

STRUCTURAL CALCULATIONS and DETAILS

for

MASS BLOCKWORK GARDEN RETAINING WALLS.

for

NEW DOMESTIC DWELLING @
143, HIGH STREET,
GLYNEATH.
NEATH PORT TALBOT.
SA11 5DA.

for

Mr S. JOHN.

TOTAL BUILDING CONTROL
SWANSEA.

DECEMBER 2019.

STRUCTURAL CALCULATIONS and DETAILS for:-

GARDEN MASS BLOCKWORK RETAINING WALLS for: SHEET No: 1.
NEW DOMESTIC DWELLING @ 143, HIGH STREET, GLYNEATH. SA11 5DA.
Mr S. JOHN / TOTAL BUILDING CONTROL – SWANSEA. **DATE:- DEC 2019.**

BRIEF.

- TO PROVIDE STRUCTURAL CALCULATIONS & DETAILS FOR THE PROPOSED GARDEN MASS BLOCKWORK RETAINING WALLS.
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REFERENCES:-

DRAWING and DETAILS PROVIDED BY THE OWNER / BUILDER.

BS EN 1990 : Eurocode 0 - Basic of Structural Design.

BS EN 1991 : Eurocode 1 / BS - 6399 – Loadings on Structures

BS EN 1991 : Eurocode 1 / BS - 648 - Weights of Materials.

BS EN 1996 : Eurocode 6 / BS - 5268 Design of Masonry Structures.

BS EN 1991 : Eurocode 2 / BS - 8100 – Design of Concrete Structures.

BS EN 1997 : Eurocode 7 / BS - 8002 - Design of Earth Retaining Structures.

BS EN 1997 : Eurocode 7 / BS - 8004 - Foundations / Geotechnical Design.

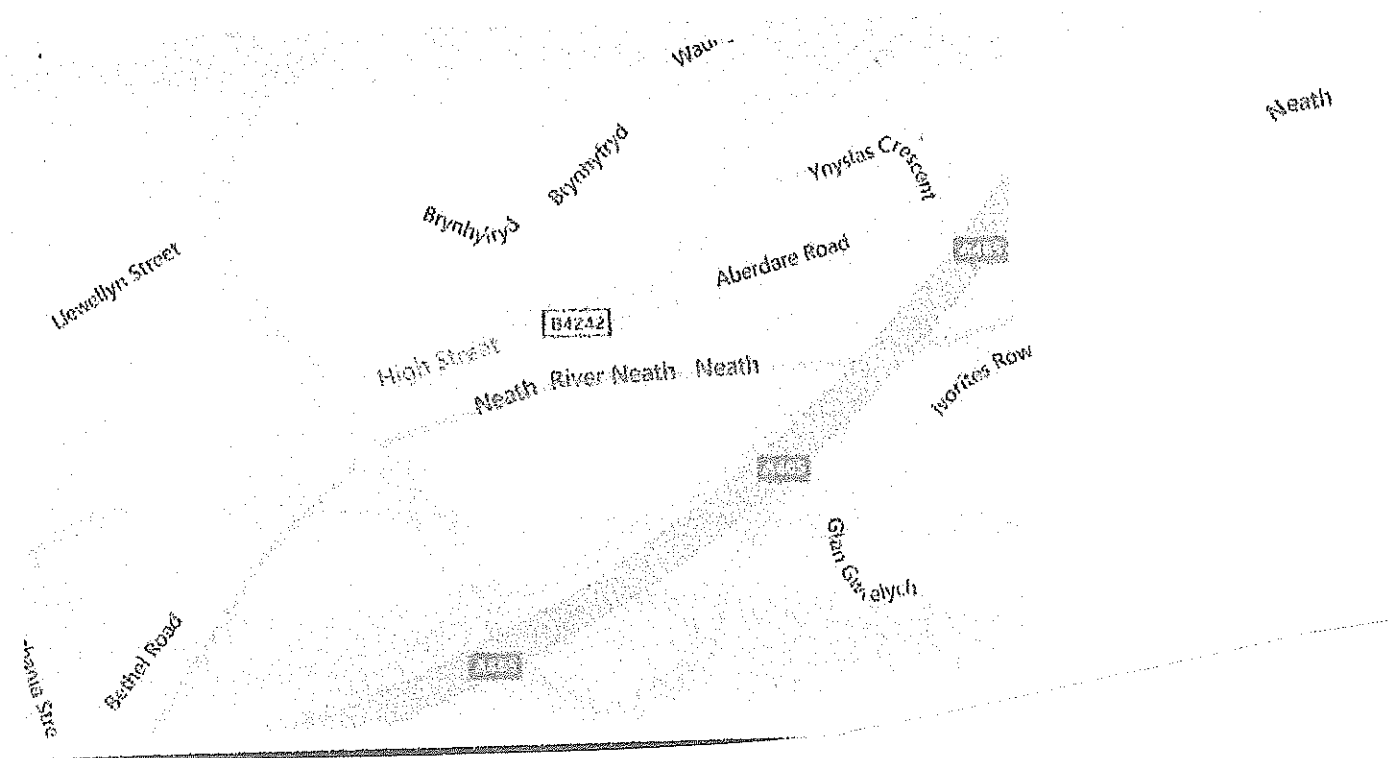
GENERAL NOTES.

