

Project 4 Brynsiriol, Tonmawr Rd,				Job no. 23-085	
Calcs for Gabion Wall to Driveway				Start page no./Revision 1	
Calcs by JD	Calcs date 14/09/2023	Checked by	Checked date	Approved by	Approved date



INTRODUCTION

Solutions to Structures Ltd have been instructed to verify the design of the single gabion wall supporting the drive at the above property.

The wall follows the line of the previous garden wall and utilises the original foundation as a level base to seat the gabion,

The existing concrete race and backing to the footway back edging remain insitu with the parking bay brought to footway level with granular fill to a plastic geogrid ensuring the stability of the footway.

This also provides a porous surfacing and wall construction where rainwater can soakaway as per the previous garden.

As a domestic driveway for cars or similar light vehicles the retaining wall has been designed for a surcharge of 5kN /m²

The top of the gabion is not yet completed and filling needs to be completed and the top of the basket tied.

GABION RETAINING WALL ANALYSIS & DESIGN

In accordance with BS8002:2015 - Code of Practice for Earth Retaining Structures and the UK National Annex

Tedds calculation version 2.0.02

Design summary

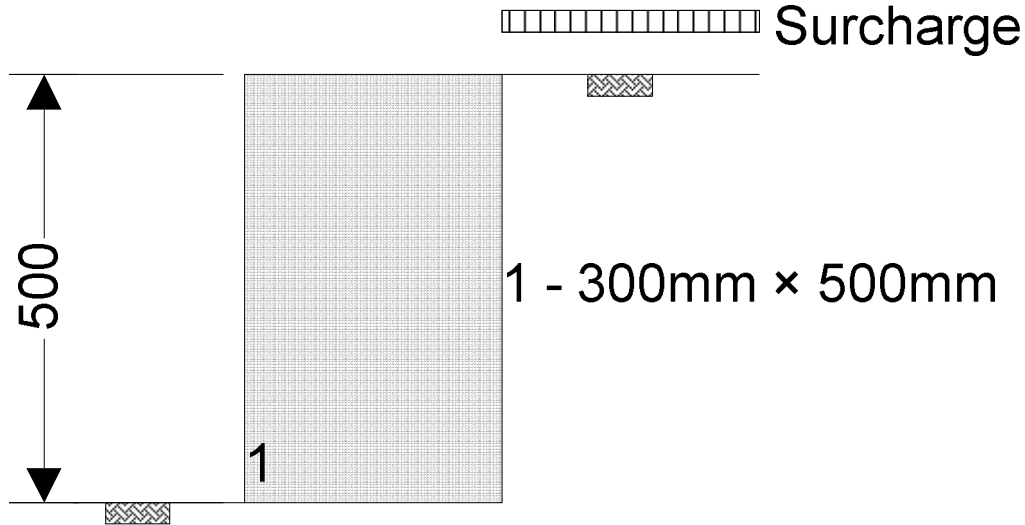
Combination 1

Action	Resistance	Force	FoS	Allowable FoS	Status
Overturning, sliding and bearing at base level					
Overturning (kNm/m)	0.5	0.3	1.645	1.000	PASS
Sliding (kN/m)	2.2	1.5	1.516	1.000	PASS
Bearing (kN/m ²)	100.0	19.8	5.051	1.000	PASS
Eccentricity (mm)	Reaction acts within the middle third of base				PASS

Combination 2

Action	Resistance	Force	FoS	Allowable FoS	Status
Overturning, sliding and bearing at base level					
Overturning (kNm/m)	0.5	0.3	1.554	1.000	PASS
Sliding (kN/m)	1.8	1.5	1.158	1.000	PASS
Bearing (kN/m ²)	100.0	19.8	5.051	1.000	PASS
Eccentricity (mm)	Reaction acts within the middle third of base				PASS

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Wall geometry

Width of gabion 1;
Height of gabion 1;
Wall inclination;

