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 2.0.03

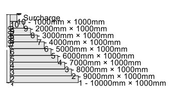
Design summary

Combination 1

Action	Resistance	Force	FoS	Allowable FoS	Status
Overturning, sliding and bearing at base level					
Overturning (kNm/m)	8869.5	1949.0	4.551	1.000	PASS
Sliding (kN/m)	1188.5	555.6	2.139	1.000	PASS
Bearing (kN/m^2)	300.0	263.7	1.138	1.000	PASS
Eccentricity (mm)	Reaction acts within the middle third of base				PASS
Overturning and sliding between courses 1 and 2					
Overturning (kNm/m)	6468.2	1446.1	4.473	1.000	PASS
Sliding (kN/m)	998.7	455.8	2.191	1.000	PASS
Overturning and sliding between courses 2 and 3					
Overturning (kNm/m)	4544.9	1037.7	4.380	1.000	PASS
Sliding (kN/m)	788.5	365.8	2.155	1.000	PASS
Overturning and sliding between courses 3 and 4					
Overturning (kNm/m)	3046.6	714.1	4.266	1.000	PASS
Sliding (kN/m)	603.1	285.6	2.112	1.000	PASS
Overturning and sliding between courses 4 and 5					
Overturning (kNm/m)	1920.0	465.4	4.126	1.000	PASS
Sliding (kN/m)	442.6	215.1	2.057	1.000	PASS
Overturning and sliding between courses 5 and 6					
Overturning (kNm/m)	1112.4	281.8	3.947	1.000	PASS
Sliding (kN/m)	307.0	154.5	1.987	1.000	PASS
Overturning and sliding between courses 6 and 7					
Overturning (kNm/m)	570.6	153.6	3.714	1.000	PASS
Sliding (kN/m)	196.2	103.5	1.896	1.000	PASS
Overturning and sliding between courses 7 and 8					
Overturning (kNm/m)	241.6	71.0	3.404	1.000	PASS
Sliding (kN/m)	110.3	62.2	1.772	1.000	PASS
Overturning and sliding between courses 8 and 9					
Overturning (kNm/m)	72.4	24.1	3.007	1.000	PASS
Sliding (kN/m)	49.3	30.5	1.618	1.000	PASS
Overturning and sliding between courses 9 and 10					
Overturning (kNm/m)	10.1	3.2	3.126	1.000	PASS
Sliding (kN/m)	13.4	7.6	1.754	1.000	PASS

Combination 2

Action	Resistance	Force	FoS	Allowable FoS	Status
Overturning, sliding and bearing at base level					
Overturning (kNm/m)	8903.7	1779.0	5.005	1.000	PASS
Sliding (kN/m)	953.5	503.4	1.894	1.000	PASS
Bearing (kN/m^2)	300.0	263.7	1.138	1.000	PASS
Eccentricity (mm)	Reaction acts within the middle third of base				PASS
Overturning and sliding between courses 1 and 2					
Overturning (kNm/m)	6495.6	1321.9	4.914	1.000	PASS
Sliding (kN/m)	801.4	413.3	1.939	1.000	PASS
Overturning and sliding between courses 2 and 3					
Overturning (kNm/m)	4566.2	950.2	4.805	1.000	PASS
Sliding (kN/m)	632.9	332.1	1.906	1.000	PASS
Overturning and sliding between courses 3 and 4					
Overturning (kNm/m)	3062.5	655.3	4.673	1.000	PASS
Sliding (kN/m)	484.3	259.6	1.865	1.000	PASS
Overturning and sliding between courses 4 and 5					
Overturning (kNm/m)	1931.4	428.3	4.510	1.000	PASS
Sliding (kN/m)	355.5	195.9	1.815	1.000	PASS
Overturning and sliding between courses 5 and 6					
Overturning (kNm/m)	1120.0	260.3	4.303	1.000	PASS
Sliding (kN/m)	246.7	141.0	1.750	1.000	PASS
Overturning and sliding between courses 6 and 7					
Overturning (kNm/m)	575.2	142.6	4.033	1.000	PASS
Sliding (kN/m)	157.8	94.9	1.663	1.000	PASS
Overturning and sliding between courses 7 and 8					
Overturning (kNm/m)	243.9	66.4	3.672	1.000	PASS
Sliding (kN/m)	88.8	57.4	1.546	1.000	PASS
Overturning and sliding between courses 8 and 9					
Overturning (kNm/m)	73.2	22.9	3.193	1.000	PASS
Sliding (kN/m)	39.7	28.6	1.390	1.000	PASS
Overturning and sliding between courses 9 and 10					
Overturning (kNm/m)	10.1	3.3	3.038	1.000	PASS
Sliding (kN/m)	10.7	7.7	1.384	1.000	PASS



Wall geometry

Width of gabion 1	w_1 = **10000** mm
Height of gabion 1	h_1 = **1000** mm
Width of gabion 2	w_2 = **9000** mm
Height of gabion 2	h_2 = **1000** mm
Step to front face between courses 1 and 2	s_2 = **0** mm
Width of gabion 3	w_3 = **8000** mm
Height of gabion 3	h_3 = **1000** mm
Step to front face between courses 2 and 3	s_3 = **0** mm
Width of gabion 4	w_4 = **7000** mm
Height of gabion 4	h_4 = **1000** mm
Step to front face between courses 3 and 4	s_4 = **0** mm
Width of gabion 5	w_5 = **6000** mm
Height of gabion 5	h_5 = **1000** mm
Step to front face between courses 4 and 5	s_5 = **0** mm
Width of gabion 6	w_6 = **5000** mm
Height of gabion 6	h_6 = **1000** mm
Step to front face between courses 5 and 6	s_6 = **0** mm
Width of gabion 7	w_7 = **4000** mm
Height of gabion 7	h_7 = **1000** mm
Step to front face between courses 6 and 7	s_7 = **0** mm
Width of gabion 8	w_8 = **3000** mm
Height of gabion 8	h_8 = **1000** mm
Step to front face between courses 7 and 8	s_8 = **0** mm
Width of gabion 9	w_9 = **2000** mm

Height of gabion 9	h_9 = **1000** mm
Step to front face between courses 8 and 9	s_9 = **0** mm
Width of gabion 10	w_{10} = **1000** mm
Height of gabion 10	h_{10} = **1000** mm
Step to front face between courses 9 and 10	s_{10} = **0** mm
Wall inclination	ε = **0** deg

Gabion properties

Unit weight of fill	γ_d = **18.0** kN/m^3
Friction between gabions	$\delta_{bg.k}$ = **35.0** deg

Loading

Variable surcharge	$p_{o,Q}$ = **10** 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} = **19.0** kN/m^3
Coefficient for wall friction	$k_{membrane}$ = **0.75**
Wall friction angle	$\delta_{r.k}$ = **22.5** deg
Characteristic base friction angle	$\delta_{bb.k}$ = **34.0** deg
Bearing capacity of founding soil	q = **300** kN/m^2

Wall geometry

Horizontal distance to centre of gravity gabion 1	$x_{g1} = w_1 / 2$ = **5000** mm
Vertical distance to centre of gravity gabion 1	$y_{g1} = h_1 / 2$ = **500** mm
Weight of gabion 1	$W_{g1} = \gamma_d \times w_1 \times h_1$ = **180.0** kN/m
Horizontal distance to centre of gravity gabion 2	$x_{g2} = w_2 / 2 + s_2$ = **4500** mm
Vertical distance to centre of gravity gabion 2	$y_{g2} = h_2 / 2 + h_1$ = **1500** mm
Weight of gabion 2	$W_{g2} = \gamma_d \times w_2 \times h_2$ = **162.0** kN/m
Horizontal distance to centre of gravity gabion 3	$x_{g3} = w_3 / 2 + s_2 + s_3$ = **4000** mm
Vertical distance to centre of gravity gabion 3	$y_{g3} = h_3 / 2 + h_1 + h_2$ = **2500** mm
Weight of gabion 3	$W_{g3} = \gamma_d \times w_3 \times h_3$ = **144.0** kN/m
Horizontal distance to centre of gravity gabion 4	$x_{g4} = w_4 / 2 + s_2 + s_3 + s_4$ = **3500** mm
Vertical distance to centre of gravity gabion 4	$y_{g4} = h_4 / 2 + h_1 + h_2 + h_3$ = **3500** mm
Weight of gabion 4	$W_{g4} = \gamma_d \times w_4 \times h_4$ = **126.0** kN/m
Horizontal distance to centre of gravity gabion 5	$x_{g5} = w_5 / 2 + s_2 + s_3 + s_4 + s_5$ = **3000** mm
Vertical distance to centre of gravity gabion 5	$y_{g5} = h_5 / 2 + h_1 + h_2 + h_3 + h_4$ = **4500** mm
Weight of gabion 5	$W_{g5} = \gamma_d \times w_5 \times h_5$ = **108.0** kN/m
Horizontal distance to centre of gravity gabion 6	$x_{g6} = w_6 / 2 + s_2 + s_3 + s_4 + s_5 + s_6$ = **2500** mm
Vertical distance to centre of gravity gabion 6	$y_{g6} = h_6 / 2 + h_1 + h_2 + h_3 + h_4 + h_5$ = **5500** mm
Weight of gabion 6	$W_{g6} = \gamma_d \times w_6 \times h_6$ = **90.0** kN/m
Horizontal distance to centre of gravity gabion 7	$x_{g7} = w_7 / 2 + s_2 + s_3 + s_4 + s_5 + s_6 + s_7$ = **2000** mm
Vertical distance to centre of gravity gabion 7	$y_{g7} = h_7 / 2 + h_1 + h_2 + h_3 + h_4 + h_5 + h_6$ = **6500** mm
Weight of gabion 7	$W_{g7} = \gamma_d \times w_7 \times h_7$ = **72.0** kN/m

Horizontal distance to centre of gravity gabion 8	$x_{g8} = w_8 / 2 + s_2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8$ = **1500** mm
Vertical distance to centre of gravity gabion 8	$y_{g8} = h_8 / 2 + h_1 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7$ = **7500** mm
Weight of gabion 8	$W_{g8} = \gamma_d \times w_8 \times h_8$ = **54.0** kN/m
Horizontal distance to centre of gravity gabion 9	$x_{g9} = w_9 / 2 + s_2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9$ = **1000** mm
Vertical distance to centre of gravity gabion 9	$y_{g9} = h_9 / 2 + h_1 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8$ = **8500** mm
Weight of gabion 9	$W_{g9} = \gamma_d \times w_9 \times h_9$ = **36.0** kN/m
Horizontal distance to centre of gravity gabion 10	$x_{g10} = w_{10} / 2 + s_2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9 + s_{10}$ = **500** mm
Vertical distance to centre of gravity gabion 10	$y_{g10} = h_{10} / 2 + h_1 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8 + h_9$ = **9500** mm
Weight of gabion 10	$W_{g10} = \gamma_d \times w_{10} \times h_{10}$ = **18.0** kN/m
Weight of entire gabion	$W_g = W_{g1} + W_{g2} + W_{g3} + W_{g4} + W_{g5} + W_{g6} + W_{g7} + W_{g8} + W_{g9} + W_{g10}$ = **990.0** kN/m
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g1} \times x_{g1}) + (W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5}) + (W_{g6} \times x_{g6}) + (W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g$ = **3500** mm
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g1} \times y_{g1}) + (W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5}) + (W_{g6} \times y_{g6}) + (W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g$ = **3500** mm
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **3500** mm
Vertical change in height due to wall inclination	$H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90deg - Atan((w_1 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon$ = **48.0** deg
Effective face angle	$\theta = 90deg - \varepsilon$ = **90.0** deg
Effective height of wall	$H = (y_{g10} + h_{10} / 2) + (w_1 \times \sin(\varepsilon)) - H_f$ = **10000** mm
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon))$ = **10000**mm
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r.k})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.k}) \times (1 + \sqrt{}(\sin(\phi'_{r.k} + \delta_{r.k}) \times \sin(\phi'_{r.k} - \beta) / (\sin(\alpha - \delta_{r.k}) \times \sin(\alpha + \beta))))^2)$ = **0.901**
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{sr} \times H^2$ = **855.5** kN/m

