

Structural Calculations

Design Stage March 2021

FOR

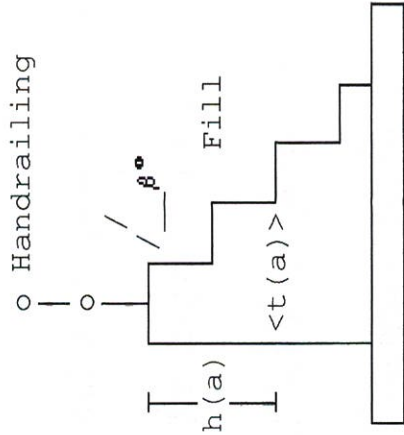
RETAINING WALL

AT

CRUG WYLLT FAWR FARM
MARGAM, PORT TALBOT

Masonry gravity wall

Designed in accordance with BS5628:Part 1: 1992.
Location: Back Garden.



Steps are numbered down from the top.
h(a) is height at step a (from top)
t(a) is thickness at step a

Soil details

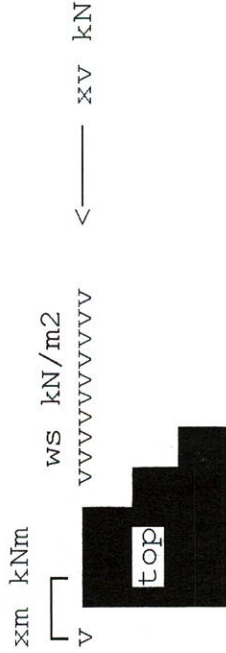
Weight/unit volume of soil & wall $w_e=18 \text{ kN/m}^3$
Internal angle of friction $\phi=35^\circ$
Angle of backfill $\beta=0^\circ$
Active soil pressure is applicable.
Sine angle of internal friction $\sin(\phi)=0.5736$
Active pressure coefficient $C_a=\frac{(1-\sin(\phi))}{(1+\sin(\phi))}=\frac{(1-0.5736)}{(1+0.5736)}=0.271$

Masonry details

Mortar designation to Table 1 $\text{mortar}=3$
Masonry type (1=clay 2=cal silicate 3=conc brick 4=block)
 $\text{typ}(1)=4$
Concrete Blocks Dimensions
Height $h_b=215 \text{ mm}$
Least horiz dimension $l_{hd}=100 \text{ mm}$
ratio height/least horiz dim $r_b=\frac{h_b}{l_{hd}}=\frac{215}{100}=2.15$
Compressive strength of blocks $p_o=7.35 \text{ N/mm}^2$

Characteristic flexural strength for bed failure and leaf greater than 250mm thick - Table 3
 $fb(a)=TABLE\ 3.71\ for\ po=7.35,\ mortar=0.16\ N/mm^2$
Partial safety factor material $\gamma_{mm}=3.1$

External loading



Applied moment at top of wall $xm=0\ kNm$
Applied shear at top of wall $xv=0\ kN$
Weight/unit area of surcharge $ws=1.5\ kN/m^2$
Load factor external loads at top $\gamma_{max}=1.6$
Load factor surcharge $\gamma_{mas}=1.6$
Load factor earth pressure $\gamma_{mae}=1.4$
Load factor self weight $\gamma_{maf}=0.9$

Wall design

Number of steps proposed in wall steps=3

Step 1 Typical Analysis which is repeated for each step

Proposed height at step $h(1)=1.00\ m$
Proposed thickness at step $t(1)=0.450\ m$
Moment at height h earth $me=ce*we*h(a)^3/6=0.271*18*1^3/6=0.813\ kNm$
surcharge $ms=ce*ws*h(a)^2/2=0.271*1.5*1^2/2=0.2032\ kNm$
Ultimate moment at height h $mu=me*\gamma_{mae}+ms*\gamma_{mas}+(xm+xv*h(a))*\gamma_{max}$
 $=0.813*1.4+0.2032*1.6+(0+0*1)*1.6=1.463$
Section modulus at thickness t $z=t(a)^2/6=0.45^2/6=0.03375\ m^3$

