

Structural Calculations

Design Stage Feb 2025

FOR

MASONRY RETAINING WALL

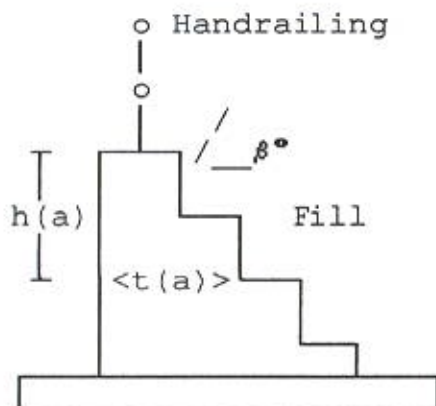
AT

2 QUEEN STREET
NEWPORT

Mr. Sam Alkarnaz BEng. C.BuildE, MCABE

Masonry gravity wall

Designed in accordance with BS5628:Part 1: 1992.
Location: Masonry Retaining Wall



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

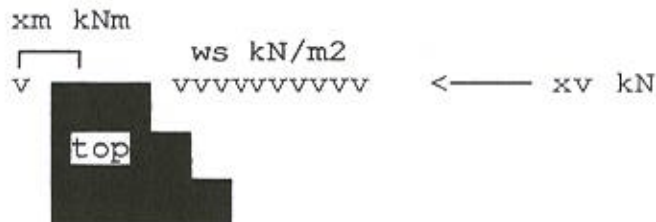
Weight/unit volume of soil & wall $w_e=18 \text{ kN/m}^3$
Internal angle of friction $\phi=35^\circ$
Angle of backfill $\beta=0^\circ$
Active soil pressure is applicable.
Sine angle of internal friction $sp=\sin(\text{RAD}(\phi))=0.5736$
Active pressure coefficient $ce=(1-sp)/(1+sp)$
 $= (1-0.5736)/(1+0.5736)$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

Masonry details

Mortar designation to Table 1 $\text{mortar}=3$
Masonry type (1=clay 2=calc 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 $po=7 \text{ N/mm}^2$

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/mm²
Partial safety factor material gammam=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=5 kN/m²
Load factor external loads at top gammax=1.6
Load factor surcharge gammas=1.6
Load factor earth pressure gammae=1.4
Load factor self weight gammaf=0.9

Wall design

Number of steps proposed in wall steps=4

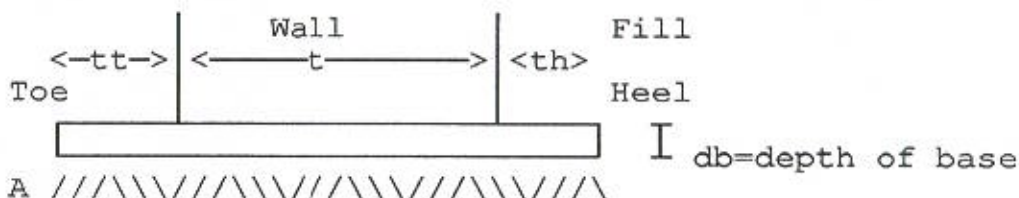
Step 1 Typical Analysis which is repeated for each step

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*5*0.45^2/2
=0.1372 kNm
Ultimate moment at height h mu=me*gammae+ms*gammass+(xm+xv*h(a))
*gammax
=0.07408*1.4+0.1372*1.6+(0+0*0.45)
*1.6
=0.3232

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 $gd = (ws + we \cdot h(a)) \cdot \gamma_{maf}/1000$
 $= (5 + 18 \cdot 0.45) \cdot 0.9/1000$
 $= 0.01179 \text{ N/mm}^2$
 Moment of resistance $mr = (fb(1)/\gamma_{mam} + gd) \cdot z \cdot 1000$
 $= (0.15/3.5 + 0.01179) \cdot 0.0176 \cdot 1000$
 $= 0.962 \text{ kNm}$
 Applied moment less than moment of resistance ($0.3232 \leq 0.962$)
 therefore section is satisfactory.
 Step 1 width 0.325 m
 height 0.45 m

Step height (m)	Step thicknes (m)	Ultimate Moments (kNm)	
		Resistance	Applied
0.45	0.325	0.962	0.3232
1	0.675	4.826	2.222
2	1.25	20.77	13.44
3.3	1.8	54.44	52.71

Stability and bearing check



Width of toe $tt = 0.25 \text{ m}$
 Width of heel $th = 0.25 \text{ m}$
 Thickness of wall $t = 1.8 \text{ m}$
 Height of wall $h = 3.3 \text{ m}$
 Width of base $tb = t + tt + th = 1.8 + 0.25 + 0.25$
 $= 2.3$
 Depth of base $db = 0.35 \text{ m}$
 Overall depth $od = h + db = 3.3 + 0.35 = 3.65 \text{ m}$
 Weight of fill and wall $wf = we \cdot (t + th) \cdot h = 18 \cdot (1.8 + 0.25) \cdot 3.3$
 $= 121.8 \text{ kN}$
 Eccentricity from A $ef = tt + (t + th)/2 = 0.25 + (1.8 + 0.25)/2$
 $= 1.275 \text{ m}$

