wall geometry

Horizontal distance to centre of gravity gabion 3 $x_{g3} = w_3 / 2$ = **700** mm

Vertical distance to centre of gravity gabion 3 $y_{g3} = h_3 / 2$ = **500** mm

Weight of gabion 3 $W_{g3} = \gamma_d \times w_3 \times h_3$ = **22.4** kN/m

Weight of entire gabion $W_g = W_{g3}$ = **22.4** kN/m

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g3} \times x_{g3})) / W_g$ = **700** mm

Vert distance to centre of gravity entire gabion $y_g = ((W_{g3} \times y_{g3})) / W_g$ = **500** mm

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **700** mm

Vertical change in height due to wall inclination $H_f = y_{g3} + h_3/2 - ((y_{g3} + h_3/2) \times \cos(\varepsilon) - (x_{g3} + w_3/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall $\alpha = 90\text{ deg} + \varepsilon$ = **90.0** deg

Effective face angle $\theta = 90\text{deg} - \varepsilon$ = **90.0** deg

Effective height of wall $H = (y_{g3} + h_3 / 2) + (w_3 \times \sin(\varepsilon)) - H_f$ = **1000** mm

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g3} + h_3 / 2) \times \cos(\varepsilon) - (x_{g3} - (w_3 / 2)) \times \sin(\varepsilon))$ = **1000**mm

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{}(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))))^2)$ = **0.296**

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **3.1** kN/m

Horizontal forces

Retained soil $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **3.9** kN/m

Surcharge $F_{surch\_h} = p_{o,G} \times \gamma_G \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **1.8** kN/m

Vertical forces

Gabion weight $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **22.4** kN/m

Retained soil $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **1.2** kN/m

Surcharge $F_{surch\_v,f} = p_{o,G} \times \gamma_{G,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **0.6** kN/m

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **2.2** kNm/m

Restoring moment $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **18.1** kNm/m

Factor of safety $FoS_M = M_R / M_o$ = **8.181**

Allowable factor of safety FoS_{M_allow} = **1.000**

PASS - Design FOS for overturning exceeds min allowable FOS for overturning

Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force $T = F_{soil\_h} + F_{surch\_h}$ = **5.7** kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **24.2** kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **5.7** kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **16.9** kN/m

Factor of safety $FoS_S = F_R / F_f$ = **2.953**

Allowable factor of safety FoS_{S_allow} = **1.000**

PASS - Design FOS for sliding exceeds min allowable FOS for sliding

Design approach 1

Partial factors on actions - Section A.3.1 - Combination 2

Action factor set A2

Permanent unfavourable action γ_G = **1.00**

Permanent favourable action $\gamma_{G,f}$ = **1.00**

Variable unfavourable action γ_Q = **1.30**

Variable favourable action $\gamma_{Q,f}$ = **0.00**

Partial factors for soil parameters - Section A.3.2 - Combination 2

Soil factor set M2

Angle of shearing resistance $\gamma_{\phi'}$ = **1.25**

Weight density γ_γ = **1.00**

Design soil properties

Design effective shearing resistance angle $\phi'_{r.d} = \text{Atan}(\tan(\phi'_{r.k}) / \gamma_{\phi'})$ = **24.8** deg

Design saturated density of retained soil $\gamma_{s.d} = \gamma_{sr} / \gamma_\gamma$ = **21.0** kN/m^3

Design wall friction angle $\delta_{r.d} = \min(\text{atan}(\tan(\delta_{r.k}) / \gamma_{\phi'}), \phi'_{r.d} \times k_{membrane})$ = **18.3** deg

Design base friction angle $\delta_{bb.d} = \text{Atan}(\tan(\delta_{bb.k}) / \gamma_{\phi'})$ = **24.8** deg

Design friction between gabions $\delta_{bg.d} = \text{Atan}(\tan(\delta_{bg.k}) / \gamma_{\phi'})$ = **29.3** deg

Wall geometry

Horizontal distance to centre of gravity gabion 1 $x_{g1} = w_1 / 2$ = **1000** mm

Vertical distance to centre of gravity gabion 1 $y_{g1} = h_1 / 2$ = **500** mm

Weight of gabion 1 $W_{g1} = \gamma_d \times w_1 \times h_1$ = **32.0** kN/m

Horizontal distance to centre of gravity gabion 2 $x_{g2} = w_2 / 2 + s_2$ = **1000** mm

