

Grawen Takeaway, Merthyr Tydfil
Retaining Wall
Concrete Block Option Design Calculations
Paul Deng

	Job No.:	2160
	Made by:	SDI
	Checked by:	SAF
	Date:	Feb 2024
Job Title: Grawen Takeaway – Concrete Block Retaining Wall Option	Rev.:	A
	Sheet no.:	2 of 10

Contents

1. Introduction 3

2. Ground Conditions..... 4

3. Proposed Design..... 5

4. Design 6

 4.1 Upper Wall 7

 4.2 Lower Wall 7

	Job No.:	2160
	Made by:	SDI
	Checked by:	SAF
	Date:	Feb 2024
Job Title: Grawen Takeaway – Concrete Block Retaining Wall Option	Rev.:	A
	Sheet no.:	3 of 10

1. Introduction

It is proposed to alter the existing design for the new retaining walls to simplify construction, by replacing the gabions and L-units with interlocking pre-cast concrete block walls.

This document presents the design calculations for interlocking block walls, design drawing, and designer's risk register. It should be read in conjunction with all issued previous reports and design drawings, as this redesign is based on the same information.

	Job No.:	2160
	Made by:	SDI
	Checked by:	SAF
	Date:	Feb 2024
Job Title: Grawen Takeaway – Concrete Block Retaining Wall Option	Rev.:	A
	Sheet no.:	4 of 10

2. Ground Conditions

The ground conditions comprise a thickness of made ground, overlying soft becoming firm glacial till, with suspected bedrock at depth (approximate elevation of 180.5m at the northern end of the site).

The retaining walls will largely be retaining new backfill and the made ground, and founded on glacial till or backfill. The following parameters were adopted for design in the previous calculations, and shall also be used for this design:

Made Ground

"Loose and medium dense black ashy SAND".

$$\gamma_d = 17 \text{ kN/m}^3$$

$$\gamma_{sat} = 19 \text{ kN/m}^3$$

$$\phi'_{cv} = 34^\circ$$

$$c' = 0 \text{ kPa}$$

New Backfill

Granular imported fill, e.g. 6F2 or similar.

$$\gamma_{sat} = 19 \text{ kN/m}^3$$

$$\phi'_{cv} = 34^\circ$$

$$c' = 0 \text{ kPa}$$

Glacial Till

"Soft becoming firm brown very slightly gravelly CLAY"

$$\gamma_d = 18 \text{ kN/m}^3$$

$$\gamma_{sat} = 19 \text{ kN/m}^3$$

$$\phi'_{cv} = 30^\circ$$

$$c' = 0 \text{ kPa}$$

	Job No.:	2160
	Made by:	SDI
	Checked by:	SAF
	Date:	Feb 2024
Job Title: Grawen Takeaway – Concrete Block Retaining Wall Option	Rev.:	A
	Sheet no.:	5 of 10

3. Proposed Design

The proposed design now comprises two pre-cast concrete interlocking block retaining walls, as it is felt more easily constructable given the site constraints and stability concerns.

The general layout is the same as the previous design, with the upper and lower walls being constructed along the general lines of the collapsed walls.

The lower wall will need to be constructed first, to support the bottom of the slope and allow backfill to be placed to construct the upper wall from.

 GroundSolve Ltd Consulting Geotechnical Engineers	Job No.:	2160
	Made by:	SDI
	Checked by:	SAF
	Date:	Feb 2024
	Rev.:	A
Job Title:	Grawen Takeaway – Concrete Block Retaining Wall Option	
	Sheet no.:	6 of 10

4. Design

The following cross-section has been adopted for design, based on the original topographic survey and recent site inspection:

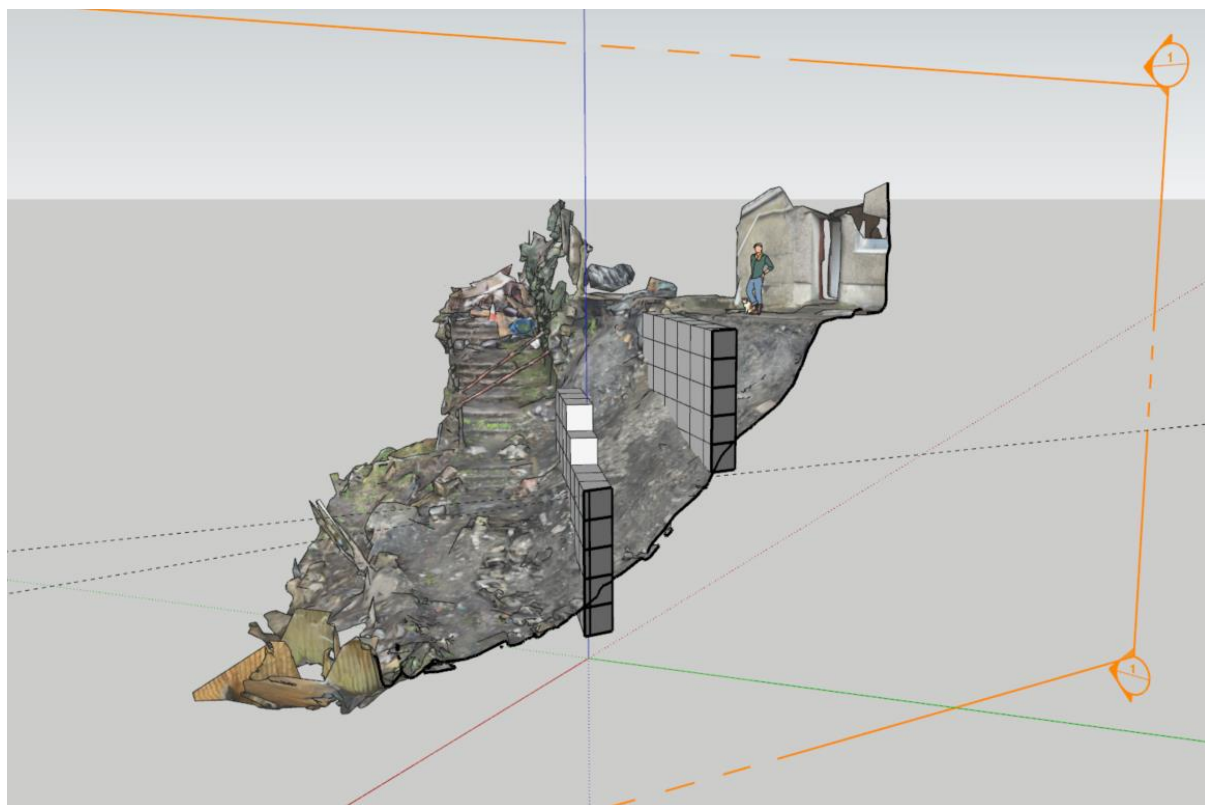


Figure 1 - Approximate design section (block layout INDICATIVE ONLY)

By inspection, and reference to the original survey, two 3m high walls are required at the worst-case (i.e., highest) section. Based on a 45° load spread, the building foundations will not load the upper wall, and the upper wall will not significantly load the lower wall, and therefore only the backfill and relevant surcharge loads will be considered in design.

A variable surcharge of 2.5kPa shall be applied to the upper wall, where pedestrian access will be available. No access will be made available to the terrace above the lower level, so no variable surcharge shall be considered. Occasional foot access for maintenance or by trespassers are not considered significant loads requiring specific consideration in design.

The upper wall shall be backfilled level, with the lower wall requiring a low-angle slope above to grade the fill to suit site levels.

	Job No.:	2160
	Made by:	SDI
	Checked by:	SAF
	Date:	Feb 2024
Job Title: Grawen Takeaway – Concrete Block Retaining Wall Option	Rev.:	A
	Sheet no.:	7 of 10

Block dimensions of 0.6m x 0.6m, and 1.0m x 0.6m (in cross-section) have been considered for use. Any change in block size will require a check of the design calculations.

The length of the blocks along the wall is irrelevant for design purposes and may be varied to suit the exact length of wall constructed, any interlocking bond pattern adopted, site constraints, and any required returns/tie-ins at the wall ends.

The walls have therefore been analysed using Tekla Tedds to confirm their stability, in accordance with the design approaches required by BS EN 1997-1:2004 and the UK National Annex, with the results presented in full in Appendix A.

4.1 Upper Wall

Calculations show that the upper wall, when backfilled with granular fill level with the top of the blocks, and subject to a 2.5kPa variable surcharge load, is stable for the following block arrangement:

- 3 upper courses, 0.6m high by 0.6m thick, set back from the front face of the wall by 400mm.
- 2 lower courses, 0.6m high by 1.0m thick.

4.2 Lower Wall

Calculations show that the upper wall, when backfilled with granular fill at an inclination of **less** than 20° and subject to no additional surcharge loading, is stable for the following block arrangement:

- 3 upper courses, 0.6m high by 0.6m thick, set back from the front face of the wall by 400mm.
- 2 lower courses, 0.6m high by 1.0m thick.

Note that the Tedds output for this wall indicates bearing capacity failure at the wall toe – however, this is based on the footprint area of the first block, not accounting for the proposed foundation which shall extend a minimum of 100mm beyond the block footprint, thereby reducing the bearing pressure at the wall toe to 115kPa, which is acceptable.

APPENDIX A

Retaining Wall Design Calculations

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project

The Grawen, Merthyr Tydfil

Job no.

2610

Calcs for

Upper Concrete Block Retaining Wall - With Surcharge

Start page no./Revision

1

Calcs by

SDI

Calcs date

28/02/2024

Checked by

SF

Checked date

27/02/2024

Approved by

SDI

Approved date

27/02/2024

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 2.0.03

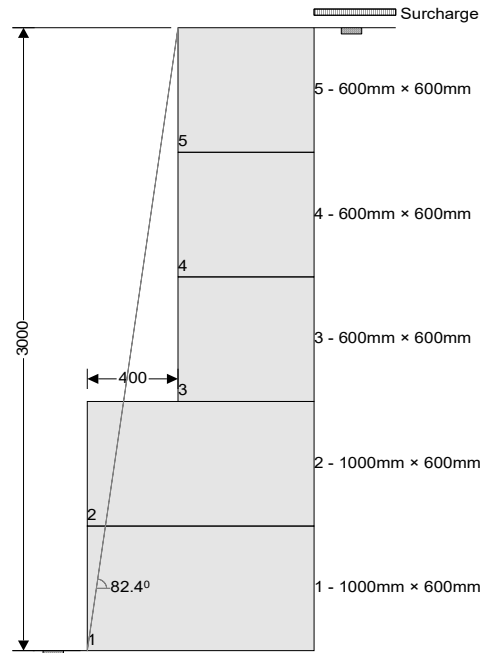
Design summary**Combination 1**

Action	Resistance	Force	FoS	Allowable FoS	Status
Overturning, sliding and bearing at base level					
Overturning (kNm/m)	46.3	28.4	1.632	1.000	PASS
Sliding (kN/m)	46.8	27.1	1.723	1.000	PASS
Bearing (kN/m ²)	125.0	122.1	1.024	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)	34.3	15.0	2.290	1.000	PASS
Sliding (kN/m)	25.4	17.8	1.432	1.000	PASS
Overturning and sliding between courses 2 and 3					
Overturning (kNm/m)	10.8	6.6	1.621	1.000	PASS
Sliding (kN/m)	16.0	10.4	1.548	1.000	PASS
Overturning and sliding between courses 3 and 4					
Overturning (kNm/m)	6.6	2.2	3.047	1.000	PASS
Sliding (kN/m)	10.2	4.9	2.068	1.000	PASS
Overturning and sliding between courses 4 and 5					
Overturning (kNm/m)	3.0	0.3	8.748	1.000	PASS
Sliding (kN/m)	4.8	1.5	3.287	1.000	PASS

Combination 2

Action	Resistance	Force	FoS	Allowable FoS	Status
Overturning, sliding and bearing at base level					
Overturning (kNm/m)	46.7	27.8	1.682	1.000	PASS
Sliding (kN/m)	37.7	26.4	1.426	1.000	PASS
Bearing (kN/m ²)	125.0	122.1	1.024	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)	34.6	14.7	2.348	1.000	PASS
Sliding (kN/m)	20.5	17.3	1.180	1.000	PASS
Overturning and sliding between courses 2 and 3					
Overturning (kNm/m)	10.9	6.6	1.651	1.000	PASS
Sliding (kN/m)	12.9	10.2	1.269	1.000	PASS
Overturning and sliding between courses 3 and 4					
Overturning (kNm/m)	6.6	2.2	3.061	1.000	PASS
Sliding (kN/m)	8.2	4.9	1.677	1.000	PASS
Overturning and sliding between courses 4 and 5					
Overturning (kNm/m)	3.0	0.4	8.549	1.000	PASS
Sliding (kN/m)	3.9	1.5	2.605	1.000	PASS

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Upper Concrete Block Retaining Wall - With Surcharge				Start page no./Revision 2	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024



Wall geometry

Width of gabion 1	$w_1 = 1000 \text{ mm}$
Height of gabion 1	$h_1 = 600 \text{ mm}$
Width of gabion 2	$w_2 = 1000 \text{ mm}$
Height of gabion 2	$h_2 = 600 \text{ mm}$
Step to front face between courses 1 and 2	$s_2 = 0 \text{ mm}$
Width of gabion 3	$w_3 = 600 \text{ mm}$
Height of gabion 3	$h_3 = 600 \text{ mm}$
Step to front face between courses 2 and 3	$s_3 = 400 \text{ mm}$
Width of gabion 4	$w_4 = 600 \text{ mm}$
Height of gabion 4	$h_4 = 600 \text{ mm}$
Step to front face between courses 3 and 4	$s_4 = 0 \text{ mm}$
Width of gabion 5	$w_5 = 600 \text{ mm}$
Height of gabion 5	$h_5 = 600 \text{ mm}$
Step to front face between courses 4 and 5	$s_5 = 0 \text{ mm}$
Wall inclination	$\varepsilon = 0 \text{ deg}$

Gabion properties

Unit weight of fill	$\gamma_d = 25.0 \text{ kN/m}^3$
Friction between gabions	$\delta_{bg,k} = 27.0 \text{ deg}$

Loading

Variable surcharge	$p_{o,Q} = 3 \text{ kN/m}^2$
--------------------	------------------------------

