

Structural Calculations

Design Stage Oct 2021

FOR

MASONRY RETAINING WALL

AT

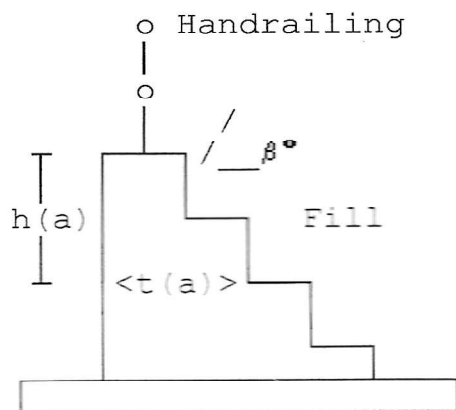
38 PENTWYN BAGLAN ROAD
BAGLAN, PORT TALBOT

Made of:

Mr. Sam Alkarnaz BEng. C.BuildE. MCABE

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

Masonry details

Mortar designation to Table 1 $\text{mortar} = 3$
Masonry type (1=clay 2=cal silicate 3=conc brick 4=block) $\text{typ}(1) = 4$
Concrete Blocks Dimensions
Height $hb = 215 \text{ mm}$
Least horiz dimension $lhd = 100 \text{ mm}$
ratio height/least horiz dim $rb = hb / lhd = 215 / 100 = 2.15$
Compressive strength of blocks $po = 7 \text{ N/mm}^2$

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Characteristic flexural strength for bed failure and leaf greater than 250mm thick - Table 3 $fb(a)=TABLE\ 3.71\ for\ po=7,\ mortar=3$
 $=0.15\ N/mm^2$

Partial safety factor material $\gamma_{mam}=3.5$

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	$ws=2\ kN/m^2$
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 $steps=4$

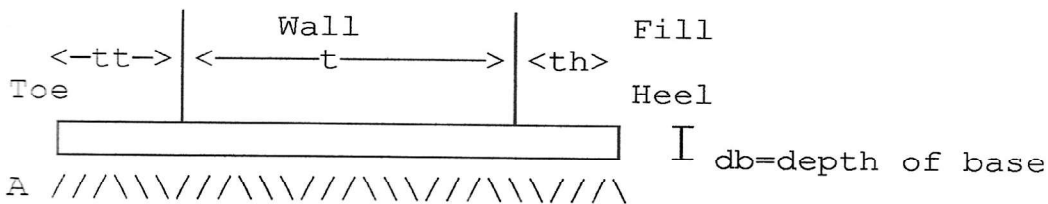
Step 1 Typical Analysis which is repeated for each step

Proposed height at step	$h(1)=0.45\ m$
Proposed thickness at step	$t(1)=0.325\ m$
Moment at height h earth	$me=ce*we*h(a)^3/6=0.271*18*0.45^3/6$ $=0.07408\ kNm$
surcharge	$ms=ce*ws*h(a)^2/2=0.271*2*0.45^2/2$ $=0.05488\ kNm$
Ultimate moment at height h	$\mu=me*\gamma_{mae}+ms*\gamma_{mas}+(xm+xv*h(a))$ $*\gamma_{max}$ $=0.07408*1.4+0.05488*1.6+(0+0$ $*0.45)*1.6$ $=0.1915$

Section modulus at thickness t $z = t(a)^2/6 = 0.325^2/6 = 0.0176 \text{ m}^3$
 Weight/unit area at depth h $gd = (ws + we \cdot h(a)) \cdot \gamma_{maf}/1000$
 $= (2 + 18 \cdot 0.45) \cdot 0.9/1000$
 $= 0.00909 \text{ N/mm}^2$
 Moment of resistance $mr = (fb(1)/\gamma_{mam} + gd) \cdot z \cdot 1000$
 $= (0.15/3.5 + 0.00909) \cdot 0.0176 \cdot 1000$
 $= 0.9145 \text{ kNm}$
 Applied moment less than moment of resistance ($0.1915 \leq 0.9145$)
 therefore section is satisfactory.
 Step 1 width 0.325 m
 height 0.45 m

Step height (m)	Step thickness (m)	Ultimate Moments (kNm)	
		Resistance	Applied
0.45	0.325	0.9145	0.1915
0.9	0.45	1.999	1.181
1.35	0.675	5.052	3.591
1.8	0.9	9.965	8.043

Stability and bearing check



Width of toe $tt = 0.15 \text{ m}$
 Width of heel $th = 0.15 \text{ m}$
 Thickness of wall $t = 0.9 \text{ m}$
 Height of wall $h = 1.8 \text{ m}$
 Width of base $tb = t + tt + th = 0.9 + 0.15 + 0.15 = 1.2$
 Depth of base $db = 0.30 \text{ m}$
 Overall depth $od = h + db = 1.8 + 0.3 = 2.1 \text{ m}$
 Weight of fill and wall $wf = we \cdot (t + th) \cdot h = 18 \cdot (0.9 + 0.15) \cdot 1.8 = 34.02 \text{ kN}$
 Eccentricity from A $ef = tt + (t + th)/2 = 0.15 + (0.9 + 0.15)/2 = 0.675 \text{ m}$