Weight/unit area at depth h

$$\begin{aligned}gd &= (ws + we \cdot h(a)) \cdot \gamma_{maf} / 1000 \\ &= (1.5 + 18 \cdot 1) \cdot 0.9 / 1000 \\ &= 0.01755 \text{ N/mm}^2\end{aligned}$$

Moment of resistance

$$\begin{aligned}mr &= (fb(1) / \gamma_{mmam} + gd) \cdot z \cdot 1000 \\ &= (0.16 / 3.1 + 0.01755) \cdot 0.03375 \cdot 1000 \\ &= 2.334 \text{ kNm}\end{aligned}$$

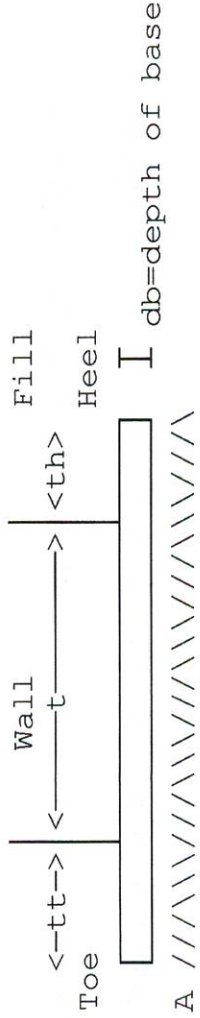
Applied moment less than moment of resistance (1.463 <= 2.334)
therefore section is satisfactory.

Step 1
width 0.45 m
height 1 m

Step height (m)	Step thicknes (m)	Ultimate Moments (kNm) Resistance Applied
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1	0.45	2.334	1.463
1.6	0.675	5.99	5.494
2.1	1.1	17.54	11.97

Stability and bearing check



Width of toe
Width of heel
Thickness of wall
Height of wall
Width of base

$$\begin{aligned}tt &= 0.15 \text{ m} \\ th &= 0.15 \text{ m} \\ t &= 1.1 \text{ m} \\ h &= 2.1 \text{ m} \\ tb &= t + tt + th = 1.1 + 0.15 + 0.15 \\ &= 1.4\end{aligned}$$

Depth of base
Overall depth
Weight of fill and wall

$$\begin{aligned}db &= 0.30 \text{ m} \\ od &= h + db = 2.1 + 0.3 = 2.4 \text{ m} \\ wf &= we \cdot (t + th) \cdot h = 18 \cdot (1.1 + 0.15) \cdot 2.1 \\ &= 47.25 \text{ kN}\end{aligned}$$

Eccentricity from A

$$\begin{aligned}ef &= tt + (t + th) / 2 = 0.15 + (1.1 + 0.15) / 2 \\ &= 0.775 \text{ m}\end{aligned}$$

Weight of base

$$wb = tb \cdot db \cdot 24 = 1.4 \cdot 0.3 \cdot 24 = 10.08 \text{ kN}$$

Earth horizontal force $sfe = ce * we * od^2 / 2 = 0.271 * 18 * 2.4^2 / 2$
= 14.05 kN
Moment due to earth pressure $me = sfe * od / 3 = 14.05 * 2.4 / 3 = 11.24$ kNm
Surcharge horizontal force $sfs = ws * ce * od = 1.5 * 0.271 * 2.4$
= 0.9756 kN
Moment due to surcharge $ms = sfs * od / 2 = 0.9756 * 2.4 / 2$
= 1.171 kNm

Wall shear

Horizontal shear force $usf = (sfe * gammae) + (sfs * gammas)$
= $(14.05 * 1.4) + (0.9756 * 1.6)$
= 21.23 kN

Shear stress at bottom of wall $uss = usf / (t * steps) * 1000$
= $21.23 / (1.1 * 1000)$
= 0.0193 N/mm²

