

Structural Calculations

Design Stage July 2022

FOR

RETAINING WALL

AT

1 ST ILLTYDS CLOSE
BAGLAN, PORT TALBOT

Retaining Wall Design

This wall is supporting Rear garden adjacent to highway

Wall height = 1.80m

The wall will be designed as blockwork wall with blockwork strength = 7.3 N/mm^2

The wall has four steps.

From computer output see detailed drawing.

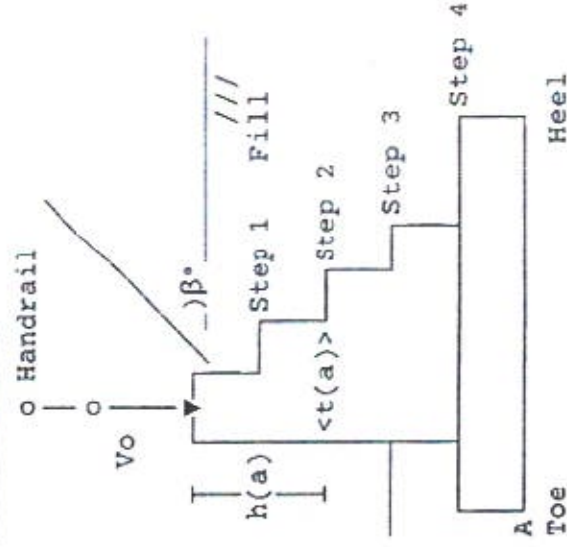
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Location: Retaining Wall

Masonry gravity wall

Designed in accordance with BS5628:Part 1:1992.

Soil details



Steps are numbered down from the top

$h(a)$ = height at step (a) from the top
 $t(a)$ = thickness at step (a)
 V_o = vertical point load on wall

As a masonry wall has limited capacity the design will assume the backfill is drained i.e. no water pressure behind the wall.

Weight/unit volume of soil & wall $w_e=18 \text{ kN/m}^3$

Internal angle of friction (fill) $\phi=35^\circ$

Angle of backfill $\beta=0^\circ$

Active soil pressure is applicable.

Sine angle of internal friction $\phi=\sin(\text{RAD}(\phi))=0.5736$

Active pressure coefficient

$$ce=(1-\phi)/(1+\phi) \\ = (1-0.5736)/(1+0.5736) \\ = 0.271$$

Masonry details

Mortar designation to Table 1 mortar=2

Masonry type (1=clay 2=cal silicate 3=conc brick 4=block)

typ(1)=4

Concrete block dimensions:

Height

$h_b=100 \text{ mm}$

Least horizontal dimension

$l_{hd}=215 \text{ mm}$

ratio height/least horiz. dim

$rb=h_b/l_{hd}=100/215=0.4651$

Compressive strength of blocks

$po=7.3 \text{ N/mm}^2$

Characteristic flexural strength for bed failure and leaf greater than

250mm thick - Table 3

$fb(a)=\text{TABLE } 3.71 \text{ for } po=7.3, \text{ mortar}=2$

$$=0.15 \text{ N/mm}^2$$

Partial safety factor material

$\gamma_{mam}=2.8$

0

External loading



Applied moment at top of wall $xm=0$ kNm
 Applied vertical load on the wall $Vo=0.5$ kN
 Applied shear at top of wall $xv=0.5$ kN
 Weight/unit area of surcharge $ws=1.5$ kN/m²
 Load factor external loads at top $gmx=1.6$
 Load factor surcharge $gams=1.6$
 Load factor earth pressure $game=1.4$
 Load factor self weight $gamf=0.9$

Wall design

Step 1 Typical Analysis which is repeated for each step

Proposed height at step $h(1)=0.3$ m
 Proposed thickness at step $t(1)=0.325$ m
 Moment at height h earth $me=ce*we*h(a)^3/6=0.271*18*0.3^3/6=0.022$ kNm
 surcharge $ms=ce*ws*h(a)^2/2=0.271*1.5*0.3^2/2=0.0183$ kNm

