

Structural Calculations

Design Stage Jan 2023

FOR

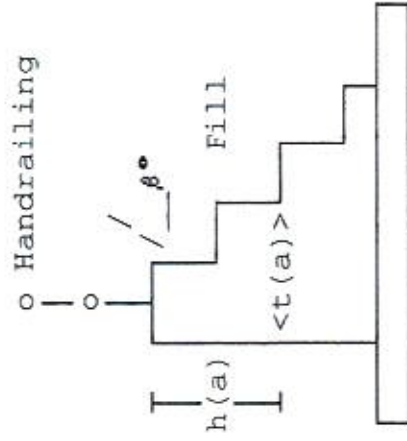
FRONT RETAINING WALL

AT

18 EFAIL FACH
PONTRYDYFEN

Masonry gravity wall

Designed in accordance with BS5628:Part 1: 1992.
Location: Wall on grid line A/1-2



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 we=18 kN/m³
Internal angle of friction $\phi=35^\circ$
Angle of backfill $\beta=0^\circ$
Active soil pressure is applicable.
Sine angle of internal friction $sp=\sin(\text{RAD}(\phi))=0.5736$
Active pressure coefficient $ce=(1-sp)/(1+sp)$
 $= (1-0.5736)/(1+0.5736)$
 $= 0.271$

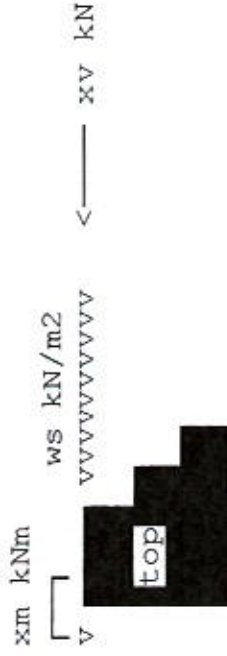
Masonry details

Mortar designation to Table 1 mortar=3
Masonry type {1=clay 2=cal silicate 3=conc brick 4=block}
typ(1)=4

Concrete Blocks Dimensions
Height hb=215 mm
Least horiz dimension lhd=100 mm
ratio height/least horiz dim rb=hb/lhd=215/100=2.15
Compressive strength of blocks po=7.3 N/mm²

Characteristic flexural strength for bed failure and leaf greater than
 250mm thick - Table 3 $f_b(a) = \text{TABLE } 3.71 \text{ for } p_o = 7.3, \text{ mortar} = 3$
 $= 0.1586 \text{ N/mm}^2$
 Partial safety factor material $\gamma_{mam} = 3.5$

External loading



Applied moment at top of wall $xm = 0 \text{ kNm}$
 Applied shear at top of wall $xv = 0 \text{ kN}$
 Weight/unit area of surcharge $ws = 5 \text{ kN/m}^2$
 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 $h(1) = 0.45 \text{ m}$
 Proposed thickness at step $t(1) = 0.225 \text{ m}$
 Moment at height h earth

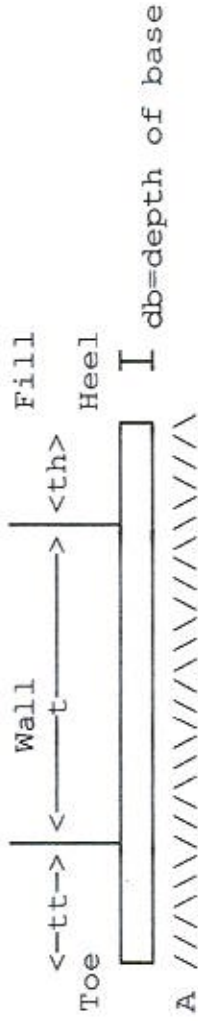
$me = ce * we * h(a)^3 / 6 = 0.271 * 18 * 0.45^3 / 6$
 $= 0.07408 \text{ kNm}$
 $ms = ce * ws * h(a)^2 / 2 = 0.271 * 5 * 0.45^2 / 2$
 $= 0.1372 \text{ kNm}$
 $mu = me * \gamma_{mae} + ms * \gamma_{mas} + (xm + xv * h(a)) * \gamma_{max}$
 $= 0.07408 * 1.4 + 0.1372 * 1.6 + (0 + 0 * 0.45) * 1.6$
 $= 0.3232$

