

Structural Calculation

87 Commercial Road

Pontardawe,

Important Note

All Calculation should be checked by Building control officer for Approval.

All measurement to be carried out by the Contractor and agreed by the Engineer Prior ordering the Steel.

Retaining wall Design

Wall retaining height = 3.00m

Surcharge = 5.00KN/m²

From the computer out put

Gabion Wall base should be 2.50m wide and 1.0m high and should be a minimum of 500mm below river bed

Middle row should be 1.5m wide and 1.0m high.

Top step 1.0m wide 1.0m high

See detailed drawing.

Project 87 Commercial Road				Job no.	
Calcs for Gabion Retaining wall 3.0m high				Start page no./Revision 1	
Calcs by	Calcs date 22/12/2020	Checked by	Checked date	Approved by	Approved date

GABION RETAINING WALL ANALYSIS & DESIGN

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

Tedds calculation version 2.0.02

Design summary

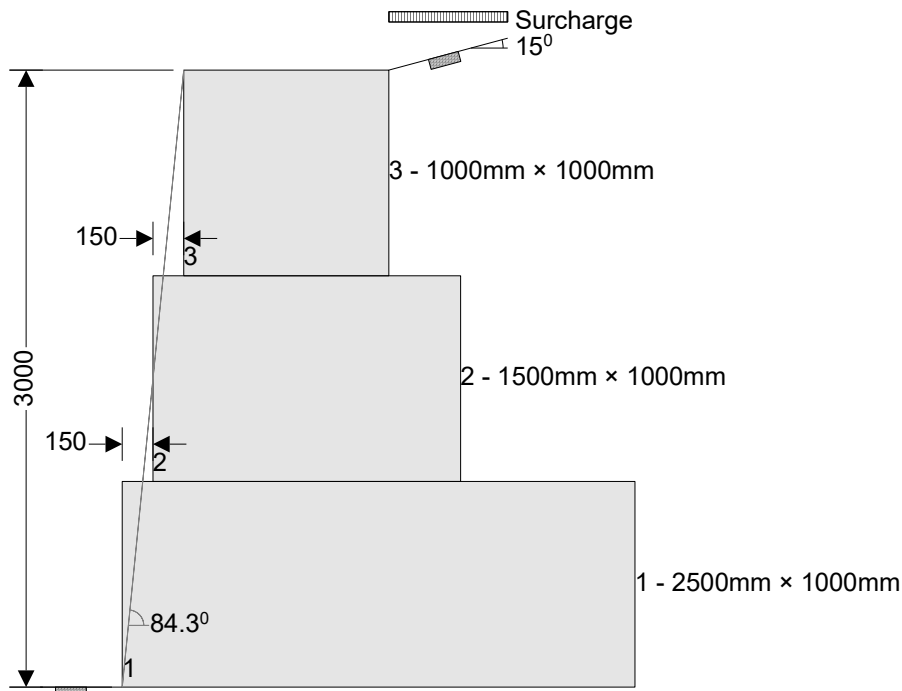
Combination 1

Action	Resistance	Force	FoS	Allowable FoS	Status
Overturning, sliding and bearing at base level					
Overturning (kNm/m)	171.2	63.4	2.699	1.000	PASS
Sliding (kN/m)	70.1	59.0	1.187	1.000	PASS
Bearing (kN/m ²)	100.0	72.5	1.380	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)	42.2	17.2	2.455	1.000	PASS
Sliding (kN/m)	35.0	23.4	1.498	1.000	PASS
Overturning and sliding between courses 2 and 3					
Overturning (kNm/m)	9.4	2.3	4.160	1.000	PASS
Sliding (kN/m)	12.2	5.8	2.111	1.000	PASS

Combination 2

Action	Resistance	Force	FoS	Allowable FoS	Status
Overturning, sliding and bearing at base level					
Overturning (kNm/m)	177.6	61.6	2.884	1.000	PASS
Sliding (kN/m)	57.4	56.7	1.013	1.000	PASS
Bearing (kN/m ²)	100.0	72.5	1.380	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)	43.4	17.3	2.507	1.000	PASS
Sliding (kN/m)	28.5	23.2	1.226	1.000	PASS
Overturning and sliding between courses 2 and 3					
Overturning (kNm/m)	9.5	2.4	3.936	1.000	PASS
Sliding (kN/m)	9.8	6.1	1.615	1.000	PASS

Project				Job no.	
87 Commercial Road					
Calcs for				Start page no./Revision	
Gabion Retaining wall 3.0m high				2	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	22/12/2020				



Wall geometry

Width of gabion 1	$w_1 = 2500$ mm
Height of gabion 1	$h_1 = 1000$ mm
Width of gabion 2	$w_2 = 1500$ mm
Height of gabion 2	$h_2 = 1000$ mm
Step to front face between courses 1 and 2	$s_2 = 150$ mm
Width of gabion 3	$w_3 = 1000$ mm
Height of gabion 3	$h_3 = 1000$ mm
Step to front face between courses 2 and 3	$s_3 = 150$ mm
Wall inclination	$\varepsilon = 0$ deg

Gabion properties

Unit weight of fill	$\gamma_d = 16.0$ kN/m ³
Friction between gabions	$\delta_{bg,k} = 35.0$ deg

Loading

Variable surcharge	$p_{o,Q} = 5$ kN/m ²
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Soil properties

Slope of retained soil	$\beta = 15.0$ deg
Characteristic effective shearing resistance angle	$\phi'_{r,k} = 35.0$ deg
Characteristic saturated density of retained soil	$\gamma_{sr} = 21.0$ kN/m ³
Coefficient for wall friction	$k_{membrane} = 0.75$
Wall friction angle	$\delta_{r,k} = 26.3$ deg
Characteristic base friction angle	$\delta_{bb,k} = 30.0$ deg
Bearing capacity of founding soil	$q = 100$ kN/m ²

