pebble engineering

Design Calculations for
Mr Wayne Rowles
Percy Road
Gabion Retaining Wall
250101-16-100-Rev B

April 2026

REFERENCE

Client	Mr Wayne Rowles
Project Name	Percy Road
Structure	Gabion Retaining Wall
Subject of Calculation	Civil/Structural Calculations

REVISIONS OF CALCULATION SET

Rev.	Issue date	Description of calculation	Originator/ Date	Checker/ Date	Reviewer/ Date
A	27/06/2025	First Issue	KJR	AGD	DJO
			23/06/2025	26/06/2025	27/06/2025
B	24/04/2026	Gabion Wall Checked in Accordance with Drawing AR02	DRJL	DJO	DJO
		Design still Suitable	24/04/2026	24/04/2026	24/04/2026

KJ Rogers BSc(Hons) CEng MICE MIStructE

Signed: Ken J Rogers

Date: 23/06/2025

A G Davies MEng(Hons) GMICE

Signed:

Date: 26/06/2025

D J Ollier BEng (Hons) CEng FICE MIStructE

Signed:

Date: 27/06/2025

COMPANY

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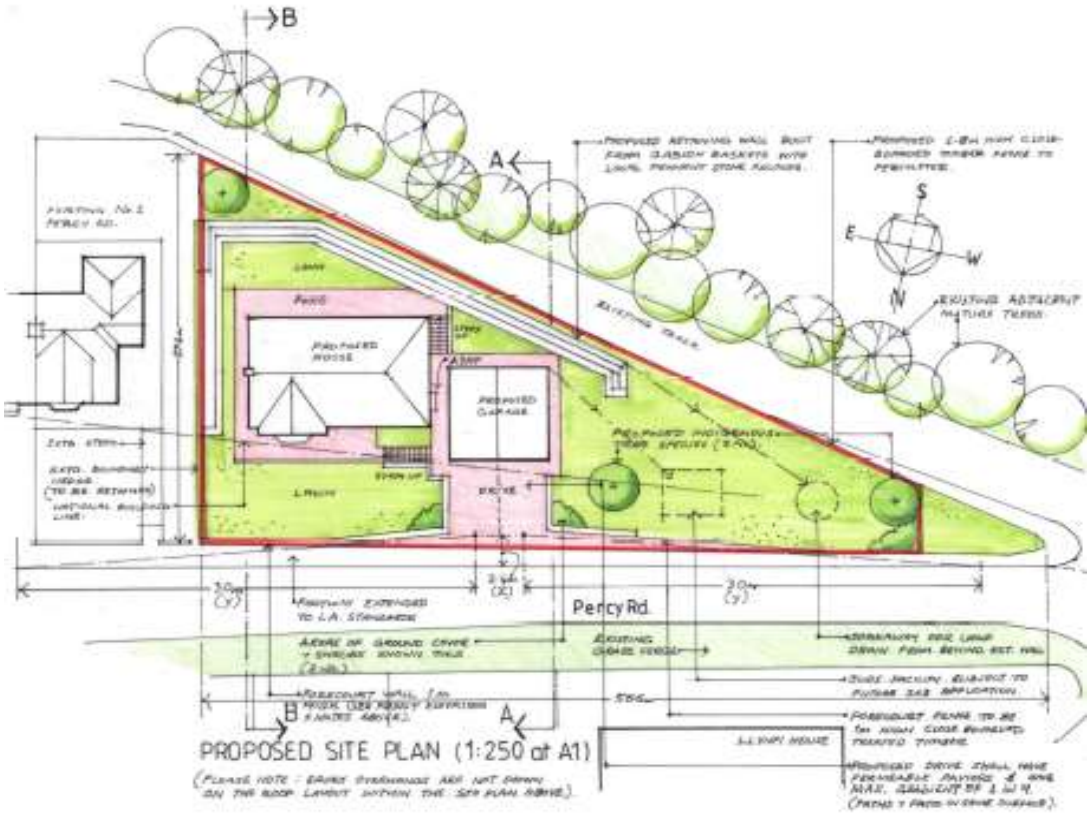
CALCULATION DESIGN CRITERIA

