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MTCCB
PLANNING DEPARTMENT

- 5 OCT 2020

RECEIVED

Structural Design Check

for

2.8m Retaining Wall

at

Trebethan Bungalow

Tydfil Terrace

CF47 8SY

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NP23 8WQ

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TREBETHAN BUNGALOW, TYDFIL TERRACE

CF47
BS4

PROJECT 2.8m RETAINING WALL

PREPARED BY CM

DATE AUG 20

JOB No. Am/cm/01 DRG No.

PAGE No. 1 of 9

CHECKED BY

DATE

REF

CALCULATIONS

DESIGN

Check reinforced blockwork retaining wall to garden area to accommodate new garage + driveway

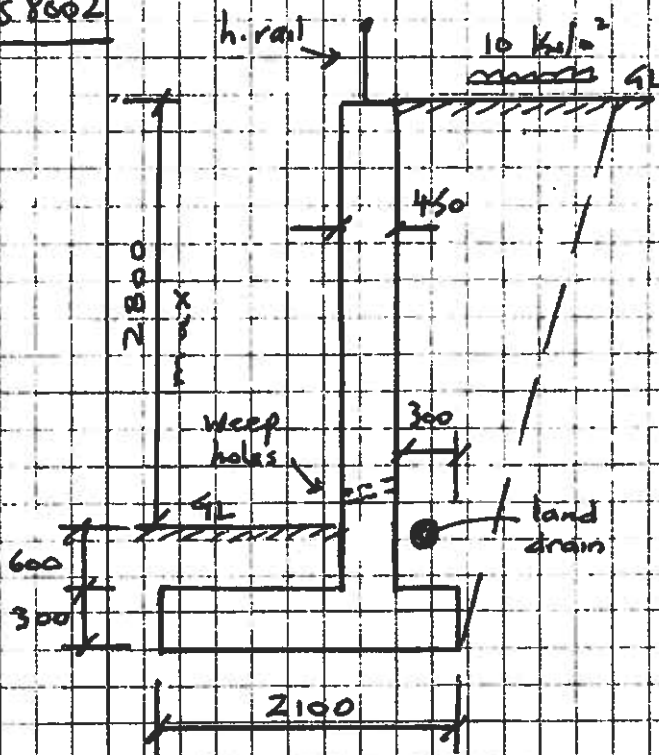
(1) STABILITY ANALYSIS

BS 8628

BS 8110

BS 8602

Use 'SCALE' software to check wall, since wall is over 3.0m retained height use 10 kN/m² surcharge.



$$\phi = 38^\circ \text{ (granular fill)}$$

$$K_a = 0.24$$

$$\gamma_{\text{wall}} = 24 \text{ kN/m}^3$$

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

$$\text{Blockwork} = 7 \text{ N/mm}^2$$

$$\text{Monitor} = 1.6$$

$$\text{Bearing capacity} = 75 \text{ kN/m}^2$$

$$\text{Surcharge} = 10 \text{ kN/m}^2$$

* see Terra Firma reports.

WALL SECTION

$$\text{FOS}_{\text{tens}} = 2.39 > 2 \quad \text{FOS}_{\text{shear}} = 2.19 > 2$$

$$\text{Bearing pressure} = 68.2 \text{ kN/m}^2 < 75$$

PROJECT	PREPARED BY	DATE
JOB No. <u>Am/Ch/01</u> DRG No.	PAGE No. <u>2 of 9</u>	CHECKED BY
		DATE

REF

CALCULATIONS

* WALL STABLE IN O/TURNING, SLIDING AND BEARING.

