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Brief

It is proposed to demolish Building B. Retaining walls can be stabilised by vertical axial loads as will be provided by this gable wall. There are two possible actions. Firstly, water pressure from the canal pushing into the building. Secondly, earth pressure from the proposed HGV turning yard.

Retaining structure to canal

Note: a modified gabion wall analysis proforma has been used for the design.

RETAINING WALL ANLYSIS & DESIGN

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

Tedds calculation version 2.0.02

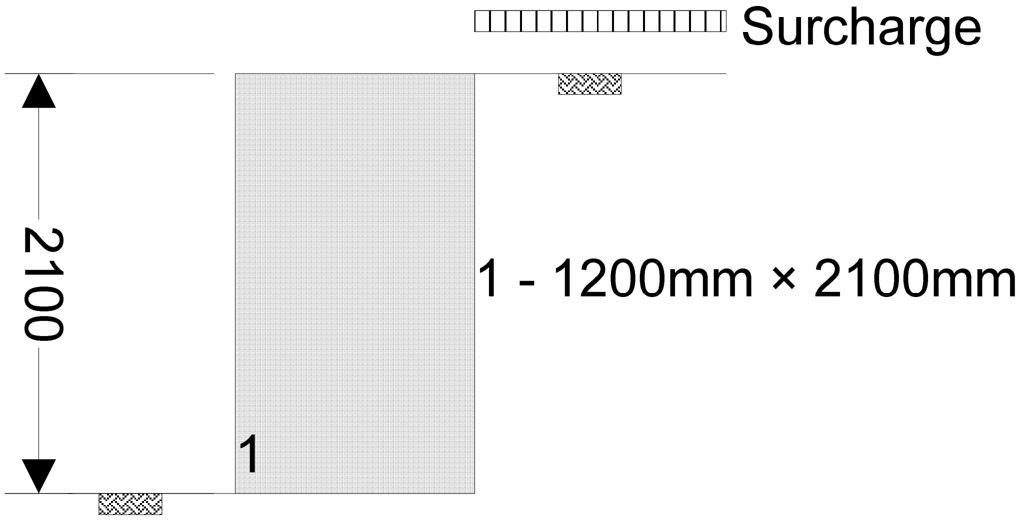
Design summary

Combination 1

Action	Resistance	Force	FoS	Allowable FoS	Status
Overturning, sliding and bearing at base level					
Overturning (kNm/m)	44.6	21.0	2.120	1.000	PASS
Sliding (kN/m)	38.9	25.7	1.512	1.000	PASS
Bearing (kN/m^2)	100.0	99.8	1.002	1.000	PASS
Eccentricity (mm)	Reaction acts within the middle third of base				PASS

Combination 2

Action	Resistance	Force	FoS	Allowable FoS	Status
Overturning, sliding and bearing at base level					
Overturning (kNm/m)	44.6	21.0	2.128	1.000	PASS
Sliding (kN/m)	31.1	25.3	1.232	1.000	PASS
Bearing (kN/m^2)	100.0	99.8	1.002	1.000	PASS
Eccentricity (mm)	Reaction acts within the middle third of base				PASS



Wall geometry

Width of gabion 1 w_1 = **1200** mm

Height of gabion 1 h_1 = **2100** mm

Wall inclination ε = **0** deg

Properties

Unit weight of fill γ_d = **24.0** kN/m^3

Loading

Variable surcharge $p_{o,Q}$ = **10** kN/m^2

Soil properties

Slope of retained soil	β = **0.0** deg
Characteristic peak shearing resistance angle	$\phi'_{pk.k}$ = **30.0** deg
Characteristic saturated density of retained soil	γ_{sr} = **21.0** kN/m^3
Coefficient for wall friction	$k_{membrane}$ = **0.75**
Wall friction angle	$\delta_{r.k}$ = **22.5** deg
Characteristic base friction angle	$\delta_{bb.k}$ = **30.0** deg
Bearing capacity of founding soil	q = **100** kN/m^2