Vertical distance to centre of gravity gabion 2 $y_{g2} = h_2 / 2 + h_1$ = **1500** mm

Weight of gabion 2 $W_{g2} = \gamma_d \times w_2 \times h_2$ = **27.2** kN/m

Horizontal distance to centre of gravity gabion 3 $x_{g3} = w_3 / 2 + s_2 + s_3$ = **1000** mm

Vertical distance to centre of gravity gabion 3 $y_{g3} = h_3 / 2 + h_1 + h_2$ = **2500** mm

Weight of gabion 3 $W_{g3} = \gamma_d \times w_3 \times h_3$ = **22.4** kN/m

Weight of entire gabion $W_g = W_{g1} + W_{g2} + W_{g3}$ = **81.6** kN/m

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g1} \times x_{g1}) + (W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3})) / W_g$ = **1000** mm

Vert distance to centre of gravity entire gabion $y_g = ((W_{g1} \times y_{g1}) + (W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3})) / W_g$ = **1382** mm

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **1000** mm

Vertical change in height due to wall inclination $H_f = y_{g3} + h_3/2 - ((y_{g3} + h_3/2) \times \cos(\varepsilon) - (x_{g3} + w_3/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall $\alpha = 90\text{deg} - \text{Atan}((w_1 - (x_{g3} + (w_3 / 2))) / (y_{g3} + h_3 / 2)) + \varepsilon$ = **84.3** deg

Effective face angle $\theta = \text{Atan}((y_{g3} + (h_3 / 2)) / ((x_{g3} - (w_3 / 2)))) - \varepsilon$ = **84.3** deg

Effective height of wall $H = (y_{g3} + h_3 / 2) + (w_1 \times \sin(\varepsilon)) - H_f$ = **3000** mm

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g3} + h_3 / 2) \times \cos(\varepsilon) - (x_{g3} - (w_3 / 2)) \times \sin(\varepsilon))$ = **3000**mm

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{}(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))))^2)$ = **0.405**

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **38.3** kN/m

Horizontal forces

Retained soil $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **35.0** kN/m

Surcharge $F_{surch\_h} = p_{o,G} \times \gamma_G \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **5.5** kN/m

Vertical forces

Gabion weight $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **81.6** kN/m

Retained soil $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **15.6** kN/m

Surcharge $F_{surch\_v,f} = p_{o,G} \times \gamma_{G,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **2.5** kN/m

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **43.3** kNm/m

Restoring moment $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **115.8** kNm/m

Factor of safety $FoS_M = M_R / M_o$ = **2.676**

Allowable factor of safety FoS_{M_allow} = **1.000**

PASS - Design FOS for overturning exceeds min allowable FOS for overturning

Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force $T = F_{soil\_h} + F_{surch\_h}$ = **40.5** kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **99.7** kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **40.5** kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bb.d})$ = **46.0** kN/m

Factor of safety $FoS_S = F_R / F_f$ = **1.137**

Allowable factor of safety FoS_{S_allow} = **1.000**

PASS - Design FOS for sliding exceeds min allowable FOS for sliding

Check overturning and sliding between courses 1 and 2

Wall geometry

Horizontal distance to centre of gravity gabion 2 $x_{g2} = w_2 / 2$ = **850** mm

Vertical distance to centre of gravity gabion 2 $y_{g2} = h_2 / 2$ = **500** mm

Weight of gabion 2 $W_{g2} = \gamma_d \times w_2 \times h_2$ = **27.2** kN/m

Horizontal distance to centre of gravity gabion 3 $x_{g3} = w_3 / 2 + s_3$ = **850** mm

Vertical distance to centre of gravity gabion 3 $y_{g3} = h_3 / 2 + h_2$ = **1500** mm

Weight of gabion 3 $W_{g3} = \gamma_d \times w_3 \times h_3$ = **22.4** kN/m

Weight of entire gabion $W_g = W_{g2} + W_{g3}$ = **49.6** kN/m

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3})) / W_g$ = **850** mm

Vert distance to centre of gravity entire gabion $y_g = ((W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3})) / W_g$ = **952** mm

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **850** mm

Vertical change in height due to wall inclination $H_f = y_{g3} + h_3/2 - ((y_{g3} + h_3/2) \times \cos(\varepsilon) - (x_{g3} + w_3/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall $\alpha = 90deg - Atan((w_2 - (x_{g3} + (w_3 / 2))) / (y_{g3} + h_3 / 2)) + \varepsilon$ = **85.7** deg