(2) STEM WALL DESIGN



$$M_A = 41.8 \times 1.5 = \underline{62.7 \text{ kNm/m}} \downarrow$$

$$V_A = 32.8 \times 1.5 = \underline{49.2 \text{ kN/m}} \rightarrow$$

$$d_{eff} = 450 - 100 - 35 - \frac{16}{2} = \underline{307 \text{ mm}}$$

$$M_x = P_{bd} \text{ gives } \phi = \frac{62.7 \times 10^6}{10^3 \times (307)^2} = \underline{0.67 \text{ N/mm}^2}$$

B55628 for $f_{tk} = 6.4 \text{ N/mm}^2$ $\gamma_m = 2.00$ $\gamma_{red} = 1.15$

$$\frac{f_{tk}}{\gamma_m} = \frac{6.4}{2} = \underline{3.2} \text{ refers to B55628 design table}$$

Q.4.24.2. gives $C = \underline{0.85}$ $f_y = 460$ $f_{cu} = 35$ $z = 0.954$

$$A_s \text{ reqd} = \frac{62.7 \times 10^6 \times 1.15}{460 \times 0.85 \times 307} = \underline{600 \text{ mm}^2/\text{m}}$$

* PROVIDE 2 x A393 MESH REINFORCEMENT (35% COVER)
TO REAR FACE OF WALL WITH 1 x A393 TO FRONT
AND T16 STARTER BARS @ 400 CRS TO BASE ($A_s = 503$)

$$\text{Shear } V = \underline{49.2 \text{ kN/m}} \quad A_s = 503 \text{ (T16 @ 400)}$$

$$\rho = \frac{A_s}{bd} = \frac{503}{10^3 \times 307} = \underline{0.002 \text{ N/mm}^2}$$

PROJECT

PREPARED BY

DATE

JOB No. AM/GM/01

DRG No.

PAGE No. 3 of 9

CHECKED BY

DATE

REF

CALCULATIONS

$$f_u = 0.35 + 17.5(p) = \underline{\underline{0.38 \text{ N/mm}^2}}$$

$$v = \frac{49.2 \times 10^3}{10^3 \times 307} = \underline{\underline{0.16 \text{ N/mm}^2}}$$

$$\frac{f_u}{\gamma_c} = \frac{0.38}{2} = 0.19 > 0.16$$

O.K

* NO ADDITIONAL SHEAR REBAR REQUIRED

(3) BASE DESIGN

$$M_A = 35.43 \times 1.5 = \underline{\underline{53.15 \text{ Km/m}}}$$

$$V_A = 44.85 \times 1.5 = \underline{\underline{67.27 \text{ Km/m}}}$$

$$d_{eff} = 300 - 40 - \frac{10}{2} = \underline{\underline{255 \text{ mm}}}$$

$$K = \frac{53.15 \times 10^6}{35 \times 10^3 \times (255)^2} = 0.02 \text{ N/mm}^2$$

$$\text{given } K' = 0.156 \quad Z \leq 0.95d$$

$$A_s = \frac{53.15 \times 10^6}{0.87 \times 460 \times (0.95 \times 255)} = \underline{\underline{548 \text{ mm}^2/\text{m}}}$$

Provide 1 x A393 + 1 x A193 mesh to bottom face

$A_s = 586$ ($A_1 = 586$) of 50A3 and 1 x A193 mesh to top with

40mm COVER

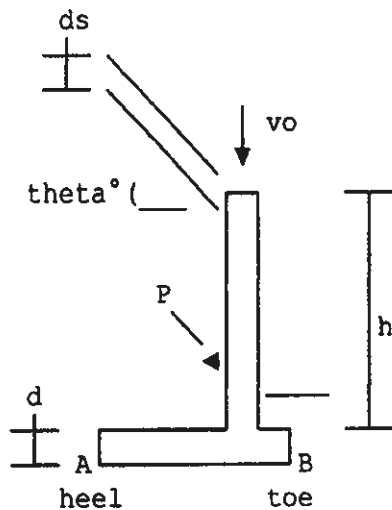
$$\text{Shear } V = \underline{\underline{67.27 \text{ Km/m}}}$$

$$v = \frac{67.27 \times 10^3}{10^3 \times 255} = \underline{\underline{0.26}} < 0.42$$

$$\left. \begin{array}{l} d = 255 \\ \frac{1500}{255} = 0.23 \\ f_y = 460 \end{array} \right\} \begin{array}{l} V_c \\ \\ \end{array} = 0.42$$

NO ADDITIONAL SHEAR REINFORCEMENT REQUIRED

Location: 2.8m Garden Retaining Wall



RC retaining wall to BS8002

Using either Rankine or Coulomb theory, the following assumptions are made:

- surface of rupture is a plane
- point of resultant pressure P on back of wall is at one third of the distance up from the base of the wall.