Wall geometry

Horizontal distance to centre of gravity gabion 1	$x_{g1} = w_1 / 2 = 1250$ mm
Vertical distance to centre of gravity gabion 1	$y_{g1} = h_1 / 2 = 500$ mm

Project				Job no.	
87 Commercial Road					
Calcs for				Start page no./Revision	
Gabion Retaining wall 3.0m high				3	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	22/12/2020				

Weight of gabion 1	$W_{g1} = \gamma_d * w_1 * h_1 = \mathbf{40.0 \text{ kN/m}}$
Horizontal distance to centre of gravity gabion 2	$x_{g2} = w_2 / 2 + s_2 = \mathbf{900 \text{ mm}}$
Vertical distance to centre of gravity gabion 2	$y_{g2} = h_2 / 2 + h_1 = \mathbf{1500 \text{ mm}}$
Weight of gabion 2	$W_{g2} = \gamma_d * w_2 * h_2 = \mathbf{24.0 \text{ kN/m}}$
Horizontal distance to centre of gravity gabion 3	$x_{g3} = w_3 / 2 + s_2 + s_3 = \mathbf{800 \text{ mm}}$
Vertical distance to centre of gravity gabion 3	$y_{g3} = h_3 / 2 + h_1 + h_2 = \mathbf{2500 \text{ mm}}$
Weight of gabion 3	$W_{g3} = \gamma_d * w_3 * h_3 = \mathbf{16.0 \text{ kN/m}}$
Weight of entire gabion	$W_g = W_{g1} + W_{g2} + W_{g3} = \mathbf{80.0 \text{ kN/m}}$
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g1} * x_{g1}) + (W_{g2} * x_{g2}) + (W_{g3} * x_{g3})) / W_g = \mathbf{1055 \text{ mm}}$
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g1} * y_{g1}) + (W_{g2} * y_{g2}) + (W_{g3} * y_{g3})) / W_g = \mathbf{1200 \text{ mm}}$
Correcting for wall inclination horiz dist	$X_g = x_g * \cos(\epsilon) + y_g * \sin(\epsilon) = \mathbf{1055 \text{ mm}}$
Vertical change in height due to wall inclination	$H_f = y_{g3} + h_3/2 - ((y_{g3} + h_3/2) * \cos(\epsilon) - (x_{g3} + w_3/2) * \sin(\epsilon)) = \mathbf{0 \text{ mm}}$

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90\text{deg} - \text{Atan}((w_1 - (x_{g3} + (w_3 / 2))) / (y_{g3} + h_3 / 2)) + \epsilon = \mathbf{68.2 \text{ deg}}$
Effective face angle	$\theta = \text{Atan}((y_{g3} + (h_3 / 2)) / ((x_{g3} - (w_3 / 2)))) - \epsilon = \mathbf{84.3 \text{ deg}}$
Effective height of wall	$H = (y_{g3} + h_3 / 2) + (w_1 * \sin(\epsilon)) - H_f = \mathbf{3000 \text{ mm}}$
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g3} + h_3 / 2) * \cos(\epsilon) - (x_{g3} - (w_3 / 2)) * \sin(\epsilon)) = \mathbf{3000\text{mm}}$
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r,k})^2 / (\sin(\alpha)^2 * \sin(\alpha - \delta_{r,k}) * (1 + \sqrt{(\sin(\phi'_{r,k} + \delta_{r,k}) * \sin(\phi'_{r,k} - \beta) / (\sin(\alpha - \delta_{r,k}) * \sin(\alpha + \beta))}))^2) = \mathbf{0.588}$
Active thrust due to soil	$P_{a,soil} = 0.5 * K_a * \gamma_{sr} * H^2 = \mathbf{55.6 \text{ kN/m}}$

Pressure at base

Horizontal forces

Retained soil	$F_{soil,h,q} = P_{a,soil} * \cos(90 - \alpha + \delta_{r,k}) = \mathbf{37.2 \text{ kN/m}}$
Height of soil thrust resolved vertically	$d_{h,soil} = H / 3 - w_1 * \sin(\epsilon) = \mathbf{1000 \text{ mm}}$
Surcharge	$F_{surch,h,q} = p_{o,Q} * K_a * H * \cos(90 - \alpha + \delta_{r,k}) = \mathbf{5.9 \text{ kN/m}}$
Height of surcharge thrust resolved vertically	$d_{h,surch} = H / 2 - w_1 * \sin(\epsilon) = \mathbf{1500 \text{ mm}}$

