

Structural Design Check
for
Masonry Garden Retaining Wall
at
Land Off Merthyr Street
Merthyr
CF47 0LD

Chris Meredith Designs
8 Beech Grove
Ebbw Vale
NP23 8WQ

(Tel: 07792798247 E.mail chrismdesigns@aol.com)

LAND OFF MERTHYR STREET, MERTHYR, CF47 0LD

PROJECT	GARDEN RETAINING WALL	PREPARED BY	CM	DATE	JUNE 24
JOB No.	BJ/CM/01	DRG No.		PAGE No.	1 OF
			CHECKED BY		DATE

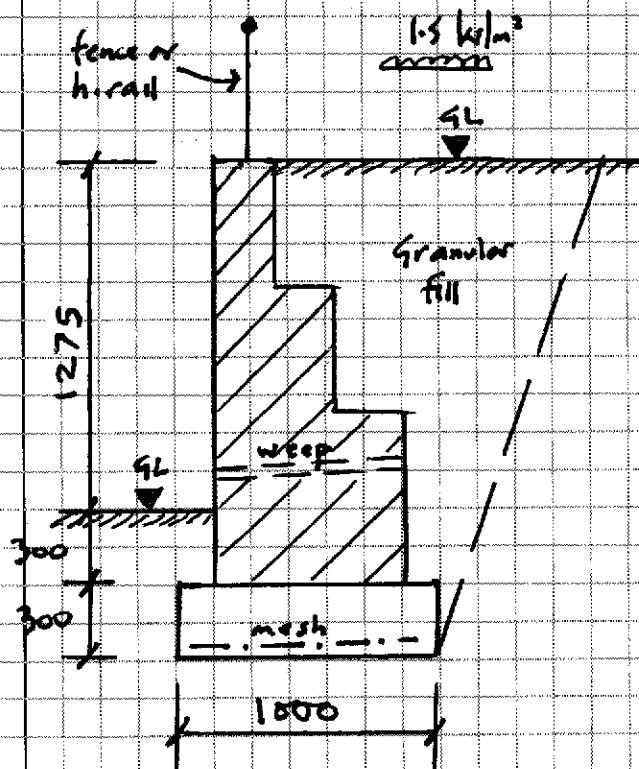
REF

CALCULATIONS

DESIGN

Check masonry retaining wall to rear garden area.

WALL DESIGN



WALL SECTION

Fill density = 18 kN/m^3 (granular)

$\phi = 35^\circ$ $K_a = 0.27$

Wall density = 18 kN/m^3

face block = 7.3 kN/m^2

Mortar mix = 1:6

Brick capacity = 75 kN/m^2 (clay)

Concrete = ST4 or RC35 mix

Surcharge garden = 1.5 kN/m^2

WALL ANALYSIS

From 'SCALE' software analysis

$$FOS_{OT} = \underline{3.01} > 2$$

$$\text{Brick pressure} = \underline{60 \text{ kN/m}^2} \text{ max} < 75$$

} o.k.

SLIDING

Factor of safety (Temporary) = $1.79 < 2$ - requires passive resistance

PROJECT

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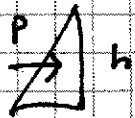
DATE

REF

CALCULATIONS

PASSIVE RESISTANCE

Consider fill at front of wall in permanent situation



$$P_p = \frac{k_p \gamma h^2}{2}$$

$$h = 0.6 \text{ m}$$

$$k_p = \frac{1 + \sin \phi}{1 - \sin \phi} = 3.65$$

$$\text{Passive resistance } P_p = \frac{3.65 \times 18 \times 0.6^2}{2} = 11.83 \text{ kN/m} \rightarrow$$