Purpose of calculation	New Development for a domestic property requiring a retaining wall to the rear boundary. Proposed Gabion Basket retaining wall. Height of the retained earth varies from 3.8m down to 3.3m with backfill soil of 30 degrees to the boundary.
Method of calculation	Developed Excel Spreadsheet Hand Calculations SAND SCALE Structural Proforma
Source documents used (including codes, standards & drawings)	[1] BS EN 1990 - Basis of Structural Design [2] BS EN 1991 - Actions on Structures [3] BS EN 1992 - Design of Concrete Structures [4] BS EN 1997 - Geotechnical Design [5] BS8002 - Code of practise for earth retaining structures [6] Enviromesh - A reference guide of the designing of mass gravity gabion walls. [7] Foundation Design and Construction - Tomlinson 7th Edition [8] Gabion wall checked in accordance with drawing AR02.
Calculation Criteria	Design undertaken to Eurocode partial factors for serviceability and ultimate limit state.
Health & Safety Risk Assessment	Designers Risk Assessment Soil instability during wall construction-resulting in serious injury. Existing ground to be inspected by competent person and TW measures to maintain soil stability during construction.
Key parameters used	Retained height to underside of base - 3.8m to 3.3m. Slope of backfill - 30 degrees max. Characteristic Internal friction angle of backfill - 35 degrees. Soil Density - 19kN/m2 and Surcharge - 10kN/m2 Allowable Bearing Pressure - 100 kN/m2 Kmembrane - 0.9 (stepped rear face of gabion) Base friction - 0.67*Φk = 23.45 degrees Gabion Wall inclination = 6 degrees. Concrete grade - C32/30, XC3 Nominal cover 50mm and 75mm for concrete cast against soil.
Other comments	
Output	See Design sketch 250101-16-SK01
Resulting drawings	None


B
A
S
E
W
N
Percy Rd.
PROPOSED SITE PLAN (1:250 at A1)