Pressure at base

Horizontal forces

Retained soil	$F_{soil\_h,q} = P_{a,soil} \times \cos(90 - \alpha + \delta_{r.k})$ = **368.5** kN/m
Height of soil thrust resolved vertically	$d_{h,soil} = H / 3 - w_1 \times \sin(\varepsilon)$ = **3333** mm
Surcharge	$F_{surch\_h,q} = p_{o,Q} \times K_a \times H \times \cos(90 - \alpha + \delta_{r.k})$ = **38.8** kN/m
Height of surcharge thrust resolved vertically	$d_{h,surch} = H / 2 - w_1 \times \sin(\varepsilon)$ = **5000** mm

Vertical forces

Gabion weight	$F_{gabion\_v,q} = W_g$ = **990.0** kN/m
Retained soil	$F_{soil\_v,q} = P_{a,soil} \times \sin(90 - \alpha + \delta_{r.k})$ = **772.1** kN/m
Horizontal dist to where soil thrust acts	$b_{v,soil} = w_1 \times \cos(\varepsilon) - (H / 3) / \tan(\alpha)$ = **7000** mm
Surcharge	$F_{surch\_v,q} = p_{o,Q} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.k})$ = **81.3** kN/m
Horizontal dist to where surcharge thrust acts	$b_{v,surch} = w_1 \times \cos(\varepsilon) - (H / 2) / \tan(\alpha)$ = **5500** mm
Total horizontal unfactored force	$T_q = F_{soil\_h,q} + F_{surch\_h,q}$ = **407.3** kN/m
Total vertical unfactored force	$N_q = F_{gabion\_v,q} + F_{soil\_v,q} + F_{surch\_v,q}$ = **1843.3** kN/m

Force normal to base	$N_s = N_q \times \cos(\varepsilon) + T_q \times \sin(\varepsilon)$ = **1843.3** kN/m
Total unfactored overturning force	$M_{o,q} = F_{soil\_h,q} \times d_{h,soil} + F_{surch\_h,q} \times d_{h,surch}$ = **1422.2** kNm/m
Total unfactored restoring force	$M_{R,q} = F_{gabion\_v,q} \times X_g + F_{soil\_v,q} \times b_{v,soil} + F_{surch\_v,q} \times b_{v,surch}$ = **9316.5** kNm/m
Eccentricity	$e = w_1 / 2 - (M_{R,q} - M_{o,q}) / N_s$ = **717** mm

Reaction acts within middle third of base

Pressure at toe	$\sigma_{toe} = N_s / w_1 \times (1 + (6 \times e / w_1))$ = **263.7** kN/m^2
Pressure at heel	$\sigma_{heel} = N_s / w_1 \times (1 - (6 \times e / w_1))$ = **105.0** kN/m^2
Factor of safety	$FoS_Q = q / \max(\sigma_{toe}, \sigma_{heel})$ = **1.138**
Allowable factor of safety	FoS_{Q_allow} = **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

Permanent unfavourable action	γ_G = **1.35**
Permanent favourable action	$\gamma_{G,f}$ = **1.00**
Variable unfavourable action	γ_Q = **1.50**
Variable favourable action	$\gamma_{Q,f}$ = **0.00**

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

Angle of shearing resistance	$\gamma_{\phi'}$ = **1.00**
Weight density	γ_γ = **1.00**

Design soil properties

Design effective shearing resistance angle	$\phi'_{r.d} = \mathrm{Atan}(\tan(\phi'_{r.k}) / \gamma_{\phi'})$ = **30.0** deg
Design saturated density of retained soil	$\gamma_{s.d} = \gamma_{sr} / \gamma_\gamma$ = **19.0** kN/m^3
Design wall friction angle	$\delta_{r.d} = \min(\mathrm{atan}(\tan(\delta_{r.k}) / \gamma_{\phi'}), \phi'_{r.d} \times k_{membrane})$ = **22.5** deg
Design base friction angle	$\delta_{bb.d} = \mathrm{Atan}(\tan(\delta_{bb.k}) / \gamma_{\phi'})$ = **34.0** deg
Design friction between gabions	$\delta_{bg.d} = \mathrm{Atan}(\tan(\delta_{bg.k}) / \gamma_{\phi'})$ = **35.0** deg
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2)$ = **0.901**
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **855.5** kN/m

Horizontal forces

Retained soil	$F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **497.4** kN/m
Surcharge	$F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **58.2** kN/m

Vertical forces

Gabion weight	$F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **990.0** kN/m
Retained soil	$F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **772.1** kN/m
Surcharge	$F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment	$M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **1949.0** kNm/m
Restoring moment	$M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **8869.5** kNm/m
Factor of safety	$FoS_M = M_R / M_o$ = **4.551**
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: $T = F_{soil\_h} + F_{surch\_h}$ = **555.6** kN/m

Total vertical force: $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **1762.1** kN/m

Sliding force: $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **555.6** kN/m

Sliding resistance: $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bb.d})$ = **1188.5** kN/m

Factor of safety: $FoS_S = F_R / F_f$ = **2.139**

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

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

<u>Check overturning and sliding between courses 1 and 2</u>

Wall geometry

Horizontal distance to centre of gravity gabion 2: $x_{g2} = w_2 / 2$ = **4500** mm

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

Weight of gabion 2: $W_{g2} = \gamma_d \times w_2 \times h_2$ = **162.0** kN/m

Horizontal distance to centre of gravity gabion 3: $x_{g3} = w_3 / 2 + s_3$ = **4000** mm

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

Weight of gabion 3: $W_{g3} = \gamma_d \times w_3 \times h_3$ = **144.0** kN/m

Horizontal distance to centre of gravity gabion 4: $x_{g4} = w_4 / 2 + s_3 + s_4$ = **3500** mm

Vertical distance to centre of gravity gabion 4: $y_{g4} = h_4 / 2 + h_2 + h_3$ = **2500** mm

Weight of gabion 4: $W_{g4} = \gamma_d \times w_4 \times h_4$ = **126.0** kN/m

Horizontal distance to centre of gravity gabion 5: $x_{g5} = w_5 / 2 + s_3 + s_4 + s_5$ = **3000** mm

Vertical distance to centre of gravity gabion 5: $y_{g5} = h_5 / 2 + h_2 + h_3 + h_4$ = **3500** mm

Weight of gabion 5: $W_{g5} = \gamma_d \times w_5 \times h_5$ = **108.0** kN/m

Horizontal distance to centre of gravity gabion 6: $x_{g6} = w_6 / 2 + s_3 + s_4 + s_5 + s_6$ = **2500** mm

Vertical distance to centre of gravity gabion 6: $y_{g6} = h_6 / 2 + h_2 + h_3 + h_4 + h_5$ = **4500** mm

Weight of gabion 6: $W_{g6} = \gamma_d \times w_6 \times h_6$ = **90.0** kN/m

Horizontal distance to centre of gravity gabion 7: $x_{g7} = w_7 / 2 + s_3 + s_4 + s_5 + s_6 + s_7$ = **2000** mm

Vertical distance to centre of gravity gabion 7: $y_{g7} = h_7 / 2 + h_2 + h_3 + h_4 + h_5 + h_6$ = **5500** mm

Weight of gabion 7: $W_{g7} = \gamma_d \times w_7 \times h_7$ = **72.0** kN/m

Horizontal distance to centre of gravity gabion 8: $x_{g8} = w_8 / 2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8$ = **1500** mm

Vertical distance to centre of gravity gabion 8: $y_{g8} = h_8 / 2 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7$ = **6500** mm

Weight of gabion 8: $W_{g8} = \gamma_d \times w_8 \times h_8$ = **54.0** kN/m

Horizontal distance to centre of gravity gabion 9: $x_{g9} = w_9 / 2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9$ = **1000** mm

Vertical distance to centre of gravity gabion 9: $y_{g9} = h_9 / 2 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8$ = **7500** mm

Weight of gabion 9: $W_{g9} = \gamma_d \times w_9 \times h_9$ = **36.0** kN/m

Horizontal distance to centre of gravity gabion 10: $x_{g10} = w_{10} / 2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9 + s_{10}$ = **500** mm

Vertical distance to centre of gravity gabion 10: $y_{g10} = h_{10} / 2 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8 + h_9$ = **8500** mm

Weight of gabion 10: $W_{g10} = \gamma_d \times w_{10} \times h_{10}$ = **18.0** kN/m

Weight of entire gabion: $W_g = W_{g2} + W_{g3} + W_{g4} + W_{g5} + W_{g6} + W_{g7} + W_{g8} + W_{g9} + W_{g10}$ = **810.0** kN/m

Horiz distance to centre of gravity entire gabion: $x_g = ((W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5}) + (W_{g6} \times x_{g6}) + (W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g$ = **3167** mm

Vert distance to centre of gravity entire gabion — $y_g = ((W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5}) + (W_{g6} \times y_{g6}) + (W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g$ = **3167** mm

Correcting for wall inclination horiz dist — $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **3167** mm

Vertical change in height due to wall inclination — $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall — $\alpha = 90\text{deg} - \text{Atan}((w_2 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon$ = **48.4** deg

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

Effective height of wall — $H = (y_{g10} + h_{10} / 2) + (w_2 \times \sin(\varepsilon)) - H_f$ = **9000** mm

Height of wall from toe to front edge of top gabion — $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon))$ = **9000**mm

Active pressure using Coulomb theory — $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2)$ = **0.890**

Active thrust due to soil — $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **684.9** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **403.4** kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **52.4** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **810.0** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **616.3** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **1446.1** kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **6468.2** kNm/m

Factor of safety — $FoS_M = M_R / M_o$ = **4.473**

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 — $T = F_{soil\_h} + F_{surch\_h}$ = **455.8** kN/m

Total vertical force — $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **1426.3** kN/m

Sliding force — $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **455.8** kN/m

Sliding resistance — $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **998.7** kN/m

Factor of safety — $FoS_S = F_R / F_f$ = **2.191**

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 — $x_{g3} = w_3 / 2$ = **4000** mm

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

Weight of gabion 3 — $W_{g3} = \gamma_d \times w_3 \times h_3$ = **144.0** kN/m

Horizontal distance to centre of gravity gabion 4 — $x_{g4} = w_4 / 2 + s_4$ = **3500** mm