$$\text{Revised FOS slg} = \frac{11.83 + 16.73}{9.34} = 3.05 > 2$$

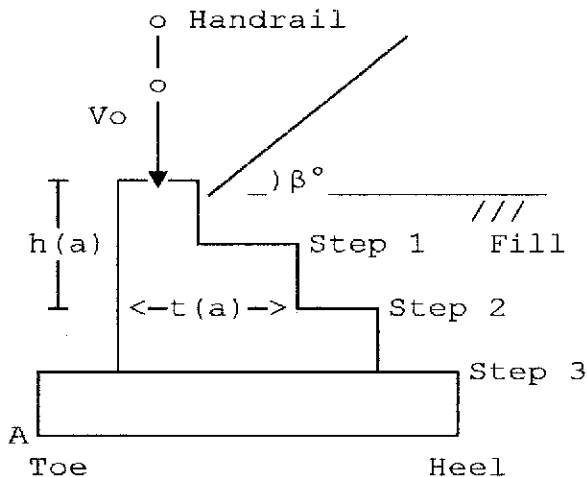
* WALL IS STABLE WHEN CHECKED FOR O/TURNING, SLIDING, AND BEARING PRESSURE AND MEETS DESIGN STANDARD OF BS 5628 FOR MASONRY.

Location: Garden Retaining Wall

Masonry gravity wall

Designed in accordance with BS5628:Part 1:2005.

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=3

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 $lhd=100 \text{ mm}$

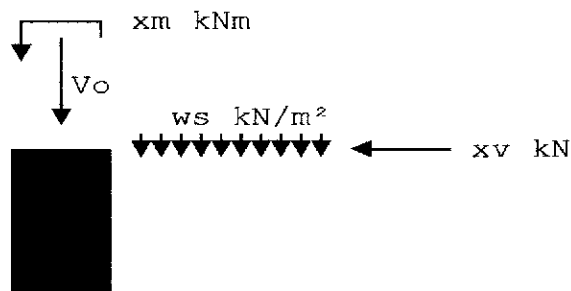
ratio height/least horiz. dim $rb=hb/lhd=215/100=2.15$

Compressive strength of blocks $po=7.3 \text{ N/mm}^2$

Characteristic flexural strength for bed failure and leaf greater than 250mm thick - Table 3
 $fb(a)=\text{TABLE 3.71 for } po=7.3, \text{ mortar}=3$
 $= 0.15 \text{ N/mm}^2$

Partial safety factor material $\gamma_{mam}=3.1$

External loading



Applied moment at top of wall	$xm=0$ kNm
Applied vertical load on the wall	$Vo=0$ kN
Applied shear at top of wall	$xv=0$ kN
Weight/unit area of surcharge	$ws=1.5$ kN/m ²
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

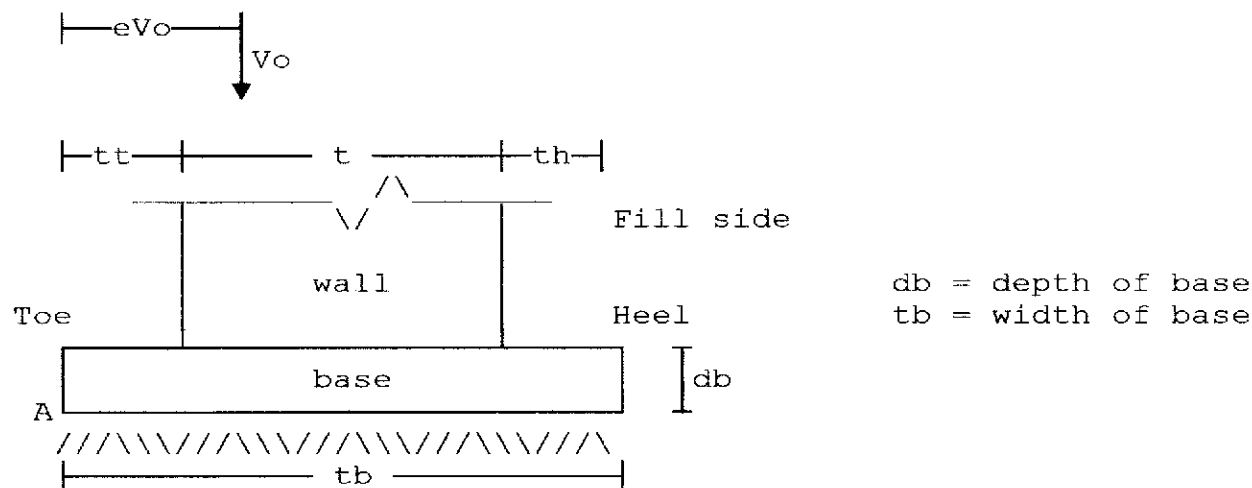
Step 1 Typical Analysis which is repeated for each step