Ultimate moment at height h :

$$\begin{aligned} mu &= me*game + ms*gams + (xm + xv*h(a))*gamx \\ &= 0.022*1.4 + 0.0183*1.6 + (0 + 0.5*0.3) \\ &\quad *1.6 \\ &= 0.3 \end{aligned}$$

Section modulus at thickness t $z = t(a)^2/6 = 0.325^2/6 = 0.0176$ m³
 Weight/unit area at depth h $gd = (ws + we*h(a) + Vo/t(a))*gamf/1000 = (1.5 + 18*0.3 + 0.5/0.325)*0.9/1000 = 0.0076$ N/mm²

Moment of resistance $mr = (fb(1)/gammam + gd)*z*1000 = (0.15/2.8 + 0.0076)*0.0176*1000 = 1.077$ kNm

Applied moment less than moment of resistance ($0.3 \leq 1.077$)
 therefore section is satisfactory.

Step 1 width 0.325 m
 height 0.3 m

0

Wall shearHorizontal shear force

$$\begin{aligned} \text{usf} &= (\text{sfe} * \text{game}) + (\text{sfs} * \text{gams}) \\ &= (10.76 * 1.4) + (0.8536 * 1.6) \\ &= 16.42 \text{ kN} \end{aligned}$$

Shear stress at bottom of wall

$$\begin{aligned} \text{uss} &= \text{usf} / (t(\text{steps}) * 1000) \\ &= 16.42 / (0.9 * 1000) \\ &= 0.0182 \text{ N/mm}^2 \end{aligned}$$

Weight at bottom of step 1

$$\begin{aligned} \text{uwt} &= t(a) * \text{we} * h(a) * \text{gamf} \\ &= 0.325 * 18 * 0.3 * 0.9 \\ &= 1.58 \text{ kN} \end{aligned}$$

Weight at bottom of step 2

$$\begin{aligned} \text{uwt} &= \text{uwt} + (t(a) * \text{we} * h(a) * \text{gamf}) \\ &= 1.58 + (0.45 * 18 * 0.8 * 0.9) \\ &= 7.412 \text{ kN} \end{aligned}$$

Weight at bottom of step 3

$$\begin{aligned} \text{uwt} &= \text{uwt} + (t(a) * \text{we} * h(a) * \text{gamf}) \\ &= 7.412 + (0.675 * 18 * 1.3 * 0.9) \\ &= 21.63 \text{ kN} \end{aligned}$$

Weight at bottom of step 4

$$\begin{aligned} \text{uwt} &= \text{uwt} + (t(a) * \text{we} * h(a) * \text{gamf}) \\ &= 21.63 + (0.9 * 18 * 1.8 * 0.9) \\ &= 47.87 \text{ kN} \end{aligned}$$

Weight per. unit area

$$\begin{aligned} \text{ga} &= (\text{uwt} + \text{Vo}) / (t(\text{steps}) * 1000) \\ &= (47.87 + 0.5) / (0.9 * 1000) \\ &= 0.0537 \text{ N/mm}^2 \end{aligned}$$

Permissible shear stress

$$\begin{aligned} \text{fv} &= 0.35 + 0.6 * \text{ga} = 0.35 + 0.6 * 0.0537 \\ &= 0.3822 \text{ N/mm}^2 \end{aligned}$$

As $\text{uss} \leq \text{fv}$ ($0.0182 \text{ N/mm}^2 \leq 0.3822 \text{ N/mm}^2$), applied shear is less than shear resistance.

OverturningOverturning moment about A

$$\begin{aligned} \text{om} &= \text{me} * \text{ms} + (\text{xm} * \text{xv} * \text{od}) \\ &= 7.529 + 0.8963 + (0 + 0.5 * 2.1) \\ &= 9.475 \text{ kNm} \end{aligned}$$

