

Chapel House, Cymmer.

Calculations for Proposed Retaining Wall.

A) Brief

To check the adequacy of the 'as-built' wall to facilitate use as a supporting wall for a hardstanding

B) Proposal/Specification

- The wall is constructed using dense concrete blocks with a minimum crushing strength of 10.5N/mm² and mortar designation 3
- Mass concrete foundations to the wall are concrete grade C40
- A surcharge of 1.5kN/m² at the top of the wall level has been used in these calculations
- Backfill is suitable free draining granular material incorporating land drainage system discharging into existing surface water drains and combined with weepholes through the wall
- The wall is detailed on the Engineering plans and the design allows for a possible 300 mm deep dig to the front of the wall.

C) Existing Ground Conditions

- No formal site investigation was carried out but the construction revealed well-compacted ground at base level. This combined with the removal of circa 2.8m of overburden has established a safe bearing pressure at formation of 100kN/m².
- No ground water was present but drainage system and weep holes have been installed as detailed.

D) Standards and Codes of Practice

- BS 5628; Structural Use of Unreinforced Masonry.
- CP 8002; Earth Retaining Structures
- BS6399; pt1; Loading for Buildings.
- BS8004; Foundations.

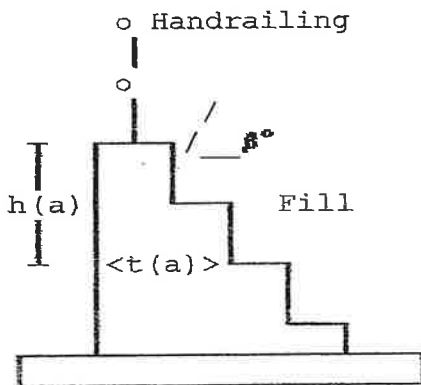
Blockwork Retaining Wall
1 Chapel House
Lloyds Terrace
Cymmer SA13 3HU

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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

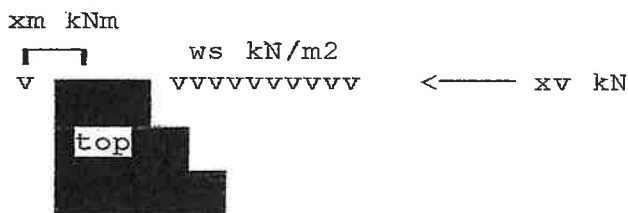
Soil details

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=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 $po = 10.5 \text{ N/mm}^2$
Characteristic flexural strength for bed failure and leaf greater than
250mm thick - Table 3 $fb(a) = \text{TABLE 3.71 for } po = 10.5, \text{ mortar} = 3$
 $= 0.25 \text{ N/mm}^2$
Partial safety factor material $\gamma_{mam} = 3.5$

External loading



Applied moment at top of wall	$xm=0.00 \text{ kNm}$
Applied shear at top of wall	$xv=0.00 \text{ kN}$
Weight/unit area of surcharge	$ws=1.5 \text{ kN/m}^2$
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=4

Step 1 Typical Analysis which is repeated for each step

Proposed height at step	$h(1)=0.78 \text{ m}$
Proposed thickness at step	$t(1)=0.45 \text{ m}$
Moment at height h earth	$me=ce*we*h(a)^{3/6}$ $=0.271*18*0.78^{3/6}$ $=0.3858 \text{ kNm}$
surcharge	$ms=ce*ws*h(a)^{2/2}$ $=0.271*1.5*0.78^{2/2}$ $=0.1237 \text{ kNm}$
Ultimate moment at height h	$mu=me*\gamma_{mae}+ms*\gamma_{mas}+(xm+xv*h(a))$ $*\gamma_{max}$ $=0.3858*1.4+0.1237*1.6+(0+0*0.78)$ $*1.6$ $=0.738$
Section modulus at thickness t	$z=t(a)^{2/6}=0.45^{2/6}=0.03375 \text{ m}^3$
Weight/unit area at depth h	$gd=(ws+we*h(a))*\gamma_{maf}/1000$ $=(1.5+18*0.78)*0.9/1000$ $=0.01399 \text{ N/mm}^2$
Moment of resistance	$mr=(fb(1)/\gamma_{mam}+gd)*z*1000$ $=(0.25/3.5+0.01399)*0.03375*1000$ $=2.883 \text{ kNm}$
Applied moment less than moment of resistance (0.738 <=2.883) therefore section is satisfactory.	
Step 1	width 0.45 m
	height 0.78 m

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Step height (m)	Step thickness (m)	Ultimate Moments (kNm)	
		Resistance	Applied
0.78	0.45	2.883	0.738
1.23	0.675	7.04	2.61
1.9	0.9	13.98	8.981
2.8	1.225	29.55	27.53

Diagram illustrating the components of a rectangular base:

- Toe**: The left end of the base.
- Wall**: The vertical structure on the left side.
- Heel**: The right end of the base.
- Fill**: The material between the wall and the heel.
- I db=depth of base**: The depth of the base.

