

COMPLETE CAD & STRUCTURAL SOLUTIONS LIMITED



Structural Calculations

Design Stage

For

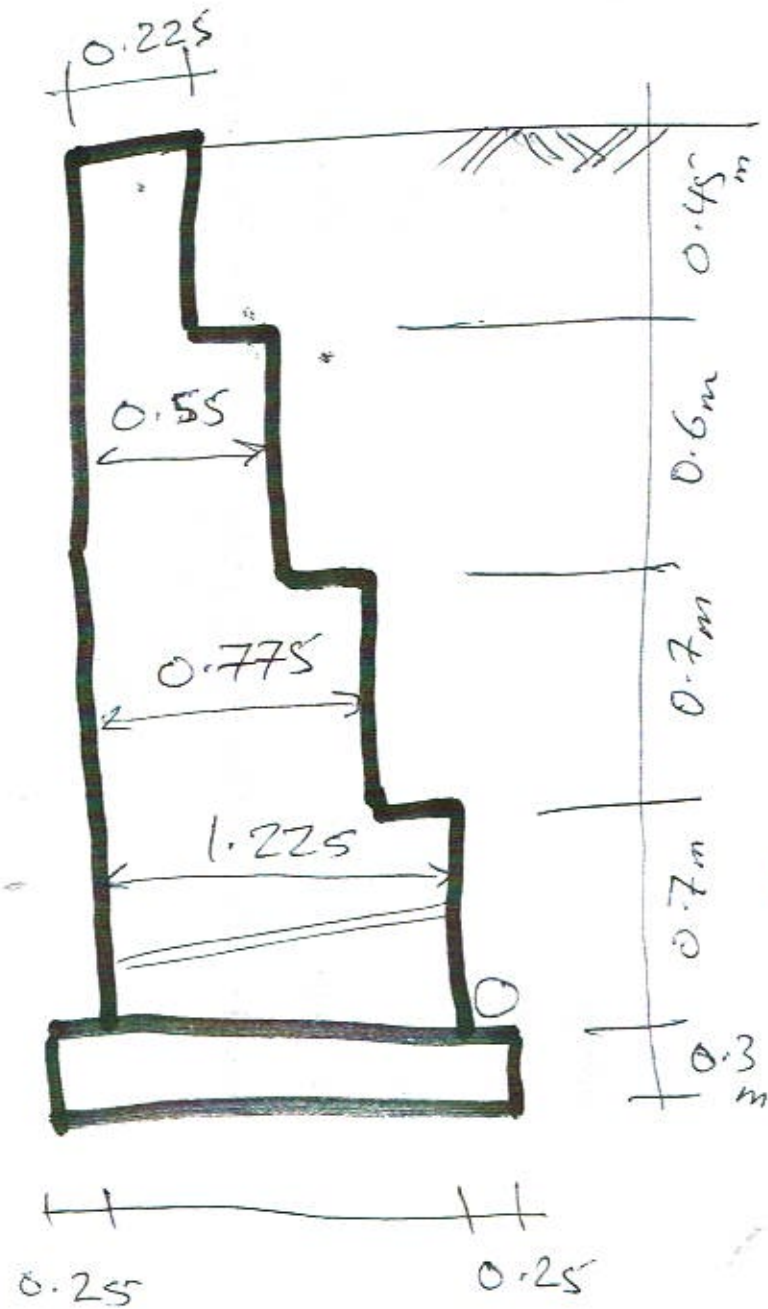
RETAINING WALL – T3

At

8 ST ANNE'S DRIVE,
TONNA,
NEATH,
SA11 3JU

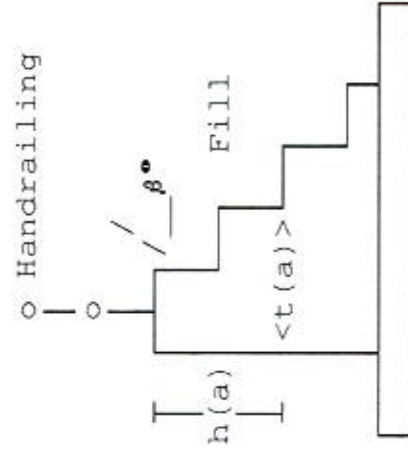
04/01/2024

T 3



Masonry gravity wall

Designed in accordance with BS5628:Part 1: 1992.
Location: Masonry Retaining Wall T3