Weight at bottom of step 1 $uwt = t(a) * we * h(a) * gammaf = 0.45 * 18 * 1 * 0.9$
= 7.29 kN

Weight at bottom of step 2 $uwt = uwt + (t(a) * we * h(a) * gammaf)$
= $7.29 + (0.675 * 18 * 1.6 * 0.9)$
= 24.79 kN

Weight at bottom of step 3 $uwt = uwt + (t(a) * we * h(a) * gammaf)$
= $24.79 + (1.1 * 18 * 2.1 * 0.9)$
= 62.21 kN

Weight per. unit area $ga = uwt / (t * steps) * 1000$
= $62.21 / (1.1 * 1000)$
= 0.05655 N/mm²

Permissible shear stress $fv = 0.15 + 0.6 * ga = 0.15 + 0.6 * 0.05655$
= 0.1839 N/mm²

Applied shear less than shear resistance (0.0193 <= 0.1839)
therefore section is satisfactory.

Overturning

Overturning moment about A $om = me + ms + (xm + xv * od)$
= $11.24 + 1.171 + (0 + 0 * 2.4)$
= 12.41 kNm

Restoring moment abt A fill/wall $rmf = wf * ef = 47.25 * 0.775 = 36.62$ kNm
base $rmb = wb * tb / 2 = 10.08 * 1.4 / 2 = 7.056$ kNm

surcharge	rms=ws*(t+th)*ef=1.5*(1.1+0.15)*0.775 =1.453
total	rm=rmf+rmb+rms=36.62+7.056+1.453 =45.13
Factor of safety	fso=rm/om=45.13/12.41=3.637
<u>Sliding (passive resistance ignored)</u>	
Sliding force	sf=sfe+sfs+xv=14.05+0.9756+0 =15.02
Details of bearing stratas	phib=40°
angle of friction	cu=0 kN/m ²
cohesion	cf=TAN(RAD(phib*2/3))
Coefficient of friction	=TAN(RAD(40*2/3)) =0.5022
Resisting force	rff=wf*cf=47.25*0.5022=23.73 kN
base	rfb=wb*cf+tb*cu/2 =10.08*0.5022+1.4*0/2 =5.062 kN
surcharge	rfs=ws*(t+th)*cf =1.5*(1.1+0.15)*0.5022 =0.9417 kN
total	rf=rff+rfb+rfs=23.73+5.062+0.9417 =29.73 kN
Factor of safety	fss=rf/sf=29.73/15.02=1.979
<u>Bearing pressure</u>	
Weight of surcharge	sw=ws*(t+th)=1.5*(1.1+0.15) =1.875 kN
Moments about centre of base	m=om+(wf+sw)*(tb/2-ef) =12.41+(47.25+1.875)*(1.4/2-0.775) =8.725 kNm
Section modulus of base	zb=tb^2/6=1.4^2/6=0.3267 m ³
Total weight	tw=wf+sw+wb=47.25+1.875+10.08 =59.21 kN
Pressure due to weight	pw=tw/tb=59.21/1.4=42.29 kN/m ²
Pressure due to moment (+/-)	pm=m/zb=8.725/0.3267=26.71 kN/m ²
Maximum pressure	pmax=pw+pm=42.29+26.71=69 kN/m ²
Minimum pressure	pmin=pw-pm=42.29-26.71=15.58 kN/m ²