Vertical forces

Gabion weight	$F_{gabion,v,q} = W_g = \mathbf{80.0 \text{ kN/m}}$
Retained soil	$F_{soil,v,q} = P_{a,soil} * \sin(90 - \alpha + \delta_{r,k}) = \mathbf{41.3 \text{ kN/m}}$
Horizontal dist to where soil thrust acts	$b_{v,soil} = w_1 * \cos(\epsilon) - (H / 3) / \tan(\alpha) = \mathbf{2100 \text{ mm}}$
Surcharge	$F_{surch,v,q} = p_{o,Q} * K_a * H * \sin(90 - \alpha + \delta_{r,k}) = \mathbf{6.6 \text{ kN/m}}$
Horizontal dist to where surcharge thrust acts	$b_{v,surch} = w_1 * \cos(\epsilon) - (H / 2) / \tan(\alpha) = \mathbf{1900 \text{ mm}}$
Total horizontal unfactored force	$T_q = F_{soil,h,q} + F_{surch,h,q} = \mathbf{43.1 \text{ kN/m}}$
Total vertical unfactored force	$N_q = F_{gabion,v,q} + F_{soil,v,q} + F_{surch,v,q} = \mathbf{127.9 \text{ kN/m}}$
Force normal to base	$N_s = N_q * \cos(\epsilon) + T_q * \sin(\epsilon) = \mathbf{127.9 \text{ kN/m}}$
Total unfactored overturning force	$M_{o,q} = F_{soil,h,q} * d_{h,soil} + F_{surch,h,q} * d_{h,surch} = \mathbf{46.0 \text{ kNm/m}}$
Total unfactored restoring force	$M_{R,q} = F_{gabion,v,q} * X_g + F_{soil,v,q} * b_{v,soil} + F_{surch,v,q} * b_{v,surch} = \mathbf{183.7 \text{ kNm/m}}$
Eccentricity	$e = w_1 / 2 - (M_{R,q} - M_{o,q}) / N_s = \mathbf{174 \text{ mm}}$

Reaction acts within middle third of base

Pressure at toe	$\sigma_{toe} = N_s / w_1 * (1 + (6 * e / w_1)) = \mathbf{72.5 \text{ kN/m}^2}$
Pressure at heel	$\sigma_{heel} = N_s / w_1 * (1 - (6 * e / w_1)) = \mathbf{29.9 \text{ kN/m}^2}$
Factor of safety	$FoS_Q = q / \max(\sigma_{toe}, \sigma_{heel}) = \mathbf{1.380}$
Allowable factor of safety	$FoS_{Q,allow} = \mathbf{1.000}$

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

Project				Job no.	
87 Commercial Road					
Calcs for				Start page no./Revision	
Gabion Retaining wall 3.0m high				4	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	22/12/2020				

Design approach 1

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

Permanent unfavourable action	$\gamma_G = 1.35$
Permanent favourable action	$\gamma_{G,f} = 1.00$
Variable unfavourable action	$\gamma_Q = 1.50$
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	$\gamma_\gamma = 1.00$

Design soil properties

Design effective shearing resistance angle	$\phi'_{r,d} = \text{Atan}(\tan(\phi'_{r,k}) / \gamma_{\phi'}) = 35.0 \text{ deg}$
Design saturated density of retained soil	$\gamma_{s,d} = \gamma_{sr} / \gamma_\gamma = 21.0 \text{ kN/m}^3$
Design wall friction angle	$\delta_{r,d} = \min(\text{atan}(\tan(\delta_{r,k}) / \gamma_{\phi'}), \phi'_{r,d} * k_{\text{membrane}}) = 26.3 \text{ deg}$
Design base friction angle	$\delta_{bb,d} = \text{Atan}(\tan(\delta_{bb,k}) / \gamma_{\phi'}) = 30.0 \text{ deg}$
Design friction between gabions	$\delta_{bg,d} = \text{Atan}(\tan(\delta_{bg,k}) / \gamma_{\phi'}) = 35.0 \text{ deg}$
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 * \sin(\alpha - \delta_{r,d}) * (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) * \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) * \sin(\alpha + \beta))))^2) = 0.588$
Active thrust due to soil	$P_{a,soil} = 0.5 * K_a * \gamma_{s,d} * H^2 = 55.6 \text{ kN/m}$

Horizontal forces

Retained soil	$F_{soil,h} = \gamma_G * P_{a,soil} * \cos(90 - \alpha + \delta_{r,d}) = 50.2 \text{ kN/m}$
Surcharge	$F_{surch,h} = p_{o,Q} * \gamma_Q * K_a * H * \cos(90 - \alpha + \delta_{r,d}) = 8.8 \text{ kN/m}$

Vertical forces

Gabion weight	$F_{gabion,v,f} = \gamma_{G,f} * W_g = 80.0 \text{ kN/m}$
Retained soil	$F_{soil,v,f} = \gamma_{G,f} * P_{a,soil} * \sin(90 - \alpha + \delta_{r,d}) = 41.3 \text{ kN/m}$
Surcharge	$F_{surch,v,f} = p_{o,Q} * \gamma_{Q,f} * K_a * H * \sin(90 - \alpha + \delta_{r,d}) = 0.0 \text{ kN/m}$

Overturning stability - take moments about the toe

Overturning moment	$M_o = F_{soil,h} * d_{h,soil} + F_{surch,h} * d_{h,surch} = 63.4 \text{ kNm/m}$
Restoring moment	$M_R = F_{gabion,v,f} * X_g + F_{soil,v,f} * b_{v,soil} + F_{surch,v,f} * b_{v,surch} = 171.2 \text{ kNm/m}$
Factor of safety	$FoSM = M_R / M_o = 2.699$
Allowable factor of safety	$FoSM_{allow} = 1.000$

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	$T = F_{soil,h} + F_{surch,h} = 59.0 \text{ kN/m}$
Total vertical force	$N = F_{gabion,v,f} + F_{soil,v,f} + F_{surch,v,f} = 121.3 \text{ kN/m}$
Sliding force	$F_f = T * \cos(\epsilon) - N * \sin(\epsilon) = 59.0 \text{ kN/m}$
Sliding resistance	$F_R = (T * \sin(\epsilon) + N * \cos(\epsilon)) * \tan(\delta_{bb,d}) = 70.1 \text{ kN/m}$
Factor of safety	$FoSS = F_R / F_f = 1.187$
Allowable factor of safety	$FoSS_{allow} = 1.000$

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	$x_{g2} = w_2 / 2 = 750 \text{ mm}$
Vertical distance to centre of gravity gabion 2	$y_{g2} = h_2 / 2 = 500 \text{ mm}$