Proposed height at step	$h(1)=0.525$ m
Proposed thickness at step	$t(1)=0.225$ m
Moment at height h earth	$me=ce*we*h(a)^3/6=0.271*18*0.525^3/6$ $=0.1176$ kNm
surcharge	$ms=ce*ws*h(a)^2/2=0.271*1.5*0.525^2/2$ $=0.056$ kNm
Ultimate moment at height h :	$mu=me*game+ms*gams+(xm+xv*h(a))*gamx$ $=0.1176*1.4+0.056*1.6+(0+0*0.525)*1.6$ $=0.2543$
Section modulus at thickness t	$z=t(a)^2/6=0.225^2/6=0.0084$ m ³
Weight/unit area at depth h	$gd=(ws+we*h(a)+Vo/t(a))*gamf/1000$ $=(1.5+18*0.525+0/0.225)*0.9/1000$ $=0.0099$ N/mm ²
Moment of resistance	$mr=(fb(1)/gammam+gd)*z*1000$ $=(0.15/3.1+0.0099)*0.0084*1000$ $=0.4914$ kNm
Applied moment less than moment of resistance ($0.2543 \leq 0.4914$) therefore section is satisfactory.	

Step 1	width	0.225 m
	height	0.525 m

Step height (m)	Step thickness (m)	Ultimate Moments (kNm)	
		Resistance	Applied
0.525	0.225	0.4914	0.2543
1.05	0.45	2.253	1.676
1.575	0.775	7.533	5.253

Stability and bearing check



Width of toe	$tt=0.125 \text{ m}$
Width of heel	$th=0.1 \text{ m}$
Point of application of V_o from A	$eVo=0.23 \text{ m}$
Thickness of wall	$t=0.775 \text{ m}$
Height of wall	$h=1.575 \text{ m}$
Width of base	$tb=t+tt+th=0.775+0.125+0.1=1 \text{ m}$
Depth of base	$db=0.3 \text{ m}$
Overall depth	$od=h+db=1.575+0.3=1.875 \text{ m}$
Weight of fill and wall	$wf=we*(t+th)*h=18*(0.775+0.1)*1.575=24.81 \text{ kN}$
Eccentricity from A (fill & wall)	$ef=tt+(t+th)/2=0.125+(0.775+0.1)/2=0.5625 \text{ m}$
Density of base	$denb=24 \text{ kN/m}^3$
Weight of base	$wb=tb*db*denb=1*0.3*24=7.2 \text{ kN}$
Earth horizontal force	$sfe=ce*we*od^2/2=0.271*18*1.875^2/2=8.574 \text{ kN}$
Moment due to earth pressure	$me=sfe*od/3=8.574*1.875/3=5.359 \text{ kNm}$
Surcharge horizontal force	$sfs=ws*ce*od=1.5*0.271*1.875=0.7622 \text{ kN}$
Moment due to surcharge	$ms=sfs*od/2=0.7622*1.875/2=0.7145 \text{ kNm}$

Wall shear

Horizontal shear force $usf = (sfe * game) + (sfs * gams)$
 $= (8.574 * 1.4) + (0.7622 * 1.6)$
 $= 13.22 \text{ kN}$

Shear stress at bottom of wall $uss = usf / (t(\text{steps}) * 1000)$
 $= 13.22 / (0.775 * 1000)$
 $= 0.0171 \text{ N/mm}^2$

Weight at bottom of step 1 $uwt = t(a) * we * h(a) * gamf$
 $= 0.225 * 18 * 0.525 * 0.9$
 $= 1.914 \text{ kN}$

Weight at bottom of step 2 $uwt = uwt + (t(a) * we * h(a) * gamf)$
 $= 1.914 + (0.45 * 18 * 1.05 * 0.9)$
 $= 9.568 \text{ kN}$

Weight at bottom of step 3 $uwt = uwt + (t(a) * we * h(a) * gamf)$
 $= 9.568 + (0.775 * 18 * 1.575 * 0.9)$
 $= 29.34 \text{ kN}$

Weight per. unit area $ga = (uwt + Vo) / (t(\text{steps}) * 1000)$
 $= (29.34 + 0) / (0.775 * 1000)$
 $= 0.0379 \text{ N/mm}^2$

Permissible shear stress $fv = 0.15 + 0.6 * ga = 0.15 + 0.6 * 0.0379$
 $= 0.1727 \text{ N/mm}^2$

As $uss \leq fv$ ($0.0171 \text{ N/mm}^2 \leq 0.1727 \text{ N/mm}^2$), applied shear is less than shear resistance.