Vertical distance to centre of gravity gabion 4 — $y_{g4} = h_4 / 2 + h_3$ = **1500** mm

Weight of gabion 4 — $W_{g4} = \gamma_d \times w_4 \times h_4 =$ **126.0** kN/m

Horizontal distance to centre of gravity gabion 5 — $x_{g5} = w_5 / 2 + s_4 + s_5 =$ **3000** mm

Vertical distance to centre of gravity gabion 5 — $y_{g5} = h_5 / 2 + h_3 + h_4 =$ **2500** mm

Weight of gabion 5 — $W_{g5} = \gamma_d \times w_5 \times h_5 =$ **108.0** kN/m

Horizontal distance to centre of gravity gabion 6 — $x_{g6} = w_6 / 2 + s_4 + s_5 + s_6 =$ **2500** mm

Vertical distance to centre of gravity gabion 6 — $y_{g6} = h_6 / 2 + h_3 + h_4 + h_5 =$ **3500** mm

Weight of gabion 6 — $W_{g6} = \gamma_d \times w_6 \times h_6 =$ **90.0** kN/m

Horizontal distance to centre of gravity gabion 7 — $x_{g7} = w_7 / 2 + s_4 + s_5 + s_6 + s_7 =$ **2000** mm

Vertical distance to centre of gravity gabion 7 — $y_{g7} = h_7 / 2 + h_3 + h_4 + h_5 + h_6 =$ **4500** mm

Weight of gabion 7 — $W_{g7} = \gamma_d \times w_7 \times h_7 =$ **72.0** kN/m

Horizontal distance to centre of gravity gabion 8 — $x_{g8} = w_8 / 2 + s_4 + s_5 + s_6 + s_7 + s_8 =$ **1500** mm

Vertical distance to centre of gravity gabion 8 — $y_{g8} = h_8 / 2 + h_3 + h_4 + h_5 + h_6 + h_7 =$ **5500** mm

Weight of gabion 8 — $W_{g8} = \gamma_d \times w_8 \times h_8 =$ **54.0** kN/m

Horizontal distance to centre of gravity gabion 9 — $x_{g9} = w_9 / 2 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9 =$ **1000** mm

Vertical distance to centre of gravity gabion 9 — $y_{g9} = h_9 / 2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8 =$ **6500** mm

Weight of gabion 9 — $W_{g9} = \gamma_d \times w_9 \times h_9 =$ **36.0** kN/m

Horizontal distance to centre of gravity gabion 10 — $x_{g10} = w_{10} / 2 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9 + s_{10} =$ **500** mm

Vertical distance to centre of gravity gabion 10 — $y_{g10} = h_{10} / 2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8 + h_9 =$ **7500** mm

Weight of gabion 10 — $W_{g10} = \gamma_d \times w_{10} \times h_{10} =$ **18.0** kN/m

Weight of entire gabion — $W_g = W_{g3} + W_{g4} + W_{g5} + W_{g6} + W_{g7} + W_{g8} + W_{g9} + W_{g10} =$ **648.0** kN/m

Horiz distance to centre of gravity entire gabion — $x_g = ((W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5}) + (W_{g6} \times x_{g6}) + (W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g =$ **2833** mm

Vert distance to centre of gravity entire gabion — $y_g = ((W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5}) + (W_{g6} \times y_{g6}) + (W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g =$ **2833** mm

Correcting for wall inclination horiz dist — $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) =$ **2833** mm

Vertical change in height due to wall inclination — $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon)) =$ **0** mm

Design dimensions

Effective angle of rear plane of wall — $\alpha = 90\text{deg} - \text{Atan}((w_3 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon =$ **48.8** deg

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

Effective height of wall — $H = (y_{g10} + h_{10} / 2) + (w_3 \times \sin(\varepsilon)) - H_f =$ **8000** mm

Height of wall from toe to front edge of top gabion — $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon)) =$ **8000**mm

Active pressure using Coulomb theory — $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2) =$ **0.877**

Active thrust due to soil — $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2 =$ **533.3** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d}) =$ **319.2** kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d}) =$ **46.7** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g =$ **648.0** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d}) =$ **478.0** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d}) =$ **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **1037.7** kNm/m

Restoring moment $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **4544.9** kNm/m

Factor of safety $FoS_M = M_R / M_o$ = **4.380**

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 $T = F_{soil\_h} + F_{surch\_h}$ = **365.8** kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **1126.0** kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **365.8** kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **788.5** kN/m

Factor of safety $FoS_S = F_R / F_f$ = **2.155**

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 3 and 4

Wall geometry

Horizontal distance to centre of gravity gabion 4 $x_{g4} = w_4 / 2$ = **3500** mm

Vertical distance to centre of gravity gabion 4 $y_{g4} = h_4 / 2$ = **500** mm

Weight of gabion 4 $W_{g4} = \gamma_d \times w_4 \times h_4$ = **126.0** kN/m

Horizontal distance to centre of gravity gabion 5 $x_{g5} = w_5 / 2 + s_5$ = **3000** mm

Vertical distance to centre of gravity gabion 5 $y_{g5} = h_5 / 2 + h_4$ = **1500** mm

Weight of gabion 5 $W_{g5} = \gamma_d \times w_5 \times h_5$ = **108.0** kN/m

Horizontal distance to centre of gravity gabion 6 $x_{g6} = w_6 / 2 + s_5 + s_6$ = **2500** mm

Vertical distance to centre of gravity gabion 6 $y_{g6} = h_6 / 2 + h_4 + h_5$ = **2500** mm

Weight of gabion 6 $W_{g6} = \gamma_d \times w_6 \times h_6$ = **90.0** kN/m

Horizontal distance to centre of gravity gabion 7 $x_{g7} = w_7 / 2 + s_5 + s_6 + s_7$ = **2000** mm

Vertical distance to centre of gravity gabion 7 $y_{g7} = h_7 / 2 + h_4 + h_5 + h_6$ = **3500** mm

Weight of gabion 7 $W_{g7} = \gamma_d \times w_7 \times h_7$ = **72.0** kN/m

Horizontal distance to centre of gravity gabion 8 $x_{g8} = w_8 / 2 + s_5 + s_6 + s_7 + s_8$ = **1500** mm

Vertical distance to centre of gravity gabion 8 $y_{g8} = h_8 / 2 + h_4 + h_5 + h_6 + h_7$ = **4500** mm

Weight of gabion 8 $W_{g8} = \gamma_d \times w_8 \times h_8$ = **54.0** kN/m

Horizontal distance to centre of gravity gabion 9 $x_{g9} = w_9 / 2 + s_5 + s_6 + s_7 + s_8 + s_9$ = **1000** mm

Vertical distance to centre of gravity gabion 9 $y_{g9} = h_9 / 2 + h_4 + h_5 + h_6 + h_7 + h_8$ = **5500** mm

Weight of gabion 9 $W_{g9} = \gamma_d \times w_9 \times h_9$ = **36.0** kN/m

Horizontal distance to centre of gravity gabion 10 $x_{g10} = w_{10} / 2 + s_5 + s_6 + s_7 + s_8 + s_9 + s_{10}$ = **500** mm

Vertical distance to centre of gravity gabion 10 $y_{g10} = h_{10} / 2 + h_4 + h_5 + h_6 + h_7 + h_8 + h_9$ = **6500** mm

Weight of gabion 10 $W_{g10} = \gamma_d \times w_{10} \times h_{10}$ = **18.0** kN/m

Weight of entire gabion $W_g = W_{g4} + W_{g5} + W_{g6} + W_{g7} + W_{g8} + W_{g9} + W_{g10}$ = **504.0** kN/m

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5}) + (W_{g6} \times x_{g6}) + (W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g$ = **2500** mm

Vert distance to centre of gravity entire gabion $y_g = ((W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5}) + (W_{g6} \times y_{g6}) + (W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g$ = **2500** mm

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **2500** mm

Vertical change in height due to wall inclination $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall $\alpha = 90\text{deg} - \text{Atan}((w_4 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon$ = **49.4** deg

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

Effective height of wall $H = (y_{g10} + h_{10} / 2) + (w_4 \times \sin(\varepsilon)) - H_f$ = **7000** mm

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon))$ = **7000**mm

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{}(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))))^2)$ = **0.861**

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **400.7** kN/m

Horizontal forces

Retained soil $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **244.7** kN/m

Surcharge $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **40.9** kN/m

Vertical forces

Gabion weight $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **504.0** kN/m

Retained soil $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **357.3** kN/m

Surcharge $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **714.1** kNm/m

Restoring moment $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **3046.6** kNm/m

Factor of safety $FoS_M = M_R / M_o$ = **4.266**

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 $T = F_{soil\_h} + F_{surch\_h}$ = **285.6** kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **861.3** kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **285.6** kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **603.1** kN/m

Factor of safety $FoS_S = F_R / F_f$ = **2.112**

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

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

<u>Check overturning and sliding between courses 4 and 5</u>

Wall geometry

Horizontal distance to centre of gravity gabion 5 $x_{g5} = w_5 / 2$ = **3000** mm

Vertical distance to centre of gravity gabion 5 $y_{g5} = h_5 / 2$ = **500** mm

Weight of gabion 5 $W_{g5} = \gamma_d \times w_5 \times h_5$ = **108.0** kN/m

Horizontal distance to centre of gravity gabion 6 $x_{g6} = w_6 / 2 + s_6$ = **2500** mm

Vertical distance to centre of gravity gabion 6 $y_{g6} = h_6 / 2 + h_5$ = **1500** mm

Weight of gabion 6 — $W_{g6} = \gamma_d \times w_6 \times h_6 =$ **90.0** kN/m

Horizontal distance to centre of gravity gabion 7 — $x_{g7} = w_7 / 2 + s_6 + s_7 =$ **2000** mm

Vertical distance to centre of gravity gabion 7 — $y_{g7} = h_7 / 2 + h_5 + h_6 =$ **2500** mm

Weight of gabion 7 — $W_{g7} = \gamma_d \times w_7 \times h_7 =$ **72.0** kN/m

Horizontal distance to centre of gravity gabion 8 — $x_{g8} = w_8 / 2 + s_6 + s_7 + s_8 =$ **1500** mm

Vertical distance to centre of gravity gabion 8 — $y_{g8} = h_8 / 2 + h_5 + h_6 + h_7 =$ **3500** mm

Weight of gabion 8 — $W_{g8} = \gamma_d \times w_8 \times h_8 =$ **54.0** kN/m

Horizontal distance to centre of gravity gabion 9 — $x_{g9} = w_9 / 2 + s_6 + s_7 + s_8 + s_9 =$ **1000** mm

Vertical distance to centre of gravity gabion 9 — $y_{g9} = h_9 / 2 + h_5 + h_6 + h_7 + h_8 =$ **4500** mm

Weight of gabion 9 — $W_{g9} = \gamma_d \times w_9 \times h_9 =$ **36.0** kN/m

Horizontal distance to centre of gravity gabion 10 — $x_{g10} = w_{10} / 2 + s_6 + s_7 + s_8 + s_9 + s_{10} =$ **500** mm

Vertical distance to centre of gravity gabion 10 — $y_{g10} = h_{10} / 2 + h_5 + h_6 + h_7 + h_8 + h_9 =$ **5500** mm