Project				Job no.	
87 Commercial Road					
Calcs for				Start page no./Revision	
Gabion Retaining wall 3.0m high				5	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	22/12/2020				

Weight of gabion 2	$W_{g2} = \gamma_d * w_2 * h_2 = \mathbf{24.0 \text{ kN/m}}$
Horizontal distance to centre of gravity gabion 3	$x_{g3} = w_3 / 2 + s_3 = \mathbf{650 \text{ mm}}$
Vertical distance to centre of gravity gabion 3	$y_{g3} = h_3 / 2 + h_2 = \mathbf{1500 \text{ mm}}$
Weight of gabion 3	$W_{g3} = \gamma_d * w_3 * h_3 = \mathbf{16.0 \text{ kN/m}}$
Weight of entire gabion	$W_g = W_{g2} + W_{g3} = \mathbf{40.0 \text{ kN/m}}$
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g2} * x_{g2}) + (W_{g3} * x_{g3})) / W_g = \mathbf{710 \text{ mm}}$
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g2} * y_{g2}) + (W_{g3} * y_{g3})) / W_g = \mathbf{900 \text{ mm}}$
Correcting for wall inclination horiz dist	$X_g = x_g * \cos(\epsilon) + y_g * \sin(\epsilon) = \mathbf{710 \text{ mm}}$
Vertical change in height due to wall inclination	$H_f = y_{g3} + h_3/2 - ((y_{g3} + h_3/2) * \cos(\epsilon) - (x_{g3} + w_3/2) * \sin(\epsilon)) = \mathbf{0 \text{ mm}}$
Design dimensions	
Effective angle of rear plane of wall	$\alpha = 90\text{deg} - \text{Atan}((w_2 - (x_{g3} + (w_3 / 2))) / (y_{g3} + h_3 / 2)) + \epsilon = \mathbf{80.1 \text{ deg}}$
Effective face angle	$\theta = \text{Atan}((y_{g3} + (h_3 / 2)) / ((x_{g3} - (w_3 / 2)))) - \epsilon = \mathbf{85.7 \text{ deg}}$
Effective height of wall	$H = (y_{g3} + h_3 / 2) + (w_2 * \sin(\epsilon)) - H_f = \mathbf{2000 \text{ mm}}$
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g3} + h_3 / 2) * \cos(\epsilon) - (x_{g3} - (w_3 / 2)) * \sin(\epsilon)) = \mathbf{2000\text{mm}}$
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 * \sin(\alpha - \delta_{r,d}) * (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) * \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) * \sin(\alpha + \beta))))^2) = \mathbf{0.404}$
Active thrust due to soil	$P_{a,soil} = 0.5 * K_a * \gamma_{s,d} * H^2 = \mathbf{17.0 \text{ kN/m}}$
Horizontal forces	
Retained soil	$F_{soil,h} = \gamma_G * P_{a,soil} * \cos(90 - \alpha + \delta_{r,d}) = \mathbf{18.5 \text{ kN/m}}$
Surcharge	$F_{surch,h} = p_{o,Q} * \gamma_Q * K_a * H * \cos(90 - \alpha + \delta_{r,d}) = \mathbf{4.9 \text{ kN/m}}$
Vertical forces	
Gabion weight	$F_{gabion,v,f} = \gamma_G * W_g = \mathbf{40.0 \text{ kN/m}}$
Retained soil	$F_{soil,v,f} = \gamma_G * P_{a,soil} * \sin(90 - \alpha + \delta_{r,d}) = \mathbf{10.0 \text{ kN/m}}$
Surcharge	$F_{surch,v,f} = p_{o,Q} * \gamma_{Q,f} * K_a * H * \sin(90 - \alpha + \delta_{r,d}) = \mathbf{0.0 \text{ kN/m}}$
Overtuning stability - take moments about the toe	
Overtuning moment	$M_o = F_{soil,h} * d_{h,soil} + F_{surch,h} * d_{h,surch} = \mathbf{17.2 \text{ kNm/m}}$
Restoring moment	$M_R = F_{gabion,v,f} * X_g + F_{soil,v,f} * b_{v,soil} + F_{surch,v,f} * b_{v,surch} = \mathbf{42.2 \text{ kNm/m}}$
Factor of safety	$FoS_M = M_R / M_o = \mathbf{2.455}$
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	$T = F_{soil,h} + F_{surch,h} = \mathbf{23.4 \text{ kN/m}}$
Total vertical force	$N = F_{gabion,v,f} + F_{soil,v,f} + F_{surch,v,f} = \mathbf{50.0 \text{ kN/m}}$
Sliding force	$F_f = T * \cos(\epsilon) - N * \sin(\epsilon) = \mathbf{23.4 \text{ kN/m}}$
Sliding resistance	$F_R = (T * \sin(\epsilon) + N * \cos(\epsilon)) * \tan(\delta_{bg,d}) = \mathbf{35.0 \text{ kN/m}}$
Factor of safety	$FoS_S = F_R / F_f = \mathbf{1.498}$
Allowable factor of safety	$FoS_{S_allow} = \mathbf{1.000}$
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	$x_{g3} = w_3 / 2 = \mathbf{500 \text{ mm}}$
Vertical distance to centre of gravity gabion 3	$y_{g3} = h_3 / 2 = \mathbf{500 \text{ mm}}$
Weight of gabion 3	$W_{g3} = \gamma_d * w_3 * h_3 = \mathbf{16.0 \text{ kN/m}}$
Weight of entire gabion	$W_g = W_{g3} = \mathbf{16.0 \text{ kN/m}}$