- DUE TO THE LOCATION OF THE WALL, ONLY A NOMINAL 1.50 kN/m^2 WILL BE TAKEN, AS IT CANNOT BE SURCHARGED BY TRAFFIC.
 - THE WALLS SHALL BE CONSTRUCTED IN MINIMUM 10 N/mm^2 STRENGTH BLOCKWORK, IN A MINIMUM OF 1 : 0 / 1/4 : 3 MOTAR.
 - THE FOUNDATION CONCRETE SHALL BE FOUNDED ON VIRGIN GROUND, HAVING A MINIMUM BEARING CAPACITY OF 100.00 kN/m^2
 - SEE SHEET No "5" for MOVEMENT / EXPANSION JOINT DETAILS.
 - THE WALL SHALL BE CHECKED FOR THE FOLLOWING FACTORS OF SAFETY:-
 - [i] A FACTOR OF SAFETY GREATER THAN 2 FOR OVERTURNING.
 - [ii] A FACTOR OF SATETY GREATER THAN 1.5 FOR SLIDING.
 - [iii] A MAXIMUM GROUND BEARING PRESSURE NOT TO EXCEED THAT STATED ABOVE.
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STRUCTURAL CALCULATIONS and DETAILS for:-

GARDEN MASS BLOCKWORK RETAINING WALLS for: SHEET No: 2.
NEW DOMESTIC DWELLING @ 143, HIGH STREET, GLYNEATH. SA11 5DA.
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(3)



LOCATION PLAN.