Soil properties

Slope of retained soil	$\beta = 0.0 \text{ deg}$
Characteristic effective shearing resistance angle	$\phi'_{r,k} = 34.0 \text{ deg}$
Characteristic saturated density of retained soil	$\gamma_{sr} = 19.0 \text{ kN/m}^3$
Coefficient for wall friction	$k_{\text{membrane}} = 1.00$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Upper Concrete Block Retaining Wall - With Surcharge				Start page no./Revision 3	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Wall friction angle	$\delta_{r,k} = 34.0 \text{ deg}$
Characteristic base friction angle	$\delta_{bb,k} = 34.0 \text{ deg}$
Bearing capacity of founding soil	$q = 125 \text{ kN/m}^2$
Wall geometry	
Horizontal distance to centre of gravity gabion 1	$x_{g1} = w_1 / 2 = 500 \text{ mm}$
Vertical distance to centre of gravity gabion 1	$y_{g1} = h_1 / 2 = 300 \text{ mm}$
Weight of gabion 1	$W_{g1} = \gamma_d \times w_1 \times h_1 = 15.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 2	$x_{g2} = w_2 / 2 + s_2 = 500 \text{ mm}$
Vertical distance to centre of gravity gabion 2	$y_{g2} = h_2 / 2 + h_1 = 900 \text{ mm}$
Weight of gabion 2	$W_{g2} = \gamma_d \times w_2 \times h_2 = 15.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 3	$x_{g3} = w_3 / 2 + s_2 + s_3 = 700 \text{ mm}$
Vertical distance to centre of gravity gabion 3	$y_{g3} = h_3 / 2 + h_1 + h_2 = 1500 \text{ mm}$
Weight of gabion 3	$W_{g3} = \gamma_d \times w_3 \times h_3 = 9.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 4	$x_{g4} = w_4 / 2 + s_2 + s_3 + s_4 = 700 \text{ mm}$
Vertical distance to centre of gravity gabion 4	$y_{g4} = h_4 / 2 + h_1 + h_2 + h_3 = 2100 \text{ mm}$
Weight of gabion 4	$W_{g4} = \gamma_d \times w_4 \times h_4 = 9.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 5	$x_{g5} = w_5 / 2 + s_2 + s_3 + s_4 + s_5 = 700 \text{ mm}$
Vertical distance to centre of gravity gabion 5	$y_{g5} = h_5 / 2 + h_1 + h_2 + h_3 + h_4 = 2700 \text{ mm}$
Weight of gabion 5	$W_{g5} = \gamma_d \times w_5 \times h_5 = 9.0 \text{ kN/m}$
Weight of entire gabion	$W_g = W_{g1} + W_{g2} + W_{g3} + W_{g4} + W_{g5} = 57.0 \text{ kN/m}$
Horiz distance to centre of gravity entire gabion	$X_g = ((W_{g1} \times x_{g1}) + (W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = 595 \text{ mm}$
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g1} \times y_{g1}) + (W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = 1311 \text{ mm}$
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\epsilon) + y_g \times \sin(\epsilon) = 595 \text{ mm}$
Vertical change in height due to wall inclination	$H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\epsilon) - (x_{g5} + w_5/2) \times \sin(\epsilon)) = 0 \text{ mm}$
Design dimensions	
Effective angle of rear plane of wall	$\alpha = 90 \text{ deg} + \epsilon = 90.0 \text{ deg}$
Effective face angle	$\theta = \text{Atan}((y_{g5} + (h_5 / 2)) / ((x_{g5} - (w_5 / 2)))) - \epsilon = 82.4 \text{ deg}$
Effective height of wall	$H = (y_{g5} + h_5 / 2) + (w_1 \times \sin(\epsilon)) - H_f = 3000 \text{ mm}$
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\epsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\epsilon)) = 3000 \text{ mm}$
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r,k})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,k}) \times (1 + \sqrt{(\sin(\phi'_{r,k} + \delta_{r,k}) \times \sin(\phi'_{r,k} - \beta) / (\sin(\alpha - \delta_{r,k}) \times \sin(\alpha + \beta))))^2) = 0.259$
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{sr} \times H^2 = 22.1 \text{ kN/m}$
Pressure at base	
Horizontal forces	
Retained soil	$F_{soil,h,q} = P_{a,soil} \times \cos(90 - \alpha + \delta_{r,k}) = 18.3 \text{ kN/m}$
Height of soil thrust resolved vertically	$d_{h,soil} = H / 3 - w_1 \times \sin(\epsilon) = 1000 \text{ mm}$
Surcharge	$F_{surch,h,q} = p_{o,Q} \times K_a \times H \times \cos(90 - \alpha + \delta_{r,k}) = 1.6 \text{ kN/m}$
Height of surcharge thrust resolved vertically	$d_{h,surch} = H / 2 - w_1 \times \sin(\epsilon) = 1500 \text{ mm}$
Vertical forces	
Gabion weight	$F_{gabion,v,q} = W_g = 57.0 \text{ kN/m}$
Retained soil	$F_{soil,v,q} = P_{a,soil} \times \sin(90 - \alpha + \delta_{r,k}) = 12.4 \text{ kN/m}$
Horizontal dist to where soil thrust acts	$b_{v,soil} = w_1 \times \cos(\epsilon) - (H / 3) / \tan(\alpha) = 1000 \text{ mm}$
Surcharge	$F_{surch,v,q} = p_{o,Q} \times K_a \times H \times \sin(90 - \alpha + \delta_{r,k}) = 1.1 \text{ kN/m}$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project

The Grawen, Merthyr Tydfil

Job no.

2610

Calcs for

Upper Concrete Block Retaining Wall - With Surcharge

Start page no./Revision

4

Calcs by

SDI

Calcs date

28/02/2024

Checked by

SF

Checked date

27/02/2024

Approved by

SDI

Approved date

27/02/2024

Horizontal dist to where surcharge thrust acts

$$b_{v,surch} = w_1 \times \cos(\varepsilon) - (H / 2) / \tan(\alpha) = 1000 \text{ mm}$$

Total horizontal unfactored force

$$T_q = F_{soil_h,q} + F_{surch_h,q} = 19.9 \text{ kN/m}$$

Total vertical unfactored force

$$N_q = F_{gabion_v,q} + F_{soil_v,q} + F_{surch_v,q} = 70.4 \text{ kN/m}$$

Force normal to base

$$N_s = N_q \times \cos(\varepsilon) + T_q \times \sin(\varepsilon) = 70.4 \text{ kN/m}$$

Total unfactored overturning force

$$M_{o,q} = F_{soil_h,q} \times d_{h,soil} + F_{surch_h,q} \times d_{h,surch} = 20.7 \text{ kNm/m}$$

Total unfactored restoring force

$$M_{R,q} = F_{gabion_v,q} \times X_g + F_{soil_v,q} \times b_{v,soil} + F_{surch_v,q} \times b_{v,surch} = 47.3 \text{ kNm/m}$$

Eccentricity

$$e = w_1 / 2 - (M_{R,q} - M_{o,q}) / N_s = 122 \text{ mm}$$

Reaction acts within middle third of base

Pressure at toe

$$\sigma_{toe} = N_s / w_1 \times (1 + (6 \times e / w_1)) = 122.1 \text{ kN/m}^2$$

Pressure at heel

$$\sigma_{heel} = N_s / w_1 \times (1 - (6 \times e / w_1)) = 18.8 \text{ kN/m}^2$$

Factor of safety

$$FoS_Q = q / \max(\sigma_{toe}, \sigma_{heel}) = 1.024$$

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

$$\gamma_\gamma = 1.00$$

Design soil properties

Design effective shearing resistance angle

$$\phi'_{r,d} = \text{Atan}(\tan(\phi'_{r,k}) / \gamma_{\phi'}) = 34.0 \text{ deg}$$

Design saturated density of retained soil

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

Design wall friction angle

$$\delta_{r,d} = \min(\text{atan}(\tan(\delta_{r,k}) / \gamma_{\phi'}), \phi'_{r,d} \times K_{\text{membrane}}) = 34.0 \text{ deg}$$

Design base friction angle

$$\delta_{bb,d} = \text{Atan}(\tan(\delta_{bb,k}) / \gamma_{\phi'}) = 34.0 \text{ deg}$$

Design friction between gabions

$$\delta_{bg,d} = \text{Atan}(\tan(\delta_{bg,k}) / \gamma_{\phi'}) = 27.0 \text{ deg}$$

Active pressure using Coulomb theory

$$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta)))^2}) = 0.259$$

Active thrust due to soil

$$P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = 22.1 \text{ kN/m}$$

Horizontal forces

Retained soil

$$F_{soil_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = 24.7 \text{ kN/m}$$

Surcharge

$$F_{surch_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r,d}) = 2.4 \text{ kN/m}$$

Vertical forces

Gabion weight

$$F_{gabion_v,f} = \gamma_{G,f} \times W_g = 57.0 \text{ kN/m}$$

Retained soil

$$F_{soil_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = 12.4 \text{ kN/m}$$

Surcharge

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

Overturning stability - take moments about the toe

Overturning moment

$$M_o = F_{soil_h} \times d_{h,soil} + F_{surch_h} \times d_{h,surch} = 28.4 \text{ kNm/m}$$

Restoring moment

$$M_R = F_{gabion_v,f} \times X_g + F_{soil_v,f} \times b_{v,soil} + F_{surch_v,f} \times b_{v,surch} = 46.3 \text{ kNm/m}$$

Factor of safety

$$FoS_M = M_R / M_o = 1.632$$

Allowable factor of safety

$$FoS_{M_allow} = 1.000$$

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

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Upper Concrete Block Retaining Wall - With Surcharge				Start page no./Revision 5	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

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

Total horizontal force	$T = F_{\text{soil}_h} + F_{\text{surch}_h} = 27.1 \text{ kN/m}$
Total vertical force	$N = F_{\text{gabion}_{v,f}} + F_{\text{soil}_{v,f}} + F_{\text{surch}_{v,f}} = 69.4 \text{ kN/m}$
Sliding force	$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = 27.1 \text{ kN/m}$
Sliding resistance	$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bb,d}) = 46.8 \text{ kN/m}$
Factor of safety	$FoS_S = F_R / F_f = 1.723$
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	$x_{g2} = w_2 / 2 = 500 \text{ mm}$
Vertical distance to centre of gravity gabion 2	$y_{g2} = h_2 / 2 = 300 \text{ mm}$
Weight of gabion 2	$W_{g2} = \gamma_d \times w_2 \times h_2 = 15.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 3	$x_{g3} = w_3 / 2 + s_3 = 700 \text{ mm}$
Vertical distance to centre of gravity gabion 3	$y_{g3} = h_3 / 2 + h_2 = 900 \text{ mm}$
Weight of gabion 3	$W_{g3} = \gamma_d \times w_3 \times h_3 = 9.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 4	$x_{g4} = w_4 / 2 + s_3 + s_4 = 700 \text{ mm}$
Vertical distance to centre of gravity gabion 4	$y_{g4} = h_4 / 2 + h_2 + h_3 = 1500 \text{ mm}$
Weight of gabion 4	$W_{g4} = \gamma_d \times w_4 \times h_4 = 9.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 5	$x_{g5} = w_5 / 2 + s_3 + s_4 + s_5 = 700 \text{ mm}$
Vertical distance to centre of gravity gabion 5	$y_{g5} = h_5 / 2 + h_2 + h_3 + h_4 = 2100 \text{ mm}$
Weight of gabion 5	$W_{g5} = \gamma_d \times w_5 \times h_5 = 9.0 \text{ kN/m}$
Weight of entire gabion	$W_g = W_{g2} + W_{g3} + W_{g4} + W_{g5} = 42.0 \text{ kN/m}$
Horiz distance to centre of gravity entire gabion	$X_g = ((W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = 629 \text{ mm}$
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = 1071 \text{ mm}$
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = 629 \text{ mm}$
Vertical change in height due to wall inclination	$H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\varepsilon) - (x_{g5} + w_5/2) \times \sin(\varepsilon)) = 0 \text{ mm}$

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90 \text{ deg} + \varepsilon = 90.0 \text{ deg}$
Effective face angle	$\theta = \text{Atan}((y_{g5} + (h_5 / 2)) / (x_{g5} - (w_5 / 2))) - \varepsilon = 80.5 \text{ deg}$
Effective height of wall	$H = (y_{g5} + h_5 / 2) + (w_2 \times \sin(\varepsilon)) - H_f = 2400 \text{ mm}$
Height of wall from toe to front edge of top gabion	$H_{\text{incl}} = ((y_{g5} + h_5 / 2) \times \cos(\varepsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\varepsilon)) = 2400 \text{ mm}$
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2 = 0.259$
Active thrust due to soil	$P_{a,\text{soil}} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = 14.1 \text{ kN/m}$

Horizontal forces

Retained soil	$F_{\text{soil}_h} = \gamma_G \times P_{a,\text{soil}} \times \cos(90 - \alpha + \delta_{r,d}) = 15.8 \text{ kN/m}$
Surcharge	$F_{\text{surch}_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r,d}) = 1.9 \text{ kN/m}$

Vertical forces

Gabion weight	$F_{\text{gabion}_{v,f}} = \gamma_{G,f} \times W_g = 42.0 \text{ kN/m}$
Retained soil	$F_{\text{soil}_{v,f}} = \gamma_{G,f} \times P_{a,\text{soil}} \times \sin(90 - \alpha + \delta_{r,d}) = 7.9 \text{ kN/m}$
Surcharge	$F_{\text{surch}_{v,f}} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r,d}) = 0.0 \text{ kN/m}$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Upper Concrete Block Retaining Wall - With Surcharge				Start page no./Revision 6	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil_h} \times d_{h,soil} + F_{surch_h} \times d_{h,surch} = 15.0 \text{ kNm/m}$
Restoring moment $M_R = F_{gabion_v,f} \times X_g + F_{soil_v,f} \times b_{v,soil} + F_{surch_v,f} \times b_{v,surch} = 34.3 \text{ kNm/m}$
Factor of safety $FoSM = M_R / M_o = 2.290$
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 $T = F_{soil_h} + F_{surch_h} = 17.8 \text{ kN/m}$
Total vertical force $N = F_{gabion_v,f} + F_{soil_v,f} + F_{surch_v,f} = 49.9 \text{ kN/m}$
Sliding force $F_f = T \times \cos(\epsilon) - N \times \sin(\epsilon) = 17.8 \text{ kN/m}$
Sliding resistance $F_R = (T \times \sin(\epsilon) + N \times \cos(\epsilon)) \times \tan(\delta_{bg,d}) = 25.4 \text{ kN/m}$
Factor of safety $FoSS = F_R / F_f = 1.432$
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 2 and 3****Wall geometry**

Horizontal distance to centre of gravity gabion 3 $x_{g3} = w_3 / 2 = 300 \text{ mm}$
Vertical distance to centre of gravity gabion 3 $y_{g3} = h_3 / 2 = 300 \text{ mm}$
Weight of gabion 3 $W_{g3} = \gamma_d \times w_3 \times h_3 = 9.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 4 $x_{g4} = w_4 / 2 + s_4 = 300 \text{ mm}$
Vertical distance to centre of gravity gabion 4 $y_{g4} = h_4 / 2 + h_3 = 900 \text{ mm}$
Weight of gabion 4 $W_{g4} = \gamma_d \times w_4 \times h_4 = 9.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 5 $x_{g5} = w_5 / 2 + s_4 + s_5 = 300 \text{ mm}$
Vertical distance to centre of gravity gabion 5 $y_{g5} = h_5 / 2 + h_3 + h_4 = 1500 \text{ mm}$
Weight of gabion 5 $W_{g5} = \gamma_d \times w_5 \times h_5 = 9.0 \text{ kN/m}$
Weight of entire gabion $W_g = W_{g3} + W_{g4} + W_{g5} = 27.0 \text{ kN/m}$
Horiz distance to centre of gravity entire gabion $x_g = ((W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = 300 \text{ mm}$
Vert distance to centre of gravity entire gabion $y_g = ((W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = 900 \text{ mm}$
Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\epsilon) + y_g \times \sin(\epsilon) = 300 \text{ mm}$
Vertical change in height due to wall inclination $H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\epsilon) - (x_{g5} + w_5/2) \times \sin(\epsilon)) = 0 \text{ mm}$

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 $H = (y_{g5} + h_5 / 2) + (w_3 \times \sin(\epsilon)) - H_f = 1800 \text{ mm}$
Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\epsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\epsilon)) = 1800 \text{ mm}$
Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2 = 0.259$
Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = 8.0 \text{ kN/m}$

Horizontal forces

Retained soil $F_{soil_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = 8.9 \text{ kN/m}$
Surcharge $F_{surch_h} = p_{o,q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r,d}) = 1.4 \text{ kN/m}$

Vertical forces

Gabion weight $F_{gabion_v,f} = \gamma_{G,f} \times W_g = 27.0 \text{ kN/m}$
Retained soil $F_{soil_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = 4.4 \text{ kN/m}$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Upper Concrete Block Retaining Wall - With Surcharge				Start page no./Revision 7	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Surcharge

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

Overtuning stability - take moments about the toe

Overtuning moment

$$M_o = F_{soil_h} \times d_{h,soil} + F_{surch_h} \times d_{h,surch} = \mathbf{6.6 \text{ kNm/m}}$$

Restoring moment

$$M_R = F_{gabion_v,f} \times X_g + F_{soil_v,f} \times b_{v,soil} + F_{surch_v,f} \times b_{v,surch} = \mathbf{10.8 \text{ kNm/m}}$$

Factor of safety

$$FoSM = M_R / M_o = \mathbf{1.621}$$

Allowable factor of safety

$$FoSM_{allow} = \mathbf{1.000}$$

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

$$T = F_{soil_h} + F_{surch_h} = \mathbf{10.4 \text{ kN/m}}$$

Total vertical force

$$N = F_{gabion_v,f} + F_{soil_v,f} + F_{surch_v,f} = \mathbf{31.4 \text{ kN/m}}$$