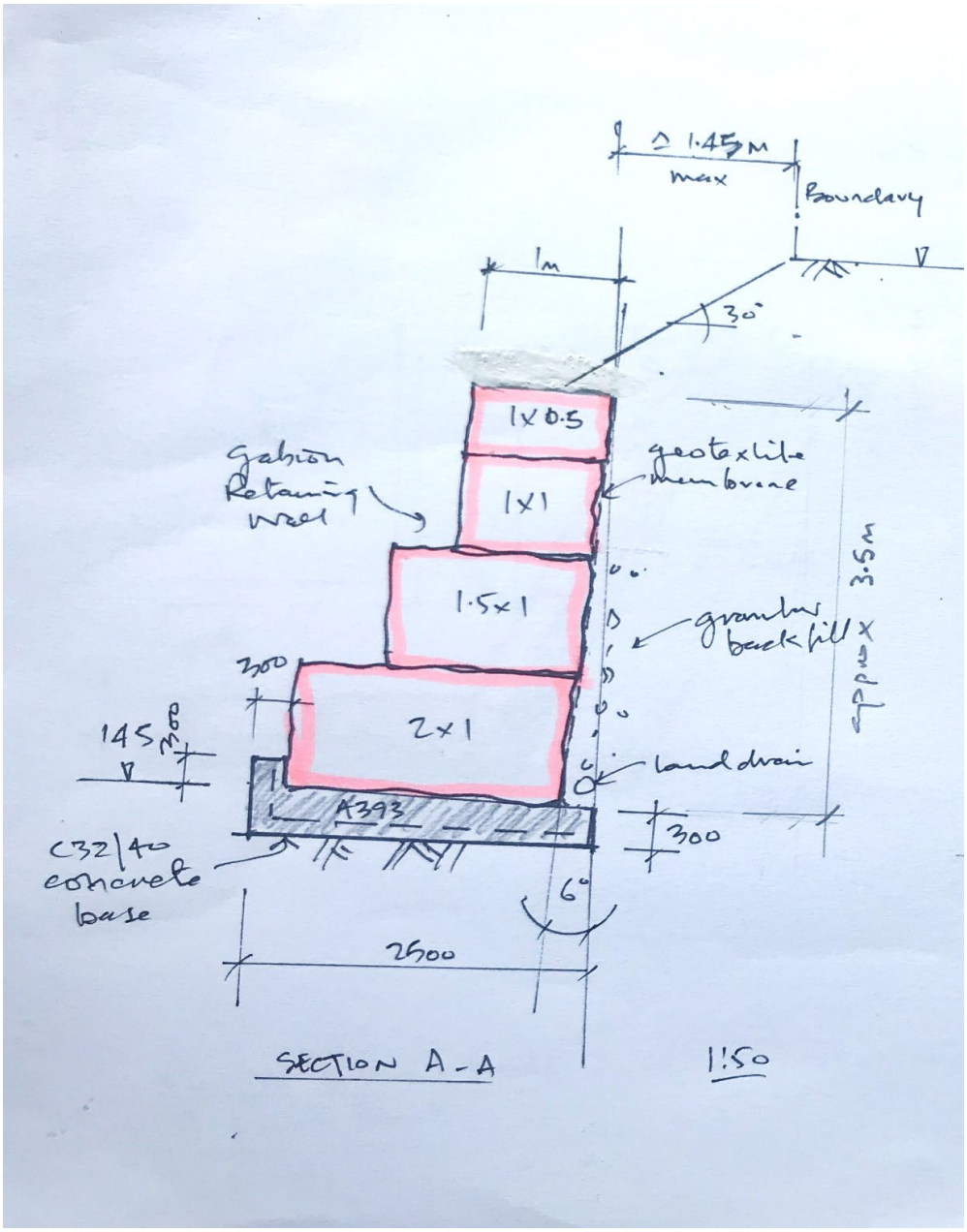
Design Statement

Ground Information on the basis of design

Backfill material is engineering fill	35	degrees
Density	19	kN/m3

Ground properties

To be confirmed on site. Design on the basis of firm ground (Glacial Till) with a angle of resistance 35 degrees.



SKO1 Section A_A Gabion Wall

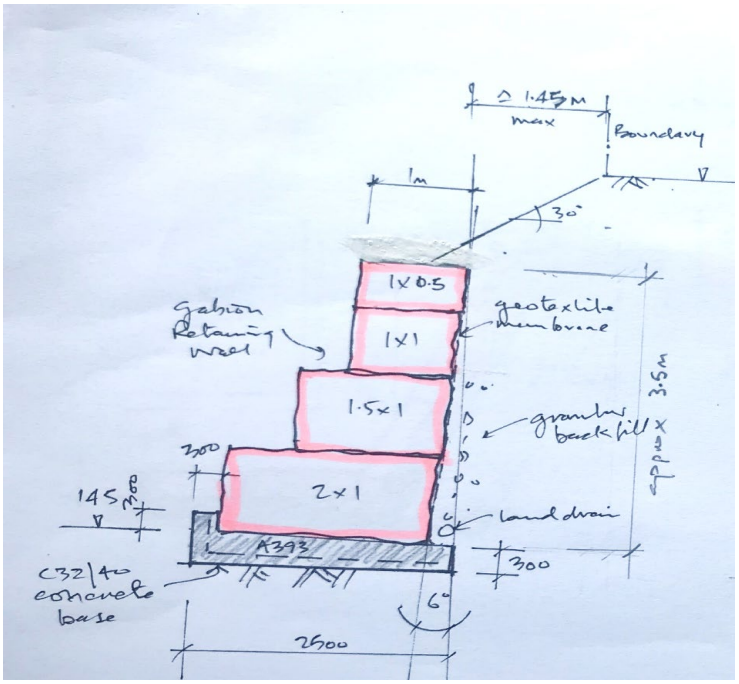
Geometry Table (no water) - Refer to following pages for calculations.

Course	Course Dimensions		Area	Mass	offset	Centre of gr abt toe		Area momts abt toe	
	Width	height		kN		xx plane	yy plane	xx plane	yy plane
4.00	1.00	0.50	0.50	8.00	1.25	1.75	3.55	0.88	1.78
3.00	1.00	1.00	1.00	16.00	1.25	1.75	2.80	1.75	2.80
2.00	1.50	1.00	1.50	24.00	0.75	1.50	1.80	2.25	2.70
1.00	2.00	1.00	2.00	32.00	0.25	1.25	0.80	2.50	1.60
Concrete	2.50	0.30	0.75	18.00	0.00	1.25	0.15	0.94	0.11
Totals			**5.75**	**98.00**				**7.38**	**8.88**

Centre of gravity	**Xg**	**Yg**
(assuming vertical)	1.28	1.54
Correcting for wall inclination α	1.44	
Effective Wall Height		
co-ords of top wall (consider vertical)	2.25	3.80
co-ords of btm wall (consider vertical)	2.50	0.00
Inclination correction		
co-ords of top wall (adjusted)	2.65	3.56
co-ords of btm wall (adjusted)	2.49	-0.26
Effective slope angle β	**-87.59**	Degrees
Or	92.41	

Density of fill	16	kN/m^3	Limestone
height of gabion wall to underside of base	3.8	m	
α	6	degrees	
Density of concrete	24	kN/m^3	

Gabion Basket Calculation Sheet - Design Approach 1, Combination 1 to BS EN 1997
Global Stability