Project				Job no.	
87 Commercial Road					
Calcs for				Start page no./Revision	
Gabion Retaining wall 3.0m high				6	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	22/12/2020				

Horiz distance to centre of gravity entire gabion	$X_g = ((W_{g3} * X_{g3})) / W_g = 500 \text{ mm}$
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g3} * y_{g3})) / W_g = 500 \text{ mm}$
Correcting for wall inclination horiz dist	$X_g = X_{g3} * \cos(\epsilon) + y_g * \sin(\epsilon) = 500 \text{ mm}$
Vertical change in height due to wall inclination	$H_f = y_{g3} + h_3/2 - ((y_{g3} + h_3/2) * \cos(\epsilon) - (X_{g3} + w_3/2) * \sin(\epsilon)) = 0 \text{ mm}$
Design dimensions	
Effective angle of rear plane of wall	$\alpha = 90 \text{ deg} + \epsilon = 90.0 \text{ deg}$
Effective face angle	$\theta = 90 \text{ deg} - \epsilon = 90.0 \text{ deg}$
Effective height of wall	$H = (y_{g3} + h_3 / 2) + (w_3 * \sin(\epsilon)) - H_f = 1000 \text{ mm}$
Height of wall from toe to front edge of top gabion	$H_{inci} = ((y_{g3} + h_3 / 2) * \cos(\epsilon) - (X_{g3} - (w_3 / 2)) * \sin(\epsilon)) = 1000 \text{ mm}$
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 * \sin(\alpha - \delta_{r,d}) * (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) * \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) * \sin(\alpha + \beta))}))^2 = 0.297$
Active thrust due to soil	$P_{a,soil} = 0.5 * K_a * \gamma_{s,d} * H^2 = 3.1 \text{ kN/m}$
Horizontal forces	
Retained soil	$F_{soil_h} = \gamma_G * P_{a,soil} * \cos(90 - \alpha + \delta_{r,d}) = 3.8 \text{ kN/m}$
Surcharge	$F_{surch_h} = p_{o,Q} * \gamma_Q * K_a * H * \cos(90 - \alpha + \delta_{r,d}) = 2.0 \text{ kN/m}$
Vertical forces	
Gabion weight	$F_{gabion_v,f} = \gamma_{G,f} * W_g = 16.0 \text{ kN/m}$
Retained soil	$F_{soil_v,f} = \gamma_{G,f} * P_{a,soil} * \sin(90 - \alpha + \delta_{r,d}) = 1.4 \text{ kN/m}$
Surcharge	$F_{surch_v,f} = p_{o,Q} * \gamma_{Q,f} * K_a * H * \sin(90 - \alpha + \delta_{r,d}) = 0.0 \text{ kN/m}$
Overtuning stability - take moments about the toe	
Overtuning moment	$M_o = F_{soil_h} * d_{h,soil} + F_{surch_h} * d_{h,surch} = 2.3 \text{ kNm/m}$
Restoring moment	$M_R = F_{gabion_v,f} * X_g + F_{soil_v,f} * b_{v,soil} + F_{surch_v,f} * b_{v,surch} = 9.4 \text{ kNm/m}$
Factor of safety	$FoSM = M_R / M_o = 4.160$
Allowable factor of safety	$FoSM_{allow} = 1.000$

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

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

Total horizontal force	$T = F_{soil_h} + F_{surch_h} = 5.8 \text{ kN/m}$
Total vertical force	$N = F_{gabion_v,f} + F_{soil_v,f} + F_{surch_v,f} = 17.4 \text{ kN/m}$
Sliding force	$F_f = T * \cos(\epsilon) - N * \sin(\epsilon) = 5.8 \text{ kN/m}$
Sliding resistance	$F_R = (T * \sin(\epsilon) + N * \cos(\epsilon)) * \tan(\delta_{bg,d}) = 12.2 \text{ kN/m}$
Factor of safety	$FoS_S = F_R / F_f = 2.111$
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	$\gamma_{\gamma} = 1.00$

Design soil properties

Design effective shearing resistance angle	$\phi'_{r,d} = \text{Atan}(\tan(\phi'_{r,k}) / \gamma_{\phi'}) = 29.3 \text{ deg}$
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Project				Job no.	
87 Commercial Road					
Calcs for				Start page no./Revision	
Gabion Retaining wall 3.0m high				7	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	22/12/2020				

Design saturated density of retained soil

$$\gamma_{s,d} = \gamma_{sr} / \gamma_f = \mathbf{21.0 \text{ kN/m}^3}$$

Design wall friction angle

$$\delta_{r,d} = \min(\text{atan}(\tan(\delta_{r,k}) / \gamma_\psi), \phi'_{r,d} * K_{\text{membrane}}) = \mathbf{21.5 \text{ deg}}$$

Design base friction angle

$$\delta_{bb,d} = \text{Atan}(\tan(\delta_{bb,k}) / \gamma_\psi) = \mathbf{24.8 \text{ deg}}$$

Design friction between gabions

$$\delta_{bg,d} = \text{Atan}(\tan(\delta_{bg,k}) / \gamma_\psi) = \mathbf{29.3 \text{ deg}}$$