Wall geometry

Horizontal distance to centre of gravity gabion 1	$x_{g1} = w_1 / 2$ = **600** mm
Vertical distance to centre of gravity gabion 1	$y_{g1} = h_1 / 2$ = **1050** mm
Weight of gabion 1	$W_{g1} = \gamma_d \times w_1 \times h_1$ = **60.5** kN/m
Weight of entire gabion	$W_g = W_{g1}$ = **60.5** kN/m
Horiz distance to centre of gravity entire gabion	$x_g = ((W_{g1} \times x_{g1})) / W_g$ = **600** mm
Vert distance to centre of gravity entire gabion	$y_g = ((W_{g1} \times y_{g1})) / W_g$ = **1050** mm
Correcting for wall inclination horiz dist	$X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **600** mm
Vertical change in height due to wall inclination	$H_f = y_{g1} + h_1/2 - ((y_{g1} + h_1/2) \times \cos(\varepsilon) - (x_{g1} + w_1/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

Effective angle of rear plane of wall	$\alpha = 90\text{ deg} + \varepsilon$ = **90.0** deg
Effective face angle	$\theta = 90\text{deg} - \varepsilon$ = **90.0** deg
Effective height of wall	$H = (y_{g1} + h_1 / 2) + (w_1 \times \sin(\varepsilon)) - H_f$ = **2100** mm
Height of wall from toe to front edge of top gabion	$H_{incl} = ((y_{g1} + h_1 / 2) \times \cos(\varepsilon) - (x_{g1} - (w_1 / 2)) \times \sin(\varepsilon))$ = **2100**mm
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r.k})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.k}) \times (1 + \sqrt{}(\sin(\phi'_{r.k} + \delta_{r.k}) \times \sin(\phi'_{r.k} - \beta) / (\sin(\alpha - \delta_{r.k}) \times \sin(\alpha + \beta))))^2)$ = **0.296**
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{sr} \times H^2$ = **13.7** kN/m
Minimum surcharge (cl.4.6.3.2)	$p_{o,min} = \min(H / H_{ref}, 1) \times q_{d,min}$ = **7.0** kN/m^2

Pressure at base

Horizontal forces

Retained soil	$F_{soil\_h,q} = P_{a,soil} \times \cos(90 - \alpha + \delta_{r.k})$ = **12.7** kN/m
Height of soil thrust resolved vertically	$d_{h,soil} = H / 3 - w_1 \times \sin(\varepsilon)$ = **700** mm
Surcharge	$F_{surch\_h,q} = \max(p_{o,Q}, p_{o,min}) \times K_a \times H \times \cos(90 - \alpha + \delta_{r.k})$ = **5.7** kN/m
Height of surcharge thrust resolved vertically	$d_{h,surch} = H / 2 - w_1 \times \sin(\varepsilon)$ = **1050** mm

Vertical forces

Gabion weight	$F_{gabion\_v,q} = W_g$ = **60.5** kN/m
Retained soil	$F_{soil\_v,q} = P_{a,soil} \times \sin(90 - \alpha + \delta_{r.k})$ = **5.3** kN/m
Horizontal dist to where soil thrust acts	$b_{v,soil} = w_1 \times \cos(\varepsilon) - (H / 3) / \tan(\alpha)$ = **1200** mm
Surcharge	$F_{surch\_v,q} = \max(p_{o,Q}, p_{o,min}) \times K_a \times H \times \sin(90 - \alpha + \delta_{r.k})$ = **2.4** kN/m
Horizontal dist to where surcharge thrust acts	$b_{v,surch} = w_1 \times \cos(\varepsilon) - (H / 2) / \tan(\alpha)$ = **1200** mm
Total horizontal unfactored force	$T_q = F_{soil\_h,q} + F_{surch\_h,q}$ = **18.4** kN/m
Total vertical unfactored force	$N_q = F_{gabion\_v,q} + F_{soil\_v,q} + F_{surch\_v,q}$ = **68.1** kN/m
Force normal to base	$N_s = N_q \times \cos(\varepsilon) + T_q \times \sin(\varepsilon)$ = **68.1** kN/m
Total unfactored overturning force	$M_{o,q} = F_{soil\_h,q} \times d_{h,soil} + F_{surch\_h,q} \times d_{h,surch}$ = **14.9** kNm/m
Total unfactored restoring force	$M_{R,q} = F_{gabion\_v,q} \times X_g + F_{soil\_v,q} \times b_{v,soil} + F_{surch\_v,q} \times b_{v,surch}$ = **45.4** kNm/m
Eccentricity	$e = w_1 / 2 - (M_{R,q} - M_{o,q}) / N_s$ = **152** mm