Summary of stability check

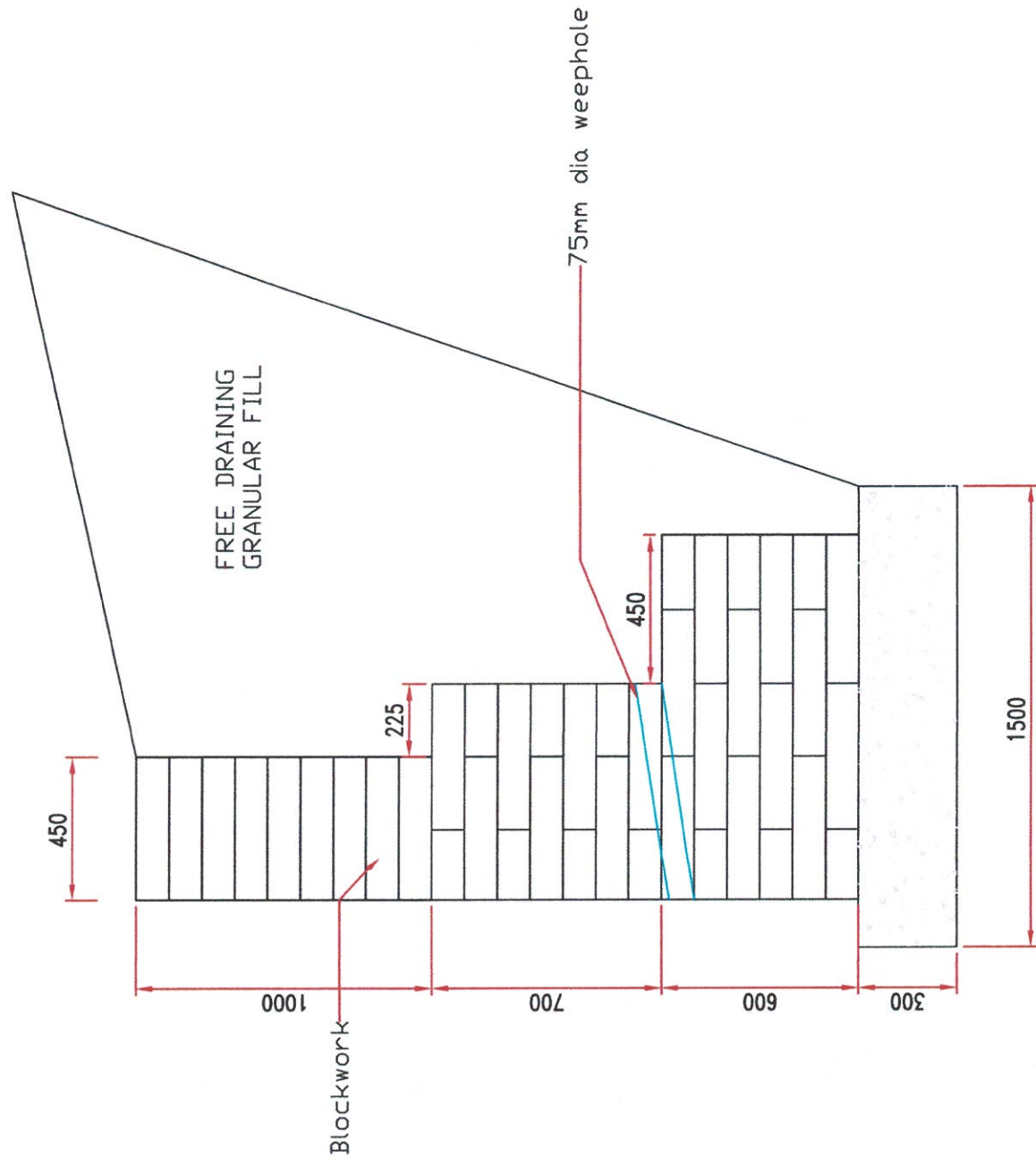
Factor of safety overturning 3.637
Factor of safety sliding 1.979
Maximum base pressure 69 kN/m²

DESIGN SUMMARY		2.1 m
Step height (m)	Wall height Wall design Step thickness (m)	Ultimate Moments (kNm) Resistance Applied
1	0.45	1.463
1.6	0.675	5.494
2.1	1.1	11.97

Summary of stability check

Factor of safety overturning 3.637
Factor of safety sliding 1.979
Maximum base pressure 69 kN/m²

THIS IS AN UPDATE AND NEEDS YOUR OWN L.NAM FILE.



PROPOSED Retaining Wall

Not To Scale