

Structural Calculation

Swansea Road

Pontardawe

Important Note

All Calculation should be checked by Building control officer for Approval.

All measurement to be carried out by the Contractor and agreed by the Engineer Prior ordering the material.

Front Garden Retaining wall design

This retaining wall is the front elevations of the property.

Maximum Retaining height = 2.20m

Surcharge = 1.5kN/m²

From computer output

block work wall

See detailed drawings.

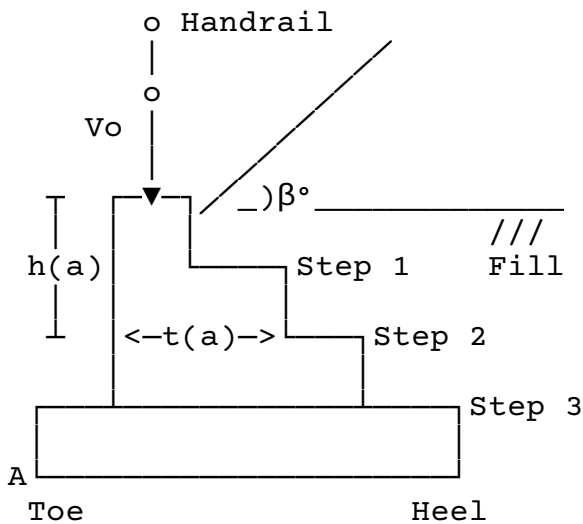
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Location: Retaining wall supporting garden

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 $\beta=10^\circ$

Active soil pressure is applicable.

Cosine angle of internal friction $cp=\cos(\text{RAD}(\phi))=0.8192$

Cosine angle of slope β $cb=\cos(\text{RAD}(\beta))=0.9848$

$$cc=(cb^2-cp^2)^{.5}$$

$$=(0.9848^2-0.8192^2)^{.5}$$

$$=0.5467$$

Horizontal active pressure coeff $ce=cb^2*(cb-cc)/(cb+cc)$

$$=0.9848^2*(0.9848-0.5467)/(0.9848+0.5467)$$

$$=0.2775$$

Masonry details

Mortar designation to Table 1 mortar=3

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

$$\text{typ}(1)=4$$

Concrete block dimensions:

Height $hb=100 \text{ mm}$

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

ratio height/least horiz. dim $rb=hb/lhd=100/100=1$

Compressive strength of blocks $po=7.35 \text{ N/mm}^2$

Characteristic flexural strength for bed failure and leaf greater than 250mm thick - Table 3

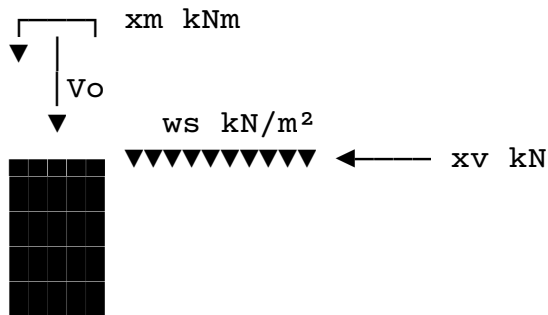
$$fb(a)=\text{TABLE 3.71 for } po=7.35, \text{ mortar}=3$$

$$=0.1516 \text{ N/mm}^2$$

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

0

External loading



Applied moment at top of wall $x_m=0$ kNm
 Applied vertical load on the wall $V_o=0$ kN
 Applied shear at top of wall $x_v=0$ kN
 Weight/unit area of surcharge $w_s=1.5$ kN/m²
 Load factor external loads at top $\gamma_{mx}=1.6$
 Load factor surcharge $\gamma_{ms}=1.6$
 Load factor earth pressure $\gamma_{me}=1.4$
 Load factor self weight $\gamma_{mf}=0.9$

Wall design

Step 1 Typical Analysis which is repeated for each step

Proposed height at step $h(1)=1.00$ m
 Proposed thickness at step $t(1)=0.450$ m
 Moment at height h earth $m_e = c_e \cdot w_e \cdot h(a)^3 / 6 = 0.2775 \cdot 18 \cdot 1^3 / 6 = 0.8324$ kNm
 surcharge $m_s = c_e \cdot w_s \cdot h(a)^2 / 2 = 0.2775 \cdot 1.5 \cdot 1^2 / 2 = 0.2081$ kNm
 Ultimate moment at height h :

$$m_u = m_e \cdot \gamma_{me} + m_s \cdot \gamma_{ms} + (x_m + x_v \cdot h(a)) \cdot \gamma_{mx}$$

$$= 0.8324 \cdot 1.4 + 0.2081 \cdot 1.6 + (0 + 0 \cdot 1) \cdot 1.6 = 1.498$$

 Section modulus at thickness t $z = t(a)^2 / 6 = 0.45^2 / 6 = 0.0338$ m³
 Weight/unit area at depth h $g_d = (w_s + w_e \cdot h(a) + V_o / t(a)) \cdot \gamma_{mf} / 1000$