Both Rankine and Coulomb give formula for resultant earth pressure on back of wall as $P = C_e \cdot w \cdot h^2 / 2$ where C_e is a pressure coefficient.

Weight/unit vol. of retained soil $w = 18 \text{ kN/m}^3$

Height of wall $h = 3.4 \text{ m}$

Pressure due to surcharge $\text{press} = 10 \text{ kN/m}^2$

Equivalent depth of surcharge $ds = \text{press}/w = 10/18 = 0.55556 \text{ m}$

Load above wall supported on stem $vo = 0 \text{ kN/m}$

Angle of slope of soil (if any) $\theta = 0^\circ$

Internal friction angle of soil $\phi = 38^\circ$

Angle of wall-to-soil friction $\delta = 25.333^\circ$

Friction factor on underside base $fb = 0.6$

Data 0.6 entered, exceeds maximum expected value 0.5

Thickness of wall $t = 0.45 \text{ m}$

Density of wall (stem) $dt = 24 \text{ kN/m}^3$

Pressure from retained soil

Cosine of surcharge angle (θ) $ct = \cos(\text{RAD}(\theta)) = 1$

Sine of friction angle (ϕ) $sp = \sin(\text{RAD}(\phi)) = 0.61566$

Cosine of friction angle (ϕ) $cp = \cos(\text{RAD}(\phi)) = 0.78801$

Cosine of wall-soil friction (δ) $cd = \cos(\text{RAD}(\delta)) = 0.90384$

Sine of ($\phi + \delta$) $ss1 = \sin(\text{RAD}(\phi) + \text{RAD}(\delta))$
 $= \sin(\text{RAD}(38) + \text{RAD}(25.333))$
 $= 0.89363$

Sine of ($\phi - \theta$) $ss2 = \sin(\text{RAD}(\phi) - \text{RAD}(\theta))$
 $= \sin(\text{RAD}(38) - \text{RAD}(0))$
 $= 0.61566$

Coulomb theory:

Factor $f = cd \cdot (1 + \text{SQR}(ss1 \cdot ss2 / (cd \cdot ct)))^2$
 $= 0.90384 \cdot (1 + \text{SQR}(0.89363 \cdot 0.61566 / (0.90384 \cdot 1)))^2$
 $= 2.8644$

Pressure coefficient $Cec = cp^2 / f = 0.78801^2 / 2.8644$
 $= 0.21679$

Rankine theory:

Factor $f = \text{SQR}(ct^2 - cp^2) = \text{SQR}(1^2 - 0.78801^2)$
 $= 0.61566$

Pressure coefficient $C_e = \frac{ct \cdot (ct - f)}{ct + f}$
 $= \frac{1 \cdot (1 - 0.61566)}{1 + 0.61566}$
 $= 0.23788$

Rankine pressure coefficient is chosen.

Resultant earth force (active) $P = C_e \cdot w \cdot h^2 / 2 = 0.23788 \cdot 18 \cdot 3.4^2 / 2$
 $= 24.749 \text{ kN/m run}$

Horiz. component of this force $P_h = P \cdot \cos(\text{RAD}(\theta))$
 $= 24.749 \cdot \cos(\text{RAD}(0))$
 $= 24.749 \text{ kN/m run}$

Vertical component of this force $P_v = P \cdot \sin(\text{RAD}(\theta))$
 $= 24.749 \cdot \sin(\text{RAD}(0))$
 $= 0 \text{ kN/m run}$

