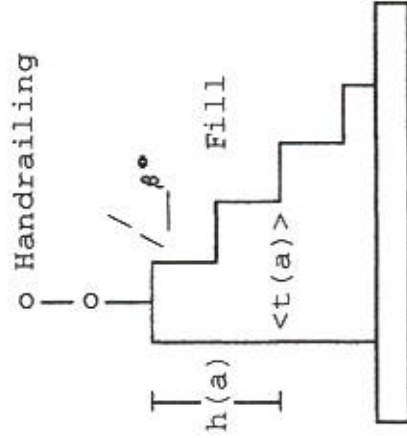


Masonry gravity wall

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

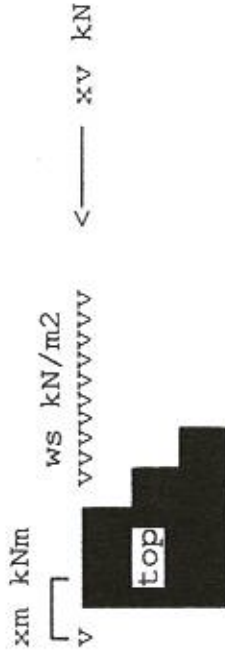
Weight/unit volume of soil & wall $w_e=18 \text{ kN/m}^3$
Internal angle of friction $\phi=35^\circ$
Angle of backfill $\beta=0^\circ$
Active soil pressure is applicable.
Sine angle of internal friction $\sin \phi = \sin(35^\circ) = 0.5736$
Active pressure coefficient
$$K_a = \frac{1 - \sin \phi}{1 +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

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 $h_b=215 \text{ mm}$
Least horiz dimension $l_{hd}=100 \text{ mm}$
ratio height/least horiz dim $r_b = h_b / l_{hd} = 215 / 100 = 2.15$
Compressive strength of blocks $p_o = 10.5 \text{ N/mm}^2$

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

External loading



Applied moment at top of wall $x_m = 0.00 \text{ kNm}$
Applied shear at top of wall $x_v = 0.00 \text{ kN}$
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 $\gamma_{mae} = 1.6$
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=5

Step 1 Typical Analysis which is repeated for each step

Proposed height at step $h(1) = 0.45 \text{ m}$
Proposed thickness at step $t(1) = 0.550 \text{ m}$
Moment at height h earth $me = ce * w_e * h(a)^3 / 6 = 0.271 * 18 * 0.45^3 / 6 = 0.07408 \text{ kNm}$
surcharge $ms = ce * w_s * h(a)^2 / 2 = 0.271 * 5 * 0.45^2 / 2 = 0.1372 \text{ kNm}$
Ultimate moment at height h $mu = me * \gamma_{mae} + ms * \gamma_{mae} + (x_m + x_v * h(a)) * \gamma_{max}$
 $= 0.07408 * 1.4 + 0.1372 * 1.6 + (0 + 0 * 0.45) * 1.6$
 $= 0.3232$

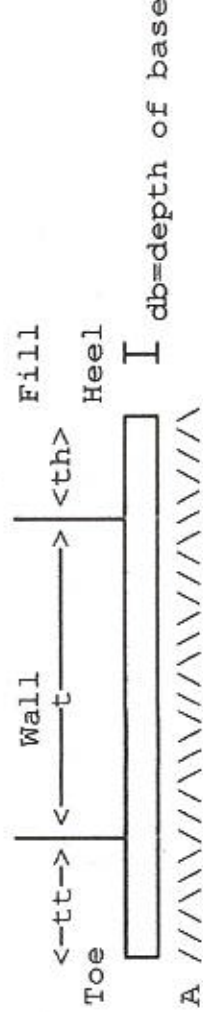
Section modulus at thickness t $z=t(a)^2/6=0.55^2/6=0.05042 \text{ m}^3$
 Weight/unit area at depth h $gd=(ws+we*h(a))*gammaf/1000$
 $= (5+18*0.45)*0.9/1000$
 $= 0.01179 \text{ N/mm}^2$
 Moment of resistance $mr=(fb(1)/gammaam+gd)*z*1000$
 $= (0.25/3.5+0.01179)*0.05042*1000$
 $= 4.196 \text{ kNm}$

Applied moment less than moment of resistance (0.3232 <= 4.196)
 therefore section is satisfactory.