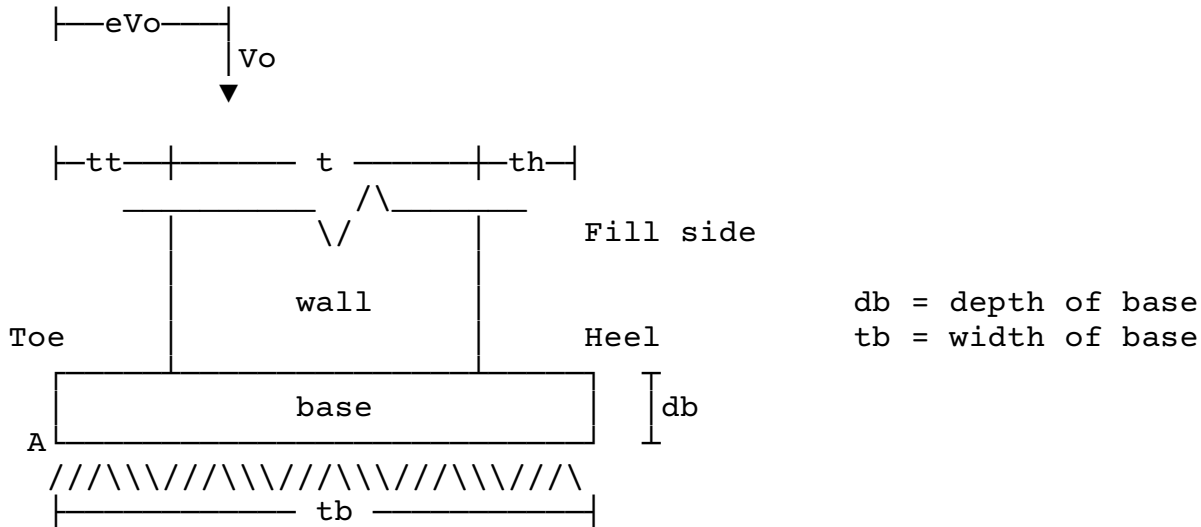
$$= (1.5 + 18 \cdot 1 + 0 / 0.45) \cdot 0.9 / 1000 = 0.0176$$
 N/mm²
 Moment of resistance $m_r = (f_b(1) / \gamma_{mam} + g_d) \cdot z \cdot 1000$

$$= (0.1516 / 3.1 + 0.0176) \cdot 0.0338 \cdot 1000 = 2.243$$
 kNm
 Applied moment less than moment of resistance ($1.498 \leq 2.243$)
 therefore section is satisfactory.

Step 1 width 0.45 m
 height 1 m

Step height (m)	Step thickness (m)	0	
		Ultimate Moments (kNm)	Resistance Applied
1	0.45	2.243	1.498
1.6	0.675	5.785	5.626
2.1	1.1	17	12.26

Stability and bearing check



Width of toe	tt=0.15 m
Width of heel	th=0.15 m
Point of application of Vo from A	eVo=0.3125 m
Thickness of wall	t=1.1 m
Height of wall	h=2.1 m
Width of base	tb=t+tt+th=1.1+0.15+0.15 =1.4
Depth of base	db=0.30 m
Overall depth	od=h+db=2.1+0.3=2.4 m
Weight of fill and wall	wf=we*(t+th)*h=18*(1.1+0.15)*2.1 =47.25 kN
Eccentricity from A (fill & wall)	ef=tt+(t+th)/2=0.15+(1.1+0.15)/2 =0.775 m
Density of base	denb=24 kN/m ³
Weight of base	wb=tb*db*denb=1.4*0.3*24 =10.08 kN
Earth horizontal force	sfe=ce*we*od ² /2=0.2775*18*2.4 ² /2 =14.38 kN
Moment due to earth pressure	me=sfe*od/3=14.38*2.4/3=11.51 kNm
Surcharge horizontal force	sfs=ws*ce*od=1.5*0.2775*2.4 =0.9989 kN
Moment due to surcharge	ms=sfs*od/2=0.9989*2.4/2 =1.199 kNm