STRUCTURAL CALCULATIONS and DETAILS for:-

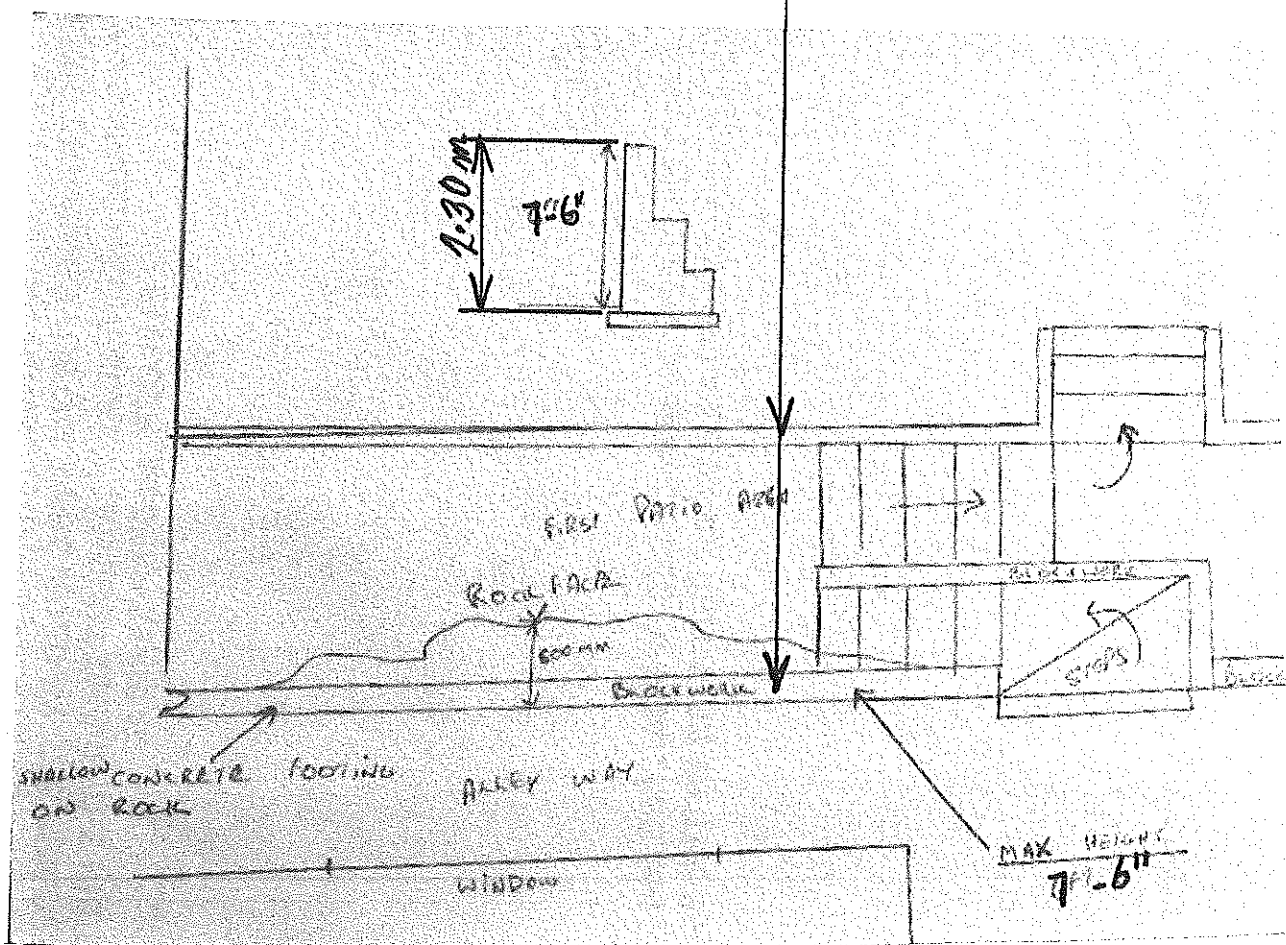
GARDEN MASS BLOCKWORK RETAINING WALLS for: SHEET No: 3.
NEW DOMESTIC DWELLING @ 143A, HIGH STREET, GLYNEATH, SA11 5DA.
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(4)

NEW GARDEN RETAINING WALLS.

MASS BLOCKWORK RETAINING WALLS
AS DETAILED ON SHEETS No's: 4 & 5.

EXPANSION / MOVEMENT JOINTS
@ MAXIMUM 6.00m CENTRES.
[SEE SHEET No: 5 for DETAILS.]