Sliding force

$$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = \mathbf{10.4 \text{ kN/m}}$$

Sliding resistance

$$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg,d}) = \mathbf{16.0 \text{ kN/m}}$$

Factor of safety

$$FoSS = F_R / F_f = \mathbf{1.548}$$

Allowable factor of safety

$$FoSS_{allow} = \mathbf{1.000}$$

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

$$x_{g4} = w_4 / 2 = \mathbf{300 \text{ mm}}$$

Vertical distance to centre of gravity gabion 4

$$y_{g4} = h_4 / 2 = \mathbf{300 \text{ mm}}$$

Weight of gabion 4

$$W_{g4} = \gamma_d \times w_4 \times h_4 = \mathbf{9.0 \text{ kN/m}}$$

Horizontal distance to centre of gravity gabion 5

$$x_{g5} = w_5 / 2 + s_5 = \mathbf{300 \text{ mm}}$$

Vertical distance to centre of gravity gabion 5

$$y_{g5} = h_5 / 2 + h_4 = \mathbf{900 \text{ mm}}$$

Weight of gabion 5

$$W_{g5} = \gamma_d \times w_5 \times h_5 = \mathbf{9.0 \text{ kN/m}}$$

Weight of entire gabion

$$W_g = W_{g4} + W_{g5} = \mathbf{18.0 \text{ kN/m}}$$

Horiz distance to centre of gravity entire gabion

$$x_g = ((W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = \mathbf{300 \text{ mm}}$$

Vert distance to centre of gravity entire gabion

$$y_g = ((W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = \mathbf{600 \text{ mm}}$$

Correcting for wall inclination horiz dist

$$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{300 \text{ mm}}$$

Vertical change in height due to wall inclination

$$H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\varepsilon) - (x_{g5} + w_5/2) \times \sin(\varepsilon)) = \mathbf{0 \text{ mm}}$$

Design dimensions

Effective angle of rear plane of wall

$$\alpha = 90 \text{ deg} + \varepsilon = \mathbf{90.0 \text{ deg}}$$

Effective face angle

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

Effective height of wall

$$H = (y_{g5} + h_5 / 2) + (w_4 \times \sin(\varepsilon)) - H_f = \mathbf{1200 \text{ mm}}$$

Height of wall from toe to front edge of top gabion

$$H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\varepsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\varepsilon)) = \mathbf{1200 \text{ mm}}$$

Active pressure using Coulomb theory

$$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))})^2) = \mathbf{0.259}$$

Active thrust due to soil

$$P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = \mathbf{3.5 \text{ kN/m}}$$

Horizontal forces

Retained soil

$$F_{soil_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{4.0 \text{ kN/m}}$$

Surcharge

$$F_{surch_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{1.0 \text{ kN/m}}$$

Vertical forces

Gabion weight

$$F_{gabion_v,f} = \gamma_{G,f} \times W_g = \mathbf{18.0 \text{ kN/m}}$$

Retained soil

$$F_{soil_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{2.0 \text{ kN/m}}$$

Surcharge

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

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Upper Concrete Block Retaining Wall - With Surcharge				Start page no./Revision 8	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil_h} \times d_{h,soil} + F_{surch_h} \times d_{h,surch} = 2.2 \text{ kNm/m}$
Restoring moment $M_R = F_{gabion_v,f} \times X_g + F_{soil_v,f} \times b_{v,soil} + F_{surch_v,f} \times b_{v,surch} = 6.6 \text{ kNm/m}$
Factor of safety $FoSM = M_R / M_o = 3.047$
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 $T = F_{soil_h} + F_{surch_h} = 4.9 \text{ kN/m}$
Total vertical force $N = F_{gabion_v,f} + F_{soil_v,f} + F_{surch_v,f} = 20.0 \text{ kN/m}$
Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = 4.9 \text{ kN/m}$
Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg,d}) = 10.2 \text{ kN/m}$
Factor of safety $FoSS = F_R / F_f = 2.068$
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 4 and 5****Wall geometry**

Horizontal distance to centre of gravity gabion 5 $x_{g5} = w_5 / 2 = 300 \text{ mm}$
Vertical distance to centre of gravity gabion 5 $y_{g5} = h_5 / 2 = 300 \text{ mm}$
Weight of gabion 5 $W_{g5} = \gamma_d \times w_5 \times h_5 = 9.0 \text{ kN/m}$
Weight of entire gabion $W_g = W_{g5} = 9.0 \text{ kN/m}$
Horiz distance to centre of gravity entire gabion $x_g = ((W_{g5} \times x_{g5})) / W_g = 300 \text{ mm}$
Vert distance to centre of gravity entire gabion $y_g = ((W_{g5} \times y_{g5})) / W_g = 300 \text{ mm}$
Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = 300 \text{ mm}$
Vertical change in height due to wall inclination $H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\varepsilon) - (x_{g5} + w_5/2) \times \sin(\varepsilon)) = 0 \text{ mm}$

Design dimensions

Effective angle of rear plane of wall $\alpha = 90 \text{ deg} + \varepsilon = 90.0 \text{ deg}$
Effective face angle $\theta = 90 \text{ deg} - \varepsilon = 90.0 \text{ deg}$
Effective height of wall $H = (y_{g5} + h_5 / 2) + (w_5 \times \sin(\varepsilon)) - H_f = 600 \text{ mm}$
Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\varepsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\varepsilon)) = 600 \text{ mm}$
Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))))^2) = 0.259$
Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = 0.9 \text{ kN/m}$

Horizontal forces

Retained soil $F_{soil_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = 1.0 \text{ kN/m}$
Surcharge $F_{surch_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r,d}) = 0.5 \text{ kN/m}$

Vertical forces

Gabion weight $F_{gabion_v,f} = \gamma_{G,f} \times W_g = 9.0 \text{ kN/m}$
Retained soil $F_{soil_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = 0.5 \text{ kN/m}$
Surcharge $F_{surch_v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r,d}) = 0.0 \text{ kN/m}$

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 $M_R = F_{gabion_v,f} \times X_g + F_{soil_v,f} \times b_{v,soil} + F_{surch_v,f} \times b_{v,surch} = 3.0 \text{ kNm/m}$
Factor of safety $FoSM = M_R / M_o = 8.748$
Allowable factor of safety $FoSM_{allow} = 1.000$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Upper Concrete Block Retaining Wall - With Surcharge				Start page no./Revision 9	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

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	$T = F_{\text{soil}_h} + F_{\text{surch}_h} = 1.5 \text{ kN/m}$
Total vertical force	$N = F_{\text{gabion}_{v,f}} + F_{\text{soil}_{v,f}} + F_{\text{surch}_{v,f}} = 9.5 \text{ kN/m}$
Sliding force	$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = 1.5 \text{ kN/m}$
Sliding resistance	$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg,d}) = 4.8 \text{ kN/m}$
Factor of safety	$FoS_s = F_R / F_f = 3.287$
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	$\phi'_{r,d} = \text{Atan}(\tan(\phi'_{r,k}) / \gamma_{\phi'}) = 28.4 \text{ deg}$
Design saturated density of retained soil	$\gamma_{s,d} = \gamma_{sr} / \gamma_\gamma = 19.0 \text{ kN/m}^3$
Design wall friction angle	$\delta_{r,d} = \min(\text{atan}(\tan(\delta_{r,k}) / \gamma_{\phi'}), \phi'_{r,d} \times k_{\text{membrane}}) = 28.4 \text{ deg}$
Design base friction angle	$\delta_{bb,d} = \text{Atan}(\tan(\delta_{bb,k}) / \gamma_{\phi'}) = 28.4 \text{ deg}$
Design friction between gabions	$\delta_{bg,d} = \text{Atan}(\tan(\delta_{bg,k}) / \gamma_{\phi'}) = 22.2 \text{ deg}$

Wall geometry

Horizontal distance to centre of gravity gabion 1	$x_{g1} = w_1 / 2 = 500 \text{ mm}$
Vertical distance to centre of gravity gabion 1	$y_{g1} = h_1 / 2 = 300 \text{ mm}$
Weight of gabion 1	$W_{g1} = \gamma_d \times w_1 \times h_1 = 15.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 2	$x_{g2} = w_2 / 2 + s_2 = 500 \text{ mm}$
Vertical distance to centre of gravity gabion 2	$y_{g2} = h_2 / 2 + h_1 = 900 \text{ mm}$
Weight of gabion 2	$W_{g2} = \gamma_d \times w_2 \times h_2 = 15.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 3	$x_{g3} = w_3 / 2 + s_2 + s_3 = 700 \text{ mm}$
Vertical distance to centre of gravity gabion 3	$y_{g3} = h_3 / 2 + h_1 + h_2 = 1500 \text{ mm}$
Weight of gabion 3	$W_{g3} = \gamma_d \times w_3 \times h_3 = 9.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 4	$x_{g4} = w_4 / 2 + s_2 + s_3 + s_4 = 700 \text{ mm}$
Vertical distance to centre of gravity gabion 4	$y_{g4} = h_4 / 2 + h_1 + h_2 + h_3 = 2100 \text{ mm}$
Weight of gabion 4	$W_{g4} = \gamma_d \times w_4 \times h_4 = 9.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 5	$x_{g5} = w_5 / 2 + s_2 + s_3 + s_4 + s_5 = 700 \text{ mm}$
Vertical distance to centre of gravity gabion 5	$y_{g5} = h_5 / 2 + h_1 + h_2 + h_3 + h_4 = 2700 \text{ mm}$
Weight of gabion 5	$W_{g5} = \gamma_d \times w_5 \times h_5 = 9.0 \text{ kN/m}$
Weight of entire gabion	$W_g = W_{g1} + W_{g2} + W_{g3} + W_{g4} + W_{g5} = 57.0 \text{ kN/m}$
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g1} \times x_{g1}) + (W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = 595 \text{ mm}$
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g1} \times y_{g1}) + (W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = 1311 \text{ mm}$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Upper Concrete Block Retaining Wall - With Surcharge				Start page no./Revision 10	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Correcting for wall inclination horiz dist

$$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{595 \text{ mm}}$$

Vertical change in height due to wall inclination

$$H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\varepsilon) - (x_{g5} + w_5/2) \times \sin(\varepsilon)) = \mathbf{0 \text{ mm}}$$

Design dimensions

Effective angle of rear plane of wall

$$\alpha = 90 \text{ deg} + \varepsilon = \mathbf{90.0 \text{ deg}}$$

Effective face angle

$$\theta = \text{Atan}((y_{g5} + (h_5 / 2)) / ((x_{g5} - (w_5 / 2)))) - \varepsilon = \mathbf{82.4 \text{ deg}}$$

Effective height of wall

$$H = (y_{g5} + h_5 / 2) + (w_1 \times \sin(\varepsilon)) - H_f = \mathbf{3000 \text{ mm}}$$

Height of wall from toe to front edge of top gabion

$$H_{\text{incl}} = ((y_{g5} + h_5 / 2) \times \cos(\varepsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\varepsilon)) = \mathbf{3000 \text{ mm}}$$

Active pressure using Coulomb theory

$$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2) = \mathbf{0.315}$$

Active thrust due to soil

$$P_{a,\text{soil}} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = \mathbf{26.9 \text{ kN/m}}$$

Horizontal forces

Retained soil

$$F_{\text{soil}_h} = \gamma_G \times P_{a,\text{soil}} \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{23.7 \text{ kN/m}}$$

Surcharge

$$F_{\text{surch}_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{2.7 \text{ kN/m}}$$

Vertical forces

Gabion weight

$$F_{\text{gabion}_v,f} = \gamma_{G,f} \times W_g = \mathbf{57.0 \text{ kN/m}}$$

Retained soil

$$F_{\text{soil}_v,f} = \gamma_{G,f} \times P_{a,\text{soil}} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{12.8 \text{ kN/m}}$$

Surcharge

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

Overturning stability - take moments about the toe

Overturning moment

$$M_o = F_{\text{soil}_h} \times d_{h,\text{soil}} + F_{\text{surch}_h} \times d_{h,\text{surch}} = \mathbf{27.8 \text{ kNm/m}}$$

Restoring moment

$$M_R = F_{\text{gabion}_v,f} \times X_g + F_{\text{soil}_v,f} \times b_{v,\text{soil}} + F_{\text{surch}_v,f} \times b_{v,\text{surch}} = \mathbf{46.7 \text{ kNm/m}}$$

Factor of safety

$$FoS_M = M_R / M_o = \mathbf{1.682}$$

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

$$T = F_{\text{soil}_h} + F_{\text{surch}_h} = \mathbf{26.4 \text{ kN/m}}$$

Total vertical force

$$N = F_{\text{gabion}_v,f} + F_{\text{soil}_v,f} + F_{\text{surch}_v,f} = \mathbf{69.8 \text{ kN/m}}$$

Sliding force

$$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = \mathbf{26.4 \text{ kN/m}}$$

Sliding resistance

$$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bb,d}) = \mathbf{37.7 \text{ kN/m}}$$

Factor of safety

$$FoS_S = F_R / F_f = \mathbf{1.426}$$

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 1 and 2****Wall geometry**

Horizontal distance to centre of gravity gabion 2

$$x_{g2} = w_2 / 2 = \mathbf{500 \text{ mm}}$$

Vertical distance to centre of gravity gabion 2

$$y_{g2} = h_2 / 2 = \mathbf{300 \text{ mm}}$$

Weight of gabion 2

$$W_{g2} = \gamma_d \times w_2 \times h_2 = \mathbf{15.0 \text{ kN/m}}$$

Horizontal distance to centre of gravity gabion 3

$$x_{g3} = w_3 / 2 + s_3 = \mathbf{700 \text{ mm}}$$

Vertical distance to centre of gravity gabion 3

$$y_{g3} = h_3 / 2 + h_2 = \mathbf{900 \text{ mm}}$$

Weight of gabion 3

$$W_{g3} = \gamma_d \times w_3 \times h_3 = \mathbf{9.0 \text{ kN/m}}$$

Horizontal distance to centre of gravity gabion 4

$$x_{g4} = w_4 / 2 + s_3 + s_4 = \mathbf{700 \text{ mm}}$$

Vertical distance to centre of gravity gabion 4

$$y_{g4} = h_4 / 2 + h_2 + h_3 = \mathbf{1500 \text{ mm}}$$

Weight of gabion 4

$$W_{g4} = \gamma_d \times w_4 \times h_4 = \mathbf{9.0 \text{ kN/m}}$$

Horizontal distance to centre of gravity gabion 5

$$x_{g5} = w_5 / 2 + s_3 + s_4 + s_5 = \mathbf{700 \text{ mm}}$$

Vertical distance to centre of gravity gabion 5

$$y_{g5} = h_5 / 2 + h_2 + h_3 + h_4 = \mathbf{2100 \text{ mm}}$$

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Upper Concrete Block Retaining Wall - With Surcharge				Start page no./Revision 11	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Weight of gabion 5	$W_{g5} = \gamma_d \times w_5 \times h_5 = \mathbf{9.0 \text{ kN/m}}$
Weight of entire gabion	$W_g = W_{g2} + W_{g3} + W_{g4} + W_{g5} = \mathbf{42.0 \text{ kN/m}}$
Horiz distance to centre of gravity entire gabion	$X_g = ((W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = \mathbf{629 \text{ mm}}$
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = \mathbf{1071 \text{ mm}}$
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{629 \text{ mm}}$
Vertical change in height due to wall inclination	$H_r = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\varepsilon) - (x_{g5} + w_5/2) \times \sin(\varepsilon)) = \mathbf{0 \text{ mm}}$

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90 \text{ deg} + \varepsilon = \mathbf{90.0 \text{ deg}}$
Effective face angle	$\theta = \text{Atan}((y_{g5} + (h_5 / 2)) / ((x_{g5} - (w_5 / 2)))) - \varepsilon = \mathbf{80.5 \text{ deg}}$
Effective height of wall	$H = (y_{g5} + h_5 / 2) + (w_2 \times \sin(\varepsilon)) - H_r = \mathbf{2400 \text{ mm}}$
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\varepsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\varepsilon)) = \mathbf{2400 \text{ mm}}$
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2 = \mathbf{0.315}$
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = \mathbf{17.2 \text{ kN/m}}$