Reaction acts within middle third of base

Pressure at toe	$\sigma_{toe} = N_s / w_1 \times (1 + (6 \times e / w_1))$ = **99.8** kN/m^2
Pressure at heel	$\sigma_{heel} = N_s / w_1 \times (1 - (6 \times e / w_1))$ = **13.7** kN/m^2
Factor of safety	$FoS_Q = q / \max(\sigma_{toe}, \sigma_{heel})$ = **1.002**
Allowable factor of safety	FoS_{Q_allow} = **1.000**

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

Design approach 1

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

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

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

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

Design soil properties

Design effective shearing resistance angle	$\phi'_{r.d} = \mathrm{Atan}(\tan(\phi'_{pk.k}) / \gamma_{\phi'})$ = **30.0** deg
Design saturated density of retained soil	$\gamma_{s.d} = \gamma_{sr} / \gamma_\gamma$ = **21.0** kN/m^3
Design wall friction angle (cl.5.4.2.1)	$\delta_{r.d} = \min(\mathrm{atan}(\tan(\delta_{r.k}) / \gamma_{\phi'}), \phi'_{r.d} \times k_{membrane})$ = **22.5** deg
Design base friction angle	$\delta_{bb.d} = \mathrm{Atan}(\tan(\delta_{bb.k}) / \gamma_{\phi'})$ = **30.0** deg
Design friction between gabions	$\delta_{bg.d} = \mathrm{Atan}(\tan(\delta_{bg.k}) / \gamma_{\phi'})$ = **35.0** deg
Active pressure using Coulomb theory	$K_a = \sin(\alpha + \phi'_{r.d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r.d}) \times (1 + \sqrt{}(\sin(\phi'_{r.d} + \delta_{r.d}) \times \sin(\phi'_{r.d} - \beta) / (\sin(\alpha - \delta_{r.d}) \times \sin(\alpha + \beta))))^2)$ = **0.296**
Active thrust due to soil	$P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **13.7** kN/m
Minimum surcharge (cl.4.6.3.2)	$p_{o,min} = \min(H / H_{ref}, 1) \times q_{d,min}$ = **7.0** kN/m^2

Horizontal forces

Retained soil	$F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **17.1** kN/m
Surcharge	$F_{surch\_h} = \max(p_{o,Q} \times \gamma_Q, p_{o,min}) \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **8.6** kN/m

Vertical forces

Gabion weight	$F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **60.5** kN/m
Retained soil	$F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **5.3** kN/m
Surcharge	$F_{surch\_v,f} = \max(p_{o,Q} \times \gamma_{Q,f}, p_{o,min}) \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **1.7** kN/m

Overturning stability - take moments about the toe

Overturning moment	$M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **21.0** kNm/m
Restoring moment	$M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **44.6** kNm/m
Factor of safety	$FoS_M = M_R / M_o$ = **2.120**
Allowable factor of safety	FoS_{M_allow} = **1.000**

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

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

Total horizontal force	$T = F_{soil\_h} + F_{surch\_h}$ = **25.7** kN/m
Total vertical force	$N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f}$ = **67.4** kN/m
Sliding force	$F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon)$ = **25.7** kN/m
Sliding resistance	$F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bb.d})$ = **38.9** kN/m
Factor of safety	$FoS_S = F_R / F_f$ = **1.512**
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 γ_G = **1.00**

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

Variable unfavourable action γ_Q = **1.30**

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

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

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

Weight density γ_γ = **1.00**

Design soil properties

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

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

Design wall friction angle (cl.5.4.2.1) $\delta_{r.d} = \min(\text{atan}(\tan(\delta_{r.k}) / \gamma_{\phi'}), \phi'_{r.d} \times k_{membrane})$ = **18.3** deg