Weight of base	$wb = tb * db * 24 = 1.2 * 0.3 * 24 = 8.64 \text{ kN}$
Earth horizontal force	$sfe = ce * we * od^2 / 2 = 0.271 * 18 * 2.1^2 / 2 = 10.76 \text{ kN}$
Moment due to earth pressure	$me = sfe * od / 3 = 10.76 * 2.1 / 3 = 7.529 \text{ kNm}$
Surcharge horizontal force	$sfs = ws * ce * od = 2 * 0.271 * 2.1 = 1.138 \text{ kN}$
Moment due to surcharge	$ms = sfs * od / 2 = 1.138 * 2.1 / 2 = 1.195 \text{ kNm}$
<u>Wall shear</u>	
Horizontal shear force	$usf = (sfe * gammae) + (sfs * gammas) = (10.76 * 1.4) + (1.138 * 1.6) = 16.88 \text{ kN}$
Shear stress at bottom of wall	$uss = usf / (t(\text{steps}) * 1000) = 16.88 / (0.9 * 1000) = 0.01875 \text{ N/mm}^2$
Weight at bottom of step 1	$uwt = t(a) * we * h(a) * gammaf = 0.325 * 18 * 0.45 * 0.9 = 2.369 \text{ kN}$
Weight at bottom of step 2	$uwt = uwt + (t(a) * we * h(a) * gammaf) = 2.369 + (0.45 * 18 * 0.9 * 0.9) = 8.93 \text{ kN}$
Weight at bottom of step 3	$uwt = uwt + (t(a) * we * h(a) * gammaf) = 8.93 + (0.675 * 18 * 1.35 * 0.9) = 23.69 \text{ kN}$
Weight at bottom of step 4	$uwt = uwt + (t(a) * we * h(a) * gammaf) = 23.69 + (0.9 * 18 * 1.8 * 0.9) = 49.94 \text{ kN}$
Weight per. unit area	$ga = uwt / (t(\text{steps}) * 1000) = 49.94 / (0.9 * 1000) = 0.05549 \text{ N/mm}^2$
Permissible shear stress	$fv = 0.15 + 0.6 * ga = 0.15 + 0.6 * 0.05549 = 0.1833 \text{ N/mm}^2$
Applied shear less than shear resistance ($0.01875 \leq 0.1833$) therefore section is satisfactory.	

Overturning

Overturning moment about A $om = me + ms + (xm + xv * od)$
 $= 7.529 + 1.195 + (0 + 0 * 2.1)$
 $= 8.724 \text{ kNm}$

Restoring moment abt A fill/wall $rmf = wf * ef = 34.02 * 0.675 = 22.96 \text{ kNm}$
base $rmb = wb * tb / 2 = 8.64 * 1.2 / 2 = 5.184 \text{ kNm}$
surcharge $rms = ws * (t + th) * ef = 2 * (0.9 + 0.15) * 0.675$
 $= 1.418$
total $rm = rmf + rmb + rms = 22.96 + 5.184 + 1.418$
 $= 29.57$

Factor of safety $fso = rm / om = 29.57 / 8.724 = 3.389$

Sliding (passive resistance ignored)

Sliding force $sf = sfe + sfs + xv = 10.76 + 1.138 + 0$
 $= 11.89$

Details of bearing stratas
angle of friction $phib = 40^\circ$
cohesion $cu = 0 \text{ kN/m}^2$
Coefficient of friction $cf = \text{TAN}(\text{RAD}(phib * 2 / 3))$
 $= \text{TAN}(\text{RAD}(40 * 2 / 3))$
 $= 0.5022$

Resisting force fill $rff = wf * cf = 34.02 * 0.5022 = 17.09 \text{ kN}$
base $rfb = wb * cf + tb * cu / 2 = 8.64 * 0.5022 + 1.2 * 0 / 2$
 $= 4.339 \text{ kN}$
surcharge $rfs = ws * (t + th) * cf = 2 * (0.9 + 0.15) * 0.5022$
 $= 1.055 \text{ kN}$
total $rf = rff + rfb + rfs = 17.09 + 4.339 + 1.055$
 $= 22.48 \text{ kN}$

Factor of safety $fss = rf / sf = 22.48 / 11.89 = 1.89$

Bearing pressure

Weight of surcharge $sw = ws * (t + th) = 2 * (0.9 + 0.15)$
 $= 2.1 \text{ kN}$

Moments about centre of base $m = om + (wf + sw) * (tb / 2 - ef)$
 $= 8.724 + (34.02 + 2.1) * (1.2 / 2 - 0.675)$
 $= 6.015 \text{ kNm}$

Section modulus of base $zb = tb^2 / 6 = 1.2^2 / 6 = 0.24 \text{ m}^3$

Total weight $tw = wf + sw + wb = 34.02 + 2.1 + 8.64$
 $= 44.76 \text{ kN}$

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Pressure due to weight $pw = tw/tb = 44.76/1.2 = 37.3 \text{ kN/m}^2$
Pressure due to moment (+/-) $pm = m/zb = 6.015/0.24 = 25.06 \text{ kN/m}^2$
Maximum pressure $pmax = pw + pm = 37.3 + 25.06 = 62.36 \text{ kN/m}^2$
Minimum pressure $pmin = pw - pm = 37.3 - 25.06 = 12.24 \text{ kN/m}^2$

Summary of stability check

Factor of safety overturning 3.389
Factor of safety sliding 1.89
Maximum base pressure 62.36 kN/m²

DESIGN SUMMARY		1.8 m	
		Wall design	
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		Resistance	Applied
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THIS IS AN UPDATE AND NEEDS YOUR OWN L.NAM FILE.