DA1 Comb 1

STR / GEO Partial Factors	
γ_G	1.35
$\gamma_{G,fav}$	1
γ_q	1.5
$\gamma_{q,fav}$	0
γ_Φ	1

EQU Partial Factors	
γ_G	1.1
$\gamma_{G,fav}$	0.9
γ_q	1.5
$\gamma_{q,fav}$	0
γ_Φ	1.1

Parameters

Height, h =	3.8	m	
Slope of retained soil ε =	30	degrees	
Internal Friction Angles Φ_k =	35	degrees	
Soil density γk =	19	kN/m^3	
Surcharge $P_{0,k}$ =	10	kN/m^2	
Surcharge $P_{0,d}$ =	15	kN/m^2	
Allowable bearing pressure σ =	100	kN/m^2	
Wall friction, δ	31.5	degrees	0.9 used for $K_{membrane}$
Base friction, ζ =	25.46	degrees	Concrete cast on soil phi - 38
Wall inclination, α =	6	degrees	
Effective plane at rear of wall, β =	92.4	degrees	

Active Pressure

Considering coulomb failure theory, active pressure on the wall is calculated by;

$$ka = \frac{\sin^2(\beta+\varphi)}{\sin^2\beta \sin(\beta-\varphi)\left[1+\sqrt{\frac{\sin(\varphi+\delta)\sin(\varphi-\varepsilon)}{\sin(\beta-\delta)\sin(\beta+\varepsilon)}}\right]^2}$$

Therefore;

$\sin^2(\beta+\Phi)$	=	0.631	
$\sin^2(\beta)$	=	0.998	
$\sin(\beta-\Phi)$	=	0.843	
$\sin(\Phi+\delta)$	=	0.917	
$\sin(\Phi-\varepsilon)$	=	0.087	
$\sin(\beta-\delta)$	=	0.874	
$\sin(\beta+\varepsilon)$	=	0.844	
k_a	=	0.425	okay

Calculation of active thrust (STR/GEO)

	$P_{a,soil} = 0.5*K_a*\gamma*h^2$	=	58.25	kN/m	SLS
	$P_{a,soil,d} = \gamma_G*0.5*K_a*\gamma*h^2$	=	78.64	kN/m	
	$P_{a,surcharge} = P_0*K_a*h$	=	16.14	kN/m	SLS
	$P_{a,surcharge,d} = \gamma_q P_0*K_a*h$	=	24.21	kN/m	
STR/GEO	$P_{a,d} = \gamma_G P_{a,soil} + \gamma_q P_{a,surcharge}$	=	102.85	kN/m	Max Loading
STR/GEO	$P_{a,d} = \gamma_G P_{a,soil} + \gamma_q P_{a,surcharge}$	=	78.64	kN/m	No favourable

Calculation of active thrust (EQU)

EQU	$P_{a,d} = \gamma_G P_{a,soil} + \gamma_q P_{a,surcharge}$	=	88.28	kN/m	Max Loading
EQU	$P_{a,d\ fav} = \gamma_{G,f} P_{a,soil} + \gamma_{q,f} P_{a,surcharge}$	=	52.43	kN/m	No Favourable

Calculation of height of loads

dh_{soil} = h/3*((H+3*hs)/(H+2hs)) = 1.45 m above heel
1.40 m SLS

dh = dh_{soil} - bwsin(α) = 1.19 m above toe
1.14 m SLS

bw = width of base = 2.5 m
hs,d = surcharge loading as equivalent height of soil = 0.79 m ULS
= 0.53 m SLS

Calculation of horizontal and vertical components

STR/GEO	Ph = $P_{a,d}$*cos(90-β+δ)	=	89.87	kN/m	Max.
STR/GEO	Pv = $P_{a,d}$*sin(90-β+δ)	=	50.01	kN/m	Max.
STR/GEO	Ph = $P_{a,d}$*cos(90-β+δ)	=	68.72	kN/m	Min.
STR/GEO	Pv = $P_{a,d}$*sin(90-β+δ)	=	38.24	kN/m	Min.
EQU	Pv = $P_{a,d}$*sin(90-β+δ)	=	42.93	kN/m	Max.
EQU	Ph = $P_{a,d}$*cos(90-β+δ)	=	77.15	kN/m	Max.
EQU	Pv = $P_{a,d}$*sin(90-β+δ)	=	25.49	kN/m	Min.
EQU	Ph = $P_{a,d}$*cos(90-β+δ)	=	45.81	kN/m	Min.