$w_1 = 300$ mm
 $h_1 = 500$ mm
 $\epsilon = 0$ deg

Gabion properties

Unit weight of fill;
Friction between gabions;

$\gamma_d = 18.0$ kN/m³
 $\delta_{bg,k} = 35.0$ deg

Loading

Variable surcharge;

$p_{o,Q} = 5$ kN/m²

Soil properties

Slope of retained soil;
Characteristic peak shearing resistance angle;
Characteristic saturated density of retained soil;
Coefficient for wall friction;
Wall friction angle;
Characteristic base friction angle;
Bearing capacity of founding soil;

$\beta = 0.0$ deg
 $\phi'_{pk,k} = 36.0$ deg
 $\gamma_{sr} = 19.0$ kN/m³
 $k_{membrane} = 0.75$
 $\delta_{r,k} = 27.0$ deg
 $\delta_{bb,k} = 36.0$ deg
 $q = 100$ kN/m²

Wall geometry

Horizontal distance to centre of gravity gabion 1;
Vertical distance to centre of gravity gabion 1;
Weight of gabion 1;
Weight of entire gabion;
Horiz distance to centre of gravity entire gabion;
Vert distance to centre of gravity entire gabion;
Correcting for wall inclination horiz dist;
Vertical change in height due to wall inclination;

$x_{g1} = w_1 / 2 = 150$ mm
 $y_{g1} = h_1 / 2 = 250$ mm
 $W_{g1} = \gamma_d \times w_1 \times h_1 = 2.7$ kN/m
 $W_g = W_{g1} = 2.7$ kN/m
 $x_g = ((W_{g1} \times x_{g1})) / W_g = 150$ mm
 $y_g = ((W_{g1} \times y_{g1})) / W_g = 250$ mm
 $X_g = x_g \times \cos(\epsilon) + y_g \times \sin(\epsilon) = 150$ mm
 $H_f = y_{g1} + h_1/2 - ((y_{g1} + h_1/2) \times \cos(\epsilon) - (x_{g1} + w_1/2) \times \sin(\epsilon)) = 0$ mm

Design dimensions

Effective angle of rear plane of wall;
Effective face angle;
Effective height of wall;

$\alpha = 90$ deg + $\epsilon = 90.0$ deg
 $\theta = 90$ deg - $\epsilon = 90.0$ deg
 $H = (y_{g1} + h_1 / 2) + (w_1 \times \sin(\epsilon)) - H_f = 500$ mm