Wall geometry

Horizontal distance to centre of gravity gabion 1

$$x_{g1} = w_1 / 2 = \mathbf{1250 \text{ mm}}$$

Vertical distance to centre of gravity gabion 1

$$y_{g1} = h_1 / 2 = \mathbf{500 \text{ mm}}$$

Weight of gabion 1

$$W_{g1} = \gamma_d * w_1 * h_1 = \mathbf{40.0 \text{ kN/m}}$$

Horizontal distance to centre of gravity gabion 2

$$x_{g2} = w_2 / 2 + s_2 = \mathbf{900 \text{ mm}}$$

Vertical distance to centre of gravity gabion 2

$$y_{g2} = h_2 / 2 + h_1 = \mathbf{1500 \text{ mm}}$$

Weight of gabion 2

$$W_{g2} = \gamma_d * w_2 * h_2 = \mathbf{24.0 \text{ kN/m}}$$

Horizontal distance to centre of gravity gabion 3

$$x_{g3} = w_3 / 2 + s_2 + s_3 = \mathbf{800 \text{ mm}}$$

Vertical distance to centre of gravity gabion 3

$$y_{g3} = h_3 / 2 + h_1 + h_2 = \mathbf{2500 \text{ mm}}$$

Weight of gabion 3

$$W_{g3} = \gamma_d * w_3 * h_3 = \mathbf{16.0 \text{ kN/m}}$$

Weight of entire gabion

$$W_g = W_{g1} + W_{g2} + W_{g3} = \mathbf{80.0 \text{ kN/m}}$$

Horiz distance to centre of gravity entire gabion

$$x_g = ((W_{g1} * x_{g1}) + (W_{g2} * x_{g2}) + (W_{g3} * x_{g3})) / W_g = \mathbf{1055 \text{ mm}}$$

Vert distance to centre of gravity entire gabion

$$y_g = ((W_{g1} * y_{g1}) + (W_{g2} * y_{g2}) + (W_{g3} * y_{g3})) / W_g = \mathbf{1200 \text{ mm}}$$

Correcting for wall inclination horiz dist

$$X_g = x_g * \cos(\epsilon) + y_g * \sin(\epsilon) = \mathbf{1055 \text{ mm}}$$

Vertical change in height due to wall inclination

$$H_f = y_{g3} + h_3/2 - ((y_{g3} + h_3/2) * \cos(\epsilon) - (x_{g3} + w_3/2) * \sin(\epsilon)) = \mathbf{0 \text{ mm}}$$

Design dimensions

Effective angle of rear plane of wall

$$\alpha = 90\text{deg} - \text{Atan}((w_1 - (x_{g3} + (w_3 / 2))) / (y_{g3} + h_3 / 2)) + \epsilon = \mathbf{68.2 \text{ deg}}$$

Effective face angle

$$\theta = \text{Atan}((y_{g3} + (h_3 / 2)) / ((x_{g3} - (w_3 / 2)))) - \epsilon = \mathbf{84.3 \text{ deg}}$$

Effective height of wall

$$H = (y_{g3} + h_3 / 2) + (w_1 * \sin(\epsilon)) - H_f = \mathbf{3000 \text{ mm}}$$

Height of wall from toe to front edge of top gabion

$$H_{\text{incl}} = ((y_{g3} + h_3 / 2) * \cos(\epsilon) - (x_{g3} - (w_3 / 2)) * \sin(\epsilon)) = \mathbf{3000 \text{ mm}}$$

Active pressure using Coulomb theory

$$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 * \sin(\alpha - \delta_{r,d}) * (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) * \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) * \sin(\alpha + \beta))))^2) = \mathbf{0.684}$$

Active thrust due to soil

$$P_{a,\text{soil}} = 0.5 * K_a * \gamma_{s,d} * H^2 = \mathbf{64.6 \text{ kN/m}}$$

Horizontal forces

Retained soil

$$F_{\text{soil}_h} = \gamma_G * P_{a,\text{soil}} * \cos(90 - \alpha + \delta_{r,d}) = \mathbf{47.0 \text{ kN/m}}$$

Surcharge

$$F_{\text{surch}_h} = p_{o,Q} * \gamma_Q * K_a * H * \cos(90 - \alpha + \delta_{r,d}) = \mathbf{9.7 \text{ kN/m}}$$

Vertical forces

Gabion weight

$$F_{\text{gabion}_v,f} = \gamma_{G,f} * W_g = \mathbf{80.0 \text{ kN/m}}$$

Retained soil

$$F_{\text{soil}_v,f} = \gamma_{G,f} * P_{a,\text{soil}} * \sin(90 - \alpha + \delta_{r,d}) = \mathbf{44.4 \text{ kN/m}}$$

Surcharge

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

Overturning stability - take moments about the toe

Overturning moment

$$M_o = F_{\text{soil}_h} * d_{h,\text{soil}} + F_{\text{surch}_h} * d_{h,\text{surch}} = \mathbf{61.6 \text{ kNm/m}}$$

Restoring moment

$$M_R = F_{\text{gabion}_v,f} * X_g + F_{\text{soil}_v,f} * b_{v,\text{soil}} + F_{\text{surch}_v,f} * b_{v,\text{surch}} = \mathbf{177.6 \text{ kNm/m}}$$

Factor of safety

$$FoS_M = M_R / M_o = \mathbf{2.884}$$

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

$$T = F_{\text{soil}_h} + F_{\text{surch}_h} = \mathbf{56.7 \text{ kN/m}}$$

Total vertical force

$$N = F_{\text{gabion}_v,f} + F_{\text{soil}_v,f} + F_{\text{surch}_v,f} = \mathbf{124.4 \text{ kN/m}}$$

Sliding force

$$F_f = T * \cos(\epsilon) - N * \sin(\epsilon) = \mathbf{56.7 \text{ kN/m}}$$

Project				Job no.	
87 Commercial Road					
Calcs for				Start page no./Revision	
Gabion Retaining wall 3.0m high				8	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	22/12/2020				

Sliding resistance $F_R = (T * \sin(\epsilon) + N * \cos(\epsilon)) * \tan(\delta_{bb,d}) = 57.4 \text{ kN/m}$