Pressure coefficient (surcharge) $C_a = \frac{(1 - sp)}{(1 + sp)}$
 $= \frac{(1 - 0.61566)}{(1 + 0.61566)}$
 $= 0.23788$

Resultant earth force (surcharge) $P_s = C_a \cdot w \cdot d_s \cdot h = 0.23788 \cdot 18 \cdot 0.55556 \cdot 3.4$
 $= 8.088 \text{ kN/m run}$

Horiz. component of this force $P_{sh} = P_s \cdot \cos(\text{RAD}(\theta))$
 $= 8.088 \cdot \cos(\text{RAD}(0))$
 $= 8.088 \text{ kN/m run}$

Vertical component of this force $P_{sv} = P_s \cdot \sin(\text{RAD}(\theta))$
 $= 8.088 \cdot \sin(\text{RAD}(0))$
 $= 0 \text{ kN/m run}$

Forces and moments on wall

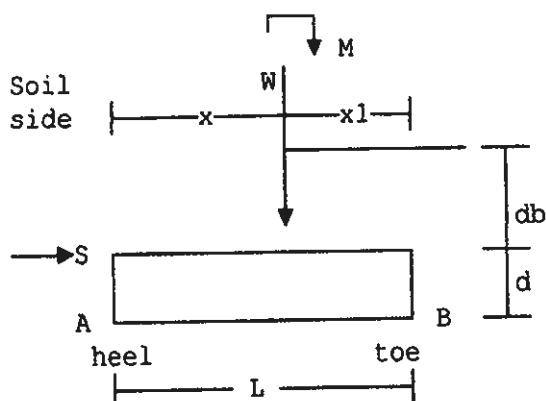
Maximum B.M. at base of stem $M = P_h \cdot h / 3 + P_{sh} \cdot h / 2$
 $= 24.749 \cdot 3.4 / 3 + 8.088 \cdot 3.4 / 2$
 $= 41.799 \text{ kNm/m}$

Maximum S.F. at base of stem $S = P_h + P_{sh} = 24.749 + 8.088 = 32.837 \text{ kN/m}$

Weight of wall $v = h \cdot t \cdot d_t = 3.4 \cdot 0.45 \cdot 24 = 36.72 \text{ kN/m run}$

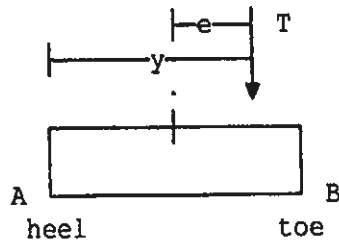
Weight of wall plus load over $v = v + v_o = 36.72 + 0 = 36.72 \text{ kN/m run}$

Base

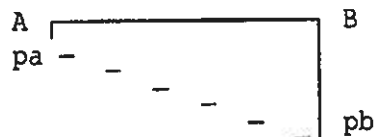


Thickness of base $d = 0.3 \text{ m}$
Length of base $L = 2.1 \text{ m}$
Distance from A to centre of stem $x = 0.525 \text{ m}$
Depth of soil over base at toe $db = 0.6 \text{ m}$
Depth of soil for passive resist. $dp = 0.9 \text{ m}$
For simplicity, the relatively-trivial effects of the self-weight and location of any key on the pressures, etc beneath the base are ignored.