Overturning Stability (EQU Verification)

M_{ed} = Ph*dh = 91.90 kNm/m

bv = bw*cos(α) - dh_{soil}/tan(β)
= 2.5474 m

M_{Rd} = Pv*bv+$\gamma_{g,fav}$Wg*Xg
= 191.7 kNm/m

Sliding Stability (STR/GEO)

N = Wg + ∑Pv = 148.01 kN
134.17 kN SLS

T = ∑Ph = 89.87 kN

F_{ed} = Tcos(α)-Nsin(α) 73.9 kN/m

F_{Rd} =Ncos(α)+Tsin(α)*tan(Φ)
= 74.6 kN

Bearing Capacity Check (SLS)

$M_{ed,\sigma}$ =(Pa,soil +Pa,surcharge)*dh= = 85.01 kNm/m

bv = bw*cos(α) - dh_{soil}/tan(β)
= 2.5454 m

Mr = Pv*bv+$\gamma_{g,fav}$Wg*Xg
= 232.9 kNm/m

e = bw/2 - (M_{Rd}-$M_{ed,\sigma}$)/N = 0.148 Check < bw/6 0.42 OK

σ_{toe} = N/bw*(1+6*e/bw) = 57.29 kN/m^2

σ_{heel} = N/bw*(1-6*e/bw) = 27.28 kN/m^2

Sliding Stability (Concrete base to gabion tier 1)

Height, h = 3.8 m

Calculation of active thrust (STR/GEO)

	$P_{a,soil} = 0.5*K_a*\gamma*h^2$	=	58.25	kN/m
	$P_{a,soil,d} = \gamma_G*0.5*K_a*\gamma*h^2$	=	78.64	kN/m
	$P_{a,surcharge} = P_0*K_a*h$	=	16.14	kN/m
	$P_{a,surcharge,d} = \gamma_q P_0*K_a*h$	=	24.21	kN/m
STR/GEO	$P_{a,d} = \gamma_G P_{a,soil} + \gamma_q P_{a,surcharge}$	=	102.85	kN/m
		Max Loading		

Sliding Stability (STR/GEO)

Calculation of horizontal and vertical components

			Max.	
STR/GEO	$Ph = P_{a,d}*\cos(90-\beta+\delta)$	=	89.87	kN/m
STR/GEO	$Pv = P_{a,d}*\sin(90-\beta+\delta)$	=	50.01	kN/m
	$N = Wg + \sum Pv$	=	130.01	kN
		=	115.72	kN SLS
	$T = \sum Ph$	=	89.87	kN
	$F_{ed} = T\cos(\alpha)-N\sin(\alpha)$		75.8	kN/m
	$F_{Rd} = N\cos(\alpha)+T\sin(\alpha)*\tan(\Phi)$ #NAME?	=	84.0	kN

Sliding Stability (gabion tier 1 to gabion tier 2)

Height, h = 2.5 m

Calculation of active thrust (STR/GEO)

	$P_{a,soil} = 0.5*K_a*\gamma*h^2$	=	25.21	kN/m
	$P_{a,soil,d} = \gamma_G*0.5*K_a*\gamma*h^2$	=	34.04	kN/m
	$P_{a,surcharge} = P_0*K_a*h$	=	10.62	kN/m
	$P_{a,surcharge,d} = \gamma_q P_0*K_a*h$	=	15.92	kN/m
STR/GEO	$P_{a,d} = \gamma_G P_{a,soil} + \gamma_q P_{a,surcharge}$	=	49.96	kN/m
		Max Loading		

