

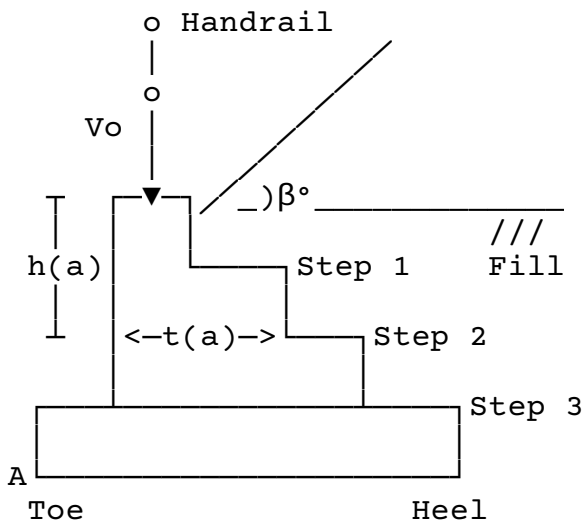
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Location: retaining wall type A

Masonry gravity wall

Designed in accordance with BS5628:Part 1:1992.

Soil details



Steps are numbered down from the top

$h(a)$ = height at step (a) from the top

$t(a)$ = thickness at step (a)

V_o = vertical point load on wall

As a masonry wall has limited capacity the design will assume the backfill is drained i.e. no water pressure behind the wall.

Weight/unit volume of soil & wall $w_e=18 \text{ kN/m}^3$

Internal angle of friction (fill) $\phi=35^\circ$

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=2

Masonry type (1=clay 2=cal silicate 3=conc brick 4=block)

typ(1)=4

Concrete block dimensions:

Height $hb=215 \text{ mm}$

Least horizontal dimension $lhd=100 \text{ mm}$

ratio height/least horiz. dim $rb=hb/lhd=215/100=2.15$

Compressive strength of blocks $po=10.5 \text{ N/mm}^2$

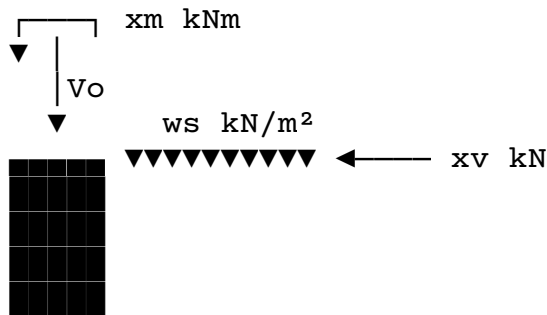
Characteristic flexural strength for bed failure and leaf greater than

250mm thick - Table 3 $fb(a)=\text{TABLE } 3.71 \text{ for } po=10.5, \text{ mortar}=2$
 $= 0.25 \text{ N/mm}^2$

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

0

External loading



Applied moment at top of wall $xm=0$ kNm
 Applied vertical load on the wall $Vo=0$ kN
 Applied shear at top of wall $xv=0000$ kN
 Weight/unit area of surcharge $ws=5$ kN/m²
 Load factor external loads at top $gamx=1.6$
 Load factor surcharge $gams=1.6$
 Load factor earth pressure $game=1.4$
 Load factor self weight $gamf=0.9$

Wall design

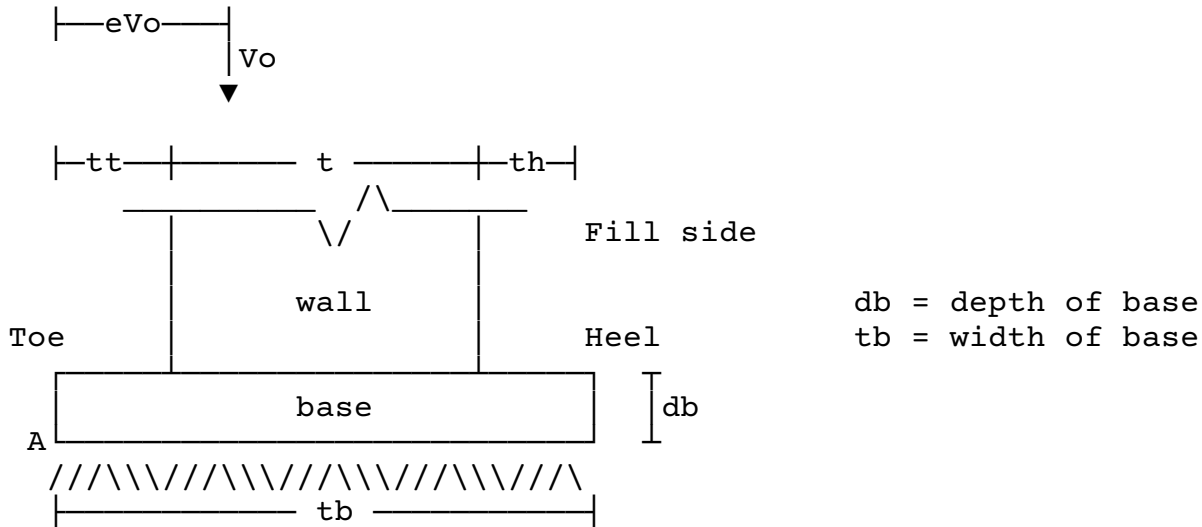
Step 1 Typical Analysis which is repeated for each step