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Height of wall from toe to front edge of top gabion;	$H_{incl} = ((y_{g1} + h_1 / 2) \times \cos(\epsilon) - (x_{g1} - (w_1 / 2)) \times \sin(\epsilon)) = 500 \text{ mm}$
Active pressure using Coulomb theory;	$K_a = \sin(\alpha + \phi'_{r,k})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,k}) \times (1 + \sqrt{(\sin(\phi'_{r,k} + \delta_{r,k}) \times \sin(\phi'_{r,k} - \beta) / (\sin(\alpha - \delta_{r,k}) \times \sin(\alpha + \beta)))^2}) = 0.235$
Active thrust due to soil;	$P_{a,soil} = 0.5 \times K_a \times \gamma_{sr} \times H^2 = 0.6 \text{ kN/m}$
Minimum surcharge (cl.4.6.3.2);	$p_{o,min} = \min(H / H_{ref}, 1) \times q_{d,min} = 1.7 \text{ kN/m}^2$
Pressure at base	
Horizontal forces	
Retained soil;	$F_{soil_h,q} = P_{a,soil} \times \cos(90 - \alpha + \delta_{r,k}) = 0.5 \text{ kN/m}$
Height of soil thrust resolved vertically;	$d_{h,soil} = H / 3 - w_1 \times \sin(\epsilon) = 167 \text{ mm}$
Surcharge;	$F_{surch_h,q} = \max(p_{o,Q}, p_{o,min}) \times K_a \times H \times \cos(90 - \alpha + \delta_{r,k}) = 0.5 \text{ kN/m}$
Height of surcharge thrust resolved vertically;	$d_{h,surch} = H / 2 - w_1 \times \sin(\epsilon) = 250 \text{ mm}$
Vertical forces	
Gabion weight;	$F_{gabion_v,q} = W_g = 2.7 \text{ kN/m}$
Retained soil;	$F_{soil_v,q} = P_{a,soil} \times \sin(90 - \alpha + \delta_{r,k}) = 0.3 \text{ kN/m}$
Horizontal dist to where soil thrust acts;	$b_{v,soil} = w_1 \times \cos(\epsilon) - (H / 3) / \tan(\alpha) = 300 \text{ mm}$
Surcharge;	$F_{surch_v,q} = \max(p_{o,Q}, p_{o,min}) \times K_a \times H \times \sin(90 - \alpha + \delta_{r,k}) = 0.3 \text{ kN/m}$
Horizontal dist to where surcharge thrust acts;	$b_{v,surch} = w_1 \times \cos(\epsilon) - (H / 2) / \tan(\alpha) = 300 \text{ mm}$
Total horizontal unfactored force;	$T_q = F_{soil_h,q} + F_{surch_h,q} = 1.0 \text{ kN/m}$
Total vertical unfactored force;	$N_q = F_{gabion_v,q} + F_{soil_v,q} + F_{surch_v,q} = 3.2 \text{ kN/m}$
Force normal to base;	$N_s = N_q \times \cos(\epsilon) + T_q \times \sin(\epsilon) = 3.2 \text{ kN/m}$
Total unfactored overturning force;	$M_{o,q} = F_{soil_h,q} \times d_{h,soil} + F_{surch_h,q} \times d_{h,surch} = 0.2 \text{ kNm/m}$
Total unfactored restoring force;	$M_{R,q} = F_{gabion_v,q} \times X_g + F_{soil_v,q} \times b_{v,soil} + F_{surch_v,q} \times b_{v,surch} = 0.6 \text{ kNm/m}$
Eccentricity;	$e = w_1 / 2 - (M_{R,q} - M_{o,q}) / N_s = 42 \text{ mm}$
Reaction acts within middle third of base	
Pressure at toe;	$\sigma_{toe} = N_s / w_1 \times (1 + (6 \times e / w_1)) = 19.8 \text{ kN/m}^2$
Pressure at heel;	$\sigma_{heel} = N_s / w_1 \times (1 - (6 \times e / w_1)) = 1.7 \text{ kN/m}^2$
Factor of safety;	$FoS_Q = q / \max(\sigma_{toe}, \sigma_{heel}) = 5.051$
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;	$\gamma_G = 1.35$
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;	$\gamma_Y = 1.00$

Design soil properties

Design effective shearing resistance angle;	$\phi'_{r,d} = \text{Atan}(\tan(\phi'_{pk,k}) / \gamma_{\phi'}) = 36.0 \text{ deg}$
Design saturated density of retained soil;	$\gamma_{s,d} = \gamma_{sr} / \gamma_Y = 19.0 \text{ kN/m}^3$
Design wall friction angle (cl.5.4.2.1);	$\delta_{r,d} = \min(\text{atan}(\tan(\delta_{r,k}) / \gamma_{\phi'}), \phi'_{r,d} \times k_{\text{membrane}}) = 27.0 \text{ deg}$
Design base friction angle;	$\delta_{bb,d} = \text{Atan}(\tan(\delta_{bb,k}) / \gamma_{\phi'}) = 36.0 \text{ deg}$
Design friction between gabions;	$\delta_{bg,d} = \text{Atan}(\tan(\delta_{bg,k}) / \gamma_{\phi'}) = 35.0 \text{ deg}$

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Active pressure using Coulomb theory;

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

Active thrust due to soil;

$$P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = \mathbf{0.6 \text{ kN/m}}$$