Distance from stem to front toe	$x_1 = L - x = 2.1 - 0.525 = 1.575 \text{ m}$
Allowable ground pressure	$p = 75 \text{ kN/m}^2$
Self-weight of foundation	$Sw = L * d * dt = 2.1 * 0.3 * 24 = 15.12 \text{ kN/m run}$
Wt. of soil behind wall (earth)	$wbe = (h + ds) * (x - t/2) * w$ $= (3.4 + 0.55556) * (0.525 - 0.45/2) * 18$ $= 21.36 \text{ kN/m run}$
Wt. of soil behind wall (slope)	$wbs = w * (x - t/2)^2 * \text{TAN}(\text{RAD}(\theta)) / 2$ $= 18 * (0.525 - 0.45/2)^2 * \text{TAN}(\text{RAD}(0)) / 2$ $= 0 \text{ kN/m run}$
Total weight of soil behind wall	$wb = wbe + wbs = 21.36 + 0 = 21.36 \text{ kN/m run}$
Weight of soil at front of wall	$wf = db * (x_1 - t/2) * w$ $= 0.6 * (1.575 - 0.45/2) * 18$ $= 14.58 \text{ kN/m run}$
Total earth pressure (active)	$Pab = Ce * ct * w * (h + d)^2 / 2$ $= 0.23788 * 1 * 18 * (3.4 + 0.3)^2 / 2$ $= 29.31 \text{ kN/m run}$
Horiz.component of this force	$Pabh = Pab * \text{COS}(\text{RAD}(\theta))$ $= 29.31 * \text{COS}(\text{RAD}(0))$ $= 29.31 \text{ kN/m run}$
Vertical component of this force	$Pabv = Pab * \text{SIN}(\text{RAD}(\theta))$ $= 29.31 * \text{SIN}(\text{RAD}(0))$ $= 0 \text{ kN/m run}$
Total earth pressure (surcharge)	$Psb = Ca * w * ds * (h + d)$ $= 0.23788 * 18 * 0.55556 * (3.4 + 0.3)$ $= 8.8017 \text{ kN/m run}$
Horiz.component of this force	$Psbh = Psb * \text{COS}(\text{RAD}(\theta))$ $= 8.8017 * \text{COS}(\text{RAD}(0))$ $= 8.8017 \text{ kN/m run}$
Vertical component of this force	$Psbv = Psb * \text{SIN}(\text{RAD}(\theta))$ $= 8.8017 * \text{SIN}(\text{RAD}(0))$ $= 0 \text{ kN/m run}$
Total load on soil beneath base	$T = v + Sw + wb + wf + Pabv + Psbv$ $= 36.72 + 15.12 + 21.36 + 14.58 + 0 + 0$ $= 87.78 \text{ kN/m run}$
Overturning moment due to earth pressure	$Mt = Pabh * (h + d) / 3 + Psbh * (h + d) / 2$ $= 29.31 * (3.4 + 0.3) / 3 + 8.8017 * (3.4 + 0.3) / 2$ $= 52.432 \text{ kNm/m run}$
Force u/s base (earth pressure)	$St = Pabh + Psbh = 29.31 + 8.8017$ $= 38.111 \text{ kN/m run}$
Clockwise moments about A due to weight of soil behind wall	$Mcb = (3 * wbe + 2 * wbs) * (x - t/2) / 6$ $= (3 * 21.36 + 2 * 0) * (0.525 - 0.45/2) / 6$ $= 3.204 \text{ kNm/m}$
Clockwise moments about A due to vert.component of earth pressure	$Mcbv = (Pabv + Psbv) * (x - t/2)$ $= (0 + 0) * (0.525 - 0.45/2)$ $= 0 \text{ kNm/m}$
Total clockwise moments about A:	$Mc = v * x + Mt + Sw * L / 2 + Mcb + Mcbv + wf * (L - (x_1 - t/2) / 2)$ $= 36.72 * 0.525 + 52.432 + 15.12 * 2.1 / 2 + 3.204 + 0 + 14.58 * (2.1 - (1.575 - 0.45/2) / 2)$ $= 111.57 \text{ kNm/m}$
Distance to centroid of load	$y = Mc / T = 111.57 / 87.78 = 1.271 \text{ m}$



Eccentricity $e = y - L/2 = 1.271 - 2.1/2 = 0.22097 \text{ m}$
Centroid of load lies within middle third. Pressure varies from p_a at A to p_b at B.