Proposed height at step $h(1)=1$ m
 Proposed thickness at step $t(1)=0.550$ m
 Moment at height h earth $me=ce*we*h(a)^3/6=0.271*18*1^3/6=0.813$ kNm
 surcharge $ms=ce*ws*h(a)^2/2=0.271*5*1^2/2=0.6775$ kNm
 Ultimate moment at height h :
 $mu=me*game+ms*gams+(xm+xv*h(a))*gamx=0.813*1.4+0.6775*1.6+(0+0*1)*1.6=2.222$
 Section modulus at thickness t $z=t(a)^2/6=0.55^2/6=0.0504$ m³
 Weight/unit area at depth h $gd=(ws+we*h(a)+Vo/t(a))*gamf/1000=(5+18*1+0/0.55)*0.9/1000=0.0207$ N/mm²
 Moment of resistance $mr=(fb(1)/gammam+gd)*z*1000=(0.25/3.5+0.0207)*0.0504*1000=4.645$ kNm
 Applied moment less than moment of resistance ($2.222 \leq 4.645$)
 therefore section is satisfactory.

Step 1 width 0.55 m
 height 1 m

Step height (m)	Step thickness (m)	0	
		Ultimate Moments (kNm)	Resistance Applied
1	0.55	4.645	2.222
1.4	0.75	9.245	5.248
1.7	0.85	12.46	8.724

Stability and bearing check



Width of toe	tt=0.10 m
Width of heel	th=0.15 m
Point of application of Vo from A	eVo=0.3125 m
Thickness of wall	t=0.85 m
Height of wall	h=1.7 m
Width of base	tb=t+tt+th=0.85+0.1+0.15 =1.1
Depth of base	db=0.3 m
Overall depth	od=h+db=1.7+0.3=2 m
Weight of fill and wall	wf=we*(t+th)*h=18*(0.85+0.15)*1.7 =30.6 kN
Eccentricity from A (fill & wall)	ef=tt+(t+th)/2=0.1+(0.85+0.15)/2 =0.6 m
Density of base	denb=24 kN/m ³
Weight of base	wb=tb*db*denb=1.1*0.3*24 =7.92 kN
Earth horizontal force	sfe=ce*we*od ² /2=0.271*18*2 ² /2 =9.756 kN
Moment due to earth pressure	me=sfe*od/3=9.756*2/3=6.504 kNm
Surcharge horizontal force	sfs=ws*ce*od=5*0.271*2=2.71 kN
Moment due to surcharge	ms=sfs*od/2=2.71*2/2=2.71 kNm

0

Wall shear

Horizontal shear force	$usf = (sfe * game) + (sfs * gams)$ $= (9.756 * 1.4) + (2.71 * 1.6)$ $= 17.99 \text{ kN}$
Shear stress at bottom of wall	$uss = usf / (t(\text{steps}) * 1000)$ $= 17.99 / (0.85 * 1000)$ $= 0.0212 \text{ N/mm}^2$
Weight at bottom of step 1	$uwt = t(a) * we * h(a) * gamf = 0.55 * 18 * 1 * 0.9$ $= 8.91 \text{ kN}$
Weight at bottom of step 2	$uwt = uwt + (t(a) * we * h(a) * gamf)$ $= 8.91 + (0.75 * 18 * 1.4 * 0.9)$ $= 25.92 \text{ kN}$
Weight at bottom of step 3	$uwt = uwt + (t(a) * we * h(a) * gamf)$ $= 25.92 + (0.85 * 18 * 1.7 * 0.9)$ $= 49.33 \text{ kN}$
Weight per. unit area	$ga = (uwt + Vo) / (t(\text{steps}) * 1000)$ $= (49.33 + 0) / (0.85 * 1000)$ $= 0.058 \text{ N/mm}^2$
Permissible shear stress	$fv = 0.35 + 0.6 * ga = 0.35 + 0.6 * 0.058$ $= 0.3848 \text{ N/mm}^2$