Restoring moment abt A fill/wall

$$\begin{aligned} \text{rmf} &= \text{wf} * \text{ef} = 35.64 * 0.75 = 26.73 \text{ kNm} \\ \text{base} &= \text{wb} * \text{tb} / 2 = 9.36 * 1.3 / 2 = 6.084 \text{ kNm} \\ \text{surcharge} &= \text{ws} * (t + \text{th}) * \text{ef} = 1.5 * (0.9 + 0.2) * 0.75 \\ &= 1.238 \end{aligned}$$

vertical load

$$\begin{aligned} \text{rmVo} &= \text{Vo} * \text{eVo} = 0.5 * 0.5 = 0.25 \text{ kNm} \\ \text{total} &= \text{rmf} + \text{rm} * \text{b} + \text{rms} + \text{rmVo} \\ &= 26.73 + 6.084 + 1.238 + 0.25 \\ &= 34.3 \end{aligned}$$

Factor of safety

$$\text{fso} = \text{rm} / \text{om} = 34.3 / 9.475 = 3.62$$

Sliding - passive resistance will be ignored

Vertical load on wall will be ignored for the sliding calculations that follow.

Sliding force

$$\begin{aligned} \text{sf} &= \text{sfe} + \text{sfs} * \text{xv} = 10.76 + 0.8536 * 0.5 \\ &= 12.11 \end{aligned}$$

Details of bearing strata:

Angle of friction (u/s of base)

$$\text{phib} = 40^\circ$$

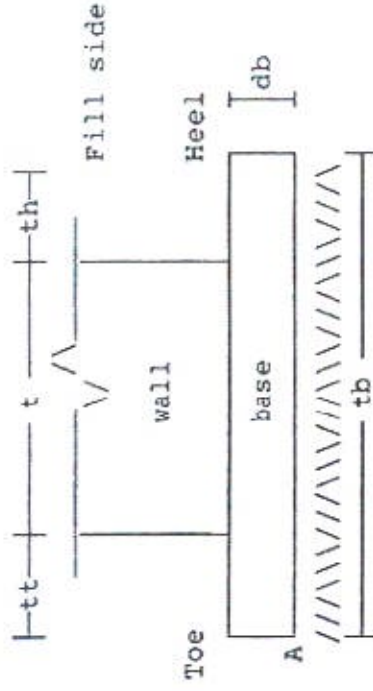
Soil cohesion

$$\text{cu} = 0 \text{ kN/m}^2$$

Step height (m)	Step thickness (m)	Ultimate Moments (kNm) Resistance Applied
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0.3	0.325	1.077
0.8	0.45	2.325
1.3	0.675	5.82
1.8	0.9	11.42

Stability and bearing check



db = depth of base
 tb = width of base

Width of toe	tt=0.20 m
Width of heel	th=0.20 m
Point of application of Vo from A	eVo=0.5 m
Thickness of wall	t=0.9 m
Height of wall	h=1.8 m
Width of base	tb=t+tt+th=0.9+0.2+0.2=1.3
Depth of base	db=0.3 m
Overall depth	od=h+db=1.8+0.3=2.1 m
Weight of fill and wall	wf=we*(t+th)*h=18*(0.9+0.2)*1.8 =35.64 kN
Eccentricity from A (fill & wall)	ef=tt+(t+th)/2=0.2+(0.9+0.2)/2 =0.75 m
Density of base	denb=24 kN/m ³
Weight of base	wb=tb*db*denb=1.3*0.3*24 =9.36 kN
Earth horizontal force	sfe=ce*we*od ² /2=0.271*18*2.1 ² /2 =10.76 kN
Moment due to earth pressure	me=sfe*od/3=10.76*2.1/3=7.529 kNm
Surcharge horizontal force	sfs=ws*ce*od=1.5*0.271*2.1 =0.8536 kN
Moment due to surcharge	ms=sfs*od/2=0.8536*2.1/2 =0.8963 kNm

Coefficient of friction ϕ
 $cf = \text{TAN}(\text{RAD}(\phi \times 2/3))$
 $= \text{TAN}(\text{RAD}(40 \times 2/3))$
 $= 0.5022$