Base area modulus $z = 1 \cdot L^2 / 6$
 $= 1 \cdot 2.1^2 / 6$
 $= 0.735 \text{ cu.m per metre run}$
Pressure at A $p_a = T / (L \cdot 1) - T \cdot e / z$
 $= 87.78 / (2.1 \cdot 1) - 87.78 \cdot 0.22097 / 0.735$
 $= 15.409 \text{ kN/m}^2$
Pressure at B $p_b = T / (L \cdot 1) + T \cdot e / z$
 $= 87.78 / (2.1 \cdot 1) + 87.78 \cdot 0.22097 / 0.735$
 $= 68.191 \text{ kN/m}^2$
Maximum pressure is at B $p_{\max} = p_b = 68.191 \text{ kN/m}^2$
As $p_{\max}$ does not exceed p ($68.191 \text{ kN/m}^2 \leq 75 \text{ kN/m}^2$),
pressure beneath base is within specified limit.

Shear forces and bending moments on base

Pressure under back of wall $p_{wa} = p_a + (p_b - p_a) \cdot (x - t/2) / L$
 $= 15.409 + (68.191 - 15.409) \cdot (0.525 - 0.45/2) / 2.1$
 $= 22.95 \text{ kN/m}^2$
Pressure under front of wall $p_{wb} = p_a + (p_b - p_a) \cdot (x + t/2) / L$
 $= 15.409 + (68.191 - 15.409) \cdot (0.525 + 0.45/2) / 2.1$
 $= 34.26 \text{ kN/m}^2$
Downward S.F. on heel $S_{ad} = dt \cdot d \cdot (x - t/2) + w_b$
 $= 24 \cdot 0.3 \cdot (0.525 - 0.45/2) + 21.36$
 $= 23.52 \text{ kN/m}$
Upward S.F. on heel $S_{au} = (p_a + p_{wa}) \cdot (x - t/2) / 2$
 $= (15.409 + 22.95) \cdot (0.525 - 0.45/2) / 2$
 $= 5.7539 \text{ kN/m}$
Downward B.M. on toe $M_{bd} = (dt \cdot d \cdot (x_1 - t/2) + w_f) \cdot (x_1 - t/2) / 2$
 $= (24 \cdot 0.3 \cdot (1.575 - 0.45/2) + 14.58) \cdot (1.575 - 0.45/2) / 2$
 $= 16.403 \text{ kNm/m}$
Downward B.M. on heel $M_{ad} = (3 \cdot w_{be} + 4 \cdot w_{bs} + 3 \cdot dt \cdot d \cdot (x - t/2)) \cdot (x - t/2) / 6$
 $= (3 \cdot 21.36 + 4 \cdot 0 + 3 \cdot 24 \cdot 0.3 \cdot (0.525 - 0.45/2)) \cdot (0.525 - 0.45/2) / 6$
 $= 3.528 \text{ kNm/m}$
Total S.F. on toe (plus is up) $S_{wb} = ((p_{wb} + p_b) / 2 - dt \cdot d) \cdot (x_1 - t/2) - w_f$
 $= ((34.26 + 68.191) / 2 - 24 \cdot 0.3) \cdot (1.575 - 0.45/2) - 14.58$

$=44.854 \text{ kN/m}$
Total S.F. on heel (plus is up) $Swa=Sau-Sad=5.7539-23.52$
 $=-17.766 \text{ kN/m}$
Total B.M. on toe (plus is up) $Mwb=(2*pb+pwb)*(x1-t/2)^2/6-Mbd$
 $=(2*68.191+34.26)*(1.575-0.45$
 $/2)^2/6-16.403$
 $=35.43 \text{ kNm/m}$
Total B.M. on heel (plus is up) $Mwa=(2*pa+pwa)*(x-t/2)^2/6-Mad$
 $=(2*15.409+22.95)*(0.525-0.45$
 $/2)^2/6-3.528$
 $=-2.7215 \text{ kNm/m}$