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

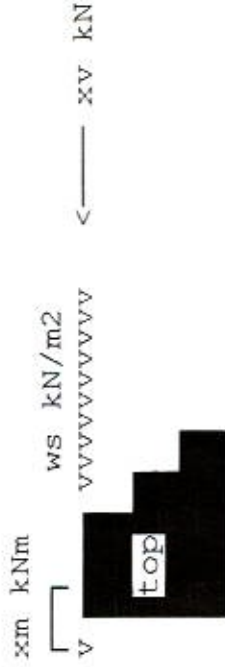
Weight/unit volume of soil & wall $w_e=18 \text{ kN/m}^3$
Internal angle of friction $\phi=35^\circ$
Angle of backfill $\beta=0^\circ$
Active soil pressure is applicable.
Sine angle of internal friction $\text{sp}=\text{SIN}(\text{RAD}(\phi))=0.5736$
Active pressure coefficient $\text{ce}=(1-\text{sp})/(1+\text{sp})$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

Masonry details

Mortar designation to Table 1 mortar=3
Masonry type (1=clay 2=cal silicate 3=conc brick 4=block)
typ(1)=4
Concrete Blocks Dimensions
Height $\text{hb}=215 \text{ mm}$
Least horiz dimension $\text{lhd}=100 \text{ mm}$
ratio height/least horiz dim $\text{rb}=\text{hb}/\text{lhd}=215/100=2.15$
Compressive strength of blocks $\text{po}=7.3 \text{ N/mm}^2$

Characteristic flexural strength for bed failure and leaf greater than
250mm thick - Table 3 $f_b(a) = \text{TABLE 3.71 for } p_o = 7.3, \text{ mortar} = 3$
 $= 0.1586 \text{ N/mm}^2$
Partial safety factor material $\gamma_{mm} = 3.5$

External loading



Applied moment at top of wall $x_m = 0 \text{ kNm}$
Applied shear at top of wall $x_v = 0 \text{ kN}$
Weight/unit area of surcharge $w_s = 1.5 \text{ kN/m}^2$
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 = 4

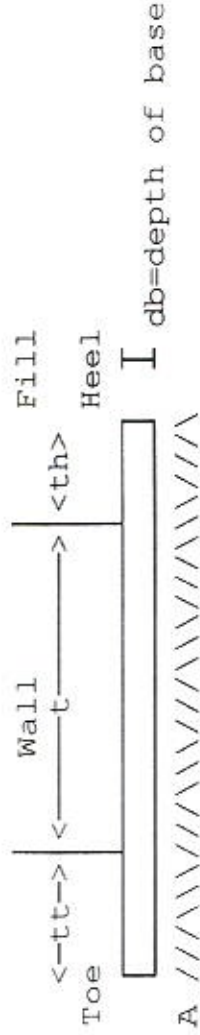
Step 1 Typical Analysis which is repeated for each step

Proposed height at step $h(1) = 0.45 \text{ m}$
Proposed thickness at step $t(1) = 0.225 \text{ m}$
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 $m_s = c e^* w s^* h(a)^2 / 2 = 0.271 * 1.5 * 0.45^2 / 2$
 $= 0.04116 \text{ kNm}$
Ultimate moment at height h $m_u = m_e^* \gamma_{mae} + m_s^* \gamma_{mas} + (x_m + x_v^* h(a))^* \gamma_{max}$
 $= 0.07408 * 1.4 + 0.04116 * 1.6 + (0 + 0$
 $* 0.45) * 1.6$
 $= 0.1696$

Section modulus at thickness t $z = t(a)^2/6 = 0.225^2/6 = 0.008438 \text{ m}^3$
 Weight/unit area at depth h $gd = (ws + we \cdot h(a)) \cdot \text{gammaf}/1000$
 $= (1.5 + 18 \cdot 0.45) \cdot 0.9/1000$
 $= 0.00864 \text{ N/mm}^2$
 Moment of resistance $mr = (fb(1)/\text{gamma}m + gd) \cdot z \cdot 1000$
 $= (0.1586/3.5 + 0.00864) \cdot 0.008438 \cdot 1000$
 $= 0.4552 \text{ kNm}$
 Applied moment less than moment of resistance (0.1696 <= 0.4552)
 therefore section is satisfactory.
 Step 1 width 0.225 m
 height 0.45 m