Horizontal forces

Retained soil	$F_{soil,h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{15.2 \text{ kN/m}}$
Surcharge	$F_{surch,h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{2.2 \text{ kN/m}}$

Vertical forces

Gabion weight	$F_{gabion,v,f} = \gamma_{G,f} \times W_g = \mathbf{42.0 \text{ kN/m}}$
Retained soil	$F_{soil,v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{8.2 \text{ kN/m}}$
Surcharge	$F_{surch,v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{0.0 \text{ kN/m}}$

Overturning stability - take moments about the toe

Overturning moment	$M_o = F_{soil,h} \times d_{h,soil} + F_{surch,h} \times d_{h,surch} = \mathbf{14.7 \text{ kNm/m}}$
Restoring moment	$M_R = F_{gabion,v,f} \times X_g + F_{soil,v,f} \times b_{v,soil} + F_{surch,v,f} \times b_{v,surch} = \mathbf{34.6 \text{ kNm/m}}$
Factor of safety	$FoSM = M_R / M_o = \mathbf{2.348}$
Allowable factor of safety	$FoSM_{allow} = \mathbf{1.000}$

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	$T = F_{soil,h} + F_{surch,h} = \mathbf{17.3 \text{ kN/m}}$
Total vertical force	$N = F_{gabion,v,f} + F_{soil,v,f} + F_{surch,v,f} = \mathbf{50.2 \text{ kN/m}}$
Sliding force	$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = \mathbf{17.3 \text{ kN/m}}$
Sliding resistance	$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg,d}) = \mathbf{20.5 \text{ kN/m}}$
Factor of safety	$FoSS = F_R / F_f = \mathbf{1.180}$
Allowable factor of safety	$FoSS_{allow} = \mathbf{1.000}$

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	$x_{g3} = w_3 / 2 = \mathbf{300 \text{ mm}}$
Vertical distance to centre of gravity gabion 3	$y_{g3} = h_3 / 2 = \mathbf{300 \text{ mm}}$
Weight of gabion 3	$W_{g3} = \gamma_d \times w_3 \times h_3 = \mathbf{9.0 \text{ kN/m}}$
Horizontal distance to centre of gravity gabion 4	$x_{g4} = w_4 / 2 + s_4 = \mathbf{300 \text{ mm}}$
Vertical distance to centre of gravity gabion 4	$y_{g4} = h_4 / 2 + h_3 = \mathbf{900 \text{ mm}}$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Upper Concrete Block Retaining Wall - With Surcharge				Start page no./Revision 12	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Weight of gabion 4	$W_{g4} = \gamma_d \times w_4 \times h_4 = \mathbf{9.0 \text{ kN/m}}$
Horizontal distance to centre of gravity gabion 5	$x_{g5} = w_5 / 2 + s_4 + s_5 = \mathbf{300 \text{ mm}}$
Vertical distance to centre of gravity gabion 5	$y_{g5} = h_5 / 2 + h_3 + h_4 = \mathbf{1500 \text{ mm}}$
Weight of gabion 5	$W_{g5} = \gamma_d \times w_5 \times h_5 = \mathbf{9.0 \text{ kN/m}}$
Weight of entire gabion	$W_g = W_{g3} + W_{g4} + W_{g5} = \mathbf{27.0 \text{ kN/m}}$
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = \mathbf{300 \text{ mm}}$
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = \mathbf{900 \text{ mm}}$
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{300 \text{ mm}}$
Vertical change in height due to wall inclination	$H_r = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\varepsilon) - (x_{g5} + w_5/2) \times \sin(\varepsilon)) = \mathbf{0 \text{ mm}}$

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90 \text{ deg} + \varepsilon = \mathbf{90.0 \text{ deg}}$
Effective face angle	$\theta = 90 \text{ deg} - \varepsilon = \mathbf{90.0 \text{ deg}}$
Effective height of wall	$H = (y_{g5} + h_5 / 2) + (w_3 \times \sin(\varepsilon)) - H_r = \mathbf{1800 \text{ mm}}$
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\varepsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\varepsilon)) = \mathbf{1800 \text{ mm}}$
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2 = \mathbf{0.315}$
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = \mathbf{9.7 \text{ kN/m}}$

Horizontal forces

Retained soil	$F_{soil,h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{8.5 \text{ kN/m}}$
Surcharge	$F_{surch,h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{1.6 \text{ kN/m}}$

Vertical forces

Gabion weight	$F_{gabion,v,f} = \gamma_{G,f} \times W_g = \mathbf{27.0 \text{ kN/m}}$
Retained soil	$F_{soil,v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{4.6 \text{ kN/m}}$
Surcharge	$F_{surch,v,f} = p_{o,Q} \times \gamma_{Q,f} \times K_a \times H \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{0.0 \text{ kN/m}}$

Overturning stability - take moments about the toe

Overturning moment	$M_o = F_{soil,h} \times d_{h,soil} + F_{surch,h} \times d_{h,surch} = \mathbf{6.6 \text{ kNm/m}}$
Restoring moment	$M_R = F_{gabion,v,f} \times X_g + F_{soil,v,f} \times b_{v,soil} + F_{surch,v,f} \times b_{v,surch} = \mathbf{10.9 \text{ kNm/m}}$
Factor of safety	$FoSM = M_R / M_o = \mathbf{1.651}$
Allowable factor of safety	$FoSM_{allow} = \mathbf{1.000}$

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	$T = F_{soil,h} + F_{surch,h} = \mathbf{10.2 \text{ kN/m}}$
Total vertical force	$N = F_{gabion,v,f} + F_{soil,v,f} + F_{surch,v,f} = \mathbf{31.6 \text{ kN/m}}$
Sliding force	$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = \mathbf{10.2 \text{ kN/m}}$
Sliding resistance	$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg,d}) = \mathbf{12.9 \text{ kN/m}}$
Factor of safety	$FoSS = F_R / F_f = \mathbf{1.269}$
Allowable factor of safety	$FoSS_{allow} = \mathbf{1.000}$

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	$x_{g4} = w_4 / 2 = \mathbf{300 \text{ mm}}$
Vertical distance to centre of gravity gabion 4	$y_{g4} = h_4 / 2 = \mathbf{300 \text{ mm}}$
Weight of gabion 4	$W_{g4} = \gamma_d \times w_4 \times h_4 = \mathbf{9.0 \text{ kN/m}}$
Horizontal distance to centre of gravity gabion 5	$x_{g5} = w_5 / 2 + s_5 = \mathbf{300 \text{ mm}}$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Upper Concrete Block Retaining Wall - With Surcharge				Start page no./Revision 13	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Vertical distance to centre of gravity gabion 5 $y_{g5} = h_5 / 2 + h_4 = \mathbf{900 \text{ mm}}$
 Weight of gabion 5 $W_{g5} = \gamma_d \times w_5 \times h_5 = \mathbf{9.0 \text{ kN/m}}$
 Weight of entire gabion $W_g = W_{g4} + W_{g5} = \mathbf{18.0 \text{ kN/m}}$
 Horiz distance to centre of gravity entire gabion $x_g = ((W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = \mathbf{300 \text{ mm}}$
 Vert distance to centre of gravity entire gabion $y_g = ((W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = \mathbf{600 \text{ mm}}$
 Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{300 \text{ mm}}$
 Vertical change in height due to wall inclination $H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\varepsilon) - (x_{g5} + w_5/2) \times \sin(\varepsilon)) = \mathbf{0 \text{ mm}}$

Design dimensions

Effective angle of rear plane of wall $\alpha = 90 \text{ deg} + \varepsilon = \mathbf{90.0 \text{ deg}}$
 Effective face angle $\theta = 90 \text{ deg} - \varepsilon = \mathbf{90.0 \text{ deg}}$
 Effective height of wall $H = (y_{g5} + h_5 / 2) + (w_4 \times \sin(\varepsilon)) - H_f = \mathbf{1200 \text{ mm}}$
 Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\varepsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\varepsilon)) = \mathbf{1200 \text{ mm}}$
 Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))))^2) = \mathbf{0.315}$
 Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = \mathbf{4.3 \text{ kN/m}}$

Horizontal forces

Retained soil $F_{soil,h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{3.8 \text{ kN/m}}$
 Surcharge $F_{surch,h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{1.1 \text{ kN/m}}$

Vertical forces

Gabion weight $F_{gabion,v,f} = \gamma_G \times W_g = \mathbf{18.0 \text{ kN/m}}$
 Retained soil $F_{soil,v,f} = \gamma_G \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{2.0 \text{ kN/m}}$
 Surcharge $F_{surch,v,f} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{0.0 \text{ kN/m}}$

Overtuning stability - take moments about the toe

Overtuning moment $M_o = F_{soil,h} \times d_{h,soil} + F_{surch,h} \times d_{h,surch} = \mathbf{2.2 \text{ kNm/m}}$
 Restoring moment $M_R = F_{gabion,v,f} \times X_g + F_{soil,v,f} \times b_{v,soil} + F_{surch,v,f} \times b_{v,surch} = \mathbf{6.6 \text{ kNm/m}}$
 Factor of safety $FoS_M = M_R / M_o = \mathbf{3.061}$
 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 $T = F_{soil,h} + F_{surch,h} = \mathbf{4.9 \text{ kN/m}}$
 Total vertical force $N = F_{gabion,v,f} + F_{soil,v,f} + F_{surch,v,f} = \mathbf{20.0 \text{ kN/m}}$
 Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = \mathbf{4.9 \text{ kN/m}}$
 Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg,d}) = \mathbf{8.2 \text{ kN/m}}$
 Factor of safety $FoS_S = F_R / F_f = \mathbf{1.677}$
 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 4 and 5****Wall geometry**

Horizontal distance to centre of gravity gabion 5 $x_{g5} = w_5 / 2 = \mathbf{300 \text{ mm}}$
 Vertical distance to centre of gravity gabion 5 $y_{g5} = h_5 / 2 = \mathbf{300 \text{ mm}}$
 Weight of gabion 5 $W_{g5} = \gamma_d \times w_5 \times h_5 = \mathbf{9.0 \text{ kN/m}}$
 Weight of entire gabion $W_g = W_{g5} = \mathbf{9.0 \text{ kN/m}}$
 Horiz distance to centre of gravity entire gabion $x_g = ((W_{g5} \times x_{g5})) / W_g = \mathbf{300 \text{ mm}}$
 Vert distance to centre of gravity entire gabion $y_g = ((W_{g5} \times y_{g5})) / W_g = \mathbf{300 \text{ mm}}$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Upper Concrete Block Retaining Wall - With Surcharge				Start page no./Revision 14	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Correcting for wall inclination horiz dist

$$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{300 \text{ mm}}$$

Vertical change in height due to wall inclination

$$H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\varepsilon) - (x_{g5} + w_5/2) \times \sin(\varepsilon)) = \mathbf{0 \text{ mm}}$$

Design dimensions

Effective angle of rear plane of wall

$$\alpha = 90 \text{ deg} + \varepsilon = \mathbf{90.0 \text{ deg}}$$

Effective face angle

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

Effective height of wall

$$H = (y_{g5} + h_5 / 2) + (w_5 \times \sin(\varepsilon)) - H_f = \mathbf{600 \text{ mm}}$$

Height of wall from toe to front edge of top gabion

$$H_{\text{incl}} = ((y_{g5} + h_5 / 2) \times \cos(\varepsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\varepsilon)) = \mathbf{600 \text{ mm}}$$

Active pressure using Coulomb theory

$$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta)))^2}) = \mathbf{0.315}$$

Active thrust due to soil

$$P_{a,\text{soil}} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = \mathbf{1.1 \text{ kN/m}}$$

Horizontal forces

Retained soil

$$F_{\text{soil}_h} = \gamma_G \times P_{a,\text{soil}} \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{0.9 \text{ kN/m}}$$

Surcharge

$$F_{\text{surch}_h} = p_{o,Q} \times \gamma_Q \times K_a \times H \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{0.5 \text{ kN/m}}$$

Vertical forces

Gabion weight

$$F_{\text{gabion}_v,f} = \gamma_{G,f} \times W_g = \mathbf{9.0 \text{ kN/m}}$$

Retained soil

$$F_{\text{soil}_v,f} = \gamma_{G,f} \times P_{a,\text{soil}} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{0.5 \text{ kN/m}}$$

Surcharge

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

Overtuning stability - take moments about the toe

Overtuning moment

$$M_o = F_{\text{soil}_h} \times d_{h,\text{soil}} + F_{\text{surch}_h} \times d_{h,\text{surch}} = \mathbf{0.4 \text{ kNm/m}}$$

Restoring moment

$$M_R = F_{\text{gabion}_v,f} \times X_g + F_{\text{soil}_v,f} \times b_{v,\text{soil}} + F_{\text{surch}_v,f} \times b_{v,\text{surch}} = \mathbf{3.0 \text{ kNm/m}}$$

Factor of safety

$$FoS_M = M_R / M_o = \mathbf{8.549}$$

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

$$T = F_{\text{soil}_h} + F_{\text{surch}_h} = \mathbf{1.5 \text{ kN/m}}$$

Total vertical force

$$N = F_{\text{gabion}_v,f} + F_{\text{soil}_v,f} + F_{\text{surch}_v,f} = \mathbf{9.5 \text{ kN/m}}$$

Sliding force

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

Sliding resistance

$$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg,d}) = \mathbf{3.9 \text{ kN/m}}$$

Factor of safety

$$FoS_S = F_R / F_f = \mathbf{2.605}$$

Allowable factor of safety

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

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

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project

The Grawen, Merthyr Tydfil

Job no.