Factor of safety $FoS_S = F_R / F_f = 1.013$

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 $x_{g2} = w_2 / 2 = 750 \text{ mm}$

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

Weight of gabion 2 $W_{g2} = \gamma_d * w_2 * h_2 = 24.0 \text{ kN/m}$

Horizontal distance to centre of gravity gabion 3 $x_{g3} = w_3 / 2 + s_3 = 650 \text{ mm}$

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

Weight of gabion 3 $W_{g3} = \gamma_d * w_3 * h_3 = 16.0 \text{ kN/m}$

Weight of entire gabion $W_g = W_{g2} + W_{g3} = 40.0 \text{ kN/m}$

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g2} * x_{g2}) + (W_{g3} * x_{g3})) / W_g = 710 \text{ mm}$

Vert distance to centre of gravity entire gabion $y_g = ((W_{g2} * y_{g2}) + (W_{g3} * y_{g3})) / W_g = 900 \text{ mm}$

Correcting for wall inclination horiz dist $X_g = x_g * \cos(\epsilon) + y_g * \sin(\epsilon) = 710 \text{ mm}$

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

Design dimensions

Effective angle of rear plane of wall $\alpha = 90\text{deg} - \text{Atan}((w_2 - (x_{g3} + (w_3 / 2))) / (y_{g3} + h_3 / 2)) + \epsilon = 80.1 \text{ deg}$

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

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

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

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 * \sin(\alpha - \delta_{r,d}) * (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) * \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) * \sin(\alpha + \beta))}))^2 = 0.495$

Active thrust due to soil $P_{a,soil} = 0.5 * K_a * \gamma_{s,d} * H^2 = 20.8 \text{ kN/m}$

Horizontal forces

Retained soil $F_{soil,h} = \gamma_G * P_{a,soil} * \cos(90 - \alpha + \delta_{r,d}) = 17.7 \text{ kN/m}$

Surcharge $F_{surch,h} = p_{o,Q} * \gamma_Q * K_a * H * \cos(90 - \alpha + \delta_{r,d}) = 5.5 \text{ kN/m}$

Vertical forces

Gabion weight $F_{gabion,v,f} = \gamma_{G,f} * W_g = 40.0 \text{ kN/m}$

Retained soil $F_{soil,v,f} = \gamma_{G,f} * P_{a,soil} * \sin(90 - \alpha + \delta_{r,d}) = 10.9 \text{ kN/m}$

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

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil,h} * d_{h,soil} + F_{surch,h} * d_{h,surch} = 17.3 \text{ kNm/m}$

Restoring moment $M_R = F_{gabion,v,f} * X_g + F_{soil,v,f} * b_{v,soil} + F_{surch,v,f} * b_{v,surch} = 43.4 \text{ kNm/m}$

Factor of safety $FoS_M = M_R / M_o = 2.507$

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 $T = F_{soil,h} + F_{surch,h} = 23.2 \text{ kN/m}$

Total vertical force $N = F_{gabion,v,f} + F_{soil,v,f} + F_{surch,v,f} = 50.9 \text{ kN/m}$

Sliding force $F_f = T * \cos(\epsilon) - N * \sin(\epsilon) = 23.2 \text{ kN/m}$

Sliding resistance $F_R = (T * \sin(\epsilon) + N * \cos(\epsilon)) * \tan(\delta_{bg,d}) = 28.5 \text{ kN/m}$

Factor of safety $FoS_S = F_R / F_f = 1.226$

Project				Job no.	
87 Commercial Road					
Calcs for				Start page no./Revision	
Gabion Retaining wall 3.0m high				9	
Calcs by	Calcs date	Checked by	Checked date	Approved by	Approved date
	22/12/2020				

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

$$x_{g3} = w_3 / 2 = 500 \text{ mm}$$

Vertical distance to centre of gravity gabion 3

$$y_{g3} = h_3 / 2 = 500 \text{ mm}$$

Weight of gabion 3

$$W_{g3} = \gamma_d * w_3 * h_3 = 16.0 \text{ kN/m}$$

Weight of entire gabion

$$W_g = W_{g3} = 16.0 \text{ kN/m}$$

Horiz distance to centre of gravity entire gabion

$$x_g = ((W_{g3} * x_{g3})) / W_g = 500 \text{ mm}$$

Vert distance to centre of gravity entire gabion

$$y_g = ((W_{g3} * y_{g3})) / W_g = 500 \text{ mm}$$

Correcting for wall inclination horiz dist

$$X_g = x_g * \cos(\epsilon) + y_g * \sin(\epsilon) = 500 \text{ mm}$$

Vertical change in height due to wall inclination

$$H_f = y_{g3} + h_3/2 - ((y_{g3} + h_3/2) * \cos(\epsilon) - (x_{g3} + w_3/2) * \sin(\epsilon)) = 0 \text{ mm}$$

Design dimensions

Effective angle of rear plane of wall

$$\alpha = 90 \text{ deg} + \epsilon = 90.0 \text{ deg}$$

Effective face angle

$$\theta = 90 \text{ deg} - \epsilon = 90.0 \text{ deg}$$

Effective height of wall

$$H = (y_{g3} + h_3 / 2) + (w_3 * \sin(\epsilon)) - H_f = 1000 \text{ mm}$$

Height of wall from toe to front edge of top gabion

$$H_{incl} = ((y_{g3} + h_3 / 2) * \cos(\epsilon) - (x_{g3} - (w_3 / 2)) * \sin(\epsilon)) = 1000 \text{ mm}$$

Active pressure using Coulomb theory

$$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 * \sin(\alpha - \delta_{r,d}) * (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) * \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) * \sin(\alpha + \beta))}))^2) = 0.383$$