Step height (m)	Step thickness (m)	Ultimate Moments (kNm) Resistance Applied
0.45	0.225	0.4552 0.1696
1.05	0.55	3.21 1.676
1.75	0.775	7.508 7.096
2.45	1.225	21.6 18.69

Stability and bearing check



Width of toe $tt = 0.25 \text{ m}$
 Width of heel $th = 0.25 \text{ m}$
 Thickness of wall $t = 1.225 \text{ m}$
 Height of wall $h = 2.45 \text{ m}$
 Width of base $tb = t + tt + th = 1.225 + 0.25 + 0.25 = 1.725$
 Depth of base $db = 0.30 \text{ m}$
 Overall depth $od = h + db = 2.45 + 0.3 = 2.75 \text{ m}$
 Weight of fill and wall $wf = we \cdot (t + th) \cdot h = 18 \cdot (1.225 + 0.25) \cdot 2.45 = 65.05 \text{ kN}$
 Eccentricity from A $ef = tt + (t + th)/2 = 0.25 + (1.225 + 0.25)/2 = 0.9875 \text{ m}$

Weight of base

$$wb = tb * db * 24 = 1.725 * 0.3 * 24 = 12.42 \text{ kN}$$

Earth horizontal force

$$sfe = ce * we * od^2 / 2 = 0.271 * 18 * 2.75^2 / 2 = 18.44 \text{ kN}$$

Moment due to earth pressure

$$me = sfe * od / 3 = 18.44 * 2.75 / 3 = 16.91 \text{ kNm}$$

Surcharge horizontal force

$$sfs = ws * ce * od = 1.5 * 0.271 * 2.75 = 1.118 \text{ kN}$$

Moment due to surcharge

$$ms = sfs * od / 2 = 1.118 * 2.75 / 2 = 1.537 \text{ kNm}$$

Wall shear

Horizontal shear force

$$usf = (sfe * gamma_{ae}) + (sfs * gamma_{as}) = (18.44 * 1.4) + (1.118 * 1.6) = 27.61 \text{ kN}$$

Shear stress at bottom of wall

$$uss = usf / (t * steps) * 1000 = 27.61 / (1.225 * 1000) = 0.02254 \text{ N/mm}^2$$

Weight at bottom of step 1

$$uwt = t(a) * we * h(a) * gamma_{af} = 0.225 * 18 * 0.45 * 0.9 = 1.64 \text{ kN}$$

Weight at bottom of step 2

$$uwt = uwt + (t(a) * we * h(a) * gamma_{af}) = 1.64 + (0.55 * 18 * 1.05 * 0.9) = 11 \text{ kN}$$

Weight at bottom of step 3

$$uwt = uwt + (t(a) * we * h(a) * gamma_{af}) = 11 + (0.775 * 18 * 1.75 * 0.9) = 32.97 \text{ kN}$$

Weight at bottom of step 4

$$uwt = uwt + (t(a) * we * h(a) * gamma_{af}) = 32.97 + (1.225 * 18 * 2.45 * 0.9) = 81.59 \text{ kN}$$

Weight per. unit area

$$ga = uwt / (t * steps) * 1000 = 81.59 / (1.225 * 1000) = 0.0666 \text{ N/mm}^2$$

Permissible shear stress

$$fv = 0.15 + 0.6 * ga = 0.15 + 0.6 * 0.0666 = 0.19 \text{ N/mm}^2$$

Applied shear less than shear resistance (0.02254 <= 0.19)
 therefore section is satisfactory.