2610

Calcs for

Lower Concrete Block Retaining Wall - With Slope

Start page no./Revision

1

Calcs by

SDI

Calcs date

28/02/2024

Checked by

SF

Checked date

27/02/2024

Approved by

SDI

Approved date

27/02/2024

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 2.0.03

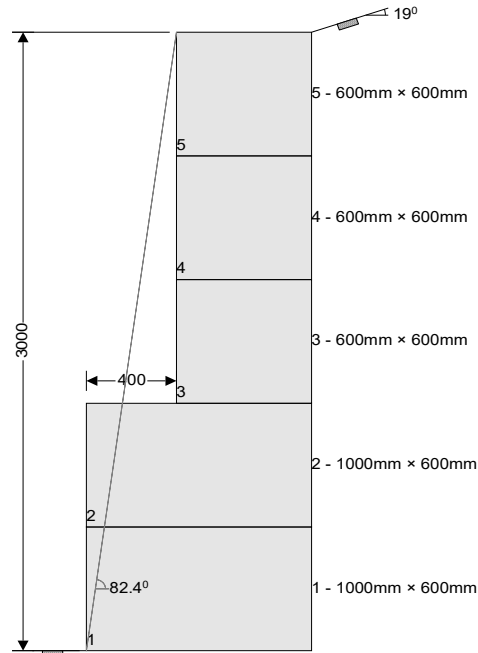
Design summary**Combination 1**

Action	Resistance	Force	FoS	Allowable FoS	Status
Overturning, sliding and bearing at base level					
Overturning (kNm/m)	50.3	32.9	1.531	1.000	PASS
Sliding (kN/m)	49.5	32.9	1.506	1.000	PASS
Bearing (kN/m ²)	125.0	137.9	0.907	1.000	FAIL
Eccentricity (mm)	Reaction acts within the middle third of base				PASS
Overturning and sliding between courses 1 and 2					
Overturning (kNm/m)	36.9	16.8	2.193	1.000	PASS
Sliding (kN/m)	26.8	21.0	1.272	1.000	PASS
Overturning and sliding between courses 2 and 3					
Overturning (kNm/m)	11.6	7.1	1.640	1.000	PASS
Sliding (kN/m)	16.8	11.8	1.417	1.000	PASS
Overturning and sliding between courses 3 and 4					
Overturning (kNm/m)	7.0	2.1	3.316	1.000	PASS
Sliding (kN/m)	10.5	5.3	1.998	1.000	PASS
Overturning and sliding between courses 4 and 5					
Overturning (kNm/m)	3.1	0.3	11.763	1.000	PASS
Sliding (kN/m)	4.9	1.3	3.741	1.000	PASS

Combination 2

Action	Resistance	Force	FoS	Allowable FoS	Status
Overturning, sliding and bearing at base level					
Overturning (kNm/m)	52.0	33.6	1.549	1.000	PASS
Sliding (kN/m)	40.5	33.6	1.207	1.000	PASS
Bearing (kN/m ²)	125.0	137.9	0.907	1.000	FAIL
Eccentricity (mm)	Reaction acts within the middle third of base				PASS
Overturning and sliding between courses 1 and 2					
Overturning (kNm/m)	38.0	17.2	2.209	1.000	PASS
Sliding (kN/m)	21.8	21.5	1.016	1.000	PASS
Overturning and sliding between courses 2 and 3					
Overturning (kNm/m)	12.0	7.3	1.656	1.000	PASS
Sliding (kN/m)	13.7	12.1	1.130	1.000	PASS
Overturning and sliding between courses 3 and 4					
Overturning (kNm/m)	7.1	2.1	3.321	1.000	PASS
Sliding (kN/m)	8.5	5.4	1.585	1.000	PASS
Overturning and sliding between courses 4 and 5					
Overturning (kNm/m)	3.1	0.3	11.666	1.000	PASS
Sliding (kN/m)	4.0	1.3	2.950	1.000	PASS

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Lower Concrete Block Retaining Wall - With Slope				Start page no./Revision 2	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024



Wall geometry

Width of gabion 1	$w_1 = 1000$ mm
Height of gabion 1	$h_1 = 600$ mm
Width of gabion 2	$w_2 = 1000$ mm
Height of gabion 2	$h_2 = 600$ mm
Step to front face between courses 1 and 2	$s_2 = 0$ mm
Width of gabion 3	$w_3 = 600$ mm
Height of gabion 3	$h_3 = 600$ mm
Step to front face between courses 2 and 3	$s_3 = 400$ mm
Width of gabion 4	$w_4 = 600$ mm
Height of gabion 4	$h_4 = 600$ mm
Step to front face between courses 3 and 4	$s_4 = 0$ mm
Width of gabion 5	$w_5 = 600$ mm
Height of gabion 5	$h_5 = 600$ mm
Step to front face between courses 4 and 5	$s_5 = 0$ mm
Wall inclination	$\varepsilon = 0$ deg

Gabion properties

Unit weight of fill	$\gamma_d = 25.0$ kN/m ³
Friction between gabions	$\delta_{bg,k} = 27.0$ deg

Loading

Soil properties

Slope of retained soil	$\beta = 19.0$ deg
Characteristic effective shearing resistance angle	$\phi'_{r,k} = 34.0$ deg
Characteristic saturated density of retained soil	$\gamma_{sr} = 19.0$ kN/m ³
Coefficient for wall friction	$k_{membrane} = 1.00$
Wall friction angle	$\delta_{r,k} = 34.0$ deg

**Tekla Tedds**

Groundsolve Ltd

Unit 1 Well House Barns
Chester Road

Bretton CH4 0DH

Project

The Grawen, Merthyr Tydfil

Job no.

2610

Calcs for

Lower Concrete Block Retaining Wall - With Slope

Start page no./Revision

3

Calcs by

SDI

Calcs date

28/02/2024

Checked by

SF

Checked date

27/02/2024

Approved by

SDI

Approved date

27/02/2024

Characteristic base friction angle

$$\delta_{bb,k} = 34.0 \text{ deg}$$

Bearing capacity of founding soil

$$q = 125 \text{ kN/m}^2$$

Wall geometry

Horizontal distance to centre of gravity gabion 1

$$x_{g1} = w_1 / 2 = 500 \text{ mm}$$

Vertical distance to centre of gravity gabion 1

$$y_{g1} = h_1 / 2 = 300 \text{ mm}$$

Weight of gabion 1

$$W_{g1} = \gamma_d \times w_1 \times h_1 = 15.0 \text{ kN/m}$$

Horizontal distance to centre of gravity gabion 2

$$x_{g2} = w_2 / 2 + s_2 = 500 \text{ mm}$$

Vertical distance to centre of gravity gabion 2

$$y_{g2} = h_2 / 2 + h_1 = 900 \text{ mm}$$

Weight of gabion 2

$$W_{g2} = \gamma_d \times w_2 \times h_2 = 15.0 \text{ kN/m}$$

Horizontal distance to centre of gravity gabion 3

$$x_{g3} = w_3 / 2 + s_2 + s_3 = 700 \text{ mm}$$

Vertical distance to centre of gravity gabion 3

$$y_{g3} = h_3 / 2 + h_1 + h_2 = 1500 \text{ mm}$$

Weight of gabion 3

$$W_{g3} = \gamma_d \times w_3 \times h_3 = 9.0 \text{ kN/m}$$

Horizontal distance to centre of gravity gabion 4

$$x_{g4} = w_4 / 2 + s_2 + s_3 + s_4 = 700 \text{ mm}$$

Vertical distance to centre of gravity gabion 4

$$y_{g4} = h_4 / 2 + h_1 + h_2 + h_3 = 2100 \text{ mm}$$

Weight of gabion 4

$$W_{g4} = \gamma_d \times w_4 \times h_4 = 9.0 \text{ kN/m}$$

Horizontal distance to centre of gravity gabion 5

$$x_{g5} = w_5 / 2 + s_2 + s_3 + s_4 + s_5 = 700 \text{ mm}$$

Vertical distance to centre of gravity gabion 5

$$y_{g5} = h_5 / 2 + h_1 + h_2 + h_3 + h_4 = 2700 \text{ mm}$$

Weight of gabion 5

$$W_{g5} = \gamma_d \times w_5 \times h_5 = 9.0 \text{ kN/m}$$

Weight of entire gabion

$$W_g = W_{g1} + W_{g2} + W_{g3} + W_{g4} + W_{g5} = 57.0 \text{ kN/m}$$

Horiz distance to centre of gravity entire gabion

$$X_g = ((W_{g1} \times x_{g1}) + (W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = 595 \text{ mm}$$

Vert distance to centre of gravity entire gabion

$$y_g = ((W_{g1} \times y_{g1}) + (W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = 1311 \text{ mm}$$

Correcting for wall inclination horiz dist

$$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = 595 \text{ mm}$$

Vertical change in height due to wall inclination

$$H_r = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\varepsilon) - (x_{g5} + w_5/2) \times \sin(\varepsilon)) = 0 \text{ mm}$$

Design dimensions

Effective angle of rear plane of wall

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

Effective face angle

$$\theta = \text{Atan}((y_{g5} + (h_5 / 2)) / ((x_{g5} - (w_5 / 2)))) - \varepsilon = 82.4 \text{ deg}$$

Effective height of wall

$$H = (y_{g5} + h_5 / 2) + (w_1 \times \sin(\varepsilon)) - H_r = 3000 \text{ mm}$$

Height of wall from toe to front edge of top gabion

$$H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\varepsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\varepsilon)) = 3000 \text{ mm}$$

Active pressure using Coulomb theory

$$K_a = \sin(\alpha + \phi'_{r,k})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,k}) \times (1 + \sqrt{(\sin(\phi'_{r,k} + \delta_{r,k}) \times \sin(\phi'_{r,k} - \beta) / (\sin(\alpha - \delta_{r,k}) \times \sin(\alpha + \beta))}))^2 = 0.344$$

Active thrust due to soil

$$P_{a,soil} = 0.5 \times K_a \times \gamma_{sr} \times H^2 = 29.4 \text{ kN/m}$$

Pressure at base**Horizontal forces**

Retained soil

$$F_{soil,h,q} = P_{a,soil} \times \cos(90 - \alpha + \delta_{r,k}) = 24.4 \text{ kN/m}$$

Height of soil thrust resolved vertically

$$d_{h,soil} = H / 3 - w_1 \times \sin(\varepsilon) = 1000 \text{ mm}$$

Vertical forces

Gabion weight

$$F_{gabion,v,q} = W_g = 57.0 \text{ kN/m}$$

Retained soil

$$F_{soil,v,q} = P_{a,soil} \times \sin(90 - \alpha + \delta_{r,k}) = 16.4 \text{ kN/m}$$

Horizontal dist to where soil thrust acts

$$b_{v,soil} = w_1 \times \cos(\varepsilon) - (H / 3) / \tan(\alpha) = 1000 \text{ mm}$$

Total horizontal unfactored force

$$T_q = F_{soil,h,q} = 24.4 \text{ kN/m}$$

Total vertical unfactored force

$$N_q = F_{gabion,v,q} + F_{soil,v,q} = 73.4 \text{ kN/m}$$

Force normal to base

$$N_s = N_q \times \cos(\varepsilon) + T_q \times \sin(\varepsilon) = 73.4 \text{ kN/m}$$

Total unfactored overturning force

$$M_{o,q} = F_{soil,h,q} \times d_{h,soil} = 24.4 \text{ kNm/m}$$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Lower Concrete Block Retaining Wall - With Slope				Start page no./Revision 4	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Total unfactored restoring force
Eccentricity

$$M_{R,q} = F_{gabion_v,q} \times X_g + F_{soil_v,q} \times b_{v,soil} = \mathbf{50.3 \text{ kNm/m}}$$

$$e = w_1 / 2 - (M_{R,q} - M_{o,q}) / N_s = \mathbf{146 \text{ mm}}$$

Reaction acts within middle third of base

Pressure at toe

$$\sigma_{toe} = N_s / w_1 \times (1 + (6 \times e / w_1)) = \mathbf{137.9 \text{ kN/m}^2}$$

Pressure at heel

$$\sigma_{heel} = N_s / w_1 \times (1 - (6 \times e / w_1)) = \mathbf{9.0 \text{ kN/m}^2}$$

Factor of safety

$$FoS_Q = q / \max(\sigma_{toe}, \sigma_{heel}) = \mathbf{0.907}$$

Allowable factor of safety

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

FAIL - Min allowable FoS for pressure to base exceeds design FoS for allowable bearing pressure

Design approach 1

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

Permanent unfavourable action	$\gamma_G = \mathbf{1.35}$
Permanent favourable action	$\gamma_{G,f} = \mathbf{1.00}$
Variable unfavourable action	$\gamma_Q = \mathbf{1.50}$
Variable favourable action	$\gamma_{Q,f} = \mathbf{0.00}$

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

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

Design soil properties

Design effective shearing resistance angle	$\phi'_{r,d} = \text{Atan}(\tan(\phi'_{r,k}) / \gamma_{\phi'}) = \mathbf{34.0 \text{ deg}}$
Design saturated density of retained soil	$\gamma_{s,d} = \gamma_{sr} / \gamma_r = \mathbf{19.0 \text{ kN/m}^3}$
Design wall friction angle	$\delta_{r,d} = \min(\text{atan}(\tan(\delta_{r,k}) / \gamma_{\phi'}), \phi'_{r,d} \times K_{\text{membrane}}) = \mathbf{34.0 \text{ deg}}$
Design base friction angle	$\delta_{bb,d} = \text{Atan}(\tan(\delta_{bb,k}) / \gamma_{\phi'}) = \mathbf{34.0 \text{ deg}}$
Design friction between gabions	$\delta_{bg,d} = \text{Atan}(\tan(\delta_{bg,k}) / \gamma_{\phi'}) = \mathbf{27.0 \text{ deg}}$
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))))^2) = \mathbf{0.344}$
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = \mathbf{29.4 \text{ kN/m}}$

Horizontal forces

Retained soil	$F_{soil_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{32.9 \text{ kN/m}}$
---------------	---

Vertical forces

Gabion weight	$F_{gabion_v,f} = \gamma_{G,f} \times W_g = \mathbf{57.0 \text{ kN/m}}$
Retained soil	$F_{soil_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{16.4 \text{ kN/m}}$

Overtuning stability - take moments about the toe

Overtuning moment	$M_o = F_{soil_h} \times d_{h,soil} = \mathbf{32.9 \text{ kNm/m}}$
Restoring moment	$M_R = F_{gabion_v,f} \times X_g + F_{soil_v,f} \times b_{v,soil} = \mathbf{50.3 \text{ kNm/m}}$
Factor of safety	$FoS_M = M_R / M_o = \mathbf{1.531}$
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	$T = F_{soil_h} = \mathbf{32.9 \text{ kN/m}}$
Total vertical force	$N = F_{gabion_v,f} + F_{soil_v,f} = \mathbf{73.4 \text{ kN/m}}$
Sliding force	$F_f = T \times \cos(\epsilon) - N \times \sin(\epsilon) = \mathbf{32.9 \text{ kN/m}}$
Sliding resistance	$F_R = (T \times \sin(\epsilon) + N \times \cos(\epsilon)) \times \tan(\delta_{bb,d}) = \mathbf{49.5 \text{ kN/m}}$
Factor of safety	$FoS_S = F_R / F_f = \mathbf{1.506}$
Allowable factor of safety	$FoS_{S_allow} = \mathbf{1.000}$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Lower Concrete Block Retaining Wall - With Slope				Start page no./Revision 5	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

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	$x_{g2} = w_2 / 2 = 500 \text{ mm}$
Vertical distance to centre of gravity gabion 2	$y_{g2} = h_2 / 2 = 300 \text{ mm}$
Weight of gabion 2	$W_{g2} = \gamma_d \times w_2 \times h_2 = 15.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 3	$x_{g3} = w_3 / 2 + s_3 = 700 \text{ mm}$
Vertical distance to centre of gravity gabion 3	$y_{g3} = h_3 / 2 + h_2 = 900 \text{ mm}$
Weight of gabion 3	$W_{g3} = \gamma_d \times w_3 \times h_3 = 9.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 4	$x_{g4} = w_4 / 2 + s_3 + s_4 = 700 \text{ mm}$
Vertical distance to centre of gravity gabion 4	$y_{g4} = h_4 / 2 + h_2 + h_3 = 1500 \text{ mm}$
Weight of gabion 4	$W_{g4} = \gamma_d \times w_4 \times h_4 = 9.0 \text{ kN/m}$
Horizontal distance to centre of gravity gabion 5	$x_{g5} = w_5 / 2 + s_3 + s_4 + s_5 = 700 \text{ mm}$
Vertical distance to centre of gravity gabion 5	$y_{g5} = h_5 / 2 + h_2 + h_3 + h_4 = 2100 \text{ mm}$
Weight of gabion 5	$W_{g5} = \gamma_d \times w_5 \times h_5 = 9.0 \text{ kN/m}$
Weight of entire gabion	$W_g = W_{g2} + W_{g3} + W_{g4} + W_{g5} = 42.0 \text{ kN/m}$
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = 629 \text{ mm}$
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = 1071 \text{ mm}$
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\epsilon) + y_g \times \sin(\epsilon) = 629 \text{ mm}$
Vertical change in height due to wall inclination	$H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\epsilon) - (x_{g5} + w_5/2) \times \sin(\epsilon)) = 0 \text{ mm}$

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90 \text{ deg} + \epsilon = 90.0 \text{ deg}$
Effective face angle	$\theta = \text{Atan}((y_{g5} + (h_5 / 2)) / ((x_{g5} - (w_5 / 2)))) - \epsilon = 80.5 \text{ deg}$
Effective height of wall	$H = (y_{g5} + h_5 / 2) + (w_2 \times \sin(\epsilon)) - H_f = 2400 \text{ mm}$
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\epsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\epsilon)) = 2400 \text{ mm}$
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2 = 0.344$
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = 18.8 \text{ kN/m}$

Horizontal forces

Retained soil	$F_{soil,h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = 21.0 \text{ kN/m}$
---------------	---

Vertical forces

Gabion weight	$F_{gabion,v,f} = \gamma_{G,f} \times W_g = 42.0 \text{ kN/m}$
Retained soil	$F_{soil,v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = 10.5 \text{ kN/m}$