Active thrust due to soil

$$P_{a,soil} = 0.5 * K_a * \gamma_{s,d} * H^2 = 4.0 \text{ kN/m}$$

Horizontal forces

Retained soil

$$F_{soil_h} = \gamma_G * P_{a,soil} * \cos(90 - \alpha + \delta_{r,d}) = 3.7 \text{ kN/m}$$

Surcharge

$$F_{surch_h} = p_{o,Q} * \gamma_Q * K_a * H * \cos(90 - \alpha + \delta_{r,d}) = 2.3 \text{ kN/m}$$

Vertical forces

Gabion weight

$$F_{gabion_v,f} = \gamma_{G,f} * W_g = 16.0 \text{ kN/m}$$

Retained soil

$$F_{soil_v,f} = \gamma_{G,f} * P_{a,soil} * \sin(90 - \alpha + \delta_{r,d}) = 1.5 \text{ kN/m}$$

Surcharge

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

Overturning stability - take moments about the toe

Overturning moment

$$M_o = F_{soil_h} * d_{h,soil} + F_{surch_h} * d_{h,surch} = 2.4 \text{ kNm/m}$$

Restoring moment

$$M_R = F_{gabion_v,f} * X_g + F_{soil_v,f} * b_{v,soil} + F_{surch_v,f} * b_{v,surch} = 9.5 \text{ kNm/m}$$

Factor of safety

$$FoS_M = M_R / M_o = 3.936$$

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

$$T = F_{soil_h} + F_{surch_h} = 6.1 \text{ kN/m}$$

Total vertical force

$$N = F_{gabion_v,f} + F_{soil_v,f} + F_{surch_v,f} = 17.5 \text{ kN/m}$$

Sliding force

$$F_f = T * \cos(\epsilon) - N * \sin(\epsilon) = 6.1 \text{ kN/m}$$

Sliding resistance

$$F_R = (T * \sin(\epsilon) + N * \cos(\epsilon)) * \tan(\delta_{bg,d}) = 9.8 \text{ kN/m}$$

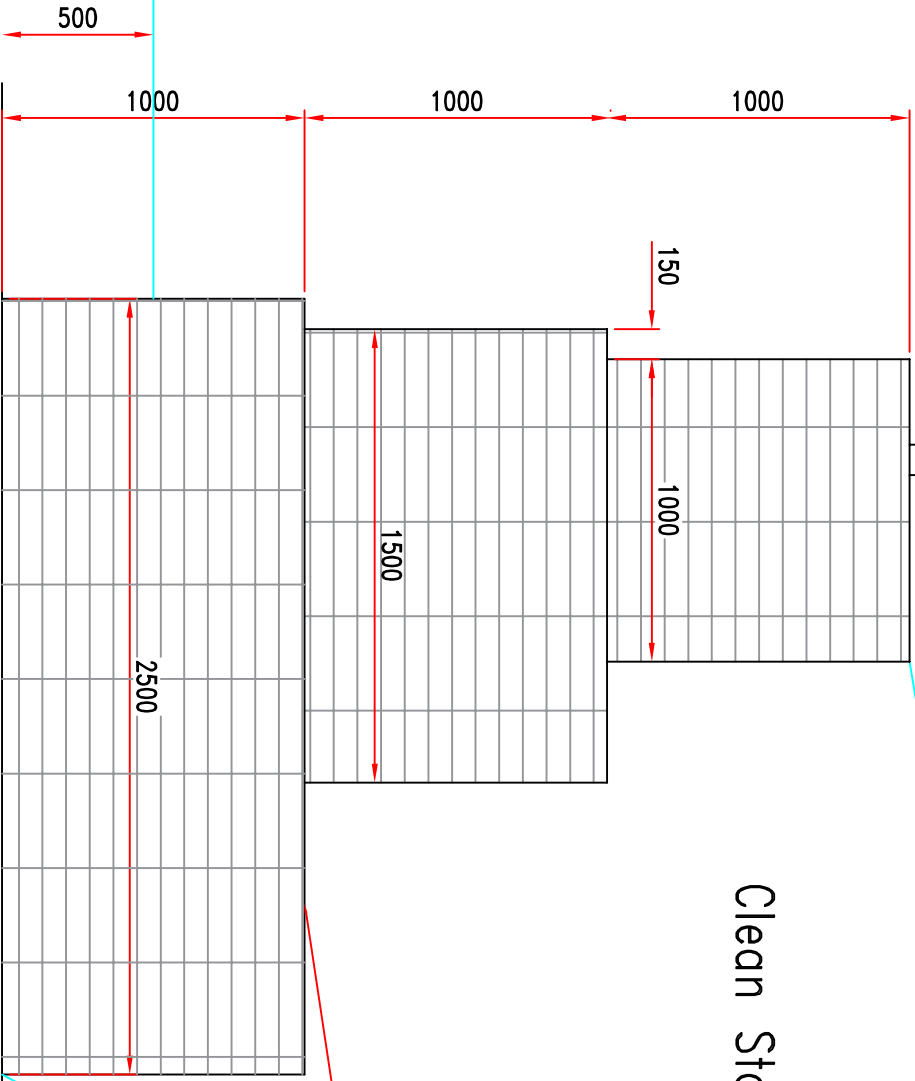
Factor of safety

$$FoS_S = F_R / F_f = 1.615$$

Allowable factor of safety

$$FoS_{S_allow} = 1.000$$

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



RETAINING WALL

3.0m High

N.T.S

Clean Stone

River Bec

500

100

100

100

1

—100

1500

250

PROPOSED GABION BASKETS:

RETAINING WALL

N.T.S.