Step 1 width 0.55 m
 height 0.45 m

Step height (m)	Step thickness (m)	Ultimate Moments (kNm) Resistance Applied
0.45	0.55	4.196 0.3232
0.9	0.675	6.873 1.708
1.35	0.775	9.79 4.776
1.8	0.875	13.41 10.15
2.5	1000	19.4E6 24.56

Stability and bearing check



Width of toe $tt=0.15 \text{ m}$
 Width of heel $th=0.15 \text{ m}$
 Thickness of wall $t=1000 \text{ m}$
 Height of wall $h=2.5 \text{ m}$
 Width of base $tb=t+tt+th=1000+0.15+0.15$
 $= 1000$
 Depth of base $db=0.60 \text{ m}$
 Overall depth $od=h+db=2.5+0.6=3.1 \text{ m}$
 Weight of fill and wall $wf=we*(t+th)*h=18*(1000+0.15)*2.5$
 $= 45007 \text{ kN}$

Eccentricity from A

$$ef = tt + (t + th) / 2 = 0.15 + (1000 + 0.15) / 2 = 500.2 \text{ m}$$

Weight of base

$$wb = tb * db * 24 = 1000 * 0.6 * 24 = 14404 \text{ kN}$$

Earth horizontal force

$$sfe = ce * we * od^2 / 2 = 0.271 * 18 * 3.1^2 / 2 = 23.44 \text{ kN}$$

Moment due to earth pressure

$$me = sfe * od / 3 = 23.44 * 3.1 / 3 = 24.22 \text{ kNm}$$

Surcharge horizontal force

$$sfs = ws * ce * od = 5 * 0.271 * 3.1 = 4.2 \text{ kN}$$

Moment due to surcharge

$$ms = sfs * od / 2 = 4.2 * 3.1 / 2 = 6.511 \text{ kNm}$$

Wall shear

Horizontal shear force

$$\begin{aligned} usf &= (sfe * gammae) + (sfs * gammaas) \\ &= (23.44 * 1.4) + (4.2 * 1.6) \\ &= 39.53 \text{ kN} \end{aligned}$$

Shear stress at bottom of wall

$$\begin{aligned} uss &= usf / (t * steps) * 1000 \\ &= 39.53 / (1000 * 1000) \\ &= 39.53E-6 \text{ N/mm}^2 \end{aligned}$$

Weight at bottom of step 1

$$\begin{aligned} uwt &= t(a) * we * h(a) * gammaaf \\ &= 0.55 * 18 * 0.45 * 0.9 \\ &= 4.01 \text{ kN} \end{aligned}$$

Weight at bottom of step 2

$$\begin{aligned} uwt &= uwt + (t(a) * we * h(a) * gammaaf) \\ &= 4.01 + (0.675 * 18 * 0.9 * 0.9) \\ &= 13.85 \text{ kN} \end{aligned}$$

Weight at bottom of step 3

$$\begin{aligned} uwt &= uwt + (t(a) * we * h(a) * gammaaf) \\ &= 13.85 + (0.775 * 18 * 1.35 * 0.9) \\ &= 30.8 \text{ kN} \end{aligned}$$

Weight at bottom of step 4

$$\begin{aligned} uwt &= uwt + (t(a) * we * h(a) * gammaaf) \\ &= 30.8 + (0.875 * 18 * 1.8 * 0.9) \\ &= 56.32 \text{ kN} \end{aligned}$$

Weight at bottom of step 5

$$\begin{aligned} uwt &= uwt + (t(a) * we * h(a) * gammaaf) \\ &= 56.32 + (1000 * 18 * 2.5 * 0.9) \\ &= 40556 \text{ kN} \end{aligned}$$

Weight per. unit area

$$\begin{aligned} ga &= uwt / (t * steps) * 1000 \\ &= 40556 / (1000 * 1000) \\ &= 0.04056 \text{ N/mm}^2 \end{aligned}$$

Permissible shear stress

$$\begin{aligned} fv &= 0.15 + 0.6 * ga = 0.15 + 0.6 * 0.04056 \\ &= 0.1743 \text{ N/mm}^2 \end{aligned}$$

Applied shear less than shear resistance (39.53E-6 <= 0.1743)
therefore section is satisfactory.

Overturning

Overturning moment about A

$$\begin{aligned}om &= me + ms + (xm + xv * od) \\ &= 24.22 + 6.511 + (0 + 0 * 3.1) \\ &= 30.73 \text{ kNm}\end{aligned}$$

Restoring moment abt A fill/wall
base

$$\begin{aligned}rmf &= wf * ef = 45007 * 500.2 = 22.51E6 \text{ kNm} \\ rmb &= wb * tb / 2 = 14404 * 1000 / 2 \\ &= 7.204E6 \text{ kNm}\end{aligned}$$

surcharge

$$\begin{aligned}rms &= ws * (t + th) * ef = 5 * (1000 + 0.15) * 500.2 \\ &= 2.502E6\end{aligned}$$

total

$$\begin{aligned}rm &= rmf + rmb + rms \\ &= 22.51E6 + 7.204E6 + 2.502E6 \\ &= 32.22E6\end{aligned}$$