Overturning stability - take moments about the toe

Overturning moment	$M_o = F_{soil,h} \times d_{h,soil} = 16.8 \text{ kNm/m}$
Restoring moment	$M_R = F_{gabion,v,f} \times X_g + F_{soil,v,f} \times b_{v,soil} = 36.9 \text{ kNm/m}$
Factor of safety	$FoSM = M_R / M_o = 2.193$
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	$T = F_{soil,h} = 21.0 \text{ kN/m}$
Total vertical force	$N = F_{gabion,v,f} + F_{soil,v,f} = 52.5 \text{ kN/m}$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Lower Concrete Block Retaining Wall - With Slope				Start page no./Revision 6	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Sliding force
Sliding resistance
Factor of safety
Allowable factor of safety

$$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = \mathbf{21.0 \text{ kN/m}}$$

$$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg,d}) = \mathbf{26.8 \text{ kN/m}}$$

$$FoS_S = F_R / F_f = \mathbf{1.272}$$

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

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
Vertical distance to centre of gravity gabion 3
Weight of gabion 3
Horizontal distance to centre of gravity gabion 4
Vertical distance to centre of gravity gabion 4
Weight of gabion 4
Horizontal distance to centre of gravity gabion 5
Vertical distance to centre of gravity gabion 5
Weight of gabion 5
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

$$x_{g3} = w_3 / 2 = \mathbf{300 \text{ mm}}$$

$$y_{g3} = h_3 / 2 = \mathbf{300 \text{ mm}}$$

$$W_{g3} = \gamma_d \times w_3 \times h_3 = \mathbf{9.0 \text{ kN/m}}$$

$$x_{g4} = w_4 / 2 + s_4 = \mathbf{300 \text{ mm}}$$

$$y_{g4} = h_4 / 2 + h_3 = \mathbf{900 \text{ mm}}$$

$$W_{g4} = \gamma_d \times w_4 \times h_4 = \mathbf{9.0 \text{ kN/m}}$$

$$x_{g5} = w_5 / 2 + s_4 + s_5 = \mathbf{300 \text{ mm}}$$

$$y_{g5} = h_5 / 2 + h_3 + h_4 = \mathbf{1500 \text{ mm}}$$

$$W_{g5} = \gamma_d \times w_5 \times h_5 = \mathbf{9.0 \text{ kN/m}}$$

$$W_g = W_{g3} + W_{g4} + W_{g5} = \mathbf{27.0 \text{ kN/m}}$$

$$x_g = ((W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = \mathbf{300 \text{ mm}}$$

$$y_g = ((W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = \mathbf{900 \text{ mm}}$$

$$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = \mathbf{300 \text{ mm}}$$

$$H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\varepsilon) - (x_{g5} + w_5/2) \times \sin(\varepsilon)) = \mathbf{0 \text{ mm}}$$

Design dimensions

Effective angle of rear plane of wall
Effective face angle
Effective height of wall
Height of wall from toe to front edge of top gabion
Active pressure using Coulomb theory

$$\alpha = 90 \text{ deg} + \varepsilon = \mathbf{90.0 \text{ deg}}$$

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

$$H = (y_{g5} + h_5 / 2) + (w_3 \times \sin(\varepsilon)) - H_f = \mathbf{1800 \text{ mm}}$$

$$H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\varepsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\varepsilon)) = \mathbf{1800 \text{ mm}}$$

$$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2 = \mathbf{0.344}$$

Active thrust due to soil

$$P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = \mathbf{10.6 \text{ kN/m}}$$

Horizontal forces

Retained soil

$$F_{soil,h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{11.8 \text{ kN/m}}$$

Vertical forces

Gabion weight

$$F_{gabion,v,f} = \gamma_{G,f} \times W_g = \mathbf{27.0 \text{ kN/m}}$$

Retained soil

$$F_{soil,v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{5.9 \text{ kN/m}}$$

Overturning stability - take moments about the toe

Overturning moment

$$M_o = F_{soil,h} \times d_{h,soil} = \mathbf{7.1 \text{ kNm/m}}$$

Restoring moment

$$M_R = F_{gabion,v,f} \times X_g + F_{soil,v,f} \times b_{v,soil} = \mathbf{11.6 \text{ kNm/m}}$$

Factor of safety

$$FoS_M = M_R / M_o = \mathbf{1.640}$$

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

$$T = F_{soil,h} = \mathbf{11.8 \text{ kN/m}}$$

Total vertical force

$$N = F_{gabion,v,f} + F_{soil,v,f} = \mathbf{32.9 \text{ kN/m}}$$

Sliding force

$$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = \mathbf{11.8 \text{ kN/m}}$$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Lower Concrete Block Retaining Wall - With Slope				Start page no./Revision 7	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Sliding resistance $F_R = (T \times \sin(\epsilon) + N \times \cos(\epsilon)) \times \tan(\delta_{bg,d}) = \mathbf{16.8 \text{ kN/m}}$

Factor of safety $FoS_S = F_R / F_f = \mathbf{1.417}$

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 3 and 4

Wall geometry

Horizontal distance to centre of gravity gabion 4 $x_{g4} = w_4 / 2 = \mathbf{300 \text{ mm}}$

Vertical distance to centre of gravity gabion 4 $y_{g4} = h_4 / 2 = \mathbf{300 \text{ mm}}$

Weight of gabion 4 $W_{g4} = \gamma_d \times w_4 \times h_4 = \mathbf{9.0 \text{ kN/m}}$

Horizontal distance to centre of gravity gabion 5 $x_{g5} = w_5 / 2 + s_5 = \mathbf{300 \text{ mm}}$

Vertical distance to centre of gravity gabion 5 $y_{g5} = h_5 / 2 + h_4 = \mathbf{900 \text{ mm}}$

Weight of gabion 5 $W_{g5} = \gamma_d \times w_5 \times h_5 = \mathbf{9.0 \text{ kN/m}}$

Weight of entire gabion $W_g = W_{g4} + W_{g5} = \mathbf{18.0 \text{ kN/m}}$

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = \mathbf{300 \text{ mm}}$

Vert distance to centre of gravity entire gabion $y_g = ((W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = \mathbf{600 \text{ mm}}$

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\epsilon) + y_g \times \sin(\epsilon) = \mathbf{300 \text{ mm}}$

Vertical change in height due to wall inclination $H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\epsilon) - (x_{g5} + w_5/2) \times \sin(\epsilon)) = \mathbf{0 \text{ mm}}$

Design dimensions

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

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

Effective height of wall $H = (y_{g5} + h_5 / 2) + (w_4 \times \sin(\epsilon)) - H_f = \mathbf{1200 \text{ mm}}$

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\epsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\epsilon)) = \mathbf{1200 \text{ mm}}$

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2 = \mathbf{0.344}$

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = \mathbf{4.7 \text{ kN/m}}$

Horizontal forces

Retained soil $F_{soil_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{5.3 \text{ kN/m}}$

Vertical forces

Gabion weight $F_{gabion_v,f} = \gamma_G \times W_g = \mathbf{18.0 \text{ kN/m}}$

Retained soil $F_{soil_v,f} = \gamma_G \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{2.6 \text{ kN/m}}$

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil_h} \times d_{h,soil} = \mathbf{2.1 \text{ kNm/m}}$

Restoring moment $M_R = F_{gabion_v,f} \times X_g + F_{soil_v,f} \times b_{v,soil} = \mathbf{7.0 \text{ kNm/m}}$

Factor of safety $FoS_M = M_R / M_o = \mathbf{3.316}$

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 $T = F_{soil_h} = \mathbf{5.3 \text{ kN/m}}$

Total vertical force $N = F_{gabion_v,f} + F_{soil_v,f} = \mathbf{20.6 \text{ kN/m}}$

Sliding force $F_f = T \times \cos(\epsilon) - N \times \sin(\epsilon) = \mathbf{5.3 \text{ kN/m}}$

Sliding resistance $F_R = (T \times \sin(\epsilon) + N \times \cos(\epsilon)) \times \tan(\delta_{bg,d}) = \mathbf{10.5 \text{ kN/m}}$

Factor of safety $FoS_S = F_R / F_f = \mathbf{1.998}$

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

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

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Lower Concrete Block Retaining Wall - With Slope				Start page no./Revision 8	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Check overturning and sliding between courses 4 and 5**Wall geometry**

Horizontal distance to centre of gravity gabion 5	$x_{g5} = w_5 / 2 = 300 \text{ mm}$
Vertical distance to centre of gravity gabion 5	$y_{g5} = h_5 / 2 = 300 \text{ mm}$
Weight of gabion 5	$W_{g5} = \gamma_d \times w_5 \times h_5 = 9.0 \text{ kN/m}$
Weight of entire gabion	$W_g = W_{g5} = 9.0 \text{ kN/m}$
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g5} \times x_{g5})) / W_g = 300 \text{ mm}$
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g5} \times y_{g5})) / W_g = 300 \text{ mm}$
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = 300 \text{ mm}$
Vertical change in height due to wall inclination	$H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\varepsilon) - (x_{g5} + w_5/2) \times \sin(\varepsilon)) = 0 \text{ mm}$

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90 \text{ deg} + \varepsilon = 90.0 \text{ deg}$
Effective face angle	$\theta = 90 \text{ deg} - \varepsilon = 90.0 \text{ deg}$
Effective height of wall	$H = (y_{g5} + h_5 / 2) + (w_5 \times \sin(\varepsilon)) - H_f = 600 \text{ mm}$
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\varepsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\varepsilon)) = 600 \text{ mm}$
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2) = 0.344$
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = 1.2 \text{ kN/m}$

Horizontal forces

Retained soil	$F_{soil,h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = 1.3 \text{ kN/m}$
---------------	--

Vertical forces

Gabion weight	$F_{gabion,v,f} = \gamma_{G,f} \times W_g = 9.0 \text{ kN/m}$
Retained soil	$F_{soil,v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = 0.7 \text{ kN/m}$

Overturning stability - take moments about the toe

Overturning moment	$M_o = F_{soil,h} \times d_{h,soil} = 0.3 \text{ kNm/m}$
Restoring moment	$M_R = F_{gabion,v,f} \times X_g + F_{soil,v,f} \times b_{v,soil} = 3.1 \text{ kNm/m}$
Factor of safety	$FoSM = M_R / M_o = 11.763$
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	$T = F_{soil,h} = 1.3 \text{ kN/m}$
Total vertical force	$N = F_{gabion,v,f} + F_{soil,v,f} = 9.7 \text{ kN/m}$
Sliding force	$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = 1.3 \text{ kN/m}$
Sliding resistance	$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg,d}) = 4.9 \text{ kN/m}$
Factor of safety	$FoSS = F_R / F_f = 3.741$
Allowable factor of safety	$FoSS_{allow} = 1.000$

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	$\gamma_{Q,f} = 0.00$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Lower Concrete Block Retaining Wall - With Slope				Start page no./Revision 9	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

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 $\phi'_{r,d} = \text{Atan}(\tan(\phi'_{r,k}) / \gamma_{\phi'}) = 28.4 \text{ deg}$

Design saturated density of retained soil $\gamma_{s,d} = \gamma_{sr} / \gamma_{\gamma} = 19.0 \text{ kN/m}^3$

Design wall friction angle $\delta_{r,d} = \min(\text{atan}(\tan(\delta_{r,k}) / \gamma_{\phi'}), \phi'_{r,d} \times K_{\text{membrane}}) = 28.4 \text{ deg}$

Design base friction angle $\delta_{bb,d} = \text{Atan}(\tan(\delta_{bb,k}) / \gamma_{\phi'}) = 28.4 \text{ deg}$

Design friction between gabions $\delta_{bg,d} = \text{Atan}(\tan(\delta_{bg,k}) / \gamma_{\phi'}) = 22.2 \text{ deg}$

Wall geometry

Horizontal distance to centre of gravity gabion 1 $x_{g1} = w_1 / 2 = 500 \text{ mm}$

Vertical distance to centre of gravity gabion 1 $y_{g1} = h_1 / 2 = 300 \text{ mm}$

Weight of gabion 1 $W_{g1} = \gamma_d \times w_1 \times h_1 = 15.0 \text{ kN/m}$

Horizontal distance to centre of gravity gabion 2 $x_{g2} = w_2 / 2 + s_2 = 500 \text{ mm}$

Vertical distance to centre of gravity gabion 2 $y_{g2} = h_2 / 2 + h_1 = 900 \text{ mm}$

Weight of gabion 2 $W_{g2} = \gamma_d \times w_2 \times h_2 = 15.0 \text{ kN/m}$

Horizontal distance to centre of gravity gabion 3 $x_{g3} = w_3 / 2 + s_2 + s_3 = 700 \text{ mm}$

Vertical distance to centre of gravity gabion 3 $y_{g3} = h_3 / 2 + h_1 + h_2 = 1500 \text{ mm}$

Weight of gabion 3 $W_{g3} = \gamma_d \times w_3 \times h_3 = 9.0 \text{ kN/m}$

Horizontal distance to centre of gravity gabion 4 $x_{g4} = w_4 / 2 + s_2 + s_3 + s_4 = 700 \text{ mm}$

Vertical distance to centre of gravity gabion 4 $y_{g4} = h_4 / 2 + h_1 + h_2 + h_3 = 2100 \text{ mm}$

Weight of gabion 4 $W_{g4} = \gamma_d \times w_4 \times h_4 = 9.0 \text{ kN/m}$

Horizontal distance to centre of gravity gabion 5 $x_{g5} = w_5 / 2 + s_2 + s_3 + s_4 + s_5 = 700 \text{ mm}$

Vertical distance to centre of gravity gabion 5 $y_{g5} = h_5 / 2 + h_1 + h_2 + h_3 + h_4 = 2700 \text{ mm}$

Weight of gabion 5 $W_{g5} = \gamma_d \times w_5 \times h_5 = 9.0 \text{ kN/m}$

Weight of entire gabion $W_g = W_{g1} + W_{g2} + W_{g3} + W_{g4} + W_{g5} = 57.0 \text{ kN/m}$

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g1} \times x_{g1}) + (W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = 595 \text{ mm}$

Vert distance to centre of gravity entire gabion $y_g = ((W_{g1} \times y_{g1}) + (W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = 1311 \text{ mm}$

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\epsilon) + y_g \times \sin(\epsilon) = 595 \text{ mm}$

Vertical change in height due to wall inclination $H_r = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\epsilon) - (x_{g5} + w_5/2) \times \sin(\epsilon)) = 0 \text{ mm}$

Design dimensions

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

Effective face angle $\theta = \text{Atan}((y_{g5} + (h_5 / 2)) / ((x_{g5} - (w_5 / 2)))) - \epsilon = 82.4 \text{ deg}$

Effective height of wall $H = (y_{g5} + h_5 / 2) + (w_1 \times \sin(\epsilon)) - H_r = 3000 \text{ mm}$

Height of wall from toe to front edge of top gabion $H_{\text{incl}} = ((y_{g5} + h_5 / 2) \times \cos(\epsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\epsilon)) = 3000 \text{ mm}$

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))})^2) = 0.446$

Active thrust due to soil $P_{a,\text{soil}} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = 38.2 \text{ kN/m}$

Horizontal forces

Retained soil $F_{\text{soil}_h} = \gamma_G \times P_{a,\text{soil}} \times \cos(90 - \alpha + \delta_{r,d}) = 33.6 \text{ kN/m}$

Vertical forces

Gabion weight $F_{\text{gabion}_v,f} = \gamma_{G,f} \times W_g = 57.0 \text{ kN/m}$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Lower Concrete Block Retaining Wall - With Slope				Start page no./Revision 10	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Retained soil

$$F_{\text{soil}_v,f} = \gamma_{G,f} \times P_{a,\text{soil}} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{18.1 \text{ kN/m}}$$

Overtuning stability - take moments about the toe

Overtuning moment

$$M_o = F_{\text{soil}_h} \times d_{h,\text{soil}} = \mathbf{33.6 \text{ kNm/m}}$$

Restoring moment

$$M_R = F_{\text{gabion}_v,f} \times X_g + F_{\text{soil}_v,f} \times b_{v,\text{soil}} = \mathbf{52.0 \text{ kNm/m}}$$

