

# Structural Calculations

Design Stage Nov 2020

FOR

MASONRY RETAINING  
WALL

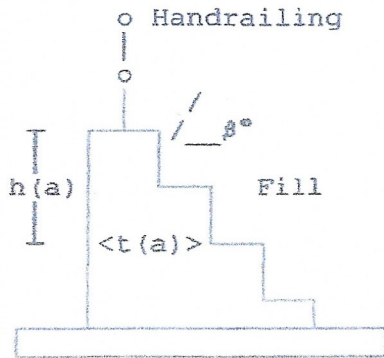
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1A WELLS CLOSE

BAGLAN

### 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

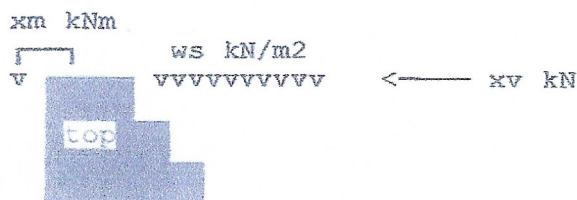
Weight/unit volume of soil & wall  $w_e=18 \text{ kN/m}^3$   
Internal angle of friction  $\phi=35^\circ$   
Angle of backfill  $\beta=0^\circ$   
Active soil pressure is applicable.  
Sine angle of internal friction  $sp=\sin(\text{RAD}(\phi))=0.5736$   
Active pressure coefficient  $ce=(1-sp)/(1+sp)$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

### Masonry details

Mortar designation to Table 1 mortar=3  
Masonry type (1=clay 2=calc silicate 3=conc brick 4=block)  
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  $p_o = 7 \text{ N/mm}^2$   
 Characteristic flexural strength for bed failure and leaf greater than  
 250mm thick - Table 3  $f_b(a) = \text{TABLE 3.71 for } p_o = 7, \text{ mortar} = 3$   
 $= 0.15 \text{ N/mm}^2$   
 Partial safety factor material  $\gamma_{mam} = 3.1$

#### External loading



Applied moment at top of wall  $x_m = 0 \text{ kNm}$   
 Applied shear at top of wall  $x_v = 0 \text{ kN}$   
 Weight/unit area of surcharge  $w_s = 5 \text{ kN/m}^2$   
 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  $\text{steps} = 3$

Step 1 Typical Analysis which is repeated for each step

Proposed height at step  $h(1) = 0.450 \text{ m}$   
 Proposed thickness at step  $t(1) = 0.325 \text{ m}$   
 Moment at height h earth  $m_e = c_e * w_e * h(a)^{3/6} = 0.271 * 18 * 0.45^{3/6}$   
 $= 0.07408 \text{ kNm}$   
 surcharge  $m_s = c_s * w_s * h(a)^{2/2} = 0.271 * 5 * 0.45^{2/2}$   
 $= 0.1372 \text{ kNm}$   
 Ultimate moment at height h  $m_u = m_e * \gamma_{mae} + m_s * \gamma_{mas} + (x_m + x_v * h(a))$   
 $* \gamma_{max}$   
 $= 0.07408 * 1.4 + 0.1372 * 1.6 + (0 + 0 * 0.45)$   
 $* 1.6$   
 $= 0.3232$

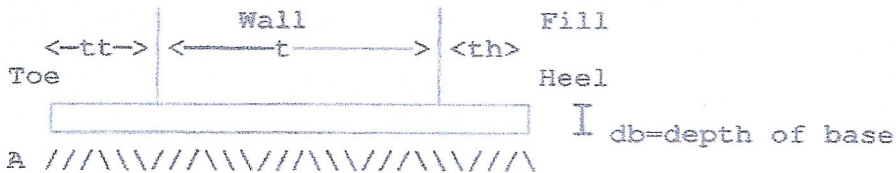
Section modulus at thickness  $t$   $z = t(a)^2/6 = 0.325^2/6 = 0.0176 \text{ m}^3$   
 Weight/unit area at depth  $h$   $gd = (ws + we \cdot h(a)) \cdot \gamma_{maf}/1000$   
 $= (5 + 18 \cdot 0.45) \cdot 0.9/1000$   
 $= 0.01179 \text{ N/mm}^2$   
 Moment of resistance  $mr = (fb(1)/\gamma_{mam} + gd) \cdot z \cdot 1000$   
 $= (0.15/3.1 + 0.01179) \cdot 0.0176 \cdot 1000$   
 $= 1.059 \text{ kNm}$