Factor of safety

$$fso = rm / om = 32.22E6 / 30.73 = 1.048E6$$

Sliding (passive resistance ignored)

Sliding force

$$\begin{aligned}sf &= sfe + sfs + xv = 23.44 + 4.2 + 0 \\ &= 27.64\end{aligned}$$

Details of bearing stratas
angle of friction
cohesion

$$phib = 40^\circ$$

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

$$cf = \text{TAN}(\text{RAD}(phib * 2 / 3))$$

$$= \text{TAN}(\text{RAD}(40 * 2 / 3))$$

$$= 0.5022$$

Coefficient of friction

Resisting force

$$rff = wf * cf = 45007 * 0.5022 = 22603 \text{ kN}$$

base

$$\begin{aligned}rfb &= wb * cf + tb * cu / 2 \\ &= 14404 * 0.5022 + 1000 * 0 / 2 \\ &= 7234 \text{ kN}\end{aligned}$$

surcharge

$$\begin{aligned}rfs &= ws * (t + th) * cf = 5 * (1000 + 0.15) * 0.5022 \\ &= 2511 \text{ kN}\end{aligned}$$

total

$$\begin{aligned}rf &= rff + rfb + rfs = 22603 + 7234 + 2511 \\ &= 32349 \text{ kN}\end{aligned}$$

Factor of safety

$$fss = rf / sf = 32349 / 27.64 = 1170$$

Bearing pressure

Weight of surcharge

$$sw=ws*(t+th)=5*(1000+0.15) \\ =5001 \text{ kN}$$

Moments about centre of base

$$m=om+(wf+sw)*(tb/2-ef) \\ =30.73+(45007+5001)*(1000/2-500.2) \\ =-3720 \text{ kNm}$$

Section modulus of base

$$zb=tb^2/6=1000^2/6=166767 \text{ m}^3 \\ tw=wf+sw+wb=45007+5001+14404 \\ =64412 \text{ kN}$$

Total weight

Pressure due to weight

$$pw=tw/tb=64412/1000=64.39 \text{ kN/m}^2$$

Pressure due to moment (+/-)

$$pm=m/zb=-3720/166767=-0.02231 \text{ kN/m}^2 \\ pmax=pw+pm=64.39+-0.02231 \\ =64.37 \text{ kN/m}^2$$

Maximum pressure

Minimum pressure

$$pmin=pw-pm=64.39--0.02231 \\ =64.41 \text{ kN/m}^2$$

Summary of stability check

Factor of safety overturning

$$1.048E6$$

Factor of safety sliding

$$1170$$

Maximum base pressure

$$64.37 \text{ kN/m}^2$$

DESIGN SUMMARY

Wall height

$$2.5 \text{ m}$$

Wall design

Step thickness

(m)

Ultimate Moments (kNm)

Resistance Applied

0.45

0.55

4.196

0.3232

0.9

0.675

6.873

1.708

1.35

0.775

9.79

4.776

1.8

0.875

13.41

10.15

2.5

1000

19.4E6

24.56

Summary of stability check

Factor of safety overturning

$$1.048E6$$

Factor of safety sliding

$$1170$$

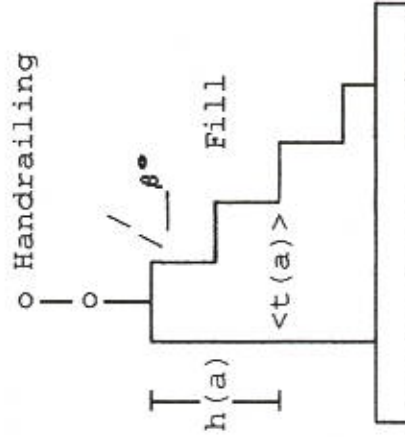
Maximum base pressure

$$64.37 \text{ kN/m}^2$$

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

Masonry details

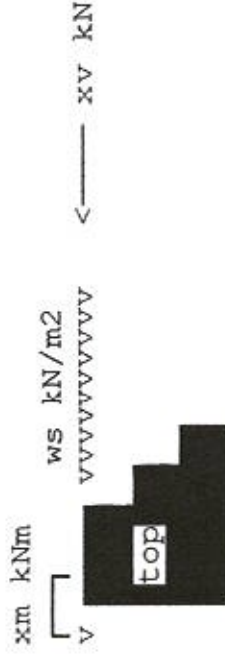
Mortar designation to Table 1 mortar=3
Masonry type (1=clay 2=cal silicate 3=conc brick 4=block)
typ(1)=4