Weight of gabion 10 — $W_{g10} = \gamma_d \times w_{10} \times h_{10} =$ **18.0** kN/m

Weight of entire gabion — $W_g = W_{g5} + W_{g6} + W_{g7} + W_{g8} + W_{g9} + W_{g10} =$ **378.0** kN/m

Horiz distance to centre of gravity entire gabion — $x_g = ((W_{g5} \times x_{g5}) + (W_{g6} \times x_{g6}) + (W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g =$ **2167** mm

Vert distance to centre of gravity entire gabion — $y_g = ((W_{g5} \times y_{g5}) + (W_{g6} \times y_{g6}) + (W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g =$ **2167** mm

Correcting for wall inclination horiz dist — $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) =$ **2167** mm

Vertical change in height due to wall inclination — $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon)) =$ **0** mm

Design dimensions

Effective angle of rear plane of wall — $\alpha = 90\text{deg} - \text{Atan}((w_5 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon =$ **50.2** deg

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

Effective height of wall — $H = (y_{g10} + h_{10} / 2) + (w_5 \times \sin(\varepsilon)) - H_f =$ **6000** mm

Height of wall from toe to front edge of top gabion — $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon)) =$ **6000**mm

Active pressure using Coulomb theory — $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2) =$ **0.839**

Active thrust due to soil — $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2 =$ **287.0** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d}) =$ **180.0** kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d}) =$ **35.1** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g =$ **378.0** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d}) =$ **254.1** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d}) =$ **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch} =$ **465.4** kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch} =$ **1920.0** kNm/m

Factor of safety — $FoS_M = M_R / M_o =$ **4.126**

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 $T = F_{soil\_h} + F_{surch\_h}$ = **215.1** kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **632.1** kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **215.1** kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **442.6** kN/m

Factor of safety $FoS_S = F_R / F_f$ = **2.057**

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 5 and 6

Wall geometry

Horizontal distance to centre of gravity gabion 6 $x_{g6} = w_6 / 2$ = **2500** mm

Vertical distance to centre of gravity gabion 6 $y_{g6} = h_6 / 2$ = **500** mm

Weight of gabion 6 $W_{g6} = \gamma_d \times w_6 \times h_6$ = **90.0** kN/m

Horizontal distance to centre of gravity gabion 7 $x_{g7} = w_7 / 2 + s_7$ = **2000** mm

Vertical distance to centre of gravity gabion 7 $y_{g7} = h_7 / 2 + h_6$ = **1500** mm

Weight of gabion 7 $W_{g7} = \gamma_d \times w_7 \times h_7$ = **72.0** kN/m

Horizontal distance to centre of gravity gabion 8 $x_{g8} = w_8 / 2 + s_7 + s_8$ = **1500** mm

Vertical distance to centre of gravity gabion 8 $y_{g8} = h_8 / 2 + h_6 + h_7$ = **2500** mm

Weight of gabion 8 $W_{g8} = \gamma_d \times w_8 \times h_8$ = **54.0** kN/m

Horizontal distance to centre of gravity gabion 9 $x_{g9} = w_9 / 2 + s_7 + s_8 + s_9$ = **1000** mm

Vertical distance to centre of gravity gabion 9 $y_{g9} = h_9 / 2 + h_6 + h_7 + h_8$ = **3500** mm

Weight of gabion 9 $W_{g9} = \gamma_d \times w_9 \times h_9$ = **36.0** kN/m

Horizontal distance to centre of gravity gabion 10 $x_{g10} = w_{10} / 2 + s_7 + s_8 + s_9 + s_{10}$ = **500** mm

Vertical distance to centre of gravity gabion 10 $y_{g10} = h_{10} / 2 + h_6 + h_7 + h_8 + h_9$ = **4500** mm

Weight of gabion 10 $W_{g10} = \gamma_d \times w_{10} \times h_{10}$ = **18.0** kN/m

Weight of entire gabion $W_g = W_{g6} + W_{g7} + W_{g8} + W_{g9} + W_{g10}$ = **270.0** kN/m

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g6} \times x_{g6}) + (W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g$ = **1833** mm

Vert distance to centre of gravity entire gabion $y_g = ((W_{g6} \times y_{g6}) + (W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g$ = **1833** mm

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **1833** mm

Vertical change in height due to wall inclination $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall $\alpha = 90\text{deg} - \text{Atan}((w_6 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon$ = **51.3** deg

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

Effective height of wall $H = (y_{g10} + h_{10} / 2) + (w_6 \times \sin(\varepsilon)) - H_f$ = **5000** mm

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon))$ = **5000**mm

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2)$ = **0.809**

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **192.2** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d}) = \mathbf{125.2}$ kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d}) = \mathbf{29.3}$ kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g = \mathbf{270.0}$ kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d}) = \mathbf{168.4}$ kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d}) = \mathbf{0.0}$ kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch} = \mathbf{281.8}$ kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch} = \mathbf{1112.4}$ kNm/m

Factor of safety — $FoS_M = M_R / M_o = \mathbf{3.947}$

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 — $T = F_{soil\_h} + F_{surch\_h} = \mathbf{154.5}$ kN/m

Total vertical force — $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f} = \mathbf{438.4}$ kN/m

Sliding force — $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = \mathbf{154.5}$ kN/m

Sliding resistance — $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d}) = \mathbf{307.0}$ kN/m

Factor of safety — $FoS_S = F_R / F_f = \mathbf{1.987}$

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

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

<u>Check overturning and sliding between courses 6 and 7</u>

Wall geometry

Horizontal distance to centre of gravity gabion 7 — $x_{g7} = w_7 / 2 = \mathbf{2000}$ mm

Vertical distance to centre of gravity gabion 7 — $y_{g7} = h_7 / 2 = \mathbf{500}$ mm

Weight of gabion 7 — $W_{g7} = \gamma_d \times w_7 \times h_7 = \mathbf{72.0}$ kN/m

Horizontal distance to centre of gravity gabion 8 — $x_{g8} = w_8 / 2 + s_8 = \mathbf{1500}$ mm

Vertical distance to centre of gravity gabion 8 — $y_{g8} = h_8 / 2 + h_7 = \mathbf{1500}$ mm

Weight of gabion 8 — $W_{g8} = \gamma_d \times w_8 \times h_8 = \mathbf{54.0}$ kN/m

Horizontal distance to centre of gravity gabion 9 — $x_{g9} = w_9 / 2 + s_8 + s_9 = \mathbf{1000}$ mm

Vertical distance to centre of gravity gabion 9 — $y_{g9} = h_9 / 2 + h_7 + h_8 = \mathbf{2500}$ mm

Weight of gabion 9 — $W_{g9} = \gamma_d \times w_9 \times h_9 = \mathbf{36.0}$ kN/m

Horizontal distance to centre of gravity gabion 10 — $x_{g10} = w_{10} / 2 + s_8 + s_9 + s_{10} = \mathbf{500}$ mm

Vertical distance to centre of gravity gabion 10 — $y_{g10} = h_{10} / 2 + h_7 + h_8 + h_9 = \mathbf{3500}$ mm

Weight of gabion 10 — $W_{g10} = \gamma_d \times w_{10} \times h_{10} = \mathbf{18.0}$ kN/m

Weight of entire gabion — $W_g = W_{g7} + W_{g8} + W_{g9} + W_{g10} = \mathbf{180.0}$ kN/m

Horiz distance to centre of gravity entire gabion — $x_g = ((W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g = \mathbf{1500}$ mm

Vert distance to centre of gravity entire gabion — $y_g = ((W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g = \mathbf{1500}$ mm

Correcting for wall inclination horiz dist — $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{1500}$ mm

Vertical change in height due to wall inclination — $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon)) = \mathbf{0}$ mm

Design dimensions

Effective angle of rear plane of wall — $\alpha = 90deg - Atan((w_7 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon$ = **53.1** deg

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

Effective height of wall — $H = (y_{g10} + h_{10} / 2) + (w_7 \times \sin(\varepsilon)) - H_f$ = **4000** mm

Height of wall from toe to front edge of top gabion — $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon))$ = **4000**mm

Active pressure using Coulomb theory — $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2)$ = **0.766**

Active thrust due to soil — $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **116.4** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **80.1** kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **23.4** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **180.0** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **100.2** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **153.6** kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **570.6** kNm/m

Factor of safety — $FoS_M = M_R / M_o$ = **3.714**

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 — $T = F_{soil\_h} + F_{surch\_h}$ = **103.5** kN/m

Total vertical force — $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **280.2** kN/m

Sliding force — $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **103.5** kN/m

Sliding resistance — $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **196.2** kN/m

Factor of safety — $FoS_S = F_R / F_f$ = **1.896**

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 7 and 8

Wall geometry

Horizontal distance to centre of gravity gabion 8 — $x_{g8} = w_8 / 2$ = **1500** mm

Vertical distance to centre of gravity gabion 8 — $y_{g8} = h_8 / 2$ = **500** mm

Weight of gabion 8 — $W_{g8} = \gamma_d \times w_8 \times h_8$ = **54.0** kN/m

Horizontal distance to centre of gravity gabion 9 — $x_{g9} = w_9 / 2 + s_9$ = **1000** mm

Vertical distance to centre of gravity gabion 9 — $y_{g9} = h_9 / 2 + h_8$ = **1500** mm

Weight of gabion 9 — $W_{g9} = \gamma_d \times w_9 \times h_9$ = **36.0** kN/m

Horizontal distance to centre of gravity gabion 10 — $x_{g10} = w_{10} / 2 + s_9 + s_{10}$ = **500** mm

Vertical distance to centre of gravity gabion 10 — $y_{g10} = h_{10} / 2 + h_8 + h_9$ = **2500** mm

Weight of gabion 10 — $W_{g10} = \gamma_d \times w_{10} \times h_{10}$ = **18.0** kN/m

Weight of entire gabion $W_g = W_{g8} + W_{g9} + W_{g10} = \mathbf{108.0}$ kN/m

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g = \mathbf{1167}$ mm

Vert distance to centre of gravity entire gabion $y_g = ((W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g = \mathbf{1167}$ mm

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{1167}$ mm

Vertical change in height due to wall inclination $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon)) = \mathbf{0}$ mm

Design dimensions

Effective angle of rear plane of wall $\alpha = 90\text{deg} - \text{Atan}((w_8 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon = \mathbf{56.3}$ deg

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

Effective height of wall $H = (y_{g10} + h_{10} / 2) + (w_8 \times \sin(\varepsilon)) - H_f = \mathbf{3000}$ mm

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon)) = \mathbf{3000}$mm

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2) = \mathbf{0.697}$

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2 = \mathbf{59.6}$ kN/m

Horizontal forces

Retained soil $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d}) = \mathbf{44.8}$ kN/m

Surcharge $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d}) = \mathbf{17.5}$ kN/m

Vertical forces

Gabion weight $F_{gabion\_v,f} = \gamma_{G,f} \times W_g = \mathbf{108.0}$ kN/m

Retained soil $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d}) = \mathbf{49.5}$ kN/m

Surcharge $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d}) = \mathbf{0.0}$ kN/m

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch} = \mathbf{71.0}$ kNm/m

Restoring moment $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch} = \mathbf{241.6}$ kNm/m