Applied moment less than moment of resistance (  $0.3232 \leq 1.059$  )  
 therefore section is satisfactory.

Step 1 width 0.325 m  
 height 0.45 m

| Step height<br>(m) | Step thickness<br>(m) | Ultimate Moments (kNm) |         |
|--------------------|-----------------------|------------------------|---------|
|                    |                       | Resistance             | Applied |
| 0.45               | 0.325                 | 1.059                  | 0.3232  |
| 0.9                | 0.45                  | 2.277                  | 1.708   |
| 1.45               | 0.675                 | 5.8                    | 5.749   |

### Stability and bearing check



Width of toe  $tt = 0.25 \text{ m}$   
 Width of heel  $th = 0.175 \text{ m}$   
 Thickness of wall  $t = 0.675 \text{ m}$   
 Height of wall  $h = 1.45 \text{ m}$   
 Width of base  $tb = t + tt + th = 0.675 + 0.25 + 0.175$   
 $= 1.1$   
 Depth of base  $db = 0.30 \text{ m}$   
 Overall depth  $od = h + db = 1.45 + 0.3 = 1.75 \text{ m}$   
 Weight of fill and wall  $wf = we \cdot (t + th) \cdot h = 18 \cdot (0.675 + 0.175) \cdot 1.45$   
 $= 22.18 \text{ kN}$   
 Eccentricity from A  $ef = tt + (t + th)/2 = 0.25 + (0.675 + 0.175)/2$   
 $= 0.675 \text{ m}$

Weight of base  $wb = tb * db * 24 = 1.1 * 0.3 * 24 = 7.92 \text{ kN}$   
 Earth horizontal force  $sfe = ce * we * od^2 / 2 = 0.271 * 18 * 1.75^2 / 2 = 7.469 \text{ kN}$   
 Moment due to earth pressure  $me = sfe * od / 3 = 7.469 * 1.75 / 3 = 4.357 \text{ kNm}$   
 Surcharge horizontal force  $sfs = ws * ce * od = 5 * 0.271 * 1.75 = 2.371 \text{ kN}$   
 Moment due to surcharge  $ms = sfs * od / 2 = 2.371 * 1.75 / 2 = 2.075 \text{ kNm}$

Wall shear

Horizontal shear force  $usf = (sfe * gammae) + (sfs * gammas) = (7.469 * 1.4) + (2.371 * 1.6) = 14.25 \text{ kN}$   
 Shear stress at bottom of wall  $uss = usf / (t * (steps) * 1000) = 14.25 / (0.675 * 1000) = 0.02111 \text{ N/mm}^2$   
 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  $uwt = uwt + (t(a) * we * h(a) * gammaf) = 8.93 + (0.675 * 18 * 1.45 * 0.9) = 24.79 \text{ kN}$   
 Weight per. unit area  $ga = uwt / (t * (steps) * 1000) = 24.79 / (0.675 * 1000) = 0.03672 \text{ N/mm}^2$   
 Permissible shear stress  $fv = 0.15 + 0.6 * ga = 0.15 + 0.6 * 0.03672 = 0.172 \text{ N/mm}^2$

Applied shear less than shear resistance (  $0.02111 \leq 0.172$  )  
 therefore section is satisfactory.