Concrete Blocks Dimensions
Height
Least horiz dimension
ratio height/least horiz dim
Compressive strength of blocks

hb=215 mm
lhd=100 mm
rb=hb/lhd=215/100=2.15
po=10.5 N/mm²

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

External loading



Applied moment at top of wall $x_m = 0.00 \text{ kNm}$
Applied shear at top of wall $x_v = 0.00 \text{ kN}$
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 $\text{steps} = 4$

Step 1 Typical Analysis which is repeated for each step

Proposed height at step $h(1) = 0.45 \text{ m}$
Proposed thickness at step $t(1) = 0.450 \text{ m}$
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 $m_s = c_e * w_s * h(a)^2 / 2 = 0.271 * 5 * 0.45^2 / 2$
 $= 0.1372 \text{ kNm}$
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
Weight/unit area at depth h

$$z = t(a)^2/6 = 0.45^2/6 = 0.03375 \text{ m}^3$$

$$gd = (ws + we \cdot h(a)) \cdot \text{gamma}f / 1000$$

$$= (5 + 18 \cdot 0.45) \cdot 0.9 / 1000$$

$$= 0.01179 \text{ N/mm}^2$$

Moment of resistance

$$mr = (fb(1) / \text{gamma}m + gd) \cdot z \cdot 1000$$

$$= (0.25 / 3.5 + 0.01179) \cdot 0.03375 \cdot 1000$$

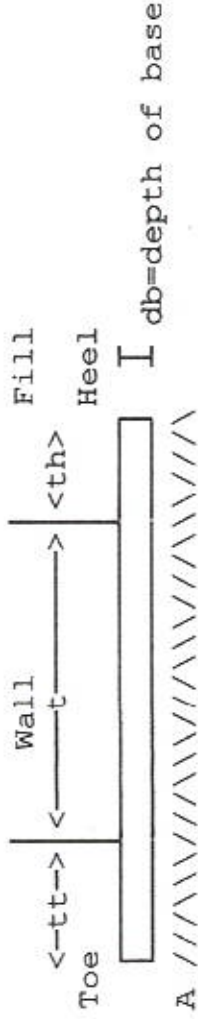
$$= 2.809 \text{ kNm}$$

Applied moment less than moment of resistance (0.3232 <= 2.809)
therefore section is satisfactory.

Step 1
width 0.45 m
height 0.45 m

Step height (m)	Step thickness (m)	Ultimate Moments (kNm) Resistance Applied
0.45	0.45	2.809 0.3232
0.9	0.55	4.563 1.708
1.35	0.675	7.427 4.776
1.8	0.775	10.52 10.15

Stability and bearing check



Width of toe
Width of heel
Thickness of wall
Height of wall
Width of base

$$tt = 0.15 \text{ m}$$

$$th = 0.15 \text{ m}$$

$$t = 0.775 \text{ m}$$

$$h = 1.8 \text{ m}$$

$$tb = t + tt + th = 0.775 + 0.15 + 0.15$$

$$= 1.075$$

Depth of base
Overall depth
Weight of fill and wall

$$db = 0.60 \text{ m}$$

$$od = h + db = 1.8 + 0.6 = 2.4 \text{ m}$$

$$wf = we \cdot (t + th) \cdot h = 18 \cdot (0.775 + 0.15) \cdot 1.8$$

$$= 29.97 \text{ kN}$$

Eccentricity from A

$$ef = tt + (t + th) / 2 = 0.15 + (0.775 + 0.15) / 2$$

$$= 0.6125 \text{ m}$$

Weight of base

$$wb=tb*db*24=1.075*0.6*24 \\ =15.48 \text{ kN}$$

Earth horizontal force

$$sfe=ce*we*od^2/2=0.271*18*2.4^2/2 \\ =14.05 \text{ kN}$$

Moment due to earth pressure
Surcharge horizontal force

$$me=sfe*od/3=14.05*2.4/3=11.24 \text{ kNm} \\ sfs=ws*ce*od=5*0.271*2.4 \\ =3.252 \text{ kN}$$

Moment due to surcharge

$$ms=sfs*od/2=3.252*2.4/2=3.902 \text{ kNm}$$

Wall shear

Horizontal shear force

$$usf=(sfe*gammae)+(sfs*gamma_s) \\ =(14.05*1.4)+(3.252*1.6) \\ =24.87 \text{ kN}$$

Shear stress at bottom of wall

$$uss=usf/(t(steps)*1000) \\ =24.87/(0.775*1000) \\ =0.03209 \text{ N/mm}^2$$

Weight at bottom of step 1

$$uwt=t(a)*we*h(a)*gamma_f \\ =0.45*18*0.45*0.9 \\ =3.281 \text{ kN}$$

Weight at bottom of step 2

$$uwt=uwt+(t(a)*we*h(a)*gamma_f) \\ =3.281+(0.55*18*0.9*0.9) \\ =11.3 \text{ kN}$$