Ultimate moment at height h

Section modulus at thickness t $z = t(a)^2/6 = 0.225^2/6 = 0.008438 \text{ m}^3$
 Weight/unit area at depth h $gd = (ws + we \cdot h(a)) \cdot \text{gamma}f/1000$
 $= (5 + 18 \cdot 0.45) \cdot 0.9/1000$
 $= 0.01179 \text{ N/mm}^2$
 Moment of resistance $mr = (fb(1)/\text{gamma}m + gd) \cdot z \cdot 1000$
 $= (0.1586/3.5 + 0.01179) \cdot 0.008438 \cdot 1000$
 $= 0.4817 \text{ kNm}$
 Applied moment less than moment of resistance (0.3232 <= 0.4817)
 therefore section is satisfactory.
 Step 1 width 0.225 m
 height 0.45 m

Step height (m)	Step thickness (m)	Ultimate Moments (kNm) Resistance Applied
0.45	0.225	0.4817 0.3232
0.9	0.45	2.173 1.708
1.2	0.675	5.258 3.528

Stability and bearing check



Width of toe $tt = 0.15 \text{ m}$
 Width of heel $th = 0.15 \text{ m}$
 Thickness of wall $t = 0.675 \text{ m}$
 Height of wall $h = 1.2 \text{ m}$
 Width of base $tb = t + tt + th = 0.675 + 0.15 + 0.15 = 0.975$
 Depth of base $db = 0.15 \text{ m}$
 Overall depth $od = h + db = 1.2 + 0.15 = 1.35 \text{ m}$
 Weight of fill and wall $wf = we \cdot (t + th) \cdot h = 18 \cdot (0.675 + 0.15) \cdot 1.2 = 17.82 \text{ kN}$
 Eccentricity from A $ef = tt + (t + th)/2 = 0.15 + (0.675 + 0.15)/2 = 0.5625 \text{ m}$

Weight of base
 $w_b = t_b \cdot d_b \cdot 24 = 0.975 \cdot 0.15 \cdot 24$
 $= 3.51 \text{ kN}$

Earth horizontal force
 $s_f = c \cdot e \cdot w \cdot \text{od}^2 / 2 = 0.271 \cdot 18 \cdot 1.35^2 / 2$
 $= 4.445 \text{ kN}$

Moment due to earth pressure
 $m = s_f \cdot \text{od} / 3 = 4.445 \cdot 1.35 / 3$
 $= 2 \text{ kNm}$

Surcharge horizontal force
 $s_f s = w_s \cdot c \cdot \text{od} = 5 \cdot 0.271 \cdot 1.35$
 $= 1.829 \text{ kN}$

Moment due to surcharge
 $m_s = s_f s \cdot \text{od} / 2 = 1.829 \cdot 1.35 / 2$
 $= 1.235 \text{ kNm}$

Wall shear

Horizontal shear force
 $u_s f = (s_f e \cdot \gamma_{mae}) + (s_f s \cdot \gamma_{mas})$
 $= (4.445 \cdot 1.4) + (1.829 \cdot 1.6)$
 $= 9.15 \text{ kN}$

Shear stress at bottom of wall
 $u_{ss} = u_s f / (t \cdot \text{steps}) \cdot 1000$
 $= 9.15 / (0.675 \cdot 1000)$
 $= 0.01355 \text{ N/mm}^2$

Weight at bottom of step 1
 $u_w t = t(a) \cdot w \cdot e \cdot h(a) \cdot \gamma_{maf}$
 $= 0.225 \cdot 18 \cdot 0.45 \cdot 0.9$
 $= 1.64 \text{ kN}$

Weight at bottom of step 2
 $u_w t = u_w t + (t(a) \cdot w \cdot e \cdot h(a) \cdot \gamma_{maf})$
 $= 1.64 + (0.45 \cdot 18 \cdot 0.9 \cdot 0.9)$
 $= 8.201 \text{ kN}$

Weight at bottom of step 3
 $u_w t = u_w t + (t(a) \cdot w \cdot e \cdot h(a) \cdot \gamma_{maf})$
 $= 8.201 + (0.675 \cdot 18 \cdot 1.2 \cdot 0.9)$
 $= 21.32 \text{ kN}$

Weight per. unit area
 $g_a = u_w t / (t \cdot \text{steps}) \cdot 1000$
 $= 21.32 / (0.675 \cdot 1000)$
 $= 0.03159 \text{ N/mm}^2$

Permissible shear stress
 $f_v = 0.15 + 0.6 \cdot g_a = 0.15 + 0.6 \cdot 0.03159$
 $= 0.169 \text{ N/mm}^2$

Applied shear less than shear resistance (0.01355 <= 0.169)
 therefore section is satisfactory.