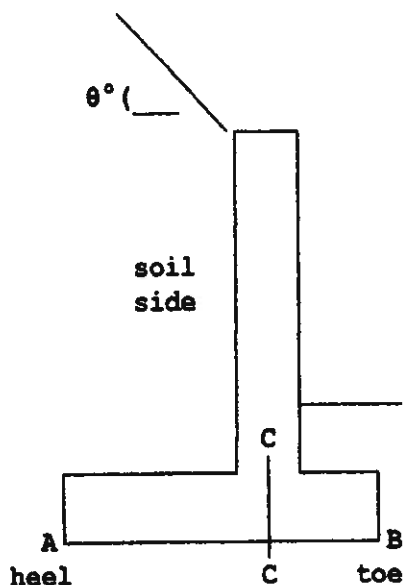
Resistance to sliding

Frictional resistance $F=fb*T=0.6*87.78=52.668 \text{ kN/m run}$
Rankine coeff.of passive pressure $Kp=(\tan(\text{RAD}(45)+\text{RAD}(\phi/2)))^2$
 $=(\tan(\text{RAD}(45)+\text{RAD}(38/2)))^2$
 $=4.2037$
Passive resistance $R=0.5*Kp*w*dp^2=0.5*4.2037*18*0.9^2$
 $=30.645 \text{ kN/m}$
FoS sliding (frict.resist.only) $FOSF=F/St=52.668/38.111$
 $=1.382$
FoS sliding (friction/cohesion + passive) $FOSF2=(F+R)/St$
 $=(52.668+30.645)/38.111$
 $=2.1861$

Resistance to overturning

Rotation assumed to occur about lowest forward edge of base (i.e. toe).
Restraining moments:

Due to soil behind wall $Mre=wbe*(L-(x-t/2)/2)+wbs*(L-(x-t/2)/3)$
 $=21.36*(2.1-(0.525-0.45/2)/2)+0$
 $*(2.1-(0.525-0.45/2)/3)$
 $=41.652 \text{ kNm/m}$
Due to base, wall and soil on toe $Mrw=v*x1+Sw*L/2+wf*(x1-t/2)/2$
 $=36.72*1.575+15.12*2.1/2+14.58$
 $*(1.575-0.45/2)/2$
 $=83.552 \text{ kNm/m}$
Due to vert.comp.of earth pres. $Mrv=(Pabv+Psbv)*(x1+t/2)$
 $=(0+0)*(1.575+0.45/2)$
 $=0 \text{ kNm/m}$
Total restraining mt.(with Mrv) $Mr1=Mre+Mrw+Mrv=41.652+83.552+0$
 $=125.2 \text{ kNm/m}$
ditto (without Mrv) $Mr2=Mre+Mrw=41.652+83.552$
 $=125.2 \text{ kNm/m}$
Total overturning moment $Mot=Mt=52.432 \text{ kNm/m}$
Safety factors against overturning:
Including vert.comp.of pressure $FOSOT1=Mr1/Mot=125.2/52.432$
 $=2.3879$
Ignoring vert.comp.of pressure $FOSOT2=Mr2/Mot=125.2/52.432$
 $=2.3879$



Design Summary

Moment at base of stem	41.799 kNm
Shear at base of stem	32.837 kN
Moment at c-c (toe)	35.43 kNm
Shear at c-c (toe)	44.854 kN
Moment at c-c (heel)	-2.7215 kNm
Shear at c-c (heel)	-17.766 kN

FoS for Overturning

(1) With vertical component of earth pressure considered	2.3879
(2) Ignoring vertical component of earth pressure	2.3879