Minimum surcharge (cl.4.6.3.2);

$$p_{o,min} = \min(H / H_{ref}, 1) \times q_{d,min} = \mathbf{1.7 \text{ kN/m}^2}$$

Horizontal forces

Retained soil;

$$F_{soil_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{0.7 \text{ kN/m}}$$

Surcharge;

$$F_{surch_h} = \max(p_{o,Q} \times \gamma_Q, p_{o,min}) \times K_a \times H \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{0.8 \text{ kN/m}}$$

Vertical forces

Gabion weight;

$$F_{gabion_v,f} = \gamma_{G,f} \times W_g = \mathbf{2.7 \text{ kN/m}}$$

Retained soil;

$$F_{soil_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{0.3 \text{ kN/m}}$$

Surcharge;

$$F_{surch_v,f} = \max(p_{o,Q} \times \gamma_{Q,f}, p_{o,min}) \times K_a \times H \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{0.1 \text{ kN/m}}$$

Overtuning stability - take moments about the toe

Overtuning moment;

$$M_o = F_{soil_h} \times d_{h,soil} + F_{surch_h} \times d_{h,surch} = \mathbf{0.3 \text{ kNm/m}}$$

Restoring moment;

$$M_R = F_{gabion_v,f} \times X_g + F_{soil_v,f} \times b_{v,soil} + F_{surch_v,f} \times b_{v,surch} = \mathbf{0.5 \text{ kNm/m}}$$

Factor of safety;

$$FoS_M = M_R / M_o = \mathbf{1.645}$$

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;

$$T = F_{soil_h} + F_{surch_h} = \mathbf{1.5 \text{ kN/m}}$$

Total vertical force;

$$N = F_{gabion_v,f} + F_{soil_v,f} + F_{surch_v,f} = \mathbf{3.0 \text{ kN/m}}$$

Sliding force;

$$F_t = T \times \cos(\epsilon) - N \times \sin(\epsilon) = \mathbf{1.5 \text{ kN/m}}$$

Sliding resistance;

$$F_R = (T \times \sin(\epsilon) + N \times \cos(\epsilon)) \times \tan(\delta_{bb,d}) = \mathbf{2.2 \text{ kN/m}}$$

Factor of safety;

$$FoS_S = F_R / F_t = \mathbf{1.516}$$

Allowable factor of safety;

$$FoS_{S_allow} = \mathbf{1.000}$$

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;

$$\gamma_G = \mathbf{1.00}$$

Permanent favourable action;

$$\gamma_{G,f} = \mathbf{1.00}$$

Variable unfavourable action;

$$\gamma_Q = \mathbf{1.30}$$

Variable favourable action;

$$\gamma_{Q,f} = \mathbf{0.00}$$

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

Angle of shearing resistance;

$$\gamma_{\phi'} = \mathbf{1.25}$$

Weight density;

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

Design soil properties

Design effective shearing resistance angle;

$$\phi'_{r,d} = \text{Atan}(\tan(\phi'_{pk,k}) / \gamma_{\phi'}) = \mathbf{30.2 \text{ deg}}$$

Design saturated density of retained soil;

$$\gamma_{s,d} = \gamma_{sr} / \gamma_{\gamma} = \mathbf{19.0 \text{ kN/m}^3}$$

Design wall friction angle (cl.5.4.2.1);

$$\delta_{r,d} = \min(\text{atan}(\tan(\delta_{r,k}) / \gamma_{\phi'}), \phi'_{r,d} \times K_{\text{membrane}}) = \mathbf{22.2 \text{ deg}}$$

Design base friction angle;

$$\delta_{bb,d} = \text{Atan}(\tan(\delta_{bb,k}) / \gamma_{\phi'}) = \mathbf{30.2 \text{ deg}}$$

Design friction between gabions;