Overturning

Overturning moment about A

$$\begin{aligned} \text{om} &= \text{me} + \text{ms} + (\text{xm} + \text{xv} * \text{od}) \\ &= 2 + 1.235 + (0 + 0 * 1.35) \\ &= 3.235 \text{ kNm} \\ \text{Restoring moment abt A fill/wall base} \\ \text{rmf} &= \text{wf} * \text{ef} = 17.82 * 0.5625 = 10.02 \text{ kNm} \\ \text{rmb} &= \text{wb} * \text{tb} / 2 = 3.51 * 0.975 / 2 \\ &= 1.711 \text{ kNm} \\ \text{surcharge} \\ \text{rms} &= \text{ws} * (\text{t} + \text{th}) * \text{ef} \\ &= 5 * (0.675 + 0.15) * 0.5625 \\ &= 2.32 \\ \text{total} \\ \text{rm} &= \text{rmf} + \text{rmb} + \text{rms} = 10.02 + 1.711 + 2.32 \\ &= 14.06 \\ \text{Factor of safety} \\ \text{fso} &= \text{rm} / \text{om} = 14.06 / 3.235 = 4.345 \end{aligned}$$

Sliding (passive resistance ignored)

Sliding force $\text{sf} = \text{sfe} + \text{sfs} + \text{xv} = 4.445 + 1.829 + 0 = 6.274$

Details of bearing stratas
angle of friction
cohesion

$$\begin{aligned} \text{phib} &= 40^\circ \\ \text{cu} &= 0 \text{ kN/m}^2 \\ \text{cf} &= \text{TAN}(\text{RAD}(\text{phib} * 2 / 3)) \\ &= \text{TAN}(\text{RAD}(40 * 2 / 3)) \\ &= 0.5022 \end{aligned}$$

Coefficient of friction

Resisting force

$$\begin{aligned} \text{fill base} \\ \text{rff} &= \text{wf} * \text{cf} = 17.82 * 0.5022 = 8.95 \text{ kN} \\ \text{rfb} &= \text{wb} * \text{cf} + \text{tb} * \text{cu} / 2 \\ &= 3.51 * 0.5022 + 0.975 * 0 / 2 \\ &= 1.763 \text{ kN} \end{aligned}$$

surcharge

$$\begin{aligned} \text{rfs} &= \text{ws} * (\text{t} + \text{th}) * \text{cf} \\ &= 5 * (0.675 + 0.15) * 0.5022 \\ &= 2.072 \text{ kN} \end{aligned}$$

total

$$\begin{aligned} \text{rf} &= \text{rff} + \text{rfb} + \text{rfs} = 8.95 + 1.763 + 2.072 \\ &= 12.78 \text{ kN} \\ \text{Factor of safety} \\ \text{fss} &= \text{rf} / \text{sf} = 12.78 / 6.274 = 2.038 \end{aligned}$$

Bearing pressure

Weight of surcharge

$$sw=ws*(t+th)=5*(0.675+0.15) \\ =4.125 \text{ kN}$$

Moments about centre of base

$$m=om+(wf+sw)*(tb/2-ef) \\ =3.235+(17.82+4.125)*(0.975/2-0.5625) \\ =1.589 \text{ kNm}$$

Section modulus of base

$$zb=tb^2/6=0.975^2/6=0.1584 \text{ m}^3 \\ tw=wf+sw+wb=17.82+4.125+3.51 \\ =25.46 \text{ kN}$$

Pressure due to weight

$$pw=tw/tb=25.46/0.975=26.11 \text{ kN/m}^2 \\ pm=m/zb=1.589/0.1584=10.03 \text{ kN/m}^2$$

Pressure due to moment (+/-)

$$pmax=pw+pm=26.11+10.03=36.14 \text{ kN/m}^2 \\ pmin=pw-pm=26.11-10.03=16.08 \text{ kN/m}^2$$

Summary of stability check

Factor of safety overturning 4.345
Factor of safety sliding 2.038
Maximum base pressure 36.14 kN/m²

DESIGN SUMMARY	Wall height Wall design Step thickness (m)	1.2 m
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Ultimate Moments (kNm) Resistance Applied
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0.45	0.225	0.4817	0.3232
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Summary of stability check

Factor of safety overturning 4.345
Factor of safety sliding 2.038
Maximum base pressure 36.14 kN/m²

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

Masonry Retaining wall for 18 Efail Fach Pontrhydyfen

FRONT WALL