Weight at bottom of step 3

$$uwt=uwt+(t(a)*we*h(a)*gamma_f) \\ =11.3+(0.675*18*1.35*0.9) \\ =26.06 \text{ kN}$$

Weight at bottom of step 4

$$uwt=uwt+(t(a)*we*h(a)*gamma_f) \\ =26.06+(0.775*18*1.8*0.9) \\ =48.66 \text{ kN}$$

Weight per. unit area

$$ga=uwt/(t(steps)*1000) \\ =48.66/(0.775*1000) \\ =0.06279 \text{ N/mm}^2$$

Permissible shear stress

$$fv=0.15+0.6*ga=0.15+0.6*0.06279 \\ =0.1877 \text{ N/mm}^2$$

Applied shear less than shear resistance (0.03209 <=0.1877)
therefore section is satisfactory.

Overturning

Overturning moment about A

$$\begin{aligned} \text{om} &= \text{me} + \text{rms} + (\text{xm} + \text{xv} * \text{od}) \\ &= 11.24 + 3.902 + (0 + 0 * 2.4) \\ &= 15.14 \text{ kNm} \end{aligned}$$

Restoring moment abt A fill/wall
base

$$\begin{aligned} \text{rmf} &= \text{wf} * \text{ef} = 29.97 * 0.6125 = 18.36 \text{ kNm} \\ \text{rmb} &= \text{wb} * \text{tb} / 2 = 15.48 * 1.075 / 2 \\ &= 8.32 \text{ kNm} \end{aligned}$$

surcharge

$$\begin{aligned} \text{rms} &= \text{ws} * (\text{t} + \text{th}) * \text{ef} \\ &= 5 * (0.775 + 0.15) * 0.6125 \\ &= 2.833 \end{aligned}$$

total

$$\begin{aligned} \text{rm} &= \text{rmf} + \text{rmb} + \text{rms} = 18.36 + 8.32 + 2.833 \\ &= 29.51 \end{aligned}$$

Factor of safety

$$\text{fso} = \text{rm} / \text{om} = 29.51 / 15.14 = 1.949$$

Sliding (passive resistance ignored)

Sliding force

$$\begin{aligned} \text{sf} &= \text{sfe} + \text{sfs} + \text{xv} = 14.05 + 3.252 + 0 \\ &= 17.3 \end{aligned}$$

Details of bearing stratas
angle of friction
cohesion

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

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

$$\text{cf} = \text{TAN}(\text{RAD}(\text{phib} * 2 / 3))$$

$$= \text{TAN}(\text{RAD}(40 * 2 / 3))$$

$$= 0.5022$$

Resisting force

$$\text{rff} = \text{wf} * \text{cf} = 29.97 * 0.5022 = 15.05 \text{ kN}$$

base

$$\begin{aligned} \text{rfb} &= \text{wb} * \text{cf} + \text{tb} * \text{cu} / 2 \\ &= 15.48 * 0.5022 + 1.075 * 0 / 2 \\ &= 7.774 \text{ kN} \end{aligned}$$

surcharge

$$\begin{aligned} \text{rfs} &= \text{ws} * (\text{t} + \text{th}) * \text{cf} \\ &= 5 * (0.775 + 0.15) * 0.5022 \\ &= 2.323 \text{ kN} \end{aligned}$$

total

$$\begin{aligned} \text{rf} &= \text{rff} + \text{rfb} + \text{rfs} = 15.05 + 7.774 + 2.323 \\ &= 25.15 \text{ kN} \end{aligned}$$

Factor of safety

$$\text{fss} = \text{rf} / \text{sf} = 25.15 / 17.3 = 1.454$$

Bearing pressure

Weight of surcharge

$$sw=ws*(t+th)=5*(0.775+0.15)$$

$$=4.625 \text{ kN}$$

Moments about centre of base

$$m=om+(wf+sw)*(tb/2-ef)$$

$$=15.14+(29.97+4.625)*(1.075/2-0.6125)$$

$$=12.55 \text{ kNm}$$

Section modulus of base

$$zb=tb^2/6=1.075^2/6=0.1926 \text{ m}^3$$

$$tw=wf+sw+wb=29.97+4.625+15.48$$

$$=50.08 \text{ kN}$$

$$\text{Eccentricity outside middle third } ecc=m/tw=12.55/50.08=0.2505 \text{ m}$$