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

Wall geometry

Horizontal distance to centre of gravity gabion 1;

$$x_{g1} = w_1 / 2 = \mathbf{150 \text{ mm}}$$

Vertical distance to centre of gravity gabion 1;

$$y_{g1} = h_1 / 2 = \mathbf{250 \text{ mm}}$$

Weight of gabion 1;

$$W_{g1} = \gamma_g \times w_1 \times h_1 = \mathbf{2.7 \text{ kN/m}}$$

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Weight of entire gabion; $W_g = W_{g1} = 2.7 \text{ kN/m}$
 Horiz distance to centre of gravity entire gabion; $x_g = ((W_{g1} \times x_{g1})) / W_g = 150 \text{ mm}$
 Vert distance to centre of gravity entire gabion; $y_g = ((W_{g1} \times y_{g1})) / W_g = 250 \text{ mm}$
 Correcting for wall inclination horiz dist; $X_g = x_g \times \cos(\epsilon) + y_g \times \sin(\epsilon) = 150 \text{ mm}$
 Vertical change in height due to wall inclination; $H_f = y_{g1} + h_1/2 - ((y_{g1} + h_1/2) \times \cos(\epsilon) - (x_{g1} + w_1/2) \times \sin(\epsilon)) = 0 \text{ mm}$

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; $H = (y_{g1} + h_1 / 2) + (w_1 \times \sin(\epsilon)) - H_f = 500 \text{ mm}$
 Height of wall from toe to front edge of top gabion; $H_{incl} = ((y_{g1} + h_1 / 2) \times \cos(\epsilon) - (x_{g1} - (w_1 / 2)) \times \sin(\epsilon)) = 500 \text{ mm}$
 Active pressure using Coulomb theory; $K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta)))^2}) = 0.295$
 Active thrust due to soil; $P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = 0.7 \text{ kN/m}$
 Minimum surcharge (cl.4.6.3.2); $p_{o,min} = \min(H / H_{ref}, 1) \times q_{d,min} = 1.7 \text{ kN/m}^2$

Horizontal forces

Retained soil; $F_{soil_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = 0.6 \text{ kN/m}$
 Surcharge; $F_{surch_h} = \max(p_{o,Q} \times \gamma_Q, p_{o,min}) \times K_a \times H \times \cos(90 - \alpha + \delta_{r,d}) = 0.9 \text{ kN/m}$

Vertical forces

Gabion weight; $F_{gabion_v,f} = \gamma_{G,f} \times W_g = 2.7 \text{ kN/m}$
 Retained soil; $F_{soil_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = 0.3 \text{ kN/m}$
 Surcharge; $F_{surch_v,f} = \max(p_{o,Q} \times \gamma_{Q,f}, p_{o,min}) \times K_a \times H \times \sin(90 - \alpha + \delta_{r,d}) = 0.1 \text{ kN/m}$

Overturning stability - take moments about the toe

Overturning moment; $M_o = F_{soil_h} \times d_{h,soil} + F_{surch_h} \times d_{h,surch} = 0.3 \text{ kNm/m}$
 Restoring moment; $M_R = F_{gabion_v,f} \times X_g + F_{soil_v,f} \times b_{v,soil} + F_{surch_v,f} \times b_{v,surch} = 0.5 \text{ kNm/m}$
 Factor of safety; $FoS_M = M_R / M_o = 1.554$
 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; $T = F_{soil_h} + F_{surch_h} = 1.5 \text{ kN/m}$
 Total vertical force; $N = F_{gabion_v,f} + F_{soil_v,f} + F_{surch_v,f} = 3.1 \text{ kN/m}$
 Sliding force; $F_f = T \times \cos(\epsilon) - N \times \sin(\epsilon) = 1.5 \text{ kN/m}$
 Sliding resistance; $F_R = (T \times \sin(\epsilon) + N \times \cos(\epsilon)) \times \tan(\delta_{bb,d}) = 1.8 \text{ kN/m}$
 Factor of safety; $FoS_S = F_R / F_f = 1.158$
 Allowable factor of safety; $FoS_{S_allow} = 1.000$

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

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