Factor of safety $FoS_M = M_R / M_o = \mathbf{3.404}$

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 $T = F_{soil\_h} + F_{surch\_h} = \mathbf{62.2}$ kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f} = \mathbf{157.5}$ kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = \mathbf{62.2}$ kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d}) = \mathbf{110.3}$ kN/m

Factor of safety $FoS_S = F_R / F_f = \mathbf{1.772}$

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

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

<u>Check overturning and sliding between courses 8 and 9</u>

Wall geometry

Horizontal distance to centre of gravity gabion 9 $x_{g9} = w_9 / 2 = \mathbf{1000}$ mm

Vertical distance to centre of gravity gabion 9 $y_{g9} = h_9 / 2 = \mathbf{500}$ mm

Weight of gabion 9 $W_{g9} = \gamma_d \times w_9 \times h_9 = \mathbf{36.0}$ kN/m

Horizontal distance to centre of gravity gabion 10 $x_{g10} = w_{10} / 2 + s_{10} = \mathbf{500}$ mm

Vertical distance to centre of gravity gabion 10 — $y_{g10} = h_{10} / 2 + h_9 =$ **1500** mm

Weight of gabion 10 — $W_{g10} = \gamma_d \times w_{10} \times h_{10} =$ **18.0** kN/m

Weight of entire gabion — $W_g = W_{g9} + W_{g10} =$ **54.0** kN/m

Horiz distance to centre of gravity entire gabion — $x_g = ((W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g =$ **833** mm

Vert distance to centre of gravity entire gabion — $y_g = ((W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g =$ **833** mm

Correcting for wall inclination horiz dist — $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) =$ **833** mm

Vertical change in height due to wall inclination — $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon)) =$ **0** mm

Design dimensions

Effective angle of rear plane of wall — $\alpha = 90deg - Atan((w_9 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon =$ **63.4** deg

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

Effective height of wall — $H = (y_{g10} + h_{10} / 2) + (w_9 \times \sin(\varepsilon)) - H_f =$ **2000** mm

Height of wall from toe to front edge of top gabion — $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon)) =$ **2000**mm

Active pressure using Coulomb theory — $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2) =$ **0.572**

Active thrust due to soil — $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2 =$ **21.7** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d}) =$ **19.2** kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d}) =$ **11.2** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g =$ **54.0** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d}) =$ **16.4** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d}) =$ **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch} =$ **24.1** kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch} =$ **72.4** kNm/m

Factor of safety — $FoS_M = M_R / M_o =$ **3.007**

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 — $T = F_{soil\_h} + F_{surch\_h} =$ **30.5** kN/m

Total vertical force — $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f} =$ **70.4** kN/m

Sliding force — $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) =$ **30.5** kN/m

Sliding resistance — $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d}) =$ **49.3** kN/m

Factor of safety — $FoS_S = F_R / F_f =$ **1.618**

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 9 and 10

Wall geometry

Horizontal distance to centre of gravity gabion 10 — $x_{g10} = w_{10} / 2 =$ **500** mm

Vertical distance to centre of gravity gabion 10 — $y_{g10} = h_{10} / 2 =$ **500** mm

Weight of gabion 10 — $W_{g10} = \gamma_d \times w_{10} \times h_{10} =$ **18.0** kN/m

Weight of entire gabion — $W_g = W_{g10} =$ **18.0** kN/m

Horiz distance to centre of gravity entire gabion — $x_g = ((W_{g10} \times x_{g10})) / W_g =$ **500** mm

Vert distance to centre of gravity entire gabion — $y_g = ((W_{g10} \times y_{g10})) / W_g =$ **500** mm

Correcting for wall inclination horiz dist — $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) =$ **500** mm

Vertical change in height due to wall inclination — $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon)) =$ **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 — $H = (y_{g10} + h_{10} / 2) + (w_{10} \times \sin(\varepsilon)) - H_f =$ **1000** mm

Height of wall from toe to front edge of top gabion — $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon)) =$ **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 — $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2 =$ **2.8** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d}) =$ **3.5** kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d}) =$ **4.1** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g =$ **18.0** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d}) =$ **1.1** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d}) =$ **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch} =$ **3.2** kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch} =$ **10.1** kNm/m

Factor of safety — $FoS_M = M_R / M_o =$ **3.126**

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 — $T = F_{soil\_h} + F_{surch\_h} =$ **7.6** kN/m

Total vertical force — $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f} =$ **19.1** kN/m

Sliding force — $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) =$ **7.6** kN/m

Sliding resistance — $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d}) =$ **13.4** kN/m

Factor of safety — $FoS_S = F_R / F_f =$ **1.754**

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

Permanent unfavourable action — $\gamma_G =$ **1.00**

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

Variable unfavourable action — $\gamma_Q =$ **1.30**

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

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

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 $\gamma_{s.d} = \gamma_{sr} / \gamma_{\gamma}$ = **19.0** 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 $\delta_{bb.d} = \text{Atan}(\tan(\delta_{bb.k}) / \gamma_{\phi'})$ = **28.4** 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 $x_{g1} = w_1 / 2$ = **5000** mm

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

Weight of gabion 1 $W_{g1} = \gamma_d \times w_1 \times h_1$ = **180.0** kN/m

Horizontal distance to centre of gravity gabion 2 $x_{g2} = w_2 / 2 + s_2$ = **4500** mm

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

Weight of gabion 2 $W_{g2} = \gamma_d \times w_2 \times h_2$ = **162.0** kN/m

Horizontal distance to centre of gravity gabion 3 $x_{g3} = w_3 / 2 + s_2 + s_3$ = **4000** mm

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

Weight of gabion 3 $W_{g3} = \gamma_d \times w_3 \times h_3$ = **144.0** kN/m

Horizontal distance to centre of gravity gabion 4 $x_{g4} = w_4 / 2 + s_2 + s_3 + s_4$ = **3500** mm

Vertical distance to centre of gravity gabion 4 $y_{g4} = h_4 / 2 + h_1 + h_2 + h_3$ = **3500** mm

Weight of gabion 4 $W_{g4} = \gamma_d \times w_4 \times h_4$ = **126.0** kN/m

Horizontal distance to centre of gravity gabion 5 $x_{g5} = w_5 / 2 + s_2 + s_3 + s_4 + s_5$ = **3000** mm

Vertical distance to centre of gravity gabion 5 $y_{g5} = h_5 / 2 + h_1 + h_2 + h_3 + h_4$ = **4500** mm

Weight of gabion 5 $W_{g5} = \gamma_d \times w_5 \times h_5$ = **108.0** kN/m

Horizontal distance to centre of gravity gabion 6 $x_{g6} = w_6 / 2 + s_2 + s_3 + s_4 + s_5 + s_6$ = **2500** mm

Vertical distance to centre of gravity gabion 6 $y_{g6} = h_6 / 2 + h_1 + h_2 + h_3 + h_4 + h_5$ = **5500** mm

Weight of gabion 6 $W_{g6} = \gamma_d \times w_6 \times h_6$ = **90.0** kN/m

Horizontal distance to centre of gravity gabion 7 $x_{g7} = w_7 / 2 + s_2 + s_3 + s_4 + s_5 + s_6 + s_7$ = **2000** mm

Vertical distance to centre of gravity gabion 7 $y_{g7} = h_7 / 2 + h_1 + h_2 + h_3 + h_4 + h_5 + h_6$ = **6500** mm

Weight of gabion 7 $W_{g7} = \gamma_d \times w_7 \times h_7$ = **72.0** kN/m

Horizontal distance to centre of gravity gabion 8 $x_{g8} = w_8 / 2 + s_2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8$ = **1500** mm

Vertical distance to centre of gravity gabion 8 $y_{g8} = h_8 / 2 + h_1 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7$ = **7500** mm

Weight of gabion 8 $W_{g8} = \gamma_d \times w_8 \times h_8$ = **54.0** kN/m

Horizontal distance to centre of gravity gabion 9 $x_{g9} = w_9 / 2 + s_2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9$ = **1000** mm

Vertical distance to centre of gravity gabion 9 $y_{g9} = h_9 / 2 + h_1 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8$ = **8500** mm

Weight of gabion 9 $W_{g9} = \gamma_d \times w_9 \times h_9$ = **36.0** kN/m

Horizontal distance to centre of gravity gabion 10 $x_{g10} = w_{10} / 2 + s_2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9 + s_{10}$ = **500** mm

Vertical distance to centre of gravity gabion 10 $y_{g10} = h_{10} / 2 + h_1 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8 + h_9$ = **9500** mm

Weight of gabion 10 $W_{g10} = \gamma_d \times w_{10} \times h_{10}$ = **18.0** kN/m

Weight of entire gabion — $W_g = W_{g1} + W_{g2} + W_{g3} + W_{g4} + W_{g5} + W_{g6} + W_{g7} + W_{g8} + W_{g9} + W_{g10}$ = **990.0** kN/m

Horiz distance to centre of gravity entire gabion — $x_g = ((W_{g1} \times x_{g1}) + (W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5}) + (W_{g6} \times x_{g6}) + (W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g$ = **3500** mm

Vert distance to centre of gravity entire gabion — $y_g = ((W_{g1} \times y_{g1}) + (W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5}) + (W_{g6} \times y_{g6}) + (W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g$ = **3500** mm

Correcting for wall inclination horiz dist — $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **3500** mm

Vertical change in height due to wall inclination — $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall — $\alpha = 90\text{deg} - \text{Atan}((w_1 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon$ = **48.0** deg

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

Effective height of wall — $H = (y_{g10} + h_{10} / 2) + (w_1 \times \sin(\varepsilon)) - H_f$ = **10000** mm

Height of wall from toe to front edge of top gabion — $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon))$ = **10000**mm

Active pressure using Coulomb theory — $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2)$ = **0.941**

Active thrust due to soil — $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **894.3** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **442.8** kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **60.6** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **990.0** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **777.0** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **1779.0** kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **8903.7** kNm/m

Factor of safety — $FoS_M = M_R / M_o$ = **5.005**

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 — $T = F_{soil\_h} + F_{surch\_h}$ = **503.4** kN/m

Total vertical force — $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **1767.0** kN/m

Sliding force — $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **503.4** kN/m

Sliding resistance — $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bb.d})$ = **953.5** kN/m