Resisting force
 fill $rff = wf \times cf = 35.64 \times 0.5022 = 17.9 \text{ kN}$
 base $rfb = wb \times cf + tb \times cu/2 = 9.36 \times 0.5022 + 1.3 \times 0/2$
 $= 4.701 \text{ kN}$
 surcharge $rfs = ws \times (t + th) \times cf = 1.5 \times (0.9 + 0.2) \times 0.5022$
 $= 0.8287 \text{ kN}$
 total $rf = rff + rfb + rfs = 17.9 + 4.701 + 0.8287$
 $= 23.43 \text{ kN}$
 Factor of safety $fss = rf/sf = 23.43/12.11 = 1.935$

Bearing pressure

Weight of surcharge
 $sw = ws \times (t + th) = 1.5 \times (0.9 + 0.2)$
 $= 1.65 \text{ kN}$

Moments about centre of base
 $m = om + (wf + sw) \times (tb/2 - ef) + Vo \times (tb/2 - eVo)$
 $= 9.475 + (35.64 + 1.65) \times (1.3/2 - 0.75)$
 $+ 0.5 \times (1.3/2 - 0.5)$
 $= 5.821 \text{ kNm}$

Section modulus of base
 Total weight $zb = tb^2/6 = 1.3^2/6 = 0.2817 \text{ m}^3$
 $tw = wf + sw + wb + Vo = 35.64 + 1.65 + 9.36 + 0.5$
 $= 47.15 \text{ kN}$

Pressure due to weight $pw = tw/tb = 47.15/1.3 = 36.27 \text{ kN/m}^2$
 Pressure due to BM (+ve or -ve) $pm = m/zb = 5.821/0.2817 = 20.67 \text{ kN/m}^2$
 Maximum pressure $pmax = pw + pm = 36.27 + 20.67 = 56.94 \text{ kN/m}^2$
 Minimum pressure $pmin = pw - pm = 36.27 - 20.67 = 15.6 \text{ kN/m}^2$

DESIGN SUMMARY

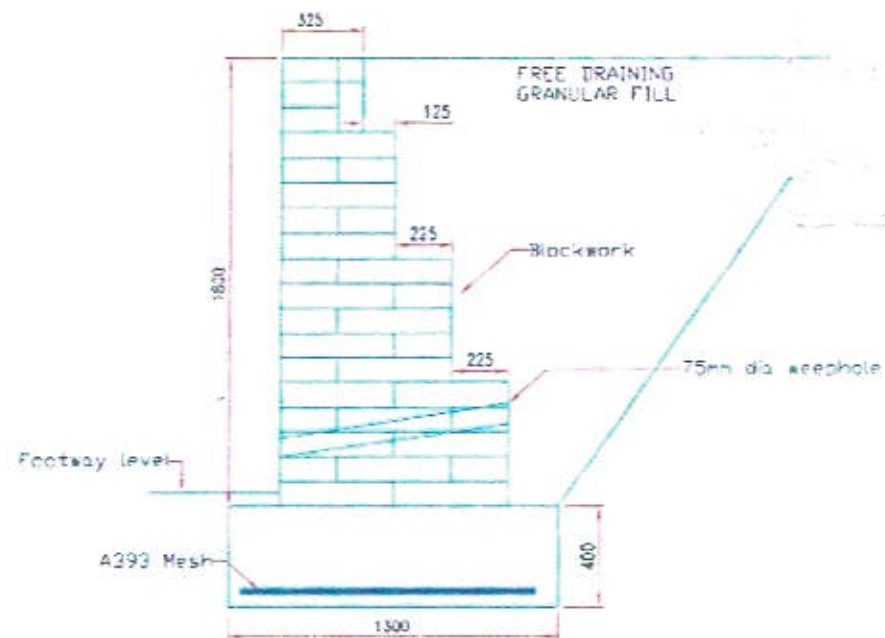
Wall height 1.8 m

Step height (m)	Step thickness (m)	Ultimate Moments (kNm)	Resistance Applied
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0.3	0.325	1.077	0.3
0.8	0.45	2.325	1.431
1.3	0.675	5.82	4.09
1.8	0.9	11.42	9.131

Summary of stability check

Factor of safety overturning	3.62
Factor of safety sliding	1.935
Maximum base pressure	56.94 kN/m ²



Proposed Retaining Wall
N.T.S.

Proposed Retaining Wall
1 St. Hyds. Close
Bogdan
Scale As shown