FoS for Sliding

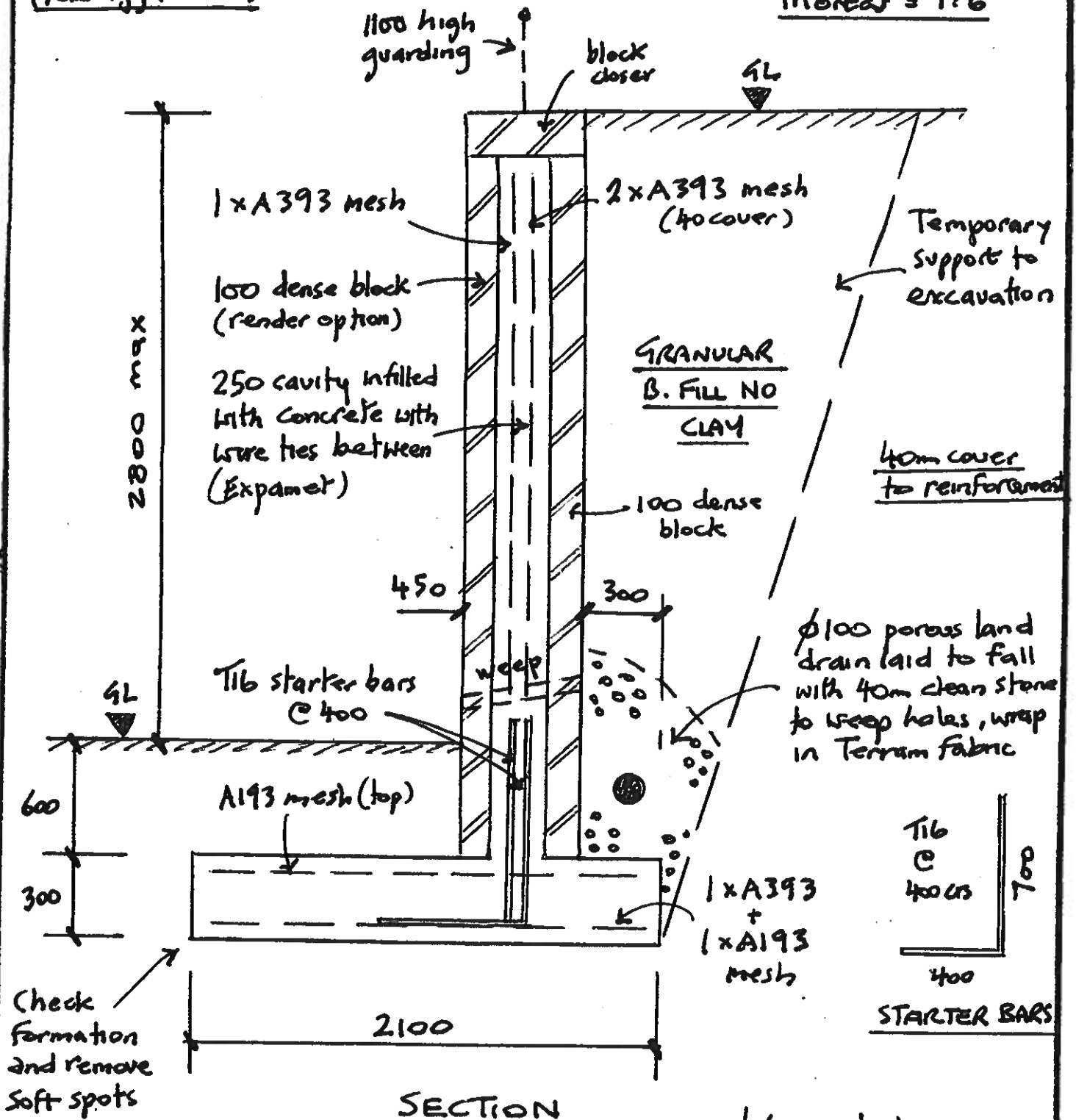
(1) Friction only	1.382
(2) Friction+passive	2.1861

Pressure at A	15.409 kN/m ²
Pressure at B	68.191 kN/m ²
Allowable GBP	75 kN/m ²

Concrete R/C35/45
(10mm agg to wall)

DO NOT SCALE

Blockwork = 7.3 m²
Mortar = 1:6



NOTES

No backfill until wall achieves minimum 3-5 days strength

Blockwork constructed in maximum 900 'lifts' unless support provided
Minimum 400 lap to mesh at joints

Project Title

2.8m GARDEN RETAINING
WALL, TREBETHAN BUNGALOW

Drawn CM

Date AUG 20

Drg. RW/AM/01

Rev.