Factor of safety — $FoS_S = F_R / F_f$ = **1.894**

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	$x_{g2} = w_2 / 2 = \mathbf{4500}$ mm
Vertical distance to centre of gravity gabion 2	$y_{g2} = h_2 / 2 = \mathbf{500}$ mm
Weight of gabion 2	$W_{g2} = \gamma_d \times w_2 \times h_2 = \mathbf{162.0}$ kN/m
Horizontal distance to centre of gravity gabion 3	$x_{g3} = w_3 / 2 + s_3 = \mathbf{4000}$ mm
Vertical distance to centre of gravity gabion 3	$y_{g3} = h_3 / 2 + h_2 = \mathbf{1500}$ mm
Weight of gabion 3	$W_{g3} = \gamma_d \times w_3 \times h_3 = \mathbf{144.0}$ kN/m
Horizontal distance to centre of gravity gabion 4	$x_{g4} = w_4 / 2 + s_3 + s_4 = \mathbf{3500}$ mm
Vertical distance to centre of gravity gabion 4	$y_{g4} = h_4 / 2 + h_2 + h_3 = \mathbf{2500}$ mm
Weight of gabion 4	$W_{g4} = \gamma_d \times w_4 \times h_4 = \mathbf{126.0}$ kN/m
Horizontal distance to centre of gravity gabion 5	$x_{g5} = w_5 / 2 + s_3 + s_4 + s_5 = \mathbf{3000}$ mm
Vertical distance to centre of gravity gabion 5	$y_{g5} = h_5 / 2 + h_2 + h_3 + h_4 = \mathbf{3500}$ mm
Weight of gabion 5	$W_{g5} = \gamma_d \times w_5 \times h_5 = \mathbf{108.0}$ kN/m
Horizontal distance to centre of gravity gabion 6	$x_{g6} = w_6 / 2 + s_3 + s_4 + s_5 + s_6 = \mathbf{2500}$ mm
Vertical distance to centre of gravity gabion 6	$y_{g6} = h_6 / 2 + h_2 + h_3 + h_4 + h_5 = \mathbf{4500}$ mm
Weight of gabion 6	$W_{g6} = \gamma_d \times w_6 \times h_6 = \mathbf{90.0}$ kN/m
Horizontal distance to centre of gravity gabion 7	$x_{g7} = w_7 / 2 + s_3 + s_4 + s_5 + s_6 + s_7 = \mathbf{2000}$ mm
Vertical distance to centre of gravity gabion 7	$y_{g7} = h_7 / 2 + h_2 + h_3 + h_4 + h_5 + h_6 = \mathbf{5500}$ mm
Weight of gabion 7	$W_{g7} = \gamma_d \times w_7 \times h_7 = \mathbf{72.0}$ kN/m
Horizontal distance to centre of gravity gabion 8	$x_{g8} = w_8 / 2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8 = \mathbf{1500}$ mm
Vertical distance to centre of gravity gabion 8	$y_{g8} = h_8 / 2 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7 = \mathbf{6500}$ mm
Weight of gabion 8	$W_{g8} = \gamma_d \times w_8 \times h_8 = \mathbf{54.0}$ kN/m
Horizontal distance to centre of gravity gabion 9	$x_{g9} = w_9 / 2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9 = \mathbf{1000}$ mm
Vertical distance to centre of gravity gabion 9	$y_{g9} = h_9 / 2 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8 = \mathbf{7500}$ mm
Weight of gabion 9	$W_{g9} = \gamma_d \times w_9 \times h_9 = \mathbf{36.0}$ kN/m
Horizontal distance to centre of gravity gabion 10	$x_{g10} = w_{10} / 2 + s_3 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9 + s_{10} = \mathbf{500}$ mm
Vertical distance to centre of gravity gabion 10	$y_{g10} = h_{10} / 2 + h_2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8 + h_9 = \mathbf{8500}$ mm
Weight of gabion 10	$W_{g10} = \gamma_d \times w_{10} \times h_{10} = \mathbf{18.0}$ kN/m
Weight of entire gabion	$W_g = W_{g2} + W_{g3} + W_{g4} + W_{g5} + W_{g6} + W_{g7} + W_{g8} + W_{g9} + W_{g10} = \mathbf{810.0}$ kN/m
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5}) + (W_{g6} \times x_{g6}) + (W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g = \mathbf{3167}$ mm
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5}) + (W_{g6} \times y_{g6}) + (W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g = \mathbf{3167}$ mm
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{3167}$ mm
Vertical change in height due to wall inclination	$H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon)) = \mathbf{0}$ mm

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90\text{deg} - \text{Atan}((w_2 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon = \mathbf{48.4}$ deg
Effective face angle	$\theta = 90\text{deg} - \varepsilon = \mathbf{90.0}$ deg
Effective height of wall	$H = (y_{g10} + h_{10} / 2) + (w_2 \times \sin(\varepsilon)) - H_f = \mathbf{9000}$ mm

Height of wall from toe to front edge of top gabion — $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon))$ = **9000**mm

Active pressure using Coulomb theory — $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{}(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))))^2)$ = **0.932**

Active thrust due to soil — $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **716.9** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **358.8** kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **54.6** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **810.0** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **620.6** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **1321.9** kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **6495.6** kNm/m

Factor of safety — $FoS_M = M_R / M_o$ = **4.914**

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 — $T = F_{soil\_h} + F_{surch\_h}$ = **413.3** kN/m

Total vertical force — $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **1430.6** kN/m

Sliding force — $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **413.3** kN/m

Sliding resistance — $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **801.4** kN/m

Factor of safety — $FoS_S = F_R / F_f$ = **1.939**

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 — $x_{g3} = w_3 / 2$ = **4000** mm

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

Weight of gabion 3 — $W_{g3} = \gamma_d \times w_3 \times h_3$ = **144.0** kN/m

Horizontal distance to centre of gravity gabion 4 — $x_{g4} = w_4 / 2 + s_4$ = **3500** mm

Vertical distance to centre of gravity gabion 4 — $y_{g4} = h_4 / 2 + h_3$ = **1500** mm

Weight of gabion 4 — $W_{g4} = \gamma_d \times w_4 \times h_4$ = **126.0** kN/m

Horizontal distance to centre of gravity gabion 5 — $x_{g5} = w_5 / 2 + s_4 + s_5$ = **3000** mm

Vertical distance to centre of gravity gabion 5 — $y_{g5} = h_5 / 2 + h_3 + h_4$ = **2500** mm

Weight of gabion 5 — $W_{g5} = \gamma_d \times w_5 \times h_5$ = **108.0** kN/m

Horizontal distance to centre of gravity gabion 6 — $x_{g6} = w_6 / 2 + s_4 + s_5 + s_6$ = **2500** mm

Vertical distance to centre of gravity gabion 6 — $y_{g6} = h_6 / 2 + h_3 + h_4 + h_5$ = **3500** mm

Weight of gabion 6 — $W_{g6} = \gamma_d \times w_6 \times h_6$ = **90.0** kN/m

Horizontal distance to centre of gravity gabion 7 — $x_{g7} = w_7 / 2 + s_4 + s_5 + s_6 + s_7$ = **2000** mm

Vertical distance to centre of gravity gabion 7 — $y_{g7} = h_7 / 2 + h_3 + h_4 + h_5 + h_6$ = **4500** mm

Weight of gabion 7 — $W_{g7} = \gamma_d \times w_7 \times h_7 =$ **72.0** kN/m

Horizontal distance to centre of gravity gabion 8 — $x_{g8} = w_8 / 2 + s_4 + s_5 + s_6 + s_7 + s_8 =$ **1500** mm

Vertical distance to centre of gravity gabion 8 — $y_{g8} = h_8 / 2 + h_3 + h_4 + h_5 + h_6 + h_7 =$ **5500** mm

Weight of gabion 8 — $W_{g8} = \gamma_d \times w_8 \times h_8 =$ **54.0** kN/m

Horizontal distance to centre of gravity gabion 9 — $x_{g9} = w_9 / 2 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9 =$ **1000** mm

Vertical distance to centre of gravity gabion 9 — $y_{g9} = h_9 / 2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8 =$ **6500** mm

Weight of gabion 9 — $W_{g9} = \gamma_d \times w_9 \times h_9 =$ **36.0** kN/m

Horizontal distance to centre of gravity gabion 10 — $x_{g10} = w_{10} / 2 + s_4 + s_5 + s_6 + s_7 + s_8 + s_9 + s_{10} =$ **500** mm

Vertical distance to centre of gravity gabion 10 — $y_{g10} = h_{10} / 2 + h_3 + h_4 + h_5 + h_6 + h_7 + h_8 + h_9 =$ **7500** mm

Weight of gabion 10 — $W_{g10} = \gamma_d \times w_{10} \times h_{10} =$ **18.0** kN/m

Weight of entire gabion — $W_g = W_{g3} + W_{g4} + W_{g5} + W_{g6} + W_{g7} + W_{g8} + W_{g9} + W_{g10} =$ **648.0** kN/m

Horiz distance to centre of gravity entire gabion — $x_g = ((W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5}) + (W_{g6} \times x_{g6}) + (W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g =$ **2833** mm

Vert distance to centre of gravity entire gabion — $y_g = ((W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5}) + (W_{g6} \times y_{g6}) + (W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g =$ **2833** mm

Correcting for wall inclination horiz dist — $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) =$ **2833** mm

Vertical change in height due to wall inclination — $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon)) =$ **0** mm

Design dimensions

Effective angle of rear plane of wall — $\alpha = 90\text{deg} - \text{Atan}((w_3 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon =$ **48.8** deg

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

Effective height of wall — $H = (y_{g10} + h_{10} / 2) + (w_3 \times \sin(\varepsilon)) - H_f =$ **8000** mm

Height of wall from toe to front edge of top gabion — $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon)) =$ **8000**mm

Active pressure using Coulomb theory — $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2) =$ **0.920**

Active thrust due to soil — $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2 =$ **559.1** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d}) =$ **283.6** kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d}) =$ **48.5** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g =$ **648.0** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d}) =$ **481.8** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d}) =$ **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch} =$ **950.2** kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch} =$ **4566.2** kNm/m

Factor of safety — $FoS_M = M_R / M_o =$ **4.805**

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 — $T = F_{soil\_h} + F_{surch\_h} =$ **332.1** kN/m

Total vertical force — $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f} =$ **1129.8** kN/m

Sliding force	$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = \mathbf{332.1}$ kN/m
Sliding resistance	$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d}) = \mathbf{632.9}$ kN/m
Factor of safety	$FoS_S = F_R / F_f = \mathbf{1.906}$
Allowable factor of safety	$FoS_{S\_allow} = \mathbf{1.000}$
	PASS - Design FOS for sliding exceeds min allowable FOS for sliding