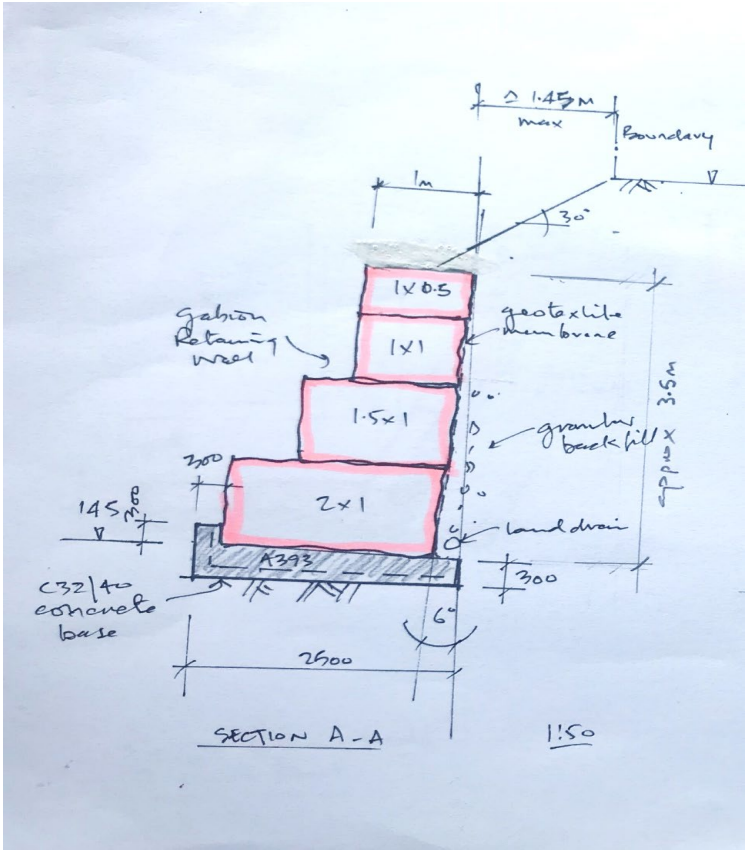
Sliding Stability (STR/GEO)

Calculation of horizontal and vertical components

			Max.	
STR/GEO	$Ph = P_{a,d}*\cos(90-\beta+\delta)$	=	43.66	kN/m
STR/GEO	$Pv = P_{a,d}*\sin(90-\beta+\delta)$	=	24.29	kN/m
	$N = Wg + \sum Pv$	=	72.29	kN
			65.35	kN SLS
	$T = \sum Ph$	=	43.66	kN
	$F_{ed} = T\cos(\alpha)-N\sin(\alpha)$	=	35.9	kN/m
	$F_{Rd} = N\cos(\alpha)+T\sin(\alpha)*\tan(\Phi)$	=	46.9	kN

No further checks necessary on upper levels, sliding OK.

Gabion Basket Calculation Sheet - Design Approach 2, Combination 2 to BS EN 1997
Global Stability



DA1 Comb 2

STR / GEO Partial Factors	
γ_G	1
$\gamma_{G,fav}$	1
γ_q	1.3
$\gamma_{q,fav}$	0
γ_Φ	1.25

Parameters

Height, h =	3.8	m	
Slope of retained soil ε =	30	degrees	
Internal Friction Angles Φ_k =	35	degrees	
Internal Friction Angles Φ_d =	28	degrees	
Soil density γk =	19	kN/m^3	
Surcharge $P_{0,k}$ =	10	kN/m^2	
Surcharge $P_{0,d}$ =	15	kN/m^2	
Allowable bearing pressure σ =	100	kN/m^2	
Wall friction, δ	31.5	degrees	0.9 used for $K_{membrane}$
Base friction, ζ =	20.368	degrees	Concrete cast on soil phi - 38
Wall inclination, α =	6	degrees	
Effective plane at rear of wall, β =	92.4	degrees	

Active Pressure

Considering coulomb failure theory, active pressure on the wall is calculated by;

$$ka = \frac{\sin^2(\beta+\varphi)}{\sin^2\beta \sin(\beta-\varphi)\left[1+\sqrt{\frac{\sin(\varphi+\delta)\sin(\varphi-\varepsilon)}{\sin(\beta-\delta)\sin(\beta+\varepsilon)}}\right]^2}$$

Therefore;

$\sin^2(\beta+\Phi)$	=	0.631
$\sin^2(\beta)$	=	0.998
$\sin(\beta-\Phi)$	=	0.843
$\sin(\Phi+\delta)$	=	0.917
$\sin(\Phi-\varepsilon)$	=	0.087
$\sin(\beta-\delta)$	=	0.874
$\sin(\beta+\varepsilon)$	=	0.844
k_a	=	0.425

Calculation of active thrust (STR/GEO)

	$P_{a,soil} = 0.5*K_a*\Upsilon*h^2$	=	58.25 kN/m	
	$P_{a,soil,d} = \Upsilon_G*0.5*K_a*\Upsilon*h^2$	=	58.25 kN/m	
	$P_{a,surcharge} = P_0*K_a*h$	=	16.14 kN/m	
	$P_{a,surcharge,d} = \Upsilon_q P_0*K_a*h$	=	20.98 kN/m	
STR/GEO	$P_{a,d} = \Upsilon_G P_{a,soil} + \Upsilon_q P_{a,surcharge}$	=	79.23 kN/m	Max Loading
STR/GEO	$P_{a,d} = \Upsilon_G P_{a,soil} + \Upsilon_q P_{a,surcharge}$	=	58.25 kN/m	No favourable