Overturning

Overturning moment about A

$$\begin{aligned} \text{om} &= \text{me} + \text{ms} + (\text{xm} + \text{xv} * \text{od}) \\ &= 16.91 + 1.537 + (0 + 0 * 2.75) \\ &= 18.44 \text{ kNm} \end{aligned}$$

Restoring moment abt A fill/wall
base

$$\begin{aligned} \text{rmf} &= \text{wf} * \text{ef} = 65.05 * 0.9875 = 64.23 \text{ kNm} \\ \text{rmb} &= \text{wb} * \text{tb} / 2 = 12.42 * 1.725 / 2 \\ &= 10.71 \text{ kNm} \end{aligned}$$

surcharge

$$\begin{aligned} \text{rms} &= \text{ws} * (\text{t} + \text{th}) * \text{ef} \\ &= 1.5 * (1.225 + 0.25) * 0.9875 \\ &= 2.185 \end{aligned}$$

total

$$\begin{aligned} \text{rm} &= \text{rmf} + \text{rmb} + \text{rms} = 64.23 + 10.71 + 2.185 \\ &= 77.13 \end{aligned}$$

Factor of safety

$$\text{fso} = \text{rm} / \text{om} = 77.13 / 18.44 = 4.182$$

Sliding (passive resistance ignored)

Sliding force

$$\begin{aligned} \text{sf} &= \text{sfe} + \text{sfs} + \text{xv} = 18.44 + 1.118 + 0 \\ &= 19.56 \end{aligned}$$

Details of bearing stratas

angle of friction

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

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

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

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

$$= 0.5022$$

Coefficient of friction

Resisting force

$$\text{fill} \quad \text{rff} = \text{wf} * \text{cf} = 65.05 * 0.5022 = 32.67 \text{ kN}$$

base

$$\begin{aligned} \text{rfb} &= \text{wb} * \text{cf} + \text{tb} * \text{cu} / 2 \\ &= 12.42 * 0.5022 + 1.725 * 0 / 2 \\ &= 6.238 \text{ kN} \end{aligned}$$

surcharge

$$\begin{aligned} \text{rfs} &= \text{ws} * (\text{t} + \text{th}) * \text{cf} \\ &= 1.5 * (1.225 + 0.25) * 0.5022 \\ &= 1.111 \text{ kN} \end{aligned}$$

total

$$\begin{aligned} \text{rf} &= \text{rff} + \text{rfb} + \text{rfs} = 32.67 + 6.238 + 1.111 \\ &= 40.02 \text{ kN} \end{aligned}$$

Factor of safety

$$\text{fss} = \text{rf} / \text{sf} = 40.02 / 19.56 = 2.046$$

Bearing pressure

Weight of surcharge

$$sw = ws * (t + th) = 1.5 * (1.225 + 0.25) = 2.213 \text{ kN}$$

Moments about centre of base

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

$$= 18.44 + (65.05 + 2.213) * (1.725 / 2 - 0.9875) = 10.04 \text{ kNm}$$

Section modulus of base

$$zb = tb^2 / 6 = 1.725^2 / 6 = 0.4959 \text{ m}^3$$

$$Total \text{ weight} \quad tw = wf + sw + wb = 65.05 + 2.213 + 12.42 = 79.68 \text{ kN}$$

Pressure due to weight

$$pw = tw / tb = 79.68 / 1.725 = 46.19 \text{ kN/m}^2$$

Pressure due to moment (+/-)

$$pm = m / zb = 10.04 / 0.4959 = 20.24 \text{ kN/m}^2$$

Maximum pressure

$$pmax = pw + pm = 46.19 + 20.24 = 66.43 \text{ kN/m}^2$$

$$pmin = pw - pm = 46.19 - 20.24 = 25.95 \text{ kN/m}^2$$

Summary of stability check

Factor of safety overturning

$$4.182$$

Factor of safety sliding

$$2.046$$

Maximum base pressure

$$66.43 \text{ kN/m}^2$$

DESIGN SUMMARY

Wall height
Wall design

2.45 m

Step height
(m)

Step thickness
(m)

Ultimate Moments (kNm)
Resistance Applied

0.45

0.225

0.4552

0.1696

1.05

0.55

3.21

1.676

1.75

0.775

7.508

7.096

2.45

1.225

21.6

18.69

Summary of stability check

Factor of safety overturning

$$4.182$$

Factor of safety sliding

$$2.046$$

Maximum base pressure

$$66.43 \text{ kN/m}^2$$

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