Length of base under pressure

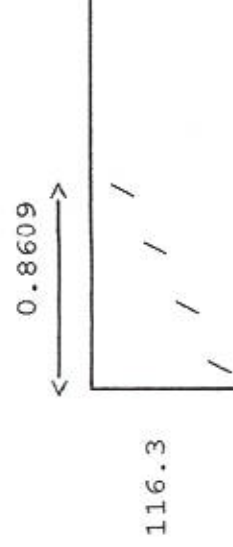
$$l=(tb/2-ecc)*3=(1.075/2-0.2505)*3$$

$$=0.8609 \text{ m}$$

Pressure

$$pmax=2*tw/l=2*50.08/0.8609$$

$$=116.3$$



Summary of stability check

Factor of safety overturning

1.949

Factor of safety sliding

1.454

Maximum base pressure

116.3 kN/m²

Proposed Steel Beams at:
54 Swansea Road
Pontardawe
Swansea

Page: 7

Made by:

Date:

12.10.22

Ref No:

RW 2

DESIGN SUMMARY		1.8 m
Step height (m)	Wall height Wall design Step thickness (m)	Ultimate Moments (kNm) Resistance Applied
0.45	0.45	2.809 0.3232
0.9	0.55	4.563 1.708
1.35	0.675	7.427 4.776
1.8	0.775	10.52 10.15

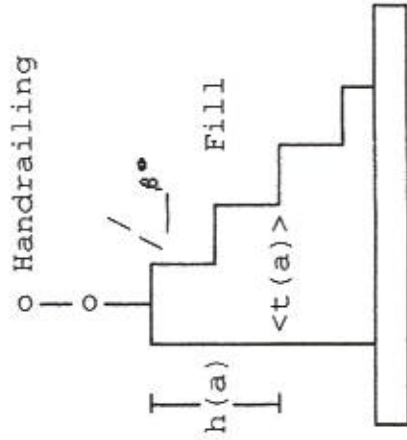
Summary of stability check

Factor of safety overturning 1.949
Factor of safety sliding 1.454
Maximum base pressure 116.3 kN/m²

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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

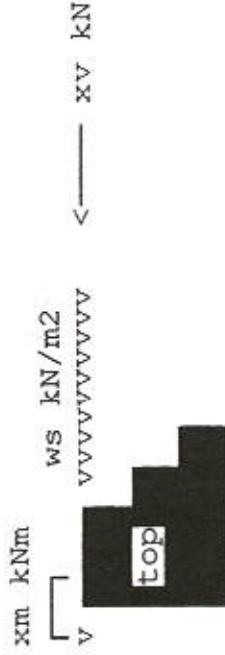
Weight/unit volume of soil & wall $w_e=18 \text{ kN/m}^3$
Internal angle of friction $\phi=35^\circ$
Angle of backfill $\beta=0^\circ$
Active soil pressure is applicable.
Sine angle of internal friction $\text{sp}=\text{SIN}(\text{RAD}(\phi))=0.5736$
Active pressure coefficient $\text{ce}=(1-\text{sp})/(1+\text{sp})$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

Masonry details

Mortar designation to Table 1 $\text{mortar}=3$
Masonry type (1=clay 2=cal silicate 3=conc brick 4=block)
 $\text{typ}(1)=4$
Concrete Blocks Dimensions
Height $\text{hb}=215 \text{ mm}$
Least horiz dimension $\text{ld}=100 \text{ mm}$
ratio height/least horiz dim $\text{rb}=\text{hb}/\text{ld}=215/100=2.15$
Compressive strength of blocks $\text{po}=10.5 \text{ N/mm}^2$

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

External loading



Applied moment at top of wall $x_m = 0.00 \text{ kNm}$
Applied shear at top of wall $x_v = 0.00 \text{ kN}$
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 steps=3

Step 1 Typical Analysis which is repeated for each step

Proposed height at step $h(1) = 0.45 \text{ m}$
Proposed thickness at step $t(1) = 0.450 \text{ m}$
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 $m_s = c_e * w_s * h(a)^2 / 2 = 0.271 * 5 * 0.45^2 / 2$
 $= 0.1372 \text{ kNm}$
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
Weight/unit area at depth h

$$z = t(a)^2/6 = 0.45^2/6 = 0.03375 \text{ m}^3$$

$$gd = (ws + we \cdot h(a)) \cdot \gamma_{maf}/1000$$

$$= (5 + 18 \cdot 0.45) \cdot 0.9/1000$$

$$= 0.01179 \text{ N/mm}^2$$

Moment of resistance

$$mr = (fb(1)/\gamma_{mam} + gd) \cdot z \cdot 1000$$

$$= (0.25/3.5 + 0.01179) \cdot 0.03375 \cdot 1000$$

$$= 2.809 \text{ kNm}$$

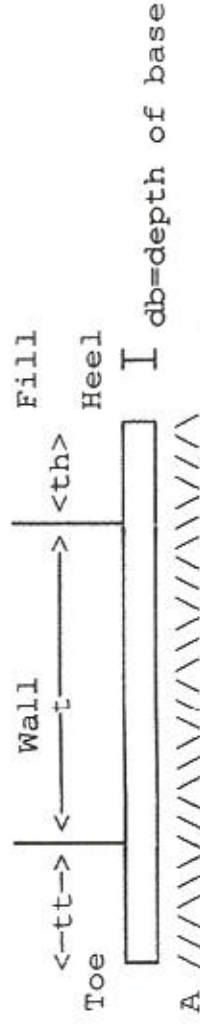
Applied moment less than moment of resistance (0.3232 <= 2.809)
therefore section is satisfactory.