Calculation of height of loads

dh_{soil} = h/3*((H+3*hs)/(H+2hs)) = 1.45 m above heel
1.40 m SLS

dh = dh_{soil} - bwsin(α) = 1.19 m above toe
1.14 m SLS

bw = width of base = 2.5 m

hs,d = surcharge loading as equivalent height of soil = = 0.79 m ULS
= 0.53 m SLS

Calculation of horizontal and vertical components

STR/GEO	Ph = $P_{a,d}$*cos(90-β+δ)	=	69.24	kN/m	Max.
STR/GEO	Pv = $P_{a,d}$*sin(90-β+δ)	=	38.52	kN/m	Max.
STR/GEO	Ph = $P_{a,d}$*cos(90-β+δ)	=	50.90	kN/m	Min.
STR/GEO	Pv = $P_{a,d}$*sin(90-β+δ)	=	28.32	kN/m	Min.

Sliding Stability (STR/GEO)

N = Wg + ∑Pv = 136.52 kN
= 134.17 kN SLS

T = ∑Ph = 65.01 kN

F_{ed} = Tcos(α)-Nsin(α) 50.4 kN/m

F_{Rd} =Ncos(α)+Tsin(α)*tan(Φ)
= 52.9 kN

Bearing Capacity Check (SLS)

$M_{ed,\sigma}$ =(Pa,soil +Pa,surcharge)*dh= = 85.01 kNm/m

bv = bw*cos(α) - dh_{soil}/tan(β)
= 2.5454 m

Mr = Pv*bv+Wg*Xg
= 238.9 kNm/m

e = bw/2 - (M_{Rd}-$M_{ed,\sigma}$)/N = 0.103 Check < bw/6 0.42 OK

σ_{toe} = N/bw*(1+6*e/bw) = 66.96 kN/m^2

σ_{heel} = N/bw*(1-6*e/bw) = 41.08 kN/m^2

Sliding Stability (Concrete base to gabion tier 1)

Height, h = 3.5 m

Calculation of active thrust (STR/GEO)

$P_{a,soil} = 0.5*K_a*\gamma*h^2$ = 49.42 kN/m

$P_{a,soil,d} = \gamma_G*0.5*K_a*\gamma*h^2$ = 49.42 kN/m

$P_{a,surcharge} = P_0*K_a*h$ = 14.86 kN/m

$P_{a,surcharge,d} = \gamma_q P_0*K_a*h$ = 19.32 kN/m

STR/GEO $P_{a,d} = \gamma_G P_{a,soil} + \gamma_q P_{a,surcharge}$ = 68.74 kN/m Max Loading

Sliding Stability (STR/GEO)

Calculation of horizontal and vertical components

STR/GEO $Ph = P_{a,d}*\cos(90-\beta+\delta)$ = 60.07 kN/m Max.

STR/GEO $Pv = P_{a,d}*\sin(90-\beta+\delta)$ = 33.42 kN/m Max.

$N = Wg + \sum Pv$ = 113.42 kN

103.87 kN SLS

$T = \sum Ph$ = 60.07 kN

$F_{ed} = T\cos(\alpha)-N\sin(\alpha)$ 60.1 kN/m

$F_{Rd} = N\cos(\alpha)+T\sin(\alpha)*\tan(\Phi)$

= 56.3 kN/m

NOTE **Add 300mm wide RC upstand to aid sliding resistance** **Okay**

Sliding Stability (gabion tier 1 to gabion tier 2)

Height, h = 2.5 m

Calculation of active thrust (STR/GEO)

$P_{a,soil} = 0.5*K_a*\gamma*h^2$ = 25.21 kN/m

$P_{a,soil,d} = \gamma_G*0.5*K_a*\gamma*h^2$ = 25.21 kN/m

$P_{a,surcharge} = P_0*K_a*h$ = 10.62 kN/m

$P_{a,surcharge,d} = \gamma_q P_0*K_a*h$ = 13.80 kN/m

STR/GEO $P_{a,d} = \gamma_G P_{a,soil} + \gamma_q P_{a,surcharge}$ = 39.02 kN/m Max Loading

Sliding Stability (STR/GEO)

Calculation of horizontal and vertical components

STR/GEO $Ph = P_{a,d}*\cos(90-\beta+\delta)$ = 34.09 kN/m Max.