Width of toe	$tt=0.38 \text{ m}$
Width of heel	$th=0.38 \text{ m}$
Thickness of wall	$t=1.225 \text{ m}$
Height of wall	$h=2.8 \text{ m}$
Width of base	$tb=t+tt+th$ $=1.225+0.38+0.38$ $=1.985$
Depth of base	$db=0.60 \text{ m}$
Overall depth	$od=h+db=2.8+0.6=3.4 \text{ m}$
Weight of fill and wall	$wf=we*(t+th)*h$ $=18*(1.225+0.38)*2.8$ $=80.89 \text{ kN}$
Eccentricity from A	$ef=tt+(t+th)/2$ $=0.38+(1.225+0.38)/2$ $=1.183 \text{ m}$
Weight of base	$wb=tb*db*24=1.985*0.6*24=28.58 \text{ kN}$
Earth horizontal force	$sfe=ce*we*od^2/2$ $=0.271*18*3.4^2/2$ $=28.19 \text{ kN}$
Moment due to earth pressure	$me=sfe*od/3=28.19*3.4/3=31.95 \text{ kNm}$
Surcharge horizontal force	$sfs=ws*ce*od$ $=1.5*0.271*3.4$ $=1.382 \text{ kN}$
Moment due to surcharge	$ms=sfs*od/2=1.382*3.4/2=2.349 \text{ kNm}$

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Overturning

Overturning moment about A $om = me + ms + (xm + xv * od)$
 $= 31.95 + 2.349 + (0 + 0 * 3.4)$
 $= 34.3 \text{ kNm}$

Restoring moment abt A fill/wall $rmf = wf * ef = 80.89 * 1.183 = 95.65 \text{ kNm}$
 base $rmb = wb * tb / 2 = 28.58 * 1.985 / 2 = 28.37 \text{ kNm}$
 surcharge $rms = ws * (t + th) * ef$
 $= 1.5 * (1.225 + 0.38) * 1.183$
 $= 2.847$

total $rm = rmf + rmb + rms$
 $= 95.65 + 28.37 + 2.847$
 $= 126.9$

Factor of safety $fso = rm / om = 126.9 / 34.3 = 3.699$

Sliding (passive resistance ignored)

Sliding force $sf = sfe + sfs + xv$
 $= 28.19 + 1.382 + 0$
 $= 29.58$

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 $rff = wf * cf = 80.89 * 0.5022 = 40.63 \text{ kN}$
 base $rfb = wb * cf + tb * cu / 2$
 $= 28.58 * 0.5022 + 1.985 * 0 / 2$
 $= 14.36 \text{ kN}$

surcharge $rfs = ws * (t + th) * cf$
 $= 1.5 * (1.225 + 0.38) * 0.5022$
 $= 1.209 \text{ kN}$

total $rf = rff + rfb + rfs$
 $= 40.63 + 14.36 + 1.209$
 $= 56.19 \text{ kN}$

Factor of safety $fss = rf / sf = 56.19 / 29.58 = 1.9$

Bearing pressure

Weight of surcharge $sw = ws * (t + th)$
 $= 1.5 * (1.225 + 0.38)$
 $= 2.408 \text{ kN}$

Moments about centre of base $m = om + (wf + sw) * (tb / 2 - ef)$
 $= 34.3 + (80.89 + 2.408) * (1.985 / 2 - 1.183)$
 $= 18.48 \text{ kNm}$

Section modulus of base $zb = tb^2 / 6 = 1.985^2 / 6 = 0.6567 \text{ m}^3$

Total weight $tw = wf + sw + wb$
 $= 80.89 + 2.408 + 28.58$
 $= 111.9 \text{ kN}$

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 Pressure due to weight $pw = tw/tb = 111.9/1.985 = 56.36 \text{ kN/m}^2$
 Pressure due to moment (+/-) $pm = m/zb = 18.48/0.6567 = 28.13 \text{ kN/m}^2$
 Maximum pressure $pmax = pw + pm = 56.36 + 28.13 = 84.5 \text{ kN/m}^2$
 Minimum pressure $pmin = pw - pm = 56.36 - 28.13 = 28.23 \text{ kN/m}^2$

Summary of stability check

Factor of safety overturning 3.699
 Factor of safety sliding 1.9
 Maximum base pressure 84.5 kN/m²

DESIGN SUMMARY		Wall height 2.8 m	
		Wall design	
Step height (m)	Step thickness (m)	Ultimate Moments (kNm)	
		Resistance	Applied
0.78	0.45	2.883	0.738
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