Overturning

Overturning moment about A $om = me + ms + (xm + xv * od)$
 $= 5.359 + 0.7145 + (0 + 0 * 1.875)$
 $= 6.073 \text{ kNm}$

Restoring moment abt A fill/wall base surcharge $rmf = wf * ef = 24.81 * 0.5625 = 13.95 \text{ kNm}$
 $rmb = wb * tb / 2 = 7.2 * 1 / 2 = 3.6 \text{ kNm}$
 $rms = ws * (t + th) * ef$
 $= 1.5 * (0.775 + 0.1) * 0.5625$
 $= 0.7383$

vertical load $rmVo = Vo * eVo = 0 * 0.23 = 0 \text{ kNm}$
total $rm = rmf + rmb + rms + rmVo$
 $= 13.95 + 3.6 + 0.7383 + 0$
 $= 18.29$

Factor of safety $fso = rm / om = 18.29 / 6.073 = 3.012$

Sliding - passive resistance will be ignored

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

Sliding force $sf = sfe + sfs + xv = 8.574 + 0.7622 + 0$
 $= 9.336$

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 $rff = wf * cf = 24.81 * 0.5022 = 12.46 \text{ kN}$
 base $rfb = wb * cf + tb * cu / 2 = 7.2 * 0.5022 + 1 * 0 / 2$
 $= 3.616 \text{ kN}$
 surcharge $rfs = ws * (t + th) * cf$
 $= 1.5 * (0.775 + 0.1) * 0.5022$
 $= 0.6592 \text{ kN}$
 total $rf = rff + rfb + rfs = 12.46 + 3.616 + 0.6592$
 $= 16.73 \text{ kN}$
Factor of safety $fss = rf / sf = 16.73 / 9.336 = 1.792$

Bearing pressure

Weight of surcharge $sw = ws * (t + th) = 1.5 * (0.775 + 0.1)$
 $= 1.313 \text{ kN}$
Moments about centre of base $m = om + (wf + sw) * (tb / 2 - ef) + Vo * (tb / 2 - eVo)$
 $= 6.073 + (24.81 + 1.313) * (1 / 2 - 0.5625) + 0$
 $* (1 / 2 - 0.23)$
 $= 4.441 \text{ kNm}$
Section modulus of base $zb = tb^2 / 6 = 1^2 / 6 = 0.1667 \text{ m}^3$
Total weight $tw = wf + sw + wb + Vo = 24.81 + 1.313 + 7.2 + 0$
 $= 33.32 \text{ kN}$
Pressure due to weight $pw = tw / tb = 33.32 / 1 = 33.32 \text{ kN/m}^2$
Pressure due to BM (+ve or -ve) $pm = m / zb = 4.441 / 0.1667 = 26.65 \text{ kN/m}^2$
Maximum pressure $pmax = pw + pm = 33.32 + 26.65 = 59.96 \text{ kN/m}^2$
Minimum pressure $pmin = pw - pm = 33.32 - 26.65 = 6.673 \text{ kN/m}^2$