Effective face angle $\theta = Atan((y_{g3} + (h_3 / 2)) / ((x_{g3} - (w_3 / 2)))) - \varepsilon$ = **85.7** deg

Effective height of wall $H = (y_{g3} + h_3 / 2) + (w_2 \times \sin(\varepsilon)) - H_f$ = **2000** mm

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g3} + h_3 / 2) \times \cos(\varepsilon) - (x_{g3} - (w_3 / 2)) \times \sin(\varepsilon))$ = **2000**mm

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2)$ = **0.394**

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **16.5** kN/m

Horizontal forces

Retained soil $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **15.3** kN/m

Surcharge $F_{surch\_h} = p_{o,G} \times \gamma_G \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **3.6** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **49.6** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **6.4** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,G} \times \gamma_{G,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **1.5** kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **13.8** kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **55.1** kNm/m

Factor of safety — $FoS_M = M_R / M_o$ = **3.991**

Allowable factor of safety — FoS_{M_allow} = **1.000**

PASS - Design FOS for overturning exceeds min allowable FOS for overturning

Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force — $T = F_{soil\_h} + F_{surch\_h}$ = **18.9** kN/m

Total vertical force — $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **57.5** kN/m

Sliding force — $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **18.9** kN/m

Sliding resistance — $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **32.2** kN/m

Factor of safety — $FoS_S = F_R / F_f$ = **1.704**

Allowable factor of safety — FoS_{S_allow} = **1.000**

PASS - Design FOS for sliding exceeds min allowable FOS for sliding

Check overturning and sliding between courses 2 and 3

Wall geometry

Horizontal distance to centre of gravity gabion 3 — $x_{g3} = w_3 / 2$ = **700** mm

Vertical distance to centre of gravity gabion 3 — $y_{g3} = h_3 / 2$ = **500** mm

Weight of gabion 3 — $W_{g3} = \gamma_d \times w_3 \times h_3$ = **22.4** kN/m

Weight of entire gabion — $W_g = W_{g3}$ = **22.4** kN/m

Horiz distance to centre of gravity entire gabion — $x_g = ((W_{g3} \times x_{g3})) / W_g$ = **700** mm

Vert distance to centre of gravity entire gabion — $y_g = ((W_{g3} \times y_{g3})) / W_g$ = **500** mm

Correcting for wall inclination horiz dist — $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **700** mm

Vertical change in height due to wall inclination — $H_f = y_{g3} + h_3/2 - ((y_{g3} + h_3/2) \times \cos(\varepsilon) - (x_{g3} + w_3/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall — $\alpha = 90\text{ deg} + \varepsilon$ = **90.0** deg

Effective face angle — $\theta = 90\text{deg} - \varepsilon$ = **90.0** deg

Effective height of wall — $H = (y_{g3} + h_3 / 2) + (w_3 \times \sin(\varepsilon)) - H_f$ = **1000** mm

Height of wall from toe to front edge of top gabion — $H_{incl} = ((y_{g3} + h_3 / 2) \times \cos(\varepsilon) - (x_{g3} - (w_3 / 2)) \times \sin(\varepsilon))$ = **1000**mm

Active pressure using Coulomb theory — $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{}(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))))^2)$ = **0.362**

Active thrust due to soil — $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **3.8** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **3.6** kN/m

Surcharge — $F_{surch\_h} = p_{o,G} \times \gamma_G \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **1.7** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **22.4** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **1.2** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,G} \times \gamma_{G,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **0.6** kN/m

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **2.1** kNm/m

Restoring moment $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **18.1** kNm/m

Factor of safety $FoS_M = M_R / M_o$ = **8.812**

Allowable factor of safety FoS_{M_allow} = **1.000**

PASS - Design FOS for overturning exceeds min allowable FOS for overturning

Sliding stability - ignore any passive pressure in front of the structure

Total horizontal force $T = F_{soil\_h} + F_{surch\_h}$ = **5.3** kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **24.2** kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **5.3** kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **13.5** kN/m

Factor of safety $FoS_S = F_R / F_f$ = **2.544**

Allowable factor of safety FoS_{S_allow} = **1.000**

PASS - Design FOS for sliding exceeds min allowable FOS for sliding