Step 1 width 0.45 m
height 0.45 m

Step height (m)	Step thickness (m)	Ultimate Moments (kNm) Resistance Applied
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0.45	0.45	2.809
0.9	0.55	4.563
1.6	0.675	7.734

Stability and bearing check



Width of toe
Width of heel
Thickness of wall
Height of wall
Width of base

$$tt = 0.15 \text{ m}$$

$$th = 0.15 \text{ m}$$

$$t = 0.675 \text{ m}$$

$$h = 1.6 \text{ m}$$

$$tb = t + tt + th = 0.675 + 0.15 + 0.15$$

$$= 0.975$$

Depth of base

$$db = 0.60 \text{ m}$$

Overall depth

$$od = h + db = 1.6 + 0.6 = 2.2 \text{ m}$$

Weight of fill and wall

$$wf = we \cdot (t + th) \cdot h = 18 \cdot (0.675 + 0.15) \cdot 1.6$$

$$= 23.76 \text{ kN}$$

Eccentricity from A

$$ef = tt + (t + th)/2 = 0.15 + (0.675 + 0.15)/2$$

$$= 0.5625 \text{ m}$$

Weight of base

$$\begin{aligned}wb &= tb * db * 24 = 0.975 * 0.6 * 24 \\&= 14.04 \text{ kN}\end{aligned}$$

Earth horizontal force

$$\begin{aligned}sfe &= ce * we * od^2 / 2 = 0.271 * 18 * 2.2^2 / 2 \\&= 11.8 \text{ kN}\end{aligned}$$

Moment due to earth pressure
Surcharge horizontal force

$$\begin{aligned}me &= sfe * od / 3 = 11.8 * 2.2 / 3 = 8.657 \text{ kNm} \\sfs &= ws * ce * od = 5 * 0.271 * 2.2 \\&= 2.981 \text{ kN}\end{aligned}$$

Moment due to surcharge

$$ms = sfs * od / 2 = 2.981 * 2.2 / 2 = 3.279 \text{ kNm}$$

Wall shear

Horizontal shear force

$$\begin{aligned}usf &= (sfe * gammae) + (sfs * gamma_s) \\&= (11.8 * 1.4) + (2.981 * 1.6) \\&= 21.3 \text{ kN}\end{aligned}$$

Shear stress at bottom of wall

$$\begin{aligned}uss &= usf / (t * steps) * 1000 \\&= 21.3 / (0.675 * 1000) \\&= 0.03155 \text{ N/mm}^2\end{aligned}$$

Weight at bottom of step 1

$$\begin{aligned}uwt &= t(a) * we * h(a) * gamma_{mf} \\&= 0.45 * 18 * 0.45 * 0.9 \\&= 3.281 \text{ kN}\end{aligned}$$

Weight at bottom of step 2

$$\begin{aligned}uwt &= uwt + (t(a) * we * h(a) * gamma_{mf}) \\&= 3.281 + (0.55 * 18 * 0.9 * 0.9) \\&= 11.3 \text{ kN}\end{aligned}$$

Weight at bottom of step 3

$$\begin{aligned}uwt &= uwt + (t(a) * we * h(a) * gamma_{mf}) \\&= 11.3 + (0.675 * 18 * 1.6 * 0.9) \\&= 28.8 \text{ kN}\end{aligned}$$

Weight per. unit area

$$\begin{aligned}ga &= uwt / (t * steps) * 1000 \\&= 28.8 / (0.675 * 1000) \\&= 0.04266 \text{ N/mm}^2\end{aligned}$$

Permissible shear stress

$$\begin{aligned}fv &= 0.15 + 0.6 * ga = 0.15 + 0.6 * 0.04266 \\&= 0.1756 \text{ N/mm}^2\end{aligned}$$

Applied shear less than shear resistance (0.03155 <= 0.1756)
therefore section is satisfactory.