<u>Check overturning and sliding between courses 3 and 4</u>

Wall geometry

Horizontal distance to centre of gravity gabion 4	$x_{g4} = w_4 / 2 = \mathbf{3500}$ mm
Vertical distance to centre of gravity gabion 4	$y_{g4} = h_4 / 2 = \mathbf{500}$ mm
Weight of gabion 4	$W_{g4} = \gamma_d \times w_4 \times h_4 = \mathbf{126.0}$ kN/m
Horizontal distance to centre of gravity gabion 5	$x_{g5} = w_5 / 2 + s_5 = \mathbf{3000}$ mm
Vertical distance to centre of gravity gabion 5	$y_{g5} = h_5 / 2 + h_4 = \mathbf{1500}$ mm
Weight of gabion 5	$W_{g5} = \gamma_d \times w_5 \times h_5 = \mathbf{108.0}$ kN/m
Horizontal distance to centre of gravity gabion 6	$x_{g6} = w_6 / 2 + s_5 + s_6 = \mathbf{2500}$ mm
Vertical distance to centre of gravity gabion 6	$y_{g6} = h_6 / 2 + h_4 + h_5 = \mathbf{2500}$ mm
Weight of gabion 6	$W_{g6} = \gamma_d \times w_6 \times h_6 = \mathbf{90.0}$ kN/m
Horizontal distance to centre of gravity gabion 7	$x_{g7} = w_7 / 2 + s_5 + s_6 + s_7 = \mathbf{2000}$ mm
Vertical distance to centre of gravity gabion 7	$y_{g7} = h_7 / 2 + h_4 + h_5 + h_6 = \mathbf{3500}$ mm
Weight of gabion 7	$W_{g7} = \gamma_d \times w_7 \times h_7 = \mathbf{72.0}$ kN/m
Horizontal distance to centre of gravity gabion 8	$x_{g8} = w_8 / 2 + s_5 + s_6 + s_7 + s_8 = \mathbf{1500}$ mm
Vertical distance to centre of gravity gabion 8	$y_{g8} = h_8 / 2 + h_4 + h_5 + h_6 + h_7 = \mathbf{4500}$ mm
Weight of gabion 8	$W_{g8} = \gamma_d \times w_8 \times h_8 = \mathbf{54.0}$ kN/m
Horizontal distance to centre of gravity gabion 9	$x_{g9} = w_9 / 2 + s_5 + s_6 + s_7 + s_8 + s_9 = \mathbf{1000}$ mm
Vertical distance to centre of gravity gabion 9	$y_{g9} = h_9 / 2 + h_4 + h_5 + h_6 + h_7 + h_8 = \mathbf{5500}$ mm
Weight of gabion 9	$W_{g9} = \gamma_d \times w_9 \times h_9 = \mathbf{36.0}$ kN/m
Horizontal distance to centre of gravity gabion 10	$x_{g10} = w_{10} / 2 + s_5 + s_6 + s_7 + s_8 + s_9 + s_{10} = \mathbf{500}$ mm
Vertical distance to centre of gravity gabion 10	$y_{g10} = h_{10} / 2 + h_4 + h_5 + h_6 + h_7 + h_8 + h_9 = \mathbf{6500}$ mm
Weight of gabion 10	$W_{g10} = \gamma_d \times w_{10} \times h_{10} = \mathbf{18.0}$ kN/m
Weight of entire gabion	$W_g = W_{g4} + W_{g5} + W_{g6} + W_{g7} + W_{g8} + W_{g9} + W_{g10} = \mathbf{504.0}$ kN/m
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5}) + (W_{g6} \times x_{g6}) + (W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g = \mathbf{2500}$ mm
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5}) + (W_{g6} \times y_{g6}) + (W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g = \mathbf{2500}$ mm
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{2500}$ mm
Vertical change in height due to wall inclination	$H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon)) = \mathbf{0}$ mm

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90deg - Atan((w_4 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon = \mathbf{49.4}$ deg
Effective face angle	$\theta = 90deg - \varepsilon = \mathbf{90.0}$ deg
Effective height of wall	$H = (y_{g10} + h_{10} / 2) + (w_4 \times \sin(\varepsilon)) - H_f = \mathbf{7000}$ mm
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon)) = \mathbf{7000}$mm

Active pressure using Coulomb theory — $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))})^2)$ = **0.904**

Active thrust due to soil — $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **420.9** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **217.2** kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **42.5** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **504.0** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **360.5** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **655.3** kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **3062.5** kNm/m

Factor of safety — $FoS_M = M_R / M_o$ = **4.673**

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 — $T = F_{soil\_h} + F_{surch\_h}$ = **259.6** kN/m

Total vertical force — $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **864.5** kN/m

Sliding force — $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **259.6** kN/m

Sliding resistance — $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **484.3** kN/m

Factor of safety — $FoS_S = F_R / F_f$ = **1.865**

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

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

<u>Check overturning and sliding between courses 4 and 5</u>

Wall geometry

Horizontal distance to centre of gravity gabion 5 — $x_{g5} = w_5 / 2$ = **3000** mm

Vertical distance to centre of gravity gabion 5 — $y_{g5} = h_5 / 2$ = **500** mm

Weight of gabion 5 — $W_{g5} = \gamma_d \times w_5 \times h_5$ = **108.0** kN/m

Horizontal distance to centre of gravity gabion 6 — $x_{g6} = w_6 / 2 + s_6$ = **2500** mm

Vertical distance to centre of gravity gabion 6 — $y_{g6} = h_6 / 2 + h_5$ = **1500** mm

Weight of gabion 6 — $W_{g6} = \gamma_d \times w_6 \times h_6$ = **90.0** kN/m

Horizontal distance to centre of gravity gabion 7 — $x_{g7} = w_7 / 2 + s_6 + s_7$ = **2000** mm

Vertical distance to centre of gravity gabion 7 — $y_{g7} = h_7 / 2 + h_5 + h_6$ = **2500** mm

Weight of gabion 7 — $W_{g7} = \gamma_d \times w_7 \times h_7$ = **72.0** kN/m

Horizontal distance to centre of gravity gabion 8 — $x_{g8} = w_8 / 2 + s_6 + s_7 + s_8$ = **1500** mm

Vertical distance to centre of gravity gabion 8 — $y_{g8} = h_8 / 2 + h_5 + h_6 + h_7$ = **3500** mm

Weight of gabion 8 — $W_{g8} = \gamma_d \times w_8 \times h_8$ = **54.0** kN/m

Horizontal distance to centre of gravity gabion 9 — $x_{g9} = w_9 / 2 + s_6 + s_7 + s_8 + s_9$ = **1000** mm

Vertical distance to centre of gravity gabion 9 — $y_{g9} = h_9 / 2 + h_5 + h_6 + h_7 + h_8$ = **4500** mm

Weight of gabion 9 — $W_{g9} = \gamma_d \times w_9 \times h_9$ = **36.0** kN/m

Horizontal distance to centre of gravity gabion 10 — $x_{g10} = w_{10} / 2 + s_6 + s_7 + s_8 + s_9 + s_{10}$ = **500** mm

Vertical distance to centre of gravity gabion 10 — $y_{g10} = h_{10} / 2 + h_5 + h_6 + h_7 + h_8 + h_9$ = **5500** mm

Weight of gabion 10 — $W_{g10} = \gamma_d \times w_{10} \times h_{10}$ = **18.0** kN/m

Weight of entire gabion — $W_g = W_{g5} + W_{g6} + W_{g7} + W_{g8} + W_{g9} + W_{g10}$ = **378.0** kN/m

Horiz distance to centre of gravity entire gabion — $x_g = ((W_{g5} \times x_{g5}) + (W_{g6} \times x_{g6}) + (W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g$ = **2167** mm

Vert distance to centre of gravity entire gabion — $y_g = ((W_{g5} \times y_{g5}) + (W_{g6} \times y_{g6}) + (W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g$ = **2167** mm

Correcting for wall inclination horiz dist — $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **2167** mm

Vertical change in height due to wall inclination — $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall — $\alpha = 90\text{deg} - \text{Atan}((w_5 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon$ = **50.2** deg

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

Effective height of wall — $H = (y_{g10} + h_{10} / 2) + (w_5 \times \sin(\varepsilon)) - H_f$ = **6000** mm

Height of wall from toe to front edge of top gabion — $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon))$ = **6000**mm

Active pressure using Coulomb theory — $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2)$ = **0.884**

Active thrust due to soil — $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **302.3** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **159.5** kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **36.4** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **378.0** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **256.7** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **428.3** kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **1931.4** kNm/m

Factor of safety — $FoS_M = M_R / M_o$ = **4.510**

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 — $T = F_{soil\_h} + F_{surch\_h}$ = **195.9** kN/m

Total vertical force — $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **634.7** kN/m

Sliding force — $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **195.9** kN/m

Sliding resistance — $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **355.5** kN/m

Factor of safety — $FoS_S = F_R / F_f$ = **1.815**

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 5 and 6

Wall geometry

Horizontal distance to centre of gravity gabion 6	$x_{g6} = w_6 / 2 = \mathbf{2500}$ mm
Vertical distance to centre of gravity gabion 6	$y_{g6} = h_6 / 2 = \mathbf{500}$ mm
Weight of gabion 6	$W_{g6} = \gamma_d \times w_6 \times h_6 = \mathbf{90.0}$ kN/m
Horizontal distance to centre of gravity gabion 7	$x_{g7} = w_7 / 2 + s_7 = \mathbf{2000}$ mm
Vertical distance to centre of gravity gabion 7	$y_{g7} = h_7 / 2 + h_6 = \mathbf{1500}$ mm
Weight of gabion 7	$W_{g7} = \gamma_d \times w_7 \times h_7 = \mathbf{72.0}$ kN/m
Horizontal distance to centre of gravity gabion 8	$x_{g8} = w_8 / 2 + s_7 + s_8 = \mathbf{1500}$ mm
Vertical distance to centre of gravity gabion 8	$y_{g8} = h_8 / 2 + h_6 + h_7 = \mathbf{2500}$ mm
Weight of gabion 8	$W_{g8} = \gamma_d \times w_8 \times h_8 = \mathbf{54.0}$ kN/m
Horizontal distance to centre of gravity gabion 9	$x_{g9} = w_9 / 2 + s_7 + s_8 + s_9 = \mathbf{1000}$ mm
Vertical distance to centre of gravity gabion 9	$y_{g9} = h_9 / 2 + h_6 + h_7 + h_8 = \mathbf{3500}$ mm
Weight of gabion 9	$W_{g9} = \gamma_d \times w_9 \times h_9 = \mathbf{36.0}$ kN/m
Horizontal distance to centre of gravity gabion 10	$x_{g10} = w_{10} / 2 + s_7 + s_8 + s_9 + s_{10} = \mathbf{500}$ mm
Vertical distance to centre of gravity gabion 10	$y_{g10} = h_{10} / 2 + h_6 + h_7 + h_8 + h_9 = \mathbf{4500}$ mm
Weight of gabion 10	$W_{g10} = \gamma_d \times w_{10} \times h_{10} = \mathbf{18.0}$ kN/m
Weight of entire gabion	$W_g = W_{g6} + W_{g7} + W_{g8} + W_{g9} + W_{g10} = \mathbf{270.0}$ kN/m
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g6} \times x_{g6}) + (W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g = \mathbf{1833}$ mm
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g6} \times y_{g6}) + (W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g = \mathbf{1833}$ mm
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{1833}$ mm
Vertical change in height due to wall inclination	$H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon)) = \mathbf{0}$ mm

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90\text{deg} - \text{Atan}((w_6 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon = \mathbf{51.3}$ deg
Effective face angle	$\theta = 90\text{deg} - \varepsilon = \mathbf{90.0}$ deg
Effective height of wall	$H = (y_{g10} + h_{10} / 2) + (w_6 \times \sin(\varepsilon)) - H_f = \mathbf{5000}$ mm
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon)) = \mathbf{5000}$mm
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{}(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))))^2) = \mathbf{0.856}$
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2 = \mathbf{203.3}$ kN/m

Horizontal forces

Retained soil	$F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d}) = \mathbf{110.7}$ kN/m
Surcharge	$F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d}) = \mathbf{30.3}$ kN/m

Vertical forces

Gabion weight	$F_{gabion\_v,f} = \gamma_{G,f} \times W_g = \mathbf{270.0}$ kN/m
Retained soil	$F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d}) = \mathbf{170.5}$ kN/m
Surcharge	$F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d}) = \mathbf{0.0}$ kN/m