Factor of safety

$$FoS_M = M_R / M_o = \mathbf{1.549}$$

Allowable factor of safety

$$FoS_{M,\text{allow}} = \mathbf{1.000}$$

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

$$T = F_{\text{soil}_h} = \mathbf{33.6 \text{ kN/m}}$$

Total vertical force

$$N = F_{\text{gabion}_v,f} + F_{\text{soil}_v,f} = \mathbf{75.1 \text{ kN/m}}$$

Sliding force

$$F_f = T \times \cos(\epsilon) - N \times \sin(\epsilon) = \mathbf{33.6 \text{ kN/m}}$$

Sliding resistance

$$F_R = (T \times \sin(\epsilon) + N \times \cos(\epsilon)) \times \tan(\delta_{bb,d}) = \mathbf{40.5 \text{ kN/m}}$$

Factor of safety

$$FoS_S = F_R / F_f = \mathbf{1.207}$$

Allowable factor of safety

$$FoS_{S,\text{allow}} = \mathbf{1.000}$$

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

$$x_{g2} = w_2 / 2 = \mathbf{500 \text{ mm}}$$

Vertical distance to centre of gravity gabion 2

$$y_{g2} = h_2 / 2 = \mathbf{300 \text{ mm}}$$

Weight of gabion 2

$$W_{g2} = \gamma_d \times w_2 \times h_2 = \mathbf{15.0 \text{ kN/m}}$$

Horizontal distance to centre of gravity gabion 3

$$x_{g3} = w_3 / 2 + s_3 = \mathbf{700 \text{ mm}}$$

Vertical distance to centre of gravity gabion 3

$$y_{g3} = h_3 / 2 + h_2 = \mathbf{900 \text{ mm}}$$

Weight of gabion 3

$$W_{g3} = \gamma_d \times w_3 \times h_3 = \mathbf{9.0 \text{ kN/m}}$$

Horizontal distance to centre of gravity gabion 4

$$x_{g4} = w_4 / 2 + s_3 + s_4 = \mathbf{700 \text{ mm}}$$

Vertical distance to centre of gravity gabion 4

$$y_{g4} = h_4 / 2 + h_2 + h_3 = \mathbf{1500 \text{ mm}}$$

Weight of gabion 4

$$W_{g4} = \gamma_d \times w_4 \times h_4 = \mathbf{9.0 \text{ kN/m}}$$

Horizontal distance to centre of gravity gabion 5

$$x_{g5} = w_5 / 2 + s_3 + s_4 + s_5 = \mathbf{700 \text{ mm}}$$

Vertical distance to centre of gravity gabion 5

$$y_{g5} = h_5 / 2 + h_2 + h_3 + h_4 = \mathbf{2100 \text{ mm}}$$

Weight of gabion 5

$$W_{g5} = \gamma_d \times w_5 \times h_5 = \mathbf{9.0 \text{ kN/m}}$$

Weight of entire gabion

$$W_g = W_{g2} + W_{g3} + W_{g4} + W_{g5} = \mathbf{42.0 \text{ kN/m}}$$

Horiz distance to centre of gravity entire gabion

$$X_g = ((W_{g2} \times x_{g2}) + (W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = \mathbf{629 \text{ mm}}$$

Vert distance to centre of gravity entire gabion

$$y_g = ((W_{g2} \times y_{g2}) + (W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = \mathbf{1071 \text{ mm}}$$

Correcting for wall inclination horiz dist

$$X_g = x_g \times \cos(\epsilon) + y_g \times \sin(\epsilon) = \mathbf{629 \text{ mm}}$$

Vertical change in height due to wall inclination

$$H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\epsilon) - (x_{g5} + w_5/2) \times \sin(\epsilon)) = \mathbf{0 \text{ mm}}$$

Design dimensions

Effective angle of rear plane of wall

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

Effective face angle

$$\theta = \text{Atan}((y_{g5} + (h_5 / 2)) / ((x_{g5} - (w_5 / 2)))) - \epsilon = \mathbf{80.5 \text{ deg}}$$

Effective height of wall

$$H = (y_{g5} + h_5 / 2) + (w_2 \times \sin(\epsilon)) - H_f = \mathbf{2400 \text{ mm}}$$

Height of wall from toe to front edge of top gabion

$$H_{\text{incl}} = ((y_{g5} + h_5 / 2) \times \cos(\epsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\epsilon)) = \mathbf{2400 \text{ mm}}$$

Active pressure using Coulomb theory

$$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2) = \mathbf{0.446}$$

Active thrust due to soil

$$P_{a,\text{soil}} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = \mathbf{24.4 \text{ kN/m}}$$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Lower Concrete Block Retaining Wall - With Slope				Start page no./Revision 11	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Horizontal forces

Retained soil $F_{\text{soil}_h} = \gamma_G \times P_{a,\text{soil}} \times \cos(90 - \alpha + \delta_{r,d}) = 21.5 \text{ kN/m}$

Vertical forces

Gabion weight $F_{\text{gabion}_v,f} = \gamma_{G,f} \times W_g = 42.0 \text{ kN/m}$

Retained soil $F_{\text{soil}_v,f} = \gamma_{G,f} \times P_{a,\text{soil}} \times \sin(90 - \alpha + \delta_{r,d}) = 11.6 \text{ kN/m}$

Overtuning stability - take moments about the toe

Overtuning moment $M_o = F_{\text{soil}_h} \times d_{h,\text{soil}} = 17.2 \text{ kNm/m}$

Restoring moment $M_R = F_{\text{gabion}_v,f} \times X_g + F_{\text{soil}_v,f} \times b_{v,\text{soil}} = 38.0 \text{ kNm/m}$

Factor of safety $FoS_M = M_R / M_o = 2.209$

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 $T = F_{\text{soil}_h} = 21.5 \text{ kN/m}$

Total vertical force $N = F_{\text{gabion}_v,f} + F_{\text{soil}_v,f} = 53.6 \text{ kN/m}$

Sliding force $F_f = T \times \cos(\epsilon) - N \times \sin(\epsilon) = 21.5 \text{ kN/m}$

Sliding resistance $F_R = (T \times \sin(\epsilon) + N \times \cos(\epsilon)) \times \tan(\delta_{bg,d}) = 21.8 \text{ kN/m}$

Factor of safety $FoS_S = F_R / F_f = 1.016$

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 $x_{g3} = w_3 / 2 = 300 \text{ mm}$

Vertical distance to centre of gravity gabion 3 $y_{g3} = h_3 / 2 = 300 \text{ mm}$

Weight of gabion 3 $W_{g3} = \gamma_d \times w_3 \times h_3 = 9.0 \text{ kN/m}$

Horizontal distance to centre of gravity gabion 4 $x_{g4} = w_4 / 2 + s_4 = 300 \text{ mm}$

Vertical distance to centre of gravity gabion 4 $y_{g4} = h_4 / 2 + h_3 = 900 \text{ mm}$

Weight of gabion 4 $W_{g4} = \gamma_d \times w_4 \times h_4 = 9.0 \text{ kN/m}$

Horizontal distance to centre of gravity gabion 5 $x_{g5} = w_5 / 2 + s_4 + s_5 = 300 \text{ mm}$

Vertical distance to centre of gravity gabion 5 $y_{g5} = h_5 / 2 + h_3 + h_4 = 1500 \text{ mm}$

Weight of gabion 5 $W_{g5} = \gamma_d \times w_5 \times h_5 = 9.0 \text{ kN/m}$

Weight of entire gabion $W_g = W_{g3} + W_{g4} + W_{g5} = 27.0 \text{ kN/m}$

Horiz distance to centre of gravity entire gabion $X_g = ((W_{g3} \times x_{g3}) + (W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = 300 \text{ mm}$

Vert distance to centre of gravity entire gabion $y_g = ((W_{g3} \times y_{g3}) + (W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = 900 \text{ mm}$

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\epsilon) + y_g \times \sin(\epsilon) = 300 \text{ mm}$

Vertical change in height due to wall inclination $H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\epsilon) - (x_{g5} + w_5/2) \times \sin(\epsilon)) = 0 \text{ mm}$

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 $H = (y_{g5} + h_5 / 2) + (w_3 \times \sin(\epsilon)) - H_f = 1800 \text{ mm}$

Height of wall from toe to front edge of top gabion $H_{\text{incl}} = ((y_{g5} + h_5 / 2) \times \cos(\epsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\epsilon)) = 1800 \text{ mm}$

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2 = 0.446$

Active thrust due to soil $P_{a,\text{soil}} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = 13.7 \text{ kN/m}$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Lower Concrete Block Retaining Wall - With Slope				Start page no./Revision 12	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Horizontal forces

Retained soil $F_{soil_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = 12.1 \text{ kN/m}$

Vertical forces

Gabion weight $F_{gabion_v,f} = \gamma_{G,f} \times W_g = 27.0 \text{ kN/m}$

Retained soil $F_{soil_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r,d}) = 6.5 \text{ kN/m}$

Overtuning stability - take moments about the toe

Overtuning moment $M_o = F_{soil_h} \times d_{h,soil} = 7.3 \text{ kNm/m}$

Restoring moment $M_R = F_{gabion_v,f} \times X_g + F_{soil_v,f} \times b_{v,soil} = 12.0 \text{ kNm/m}$

Factor of safety $FoSM = M_R / M_o = 1.656$

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 $T = F_{soil_h} = 12.1 \text{ kN/m}$

Total vertical force $N = F_{gabion_v,f} + F_{soil_v,f} = 33.5 \text{ kN/m}$

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = 12.1 \text{ kN/m}$

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg,d}) = 13.7 \text{ kN/m}$

Factor of safety $FoS_S = F_R / F_f = 1.130$

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 $x_{g4} = w_4 / 2 = 300 \text{ mm}$

Vertical distance to centre of gravity gabion 4 $y_{g4} = h_4 / 2 = 300 \text{ mm}$

Weight of gabion 4 $W_{g4} = \gamma_d \times w_4 \times h_4 = 9.0 \text{ kN/m}$

Horizontal distance to centre of gravity gabion 5 $x_{g5} = w_5 / 2 + s_5 = 300 \text{ mm}$

Vertical distance to centre of gravity gabion 5 $y_{g5} = h_5 / 2 + h_4 = 900 \text{ mm}$

Weight of gabion 5 $W_{g5} = \gamma_d \times w_5 \times h_5 = 9.0 \text{ kN/m}$

Weight of entire gabion $W_g = W_{g4} + W_{g5} = 18.0 \text{ kN/m}$

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g4} \times x_{g4}) + (W_{g5} \times x_{g5})) / W_g = 300 \text{ mm}$

Vert distance to centre of gravity entire gabion $y_g = ((W_{g4} \times y_{g4}) + (W_{g5} \times y_{g5})) / W_g = 600 \text{ mm}$

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon) = 300 \text{ mm}$

Vertical change in height due to wall inclination $H_r = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\varepsilon) - (x_{g5} + w_5/2) \times \sin(\varepsilon)) = 0 \text{ mm}$

Design dimensions

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

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

Effective height of wall $H = (y_{g5} + h_5 / 2) + (w_4 \times \sin(\varepsilon)) - H_r = 1200 \text{ mm}$

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g5} + h_5 / 2) \times \cos(\varepsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\varepsilon)) = 1200 \text{ mm}$

Active pressure using Coulomb theory $K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2 = 0.446$

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = 6.1 \text{ kN/m}$

Horizontal forces

Retained soil $F_{soil_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r,d}) = 5.4 \text{ kN/m}$

Vertical forces

Gabion weight $F_{gabion_v,f} = \gamma_{G,f} \times W_g = 18.0 \text{ kN/m}$

**Tekla Tedds**

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Lower Concrete Block Retaining Wall - With Slope				Start page no./Revision 13	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

Retained soil

$$F_{\text{soil}_v,f} = \gamma_{G,f} \times P_{a,\text{soil}} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{2.9 \text{ kN/m}}$$

Overtuning stability - take moments about the toe

Overtuning moment

$$M_o = F_{\text{soil}_h} \times d_{h,\text{soil}} = \mathbf{2.1 \text{ kNm/m}}$$

Restoring moment

$$M_R = F_{\text{gabion}_v,f} \times X_g + F_{\text{soil}_v,f} \times b_{v,\text{soil}} = \mathbf{7.1 \text{ kNm/m}}$$

Factor of safety

$$FoS_M = M_R / M_o = \mathbf{3.321}$$

Allowable factor of safety

$$FoS_{M,\text{allow}} = \mathbf{1.000}$$

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

$$T = F_{\text{soil}_h} = \mathbf{5.4 \text{ kN/m}}$$

Total vertical force

$$N = F_{\text{gabion}_v,f} + F_{\text{soil}_v,f} = \mathbf{20.9 \text{ kN/m}}$$

Sliding force

$$F_f = T \times \cos(\epsilon) - N \times \sin(\epsilon) = \mathbf{5.4 \text{ kN/m}}$$

Sliding resistance

$$F_R = (T \times \sin(\epsilon) + N \times \cos(\epsilon)) \times \tan(\delta_{bg,d}) = \mathbf{8.5 \text{ kN/m}}$$

Factor of safety

$$FoS_S = F_R / F_f = \mathbf{1.585}$$

Allowable factor of safety

$$FoS_{S,\text{allow}} = \mathbf{1.000}$$

PASS - Design FOS for sliding exceeds min allowable FOS for sliding**Check overturning and sliding between courses 4 and 5****Wall geometry**

Horizontal distance to centre of gravity gabion 5

$$x_{g5} = w_5 / 2 = \mathbf{300 \text{ mm}}$$

Vertical distance to centre of gravity gabion 5

$$y_{g5} = h_5 / 2 = \mathbf{300 \text{ mm}}$$

Weight of gabion 5

$$W_{g5} = \gamma_d \times w_5 \times h_5 = \mathbf{9.0 \text{ kN/m}}$$

Weight of entire gabion

$$W_g = W_{g5} = \mathbf{9.0 \text{ kN/m}}$$

Horiz distance to centre of gravity entire gabion

$$x_g = ((W_{g5} \times x_{g5})) / W_g = \mathbf{300 \text{ mm}}$$

Vert distance to centre of gravity entire gabion

$$y_g = ((W_{g5} \times y_{g5})) / W_g = \mathbf{300 \text{ mm}}$$

Correcting for wall inclination horiz dist

$$X_g = x_g \times \cos(\epsilon) + y_g \times \sin(\epsilon) = \mathbf{300 \text{ mm}}$$

Vertical change in height due to wall inclination

$$H_f = y_{g5} + h_5/2 - ((y_{g5} + h_5/2) \times \cos(\epsilon) - (x_{g5} + w_5/2) \times \sin(\epsilon)) = \mathbf{0 \text{ mm}}$$

Design dimensions

Effective angle of rear plane of wall

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

Effective face angle

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

Effective height of wall

$$H = (y_{g5} + h_5 / 2) + (w_5 \times \sin(\epsilon)) - H_f = \mathbf{600 \text{ mm}}$$

Height of wall from toe to front edge of top gabion

$$H_{\text{incl}} = ((y_{g5} + h_5 / 2) \times \cos(\epsilon) - (x_{g5} - (w_5 / 2)) \times \sin(\epsilon)) = \mathbf{600 \text{ mm}}$$

Active pressure using Coulomb theory

$$K_a = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times (1 + \sqrt{(\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))}))^2) = \mathbf{0.446}$$

Active thrust due to soil

$$P_{a,\text{soil}} = 0.5 \times K_a \times \gamma_{s,d} \times H^2 = \mathbf{1.5 \text{ kN/m}}$$

Horizontal forces

Retained soil

$$F_{\text{soil}_h} = \gamma_G \times P_{a,\text{soil}} \times \cos(90 - \alpha + \delta_{r,d}) = \mathbf{1.3 \text{ kN/m}}$$

Vertical forces

Gabion weight

$$F_{\text{gabion}_v,f} = \gamma_{G,f} \times W_g = \mathbf{9.0 \text{ kN/m}}$$

Retained soil

$$F_{\text{soil}_v,f} = \gamma_{G,f} \times P_{a,\text{soil}} \times \sin(90 - \alpha + \delta_{r,d}) = \mathbf{0.7 \text{ kN/m}}$$