0

Wall shear

Horizontal shear force	$usf = (sfe * game) + (sfs * gams)$ $= (14.38 * 1.4) + (0.9989 * 1.6)$ $= 21.74 \text{ kN}$
Shear stress at bottom of wall	$uss = usf / (t(steps) * 1000)$ $= 21.74 / (1.1 * 1000)$ $= 0.0198 \text{ N/mm}^2$
Weight at bottom of step 1	$uwt = t(a) * we * h(a) * gamf = 0.45 * 18 * 1 * 0.9$ $= 7.29 \text{ kN}$
Weight at bottom of step 2	$uwt = uwt + (t(a) * we * h(a) * gamf)$ $= 7.29 + (0.675 * 18 * 1.6 * 0.9)$ $= 24.79 \text{ kN}$
Weight at bottom of step 3	$uwt = uwt + (t(a) * we * h(a) * gamf)$ $= 24.79 + (1.1 * 18 * 2.1 * 0.9)$ $= 62.21 \text{ kN}$
Weight per. unit area	$ga = (uwt + Vo) / (t(steps) * 1000)$ $= (62.21 + 0) / (1.1 * 1000)$ $= 0.0566 \text{ N/mm}^2$
Permissible shear stress	$fv = 0.15 + 0.6 * ga = 0.15 + 0.6 * 0.0566$ $= 0.1839 \text{ N/mm}^2$

As $uss \leq fv$ ($0.0198 \text{ N/mm}^2 \leq 0.1839 \text{ N/mm}^2$), applied shear is less than shear resistance.

Overturning

Overturning moment about A	$om = me + ms + (xm + xv * od)$ $= 11.51 + 1.199 + (0 + 0 * 2.4)$ $= 12.71 \text{ kNm}$
Restoring moment abt A fill/wall	$rmf = wf * ef = 47.25 * 0.775 = 36.62 \text{ kNm}$
base	$rmb = wb * tb / 2 = 10.08 * 1.4 / 2 = 7.056 \text{ kNm}$
surcharge	$rms = ws * (t + th) * ef = 1.5 * (1.1 + 0.15) * 0.775$ $= 1.453$
vertical load	$rmVo = Vo * eVo = 0 * 0.3125 = 0 \text{ kNm}$
total	$rm = rmf + rmb + rms + rmVo$ $= 36.62 + 7.056 + 1.453 + 0$ $= 45.13$
Factor of safety	$fso = rm / om = 45.13 / 12.71 = 3.552$

Sliding - passive resistance will be ignored

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

Sliding force	$sf = sfe + sfs + xv = 14.38 + 0.9989 + 0$ $= 15.38$
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 $rff = wf * cf = 47.25 * 0.5022 = 23.73 \text{ kN}$