Overturning

Overturning moment about A

$$\begin{aligned} \text{om} &= \text{me} + \text{ms} + (\text{xm} + \text{xv} * \text{od}) \\ &= 8.657 + 3.279 + (0 + 0 * 2.2) \\ &= 11.94 \text{ kNm} \end{aligned}$$

Restoring moment abt A fill/wall
base

$$\begin{aligned} \text{rmf} &= \text{wf} * \text{ef} = 23.76 * 0.5625 = 13.37 \text{ kNm} \\ \text{rmb} &= \text{wb} * \text{tb} / 2 = 14.04 * 0.975 / 2 \\ &= 6.845 \text{ kNm} \end{aligned}$$

surcharge

$$\begin{aligned} \text{rms} &= \text{ws} * (\text{t} + \text{th}) * \text{ef} \\ &= 5 * (0.675 + 0.15) * 0.5625 \\ &= 2.32 \end{aligned}$$

total

$$\begin{aligned} \text{rm} &= \text{rmf} + \text{rmb} + \text{rms} = 13.37 + 6.845 + 2.32 \\ &= 22.53 \end{aligned}$$

Factor of safety

$$\text{fso} = \text{rm} / \text{om} = 22.53 / 11.94 = 1.888$$

Sliding (passive resistance ignored)

Sliding force

$$\begin{aligned} \text{sf} &= \text{sfe} + \text{sfs} + \text{xv} = 11.8 + 2.981 + 0 \\ &= 14.79 \end{aligned}$$

Details of bearing stratas
angle of friction
cohesion

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

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

$$\text{cf} = \text{TAN}(\text{RAD}(\text{phib} * 2 / 3))$$

$$= \text{TAN}(\text{RAD}(40 * 2 / 3))$$

$$= 0.5022$$

Coefficient of friction

Resisting force

$$\text{fill} \quad \text{rff} = \text{wf} * \text{cf} = 23.76 * 0.5022 = 11.93 \text{ kN}$$

base

$$\begin{aligned} \text{rfb} &= \text{wb} * \text{cf} + \text{tb} * \text{cu} / 2 \\ &= 14.04 * 0.5022 + 0.975 * 0 / 2 \\ &= 7.051 \text{ kN} \end{aligned}$$

surcharge

$$\begin{aligned} \text{rfs} &= \text{ws} * (\text{t} + \text{th}) * \text{cf} \\ &= 5 * (0.675 + 0.15) * 0.5022 \\ &= 2.072 \text{ kN} \end{aligned}$$

total

$$\begin{aligned} \text{rf} &= \text{rff} + \text{rfb} + \text{rfs} = 11.93 + 7.051 + 2.072 \\ &= 21.06 \text{ kN} \end{aligned}$$

Factor of safety

$$\text{fss} = \text{rf} / \text{sf} = 21.06 / 14.79 = 1.424$$

Bearing pressure

Weight of surcharge

$$sw = ws * (t + th) = 5 * (0.675 + 0.15) \\ = 4.125 \text{ kN}$$

Moments about centre of base

$$m = om + (wf + sw) * (tb / 2 - ef) \\ = 11.94 + (23.76 + 4.125) * (0.975 / 2 - 0.5625) \\ = 9.844 \text{ kNm}$$

Section modulus of base

$$zb = tb^2 / 6 = 0.975^2 / 6 = 0.1584 \text{ m}^3$$

$$tw = wf + sw + wb = 23.76 + 4.125 + 14.04 \\ = 41.93 \text{ kN}$$

Eccentricity outside middle third

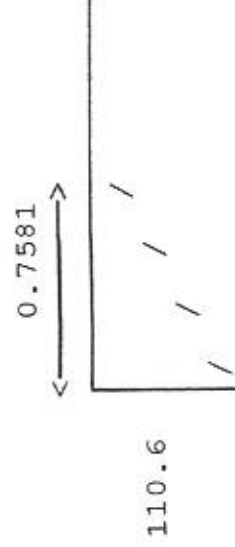
$$ecc = m / tw = 9.844 / 41.93 = 0.2348 \text{ m}$$

Length of base under pressure

$$l = (tb / 2 - ecc) * 3 = (0.975 / 2 - 0.2348) * 3 \\ = 0.7581 \text{ m}$$

Pressure

$$pmax = 2 * tw / l = 2 * 41.93 / 0.7581 \\ = 110.6$$



Summary of stability check

Factor of safety overturning

$$1.888$$

Factor of safety sliding

$$1.424$$

Maximum base pressure

$$110.6 \text{ kN/m}^2$$

Proposed Steel Beams at:
54 Swansea Road
Pontardawe
Swansea

Page: 7
Made by:
Date: 12.10.22
Ref No: RW3

DESIGN SUMMARY		1.6 m
Step height (m)	Wall height Wall design	Ultimate Moments (kNm) Resistance Applied
	Step thickness (m)	
0.45	0.45	2.809
0.9	0.55	4.563
1.6	0.675	7.734

Summary of stability check

Factor of safety overturning	1.888
Factor of safety sliding	1.424
Maximum base pressure	110.6 kN/m ²

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