DESIGN SUMMARY

Wall height 1.575 m

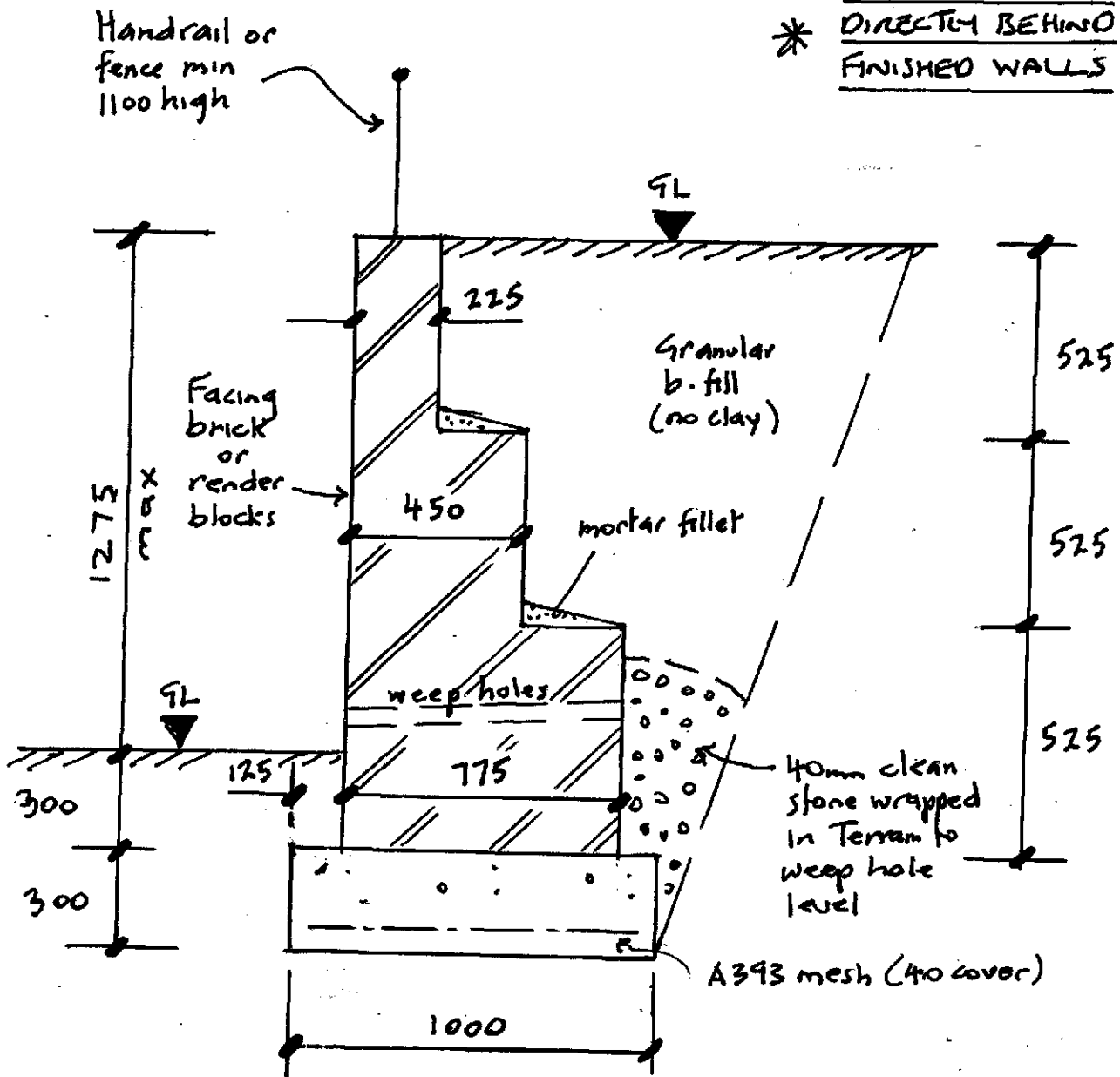
Step height (m)	Step thickness (m)	Ultimate Moments below are in kNm	
		Resistance BM	Applied BM
0.525	0.225	0.4914	0.2543
1.05	0.45	2.253	1.676
1.575	0.775	7.533	5.253

Stability check summary:
Factor of safety overturning 3.012
Factor of safety sliding 1.792
Maximum base pressure 59.96 kN/m²

DO NOT SCALE

NO HEAVY PLANT

* DIRECTLY BEHIND
FINISHED WALLS



BLOCKWORK : 7.3 N

MORTAR MIN 1:6 MIX

CONCRETE RC35/45 MIX

NOTES

CHECK FORMATION AND REMOVE AND MAKE GOOD SOFT AREAS WITH WELL COMPACTED SUB-BASE OR LEAN MIX CONC
PROVIDE 75 x 75 UHC WEEP HOLES @ 1000 CRS
PROVIDE EXPANSION JOINT TO WALL IF > 6m LONG.
FULL TEMPORARY SUPPORT PROVIDED TO ANY EXCAVATION

Project Title		
GARDEN RETAINING WALL AT		
MENTHIR ST. M. TYDFIL CF47 OLD		
Drawn	CM	Date JUNE 24
Drg.	BJ CM WALL 01	
		Rev.