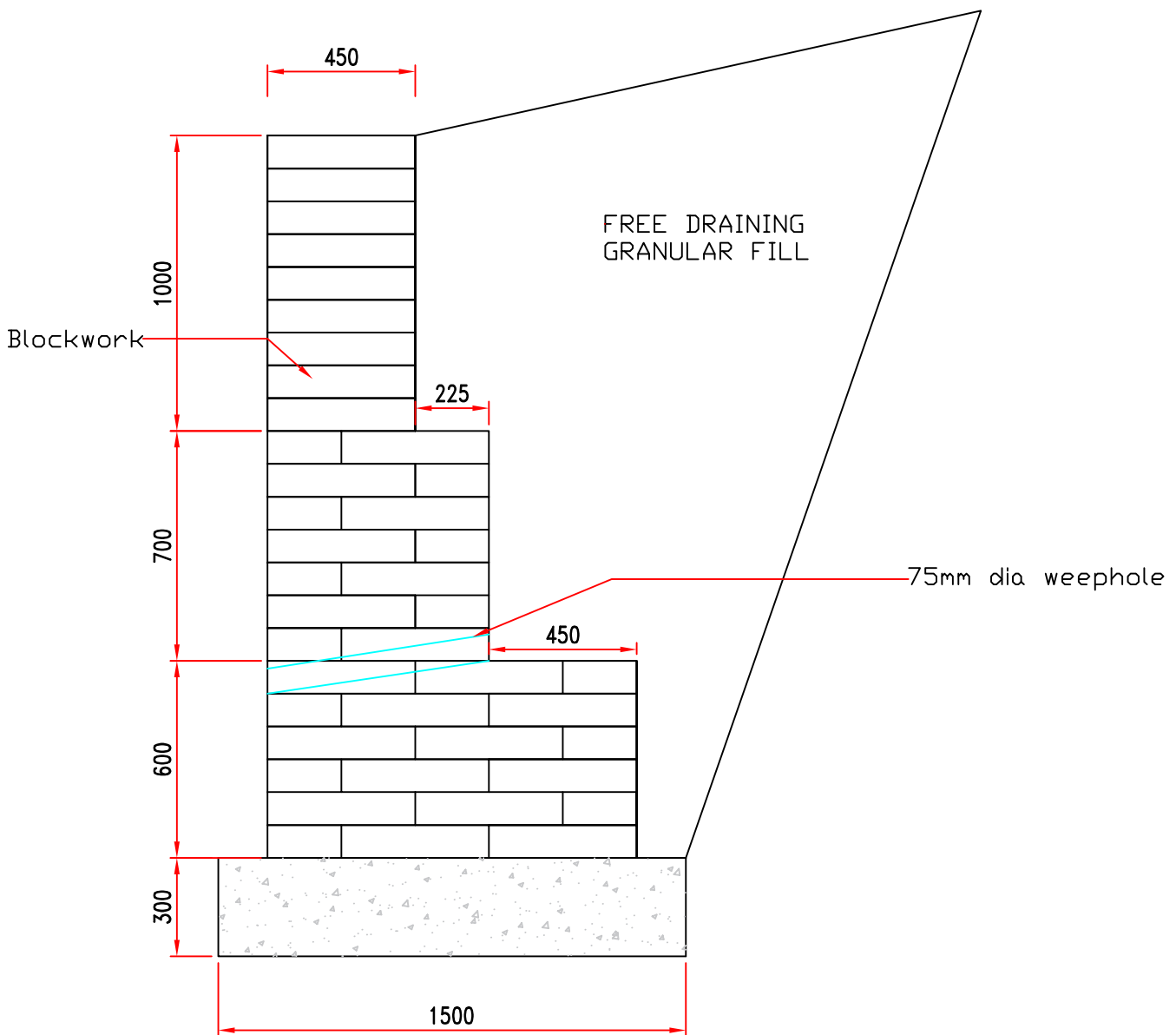
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base	$\text{rfb} = \text{wb} \cdot \text{cf} + \text{tb} \cdot \text{cu} / 2$ $= 10.08 \cdot 0.5022 + 1.4 \cdot 0 / 2$ $= 5.062 \text{ kN}$
surcharge	$\text{rfs} = \text{ws} \cdot (\text{t} + \text{th}) \cdot \text{cf}$ $= 1.5 \cdot (1.1 + 0.15) \cdot 0.5022$ $= 0.9417 \text{ kN}$
total	$\text{rf} = \text{rff} + \text{rfb} + \text{rfs} = 23.73 + 5.062 + 0.9417$ $= 29.73 \text{ kN}$
Factor of safety	$\text{fss} = \text{rf} / \text{sf} = 29.73 / 15.38 = 1.933$
<u>Bearing pressure</u>	
Weight of surcharge	$\text{sw} = \text{ws} \cdot (\text{t} + \text{th}) = 1.5 \cdot (1.1 + 0.15)$ $= 1.875 \text{ kN}$
Moments about centre of base	$\text{m} = \text{om} + (\text{wf} + \text{sw}) \cdot (\text{tb} / 2 - \text{ef}) + \text{Vo} \cdot (\text{tb} / 2 - \text{eVo})$ $= 12.71 + (47.25 + 1.875) \cdot (1.4 / 2 - 0.775)$ $+ 0 \cdot (1.4 / 2 - 0.3125)$ $= 9.022 \text{ kNm}$
Section modulus of base	$\text{zb} = \text{tb}^2 / 6 = 1.4^2 / 6 = 0.3267 \text{ m}^3$
Total weight	$\text{tw} = \text{wf} + \text{sw} + \text{wb} + \text{Vo} = 47.25 + 1.875 + 10.08 + 0$ $= 59.21 \text{ kN}$
Pressure due to weight	$\text{pw} = \text{tw} / \text{tb} = 59.21 / 1.4 = 42.29 \text{ kN/m}^2$
Pressure due to BM (+ve or -ve)	$\text{pm} = \text{m} / \text{zb} = 9.022 / 0.3267 = 27.62 \text{ kN/m}^2$
Maximum pressure	$\text{pmax} = \text{pw} + \text{pm} = 42.29 + 27.62 = 69.91 \text{ kN/m}^2$
Minimum pressure	$\text{pmin} = \text{pw} - \text{pm} = 42.29 - 27.62 = 14.67 \text{ kN/m}^2$

DESIGN SUMMARY

Wall height	2.1 m		
Step height (m)	Step thickness (m)	Ultimate Moments (kNm)	
		Resistance	Applied
1	0.45	2.243	1.498
1.6	0.675	5.785	5.626
2.1	1.1	17	12.26

Summary of stability check

Factor of safety overturning	3.552
Factor of safety sliding	1.933
Maximum base pressure	69.91 kN/m ²



PROPOSED Retaining Wall

Not To Scale