STR/GEO $Pv = P_{a,d}*\sin(90-\beta+\delta)$ = 18.97 kN/m Max.

$N = Wg + \sum Pv$ = 66.97 kN

61.55 kN SLS

$T = \sum Ph$ = 34.09 kN

$F_{ed} = T\cos(\alpha)-N\sin(\alpha)$ 26.9 kN/m

$F_{Rd} = N\cos(\alpha)+T\sin(\alpha)*\tan(\Phi)$

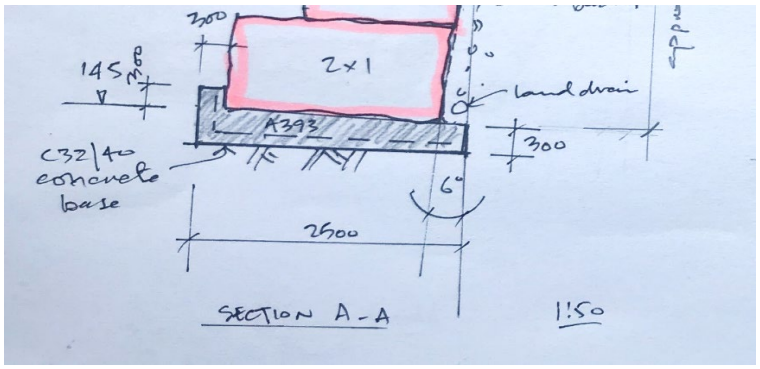
= 33.3 kN

No further checks necessary on upper levels, sliding OK.

Wall A

Reinforced Concrete Base

Section Size



Slab acts as one way spanning parallel to wall length.

Design as section depth of 300mm.

Minimum steel

=(0.26*2.9*1000*(300-75-12/2))/500 = 330.252 mm^2 C32/40 concrete

Design to span simply supported over 1.0m void in ground (firm sub-soil)

w	(weight per metre run)		=	98.00	kN
L			=	1	m
M_{Ek}		=0*0^2/8	=	12.25	kNm
M_{Ed}		=1.35*0*0^2/8	=	16.5	kNm
V_{Ek}		=0/2	=	49	kN
V_{Ed}		=1.35*0.167	=	66.15	kN

Provide A393 to bottom of slab with 75mm cover

EC2
Ultimate Design - Singly Reinforced Section

MEd =	16.54	kNm	(ULS)
VEd =	66.15	kN	(ULS)

Section Parameters:

Width, b =	1000	mm	
Concrete cylinder strength, fck =	32	N/mm²	(i.e32N/mm² for C32/40)
Steel yield strength, fyk =	500	N/mm²	
Height of section, H =	300	mm	
Main Reinforcement dia =	10	mm	
Transverse Reinforcement dia =	10	mm	
Cover =	75	mm	
Depth to tension reinforcement, d =	210	mm	

Ɣconcrete = 1.5

Design compressive strength of concrete, fcd = 0.85 fck/Ɣconcrete = 18.13 N/mm²

Maximum moment section can resist without comp steel = 0.167 x fck x b x d² = 236 kNm

k = MEd/bd²fck = 0.012 but not > than 0.167
k = 0.01171875

z = d/2*(1+√(1-3.53k) = 208 **but not > 0.95d =** 200
z = 200

As Req'd = MEd/(0.87*fyk*z) = 191 mm²
Stress low, design based on minimum steel

As min = 0.26*fctm*b*d/fyk

Tensile cracking strength, fctm = 0.3fck^(2/3) = 3.0 N/mm²
As min = 330 mm²
As Req'd = 330 mm²

As max = 0.04Ac = 12000 mm²

As Prov = 393 mm²

H10's @ 150 =	523	mm²
H12's @ 150 =	754	mm²
H16's @ 150 =	1340	mm²
H20's @ 150 =	2094	mm²
H10's @ 200 =	393	mm²
H10's @ 100 =	785	mm²
H12's @ 200 =	565	mm²
H16's @ 200 =	1005	mm²

VEd < Vrdc

As/bd = 0.0019 < 0.02
As/bd = 0.0019

k = 1+(200/d)^0.5 = 1.98 < 2
k = 1.98

vRdc = (As/bd*100)*fck^(1/3) = 1.82

Vrdc = 0.12*k*b*d*vRdc/1000 90.42 kN

Min Stress, Vmin = 0.035*k^1.5*fck^0.5 = 0.55 N/mm²

VRdm = Vmin*b*d/1000 = 115.48 kN

Provide H10 @ 200 mesh in each base for minimum steel