Overturning

Overturning moment about A

$$\begin{aligned} om &= me + ms + (xm + xv * od) \\ &= 4.357 + 2.075 + (0 + 0 * 1.75) \\ &= 6.432 \text{ kNm} \end{aligned}$$

Restoring moment abt A fill/wall

$$rmf = wf * ef = 22.18 * 0.675 = 14.97 \text{ kNm}$$

base

$$rmb = wb * tb / 2 = 7.92 * 1.1 / 2 = 4.356 \text{ kNm}$$

surcharge

$$\begin{aligned} rms &= ws * (t + th) * ef \\ &= 5 * (0.675 + 0.175) * 0.675 \\ &= 2.869 \end{aligned}$$

total

$$\begin{aligned} rm &= rmf + rmb + rms = 14.97 + 4.356 + 2.869 \\ &= 22.2 \end{aligned}$$

Factor of safety

$$fso = rm / om = 22.2 / 6.432 = 3.452$$

Sliding (passive resistance ignored)

Sliding force

$$\begin{aligned} sf &= sfe + sfs + xv = 7.469 + 2.371 + 0 \\ &= 9.84 \end{aligned}$$

Details of bearing stratas

angle of friction

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

cohesion

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

Coefficient of friction

$$\begin{aligned} cf &= \text{TAN}(\text{RAD}(\text{phib} * 2/3)) \\ &= \text{TAN}(\text{RAD}(40 * 2/3)) \\ &= 0.5022 \end{aligned}$$

Resisting force

fill

$$rff = wf * cf = 22.18 * 0.5022 = 11.14 \text{ kN}$$

base

$$\begin{aligned} rfb &= wb * cf + tb * cu / 2 = 7.92 * 0.5022 + 1.1 * 0 / 2 \\ &= 3.978 \text{ kN} \end{aligned}$$

surcharge

$$\begin{aligned} rfs &= ws * (t + th) * cf \\ &= 5 * (0.675 + 0.175) * 0.5022 \\ &= 2.134 \text{ kN} \end{aligned}$$

total

$$\begin{aligned} rf &= rff + rfb + rfs = 11.14 + 3.978 + 2.134 \\ &= 17.25 \text{ kN} \end{aligned}$$

Factor of safety

$$fss = rf / sf = 17.25 / 9.84 = 1.753$$

Bearing pressure

Weight of surcharge

$$sw = ws * (t + th) = 5 * (0.675 + 0.175) = 4.25 \text{ kN}$$

Moments about centre of base

$$m = om + (wf + sw) * (tb/2 - ef) = 6.432 + (22.18 + 4.25) * (1.1/2 - 0.675) = 3.127 \text{ kNm}$$

Section modulus of base

$$zb = tb^2/6 = 1.1^2/6 = 0.2017 \text{ m}^3$$

Total weight

$$tw = wf + sw + wb = 22.18 + 4.25 + 7.92 = 34.36 \text{ kN}$$

Pressure due to weight

$$pw = tw/tb = 34.36/1.1 = 31.23 \text{ kN/m}^2$$

Pressure due to moment (+/-)

$$pm = m/zb = 3.127/0.2017 = 15.51 \text{ kN/m}^2$$

Maximum pressure

$$pmax = pw + pm = 31.23 + 15.51 = 46.74 \text{ kN/m}^2$$

Minimum pressure

$$pmin = pw - pm = 31.23 - 15.51 = 15.72 \text{ kN/m}^2$$

## Summary of stability check

Factor of safety overturning

3.452

Factor of safety sliding

1.753

Maximum base pressure

46.74 kN/m<sup>2</sup>

## DESIGN SUMMARY

Wall height

1.45 m

Wall design

Step height

Step thickness

Ultimate Moments (kNm)

(m)

(m)

Resistance Applied

0.45

0.325

1.059

0.3232

0.9

0.45

2.277

1.708

1.45

0.675

5.8

5.749

## Summary of stability check

Factor of safety overturning

3.452

Factor of safety sliding

1.753

Maximum base pressure

46.74 kN/m<sup>2</sup>

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