Overtuning stability - take moments about the toe

Overtuning moment

$$M_o = F_{\text{soil}_h} \times d_{h,\text{soil}} = \mathbf{0.3 \text{ kNm/m}}$$

Restoring moment

$$M_R = F_{\text{gabion}_v,f} \times X_g + F_{\text{soil}_v,f} \times b_{v,\text{soil}} = \mathbf{3.1 \text{ kNm/m}}$$

Factor of safety

$$FoS_M = M_R / M_o = \mathbf{11.666}$$

Allowable factor of safety

$$FoS_{M,\text{allow}} = \mathbf{1.000}$$

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



Tekla Tedds

Groundsolve Ltd
Unit 1 Well House Barns
Chester Road
Bretton CH4 0DH

Project The Grawen, Merthyr Tydfil				Job no. 2610	
Calcs for Lower Concrete Block Retaining Wall - With Slope				Start page no./Revision 14	
Calcs by SDI	Calcs date 28/02/2024	Checked by SF	Checked date 27/02/2024	Approved by SDI	Approved date 27/02/2024

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

Total horizontal force

$$T = F_{\text{soil}_h} = 1.3 \text{ kN/m}$$

Total vertical force

$$N = F_{\text{gabion}_v,f} + F_{\text{soil}_v,f} = 9.7 \text{ kN/m}$$

Sliding force

$$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) = 1.3 \text{ kN/m}$$

Sliding resistance

$$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bg,d}) = 4.0 \text{ kN/m}$$

Factor of safety

$$FoS_S = F_R / F_f = 2.950$$

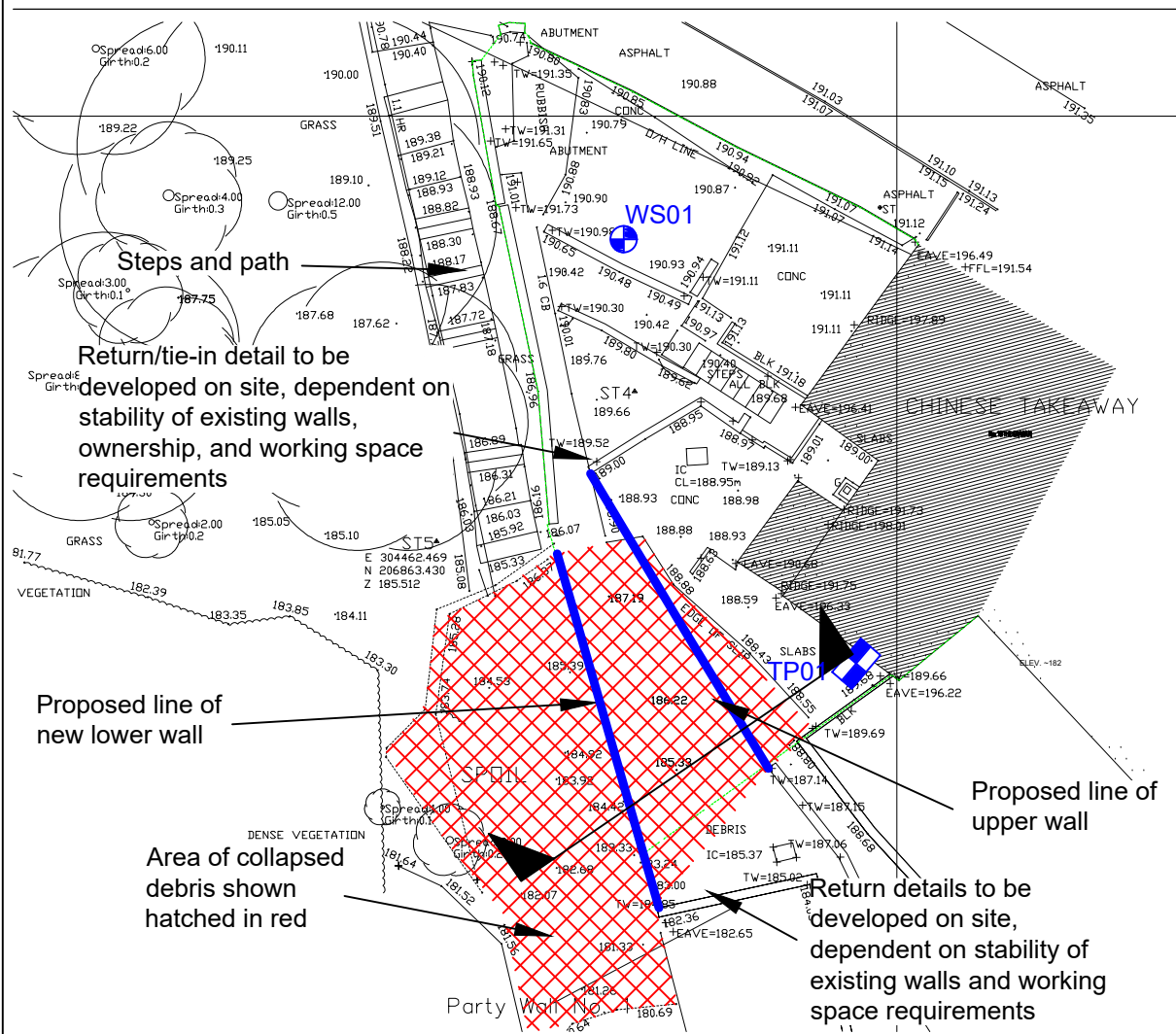
Allowable factor of safety

$$FoS_{S_allow} = 1.000$$

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

APPENDIX B

Design Drawing



Site Plan

Scale 1:200 @ A3

Notes

General

1. These notes and drawing should be read in conjunction with the Designer Risk Register.
2. All underground services shall be identified prior to any excavation works commencing. A foul drain crosses the collapsed area at some point, and is assumed to run into a drain in the access lane.
3. Access to the site is available from The Grawen road at the top of the steps, or via an access land from below. The lower access lane is assumed to be the main access for these works.
4. The contractor shall ensure that the site access is suitable for all operations that are required on site, particularly excavation/earthworks plant access and for any lifting operations required including the precast concrete units proposed for use.

Spoil Removal

5. The existing spoil/collapse debris will need to be removed from site before any further works can be undertaken.
6. Japanese Knotweed has been identified growing in this material, and therefore appropriate disposal routes will need to be identified by the appointed contractor. It may be possible to sort the debris to remove coarse stone and masonry materials, which could be disposed of separately or crushed and reused in the works.

Earthworks and Temporary Works

7. All earthworks carried out on site shall be carried out in accordance with the Manual of Contract Documents for Highway Works (MCDHW), Volume 1 Specification for Highway Works Series 600 Earthworks. This can be downloaded from <http://www.standardsforhighways.co.uk/ha/standards/mchw/vol1/index.htm>
8. The proposed temporary works arrangements should be submitted by the contractor for approval by the designer prior to works beginning.
9. Temporary cuts in the glacial till are anticipated to be possible at angles of 60°.
10. All temporary cuts shall be carried out in bays of no greater than 4m length, with the retaining structure constructed and backfilled within the bay before a second bay is cut, in order to maintain stability of the overall slope.
11. Cuts into the upper slope adjacent to the building shall be avoided as far as is practical, and the proposed design takes this into account.
12. The precast concrete block walls should be backfilled in layers as each layer of blocks is constructed.
13. Methods of compaction shall be in accordance with MCDHW Series 600 Clause 612.

14. Any material proposed for use in the earthworks, i.e., for retaining wall backfill, shall be classified in accordance with the SHW and confirmed as suitable by the designer prior to use.
15. All placed backfill material shall be suitably benched into the existing slope, as far as can be achieved given the stability concerns.

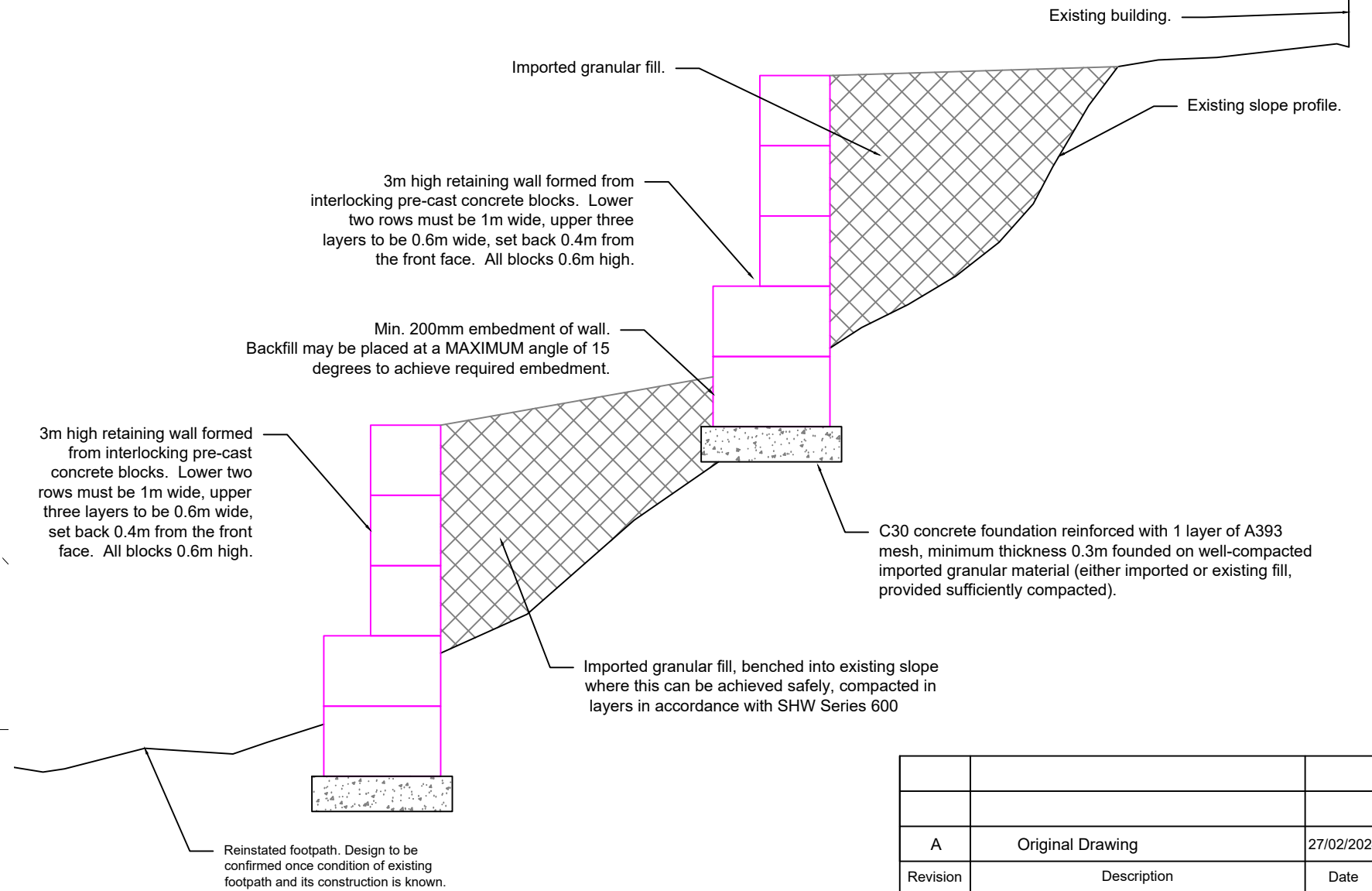
Interlocking Precast Concrete Block Walls

16. The walls are to extend the lengths shown.
17. The foundations shall be a minimum thickness of 0.3m, extend at least 100mm outside the block footprints, and be reinforced with 1 layer of A393 mesh.
18. The precast blocks shall have a cross-section of 600mm x 600mm for the upper three rows, and 1000mm x 600mm for the lower rows. The lengths of the blocks may vary to suit the site and interlocking pattern required.
19. The upper three courses shall be set back 0.4m from the front face of the wall, to maintain stability.
20. The end tie-in or return details will need to be determined on site, and will be subject to ownership of the adjacent walls, any requirement to remove or replace unstable sections, and working space constraints.
21. The joints between the blocks should not be infilled, to allow any water collecting behind the wall to drain and avoid build-up of any water pressure on the walls.

Proposed Remedial Works

Section line indicated on site plan

Scale 1:50 @ A3



A	Original Drawing	27/02/2024
Revision	Description	Date

GroundSolve Ltd

Consulting Geotechnical, Engineering Geology
and Environmental Engineers

Unit 1, Charter Court
Well House Barns
Chester Road Bretton
Flintshire CH4 0DH

Job Title

THE GRAWEN, MERTHYR TYDFIL

Drawing Title

COLLAPSED RETAINING WALLS PROPOSED REMEDIAL WORKS GENERAL ARRANGEMENT

Drawing Scale	Drawn By	Approved By
As Shown	SDI	SF
Drawing Status		Date of Issue
FOR TENDER		27/02/2024
Drawing No		Revision
2610/TD/02		A

APPENDIX C

Designer's Risk Register

Project The Grawen, Merthyr Tydfil

Job Number

2610

Package/Topic Remedial Works - Interlocking pre-cast concrete block walls

Design Stage

Tender

Remember: Avoid – Reduce – Control and communicate relevant information to others (CDM Regulation 13)

Date (+ initials)	Area/Location of Risk Exposure	Description of Hazard and Risk Exposue	Mitigation of Risk (Potential or Achieved)	A	R	C	Further Action	by	Status
									Active/closed
02/24 SDI	Services	Buried services may be present beneath the wall locations. A foul drain is anticipated to cross the site at the northernmost extent of the proposed works, and enter an assumed drain in the footpath.	Contractor to identify services and adopt methods of working that take these into account.			✓	Contractor to consider this in their method of working	Contractor	Active
02/24 SDI	Instability of the existing slope	The slope is currently covered by the collapse debris, and may be destabilised by the removal of this material	Contractor to provide a method statement showing their intended method of working and temporary works arrangements.			✓	Contractor to consider this in their method of working	Contractor	Active
02/24 SDI	Groundwater / surface water	Potential for water to collect behind walls	Groundwater not encountered in slope during any site visits, and slope comprises granular material that will allow water to flow through rather than collecting. Gaps between blocks are not to be sealed, to allow any water that does collect to escape. Consideration should be given by the contractor to installation of formal drainage measures if a discharge point is available. Surface water from the existing building drainage should not be allowed to discharge into or onto the slope. The existing drainage arrangement should be checked as part of the works, and any flows into the slope diverted accordingly.			✓	Contractor to consider this in their method of working	Contractor/client	Active
02/24 SDI	Instability of the temporary cut slopes	The cut slopes will be overly steep in the temporary case before backfilling.	Temporary cuts shall be limited to bays of 4m length, and slope angles of up to 60 degrees in any glacial till encountered. New retaining walls to be backfilled up to each finished course as construction progresses.			✓	Contractor to consider this in their method of working	Contractor	Active
02/24 SDI	Access	Difficult access to site will restrict plant that may be used, especially for lifting operations				✓	Contractor to consider this in their method of working	Contractor	Active

Date (+ initials)	Area/Location of Risk Exposure	Description of Hazard and Risk Exposue	Mitigation of Risk (Potential or Achieved)	A	R	C	Further Action	by	Status
									Active/closed
02/24 SDI	Japanese Knotweed	Knotweed has been identified growing within the slope and in the collapse debris	The material will need to be disposed of to a suitably licensed tip. Any knotweed remaining the slope will need to be left in place and treated accordingly, to avoid destabilising the slope further.			✓	Contractor to consider this in their method of working	Contractor	Active
02/24 SDI	Tie-in to existing walls	The tie-in details have not been determined at this stage due to limited access until the debris is cleared. There may also be ownership issues that affect the requirements.	The contractor will need to consider how the proposed design can be tied into or terminate adjacent to the existing walls.			✓	Contractor to propsose a tie-in solution and agree with designer	Contractor/ Designer	Active