Overturning stability - take moments about the toe

Overturning moment	$M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **260.3** kNm/m
Restoring moment	$M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **1120.0** kNm/m
Factor of safety	$FoS_M = M_R / M_o$ = **4.303**
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	$T = F_{soil\_h} + F_{surch\_h}$ = **141.0** kN/m
Total vertical force	$N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **440.5** kN/m
Sliding force	$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **141.0** kN/m
Sliding resistance	$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **246.7** kN/m
Factor of safety	$FoS_S = F_R / F_f$ = **1.750**
Allowable factor of safety	FoS_{S_allow} = **1.000**

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

<u>Check overturning and sliding between courses 6 and 7</u>

Wall geometry

Horizontal distance to centre of gravity gabion 7	$x_{g7} = w_7 / 2$ = **2000** mm
Vertical distance to centre of gravity gabion 7	$y_{g7} = h_7 / 2$ = **500** mm
Weight of gabion 7	$W_{g7} = \gamma_d \times w_7 \times h_7$ = **72.0** kN/m
Horizontal distance to centre of gravity gabion 8	$x_{g8} = w_8 / 2 + s_8$ = **1500** mm
Vertical distance to centre of gravity gabion 8	$y_{g8} = h_8 / 2 + h_7$ = **1500** mm
Weight of gabion 8	$W_{g8} = \gamma_d \times w_8 \times h_8$ = **54.0** kN/m
Horizontal distance to centre of gravity gabion 9	$x_{g9} = w_9 / 2 + s_8 + s_9$ = **1000** mm
Vertical distance to centre of gravity gabion 9	$y_{g9} = h_9 / 2 + h_7 + h_8$ = **2500** mm
Weight of gabion 9	$W_{g9} = \gamma_d \times w_9 \times h_9$ = **36.0** kN/m
Horizontal distance to centre of gravity gabion 10	$x_{g10} = w_{10} / 2 + s_8 + s_9 + s_{10}$ = **500** mm
Vertical distance to centre of gravity gabion 10	$y_{g10} = h_{10} / 2 + h_7 + h_8 + h_9$ = **3500** mm
Weight of gabion 10	$W_{g10} = \gamma_d \times w_{10} \times h_{10}$ = **18.0** kN/m
Weight of entire gabion	$W_g = W_{g7} + W_{g8} + W_{g9} + W_{g10}$ = **180.0** kN/m
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g7} \times x_{g7}) + (W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g$ = **1500** mm
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g7} \times y_{g7}) + (W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g$ = **1500** mm
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **1500** mm
Vertical change in height due to wall inclination	$H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90deg - Atan((w_7 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon$ = **53.1** deg
Effective face angle	$\theta = 90deg - \varepsilon$ = **90.0** deg
Effective height of wall	$H = (y_{g10} + h_{10} / 2) + (w_7 \times \sin(\varepsilon)) - H_f$ = **4000** mm
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon))$ = **4000**mm
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2)$ = **0.815**
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **123.9** kN/m

Horizontal forces

Retained soil — $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **70.7** kN/m

Surcharge — $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **24.2** kN/m

Vertical forces

Gabion weight — $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **180.0** kN/m

Retained soil — $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **101.7** kN/m

Surcharge — $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment — $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **142.6** kNm/m

Restoring moment — $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **575.2** kNm/m

Factor of safety — $FoS_M = M_R / M_o$ = **4.033**

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 — $T = F_{soil\_h} + F_{surch\_h}$ = **94.9** kN/m

Total vertical force — $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **281.7** kN/m

Sliding force — $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **94.9** kN/m

Sliding resistance — $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **157.8** kN/m

Factor of safety — $FoS_S = F_R / F_f$ = **1.663**

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 7 and 8

Wall geometry

Horizontal distance to centre of gravity gabion 8 — $x_{g8} = w_8 / 2$ = **1500** mm

Vertical distance to centre of gravity gabion 8 — $y_{g8} = h_8 / 2$ = **500** mm

Weight of gabion 8 — $W_{g8} = \gamma_d \times w_8 \times h_8$ = **54.0** kN/m

Horizontal distance to centre of gravity gabion 9 — $x_{g9} = w_9 / 2 + s_9$ = **1000** mm

Vertical distance to centre of gravity gabion 9 — $y_{g9} = h_9 / 2 + h_8$ = **1500** mm

Weight of gabion 9 — $W_{g9} = \gamma_d \times w_9 \times h_9$ = **36.0** kN/m

Horizontal distance to centre of gravity gabion 10 — $x_{g10} = w_{10} / 2 + s_9 + s_{10}$ = **500** mm

Vertical distance to centre of gravity gabion 10 — $y_{g10} = h_{10} / 2 + h_8 + h_9$ = **2500** mm

Weight of gabion 10 — $W_{g10} = \gamma_d \times w_{10} \times h_{10}$ = **18.0** kN/m

Weight of entire gabion — $W_g = W_{g8} + W_{g9} + W_{g10}$ = **108.0** kN/m

Horiz distance to centre of gravity entire gabion — $x_g = ((W_{g8} \times x_{g8}) + (W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g$ = **1167** mm

Vert distance to centre of gravity entire gabion — $y_g = ((W_{g8} \times y_{g8}) + (W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g$ = **1167** mm

Correcting for wall inclination horiz dist — $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **1167** mm

Vertical change in height due to wall inclination — $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall — $\alpha = 90\text{deg} - \text{Atan}((w_8 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon$ = **56.3** deg

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

Effective height of wall $H = (y_{g10} + h_{10} / 2) + (w_8 \times \sin(\varepsilon)) - H_f =$ **3000** mm

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon)) =$ **3000**mm

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{}(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))))^2) =$ **0.750**

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2 =$ **64.1** kN/m

Horizontal forces

Retained soil $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d}) =$ **39.4** kN/m

Surcharge $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d}) =$ **18.0** kN/m

Vertical forces

Gabion weight $F_{gabion\_v,f} = \gamma_{G,f} \times W_g =$ **108.0** kN/m

Retained soil $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d}) =$ **50.5** kN/m

Surcharge $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d}) =$ **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch} =$ **66.4** kNm/m

Restoring moment $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch} =$ **243.9** kNm/m

Factor of safety $FoS_M = M_R / M_o =$ **3.672**

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 $T = F_{soil\_h} + F_{surch\_h} =$ **57.4** kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f} =$ **158.5** kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) =$ **57.4** kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d}) =$ **88.8** kN/m

Factor of safety $FoS_S = F_R / F_f =$ **1.546**

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 8 and 9

Wall geometry

Horizontal distance to centre of gravity gabion 9 $x_{g9} = w_9 / 2 =$ **1000** mm

Vertical distance to centre of gravity gabion 9 $y_{g9} = h_9 / 2 =$ **500** mm

Weight of gabion 9 $W_{g9} = \gamma_d \times w_9 \times h_9 =$ **36.0** kN/m

Horizontal distance to centre of gravity gabion 10 $x_{g10} = w_{10} / 2 + s_{10} =$ **500** mm

Vertical distance to centre of gravity gabion 10 $y_{g10} = h_{10} / 2 + h_9 =$ **1500** mm

Weight of gabion 10 $W_{g10} = \gamma_d \times w_{10} \times h_{10} =$ **18.0** kN/m

Weight of entire gabion $W_g = W_{g9} + W_{g10} =$ **54.0** kN/m

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g9} \times x_{g9}) + (W_{g10} \times x_{g10})) / W_g =$ **833** mm

Vert distance to centre of gravity entire gabion $y_g = ((W_{g9} \times y_{g9}) + (W_{g10} \times y_{g10})) / W_g =$ **833** mm

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) =$ **833** mm

Vertical change in height due to wall inclination $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon)) =$ **0** mm

Design dimensions

Effective angle of rear plane of wall $\alpha = 90\text{deg} - \text{Atan}((w_9 - (x_{g10} + (w_{10} / 2))) / (y_{g10} + h_{10} / 2)) + \varepsilon$ = **63.4** deg

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

Effective height of wall $H = (y_{g10} + h_{10} / 2) + (w_9 \times \sin(\varepsilon)) - H_f$ = **2000** mm

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon))$ = **2000**mm

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta)))})^2)$ = **0.630**

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **23.9** kN/m

Horizontal forces

Retained soil $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **17.0** kN/m

Surcharge $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **11.6** kN/m

Vertical forces

Gabion weight $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **54.0** kN/m

Retained soil $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **16.9** kN/m

Surcharge $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **0.0** kN/m

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **22.9** kNm/m

Restoring moment $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **73.2** kNm/m

Factor of safety $FoS_M = M_R / M_o$ = **3.193**

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 $T = F_{soil\_h} + F_{surch\_h}$ = **28.6** kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **70.9** kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **28.6** kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d})$ = **39.7** kN/m

Factor of safety $FoS_S = F_R / F_f$ = **1.390**

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 9 and 10

Wall geometry

Horizontal distance to centre of gravity gabion 10 $x_{g10} = w_{10} / 2$ = **500** mm

Vertical distance to centre of gravity gabion 10 $y_{g10} = h_{10} / 2$ = **500** mm

Weight of gabion 10 $W_{g10} = \gamma_d \times w_{10} \times h_{10}$ = **18.0** kN/m

Weight of entire gabion $W_g = W_{g10}$ = **18.0** kN/m

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g10} \times x_{g10})) / W_g$ = **500** mm

Vert distance to centre of gravity entire gabion $y_g = ((W_{g10} \times y_{g10})) / W_g$ = **500** mm

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **500** mm

Vertical change in height due to wall inclination $H_f = y_{g10} + h_{10}/2 - ((y_{g10} + h_{10}/2) \times \cos(\varepsilon) - (x_{g10} + w_{10}/2) \times \sin(\varepsilon))$ = **0** mm

Project	GABION WALL DESIGN				Job Ref.	
Section					Sheet no./rev. 32	
Calc. by VIC	Date 8/14/2023	Chk'd by	Date		App'd by	Date

Design dimensions

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

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

Effective height of wall $H = (y_{g10} + h_{10} / 2) + (w_{10} \times \sin(\varepsilon)) - H_f = \mathbf{1000}$ mm

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g10} + h_{10} / 2) \times \cos(\varepsilon) - (x_{g10} - (w_{10} / 2)) \times \sin(\varepsilon)) = \mathbf{1000}$mm

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

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2 = \mathbf{3.4}$ kN/m

Horizontal forces

Retained soil $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d}) = \mathbf{3.3}$ kN/m

Surcharge $F_{surch\_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d}) = \mathbf{4.5}$ kN/m

Vertical forces

Gabion weight $F_{gabion\_v,f} = \gamma_{G,f} \times W_g = \mathbf{18.0}$ kN/m

Retained soil $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d}) = \mathbf{1.1}$ kN/m

Surcharge $F_{surch\_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d}) = \mathbf{0.0}$ kN/m

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch} = \mathbf{3.3}$ kNm/m

Restoring moment $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch} = \mathbf{10.1}$ kNm/m

Factor of safety $FoS_M = M_R / M_o = \mathbf{3.038}$

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 $T = F_{soil\_h} + F_{surch\_h} = \mathbf{7.7}$ kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f} = \mathbf{19.1}$ kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = \mathbf{7.7}$ kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg.d}) = \mathbf{10.7}$ kN/m

Factor of safety $FoS_S = F_R / F_f = \mathbf{1.384}$

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

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