Weight of base	$wb = tb \cdot db \cdot 24 = 2.3 \cdot 0.35 \cdot 24 = 19.32 \text{ kN}$
Earth horizontal force	$sfe = ce \cdot we \cdot od^2 / 2 = 0.271 \cdot 18 \cdot 3.65^2 / 2$ $= 32.49 \text{ kN}$
Moment due to earth pressure	$me = sfe \cdot od / 3 = 32.49 \cdot 3.65 / 3$ $= 39.53 \text{ kNm}$
Surcharge horizontal force	$sfs = ws \cdot ce \cdot od = 5 \cdot 0.271 \cdot 3.65$ $= 4.946 \text{ kN}$
Moment due to surcharge	$ms = sfs \cdot od / 2 = 4.946 \cdot 3.65 / 2$ $= 9.026 \text{ kNm}$
<u>Wall shear</u>	
Horizontal shear force	$usf = (sfe \cdot \gamma_{mae}) + (sfs \cdot \gamma_{mas})$ $= (32.49 \cdot 1.4) + (4.946 \cdot 1.6)$ $= 53.4 \text{ kN}$
Shear stress at bottom of wall	$uss = usf / (t(\text{steps}) \cdot 1000)$ $= 53.4 / (1.8 \cdot 1000)$ $= 0.02967 \text{ N/mm}^2$
Weight at bottom of step 1	$uwt = t(a) \cdot we \cdot h(a) \cdot \gamma_{maf}$ $= 0.325 \cdot 18 \cdot 0.45 \cdot 0.9$ $= 2.369 \text{ kN}$
Weight at bottom of step 2	$uwt = uwt + (t(a) \cdot we \cdot h(a) \cdot \gamma_{maf})$ $= 2.369 + (0.675 \cdot 18 \cdot 1 \cdot 0.9)$ $= 13.3 \text{ kN}$
Weight at bottom of step 3	$uwt = uwt + (t(a) \cdot we \cdot h(a) \cdot \gamma_{maf})$ $= 13.3 + (1.25 \cdot 18 \cdot 2 \cdot 0.9)$ $= 53.8 \text{ kN}$
Weight at bottom of step 4	$uwt = uwt + (t(a) \cdot we \cdot h(a) \cdot \gamma_{maf})$ $= 53.8 + (1.8 \cdot 18 \cdot 3.3 \cdot 0.9)$ $= 150 \text{ kN}$
Weight per. unit area	$ga = uwt / (t(\text{steps}) \cdot 1000) = 150 / (1.8 \cdot 1000)$ $= 0.08335 \text{ N/mm}^2$
Permissible shear stress	$fv = 0.15 + 0.6 \cdot ga = 0.15 + 0.6 \cdot 0.08335$ $= 0.2 \text{ N/mm}^2$

Applied shear less than shear resistance ($0.02967 \leq 0.2$)
therefore section is satisfactory.

Overturning

Overturning moment about A	$om = me + ms + (xm + xv * od)$ $= 39.53 + 9.026 + (0 + 0 * 3.65)$ $= 48.56 \text{ kNm}$
Restoring moment abt A fill/wall	$rmf = wf * ef = 121.8 * 1.275 = 155.3 \text{ kNm}$
base	$rmb = wb * tb / 2 = 19.32 * 2.3 / 2 = 22.22 \text{ kNm}$
surcharge	$rms = ws * (t + th) * ef = 5 * (1.8 + 0.25) * 1.275$ $= 13.07$
total	$rm = rmf + rmb + rms = 155.3 + 22.22 + 13.07$ $= 190.5$
Factor of safety	$fso = rm / om = 190.5 / 48.56 = 3.924$

Sliding (passive resistance ignored)

Sliding force	$sf = sfe + sfs + xv = 32.49 + 4.946 + 0$ $= 37.44$
Details of bearing stratas	
angle of friction	$\text{phib} = 40^\circ$
cohesion	$cu = 0 \text{ kN/m}^2$
Coefficient of friction	$cf = \text{TAN}(\text{RAD}(\text{phib} * 2/3))$ $= \text{TAN}(\text{RAD}(40 * 2/3))$ $= 0.5022$
Resisting force	
fill	$rff = wf * cf = 121.8 * 0.5022 = 61.16 \text{ kN}$
base	$rfb = wb * cf + tb * cu / 2$ $= 19.32 * 0.5022 + 2.3 * 0 / 2$ $= 9.703 \text{ kN}$
surcharge	$rfs = ws * (t + th) * cf = 5 * (1.8 + 0.25) * 0.5022$ $= 5.148 \text{ kN}$
total	$rf = rff + rfb + rfs = 61.16 + 9.703 + 5.148$ $= 76.01 \text{ kN}$
Factor of safety	$fss = rf / sf = 76.01 / 37.44 = 2.03$

Bearing pressure

Weight of surcharge	$sw = ws * (t + th) = 5 * (1.8 + 0.25)$ $= 10.25 \text{ kN}$
Moments about centre of base	$m = om + (wf + sw) * (tb / 2 - ef)$ $= 48.56 + (121.8 + 10.25) * (2.3 / 2 - 1.275)$ $= 32.06 \text{ kNm}$
Section modulus of base	$zb = tb^2 / 6 = 2.3^2 / 6 = 0.8817 \text{ m}^3$

Proposed Retaining Wall At:
2 Queens Close
Newport

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Total weight $tw = wf + sw + wb = 121.8 + 10.25 + 19.32 = 151.3 \text{ kN}$
Pressure due to weight $pw = tw/tb = 151.3/2.3 = 65.8 \text{ kN/m}^2$
Pressure due to moment (+/-) $pm = m/zb = 32.06/0.8817 = 36.36 \text{ kN/m}^2$
Maximum pressure $pmax = pw + pm = 65.8 + 36.36 = 102.2 \text{ kN/m}^2$
Minimum pressure $pmin = pw - pm = 65.8 - 36.36 = 29.44 \text{ kN/m}^2$

Summary of stability check

Factor of safety overturning 3.924
Factor of safety sliding 2.03
Maximum base pressure 102.2 kN/m²

DESIGN SUMMARY		Wall height 3.3 m	
		Wall design	
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		Resistance	Applied
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THIS IS AN UPDATE AND NEEDS YOUR OWN L.NAM FILE.

Retaining Wall