As $uss \leq fv$ ($0.0212 \text{ N/mm}^2 \leq 0.3848 \text{ N/mm}^2$), applied shear is less than shear resistance.

Overturning

Overturning moment about A	$om = me + ms + (xm + xv * od)$ $= 6.504 + 2.71 + (0 + 0 * 2)$ $= 9.214 \text{ kNm}$
Restoring moment abt A fill/wall	$rmf = wf * ef = 30.6 * 0.6 = 18.36 \text{ kNm}$
base	$rmb = wb * tb / 2 = 7.92 * 1.1 / 2 = 4.356 \text{ kNm}$
surcharge	$rms = ws * (t + th) * ef = 5 * (0.85 + 0.15) * 0.6$ $= 3$
vertical load	$rmVo = Vo * eVo = 0 * 0.3125 = 0 \text{ kNm}$
total	$rm = rmf + rmb + rms + rmVo = 18.36 + 4.356 + 3 + 0$ $= 25.72$
Factor of safety	$fso = rm / om = 25.72 / 9.214 = 2.791$

Sliding - passive resistance will be ignored

Vertical load on wall will be ignored for the sliding calculations that follow.

Sliding force	$sf = sfe + sfs + xv = 9.756 + 2.71 + 0$ $= 12.47$
Details of bearing strata:	
Angle of friction (u/s of base)	$phib = 40^\circ$
Soil 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 $rff = wf * cf = 30.6 * 0.5022 = 15.37 \text{ kN}$
	base $rfb = wb * cf + tb * cu / 2 = 7.92 * 0.5022 + 1.1 * 0 / 2$ $= 3.978 \text{ kN}$

0

surcharge $rfs = ws \cdot (t + th) \cdot cf = 5 \cdot (0.85 + 0.15) \cdot 0.5022$
 $= 2.511 \text{ kN}$

total $rf = rff + rfb + rfs = 15.37 + 3.978 + 2.511$
 $= 21.86 \text{ kN}$

Factor of safety $fss = rf / sf = 21.86 / 12.47 = 1.753$

Bearing pressure

Weight of surcharge $sw = ws \cdot (t + th) = 5 \cdot (0.85 + 0.15)$
 $= 5 \text{ kN}$

Moments about centre of base $m = om + (wf + sw) \cdot (tb / 2 - ef) + Vo \cdot (tb / 2 - eVo)$
 $= 9.214 + (30.6 + 5) \cdot (1.1 / 2 - 0.6) + 0 \cdot (1.1 / 2 - 0.3125)$
 $= 7.434 \text{ kNm}$

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

Total weight $tw = wf + sw + wb + Vo = 30.6 + 5 + 7.92 + 0$
 $= 43.52 \text{ kN}$

Pressure due to weight $pw = tw / tb = 43.52 / 1.1 = 39.56 \text{ kN/m}^2$

Pressure due to BM (+ve or -ve) $pm = m / zb = 7.434 / 0.2017 = 36.86 \text{ kN/m}^2$

Maximum pressure $pmax = pw + pm = 39.56 + 36.86 = 76.42 \text{ kN/m}^2$

Minimum pressure $pmin = pw - pm = 39.56 - 36.86 = 2.703 \text{ kN/m}^2$

DESIGN SUMMARY

Wall height	1.7 m		
Step height (m)	Step thickness (m)	Ultimate Moments (kNm)	
		Resistance	Applied
1	0.55	4.645	2.222
1.4	0.75	9.245	5.248
1.7	0.85	12.46	8.724

Summary of stability check

Factor of safety overturning 2.791
Factor of safety sliding 1.753
Maximum base pressure 76.42 kN/m²