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

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

Wall geometry

Horizontal distance to centre of gravity gabion 1 $x_{g1} = w_1 / 2$ = **600** mm

Vertical distance to centre of gravity gabion 1 $y_{g1} = h_1 / 2$ = **1050** mm

Weight of gabion 1 $W_{g1} = \gamma_d \times w_1 \times h_1$ = **60.5** kN/m

Weight of entire gabion $W_g = W_{g1}$ = **60.5** kN/m

Horiz distance to centre of gravity entire gabion $x_g = ((W_{g1} \times x_{g1})) / W_g$ = **600** mm

Vert distance to centre of gravity entire gabion $y_g = ((W_{g1} \times y_{g1})) / W_g$ = **1050** mm

Correcting for wall inclination horiz dist $X_g = x_g \times \cos(\varepsilon) + y_g \times \sin(\varepsilon)$ = **600** mm

Vertical change in height due to wall inclination $H_f = y_{g1} + h_1/2 - ((y_{g1} + h_1/2) \times \cos(\varepsilon) - (x_{g1} + w_1/2) \times \sin(\varepsilon))$ = **0** mm

Design dimensions

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

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

Effective height of wall $H = (y_{g1} + h_1 / 2) + (w_1 \times \sin(\varepsilon)) - H_f$ = **2100** mm

Height of wall from toe to front edge of top gabion $H_{incl} = ((y_{g1} + h_1 / 2) \times \cos(\varepsilon) - (x_{g1} - (w_1 / 2)) \times \sin(\varepsilon))$ = **2100**mm

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

Active thrust due to soil $P_{a,soil} = 0.5 \times K_a \times \gamma_{s.d} \times H^2$ = **16.7** kN/m

Minimum surcharge (cl.4.6.3.2) $p_{o,min} = \min(H / H_{ref}, 1) \times q_{d,min}$ = **7.0** kN/m^2

Horizontal forces

Retained soil $F_{soil\_h} = \gamma_G \times P_{a,soil} \times \cos(90 - \alpha + \delta_{r.d})$ = **15.9** kN/m

Surcharge $F_{surch\_h} = \max(p_{o,Q} \times \gamma_Q, p_{o,min}) \times K_a \times H \times \cos(90 - \alpha + \delta_{r.d})$ = **9.4** kN/m

Vertical forces

Gabion weight $F_{gabion\_v,f} = \gamma_{G,f} \times W_g$ = **60.5** kN/m

Retained soil $F_{soil\_v,f} = \gamma_{G,f} \times P_{a,soil} \times \sin(90 - \alpha + \delta_{r.d})$ = **5.3** kN/m

Surcharge $F_{surch\_v,f} = \max(p_{o,Q} \times \gamma_{Q,f}, p_{o,min}) \times K_a \times H \times \sin(90 - \alpha + \delta_{r.d})$ = **1.7** kN/m

Overturning stability - take moments about the toe

Overturning moment $M_o = F_{soil\_h} \times d_{h,soil} + F_{surch\_h} \times d_{h,surch}$ = **21.0** kNm/m

Restoring moment $M_R = F_{gabion\_v,f} \times X_g + F_{soil\_v,f} \times b_{v,soil} + F_{surch\_v,f} \times b_{v,surch}$ = **44.6** kNm/m

Factor of safety $FoS_M = M_R / M_o =$ **2.128**

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

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

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

Total horizontal force $T = F_{soil\_h} + F_{surch\_h} =$ **25.3** kN/m

Total vertical force $N = F_{gabion\_v,f} + F_{soil\_v,f} + F_{surch\_v,f} =$ **67.4** kN/m

Sliding force $F_f = T \times \cos(\varepsilon) - N \times \sin(\varepsilon) =$ **25.3** kN/m

Sliding resistance $F_R = (T \times \sin(\varepsilon) + N \times \cos(\varepsilon)) \times \tan(\delta_{bb.d}) =$ **31.1** kN/m

Factor of safety $FoS_S = F_R / F_f =$ **1.232**

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

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

Use 1.2m wide poured mass concrete retaining wall. Minimum ground bearing pressure of 100 kN/m²^2.