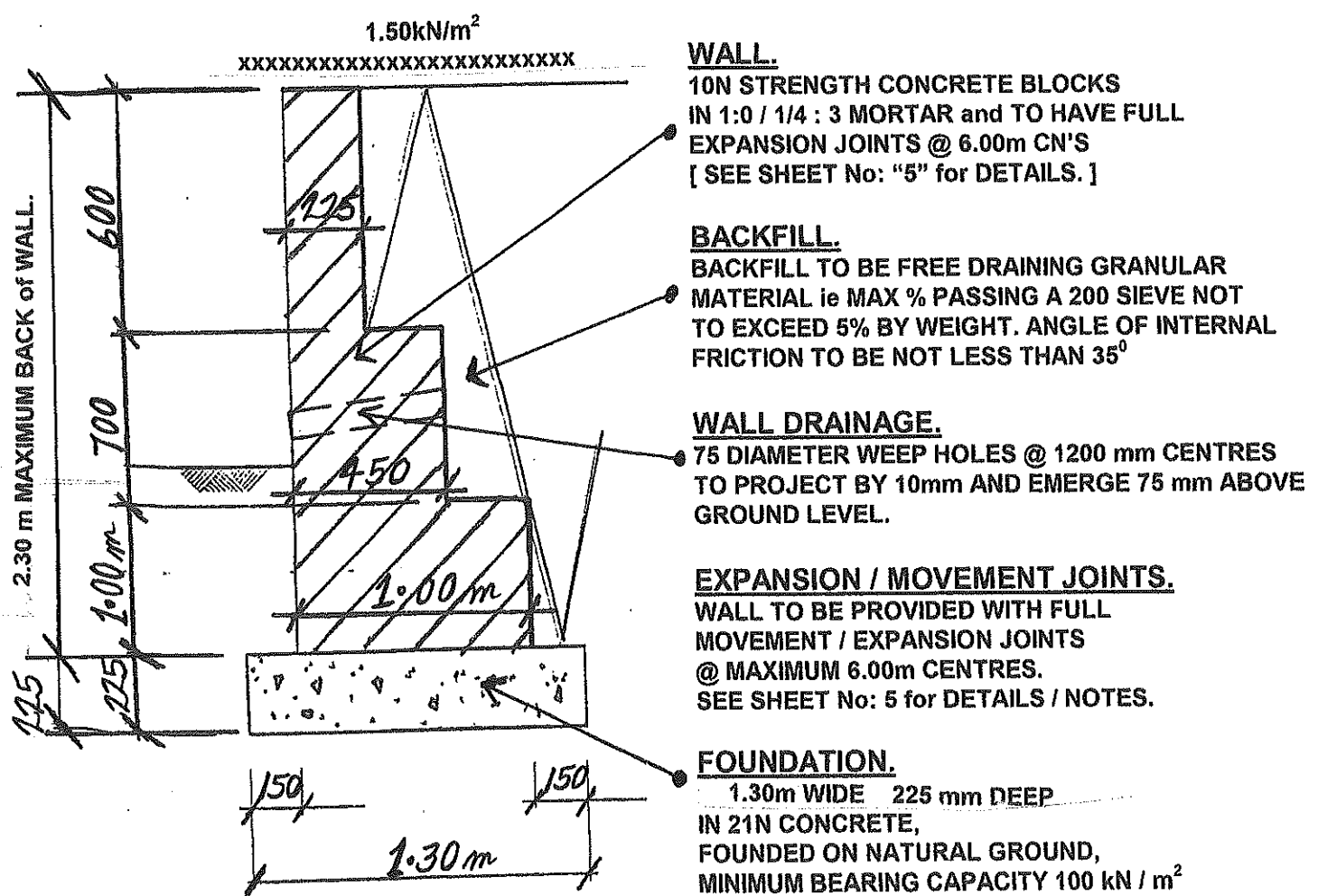


PLAN etc.

STRUCTURAL CALCULATIONS and DETAILS for:-

GARDEN MASS BLOCKWORK RETAINING WALLS for: SHEET No: 4.
NEW DOMESTIC DWELLING @ 143, HIGH STREET, GLYNEATH. SA11 5DA.
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(5)



TYPICAL WALL SECTION and NOTES.

STRUCTURAL CALCULATIONS and DETAILS for:-

GARDEN MASS BLOCKWORK RETAINING WALLS for: SHEET No: 5.

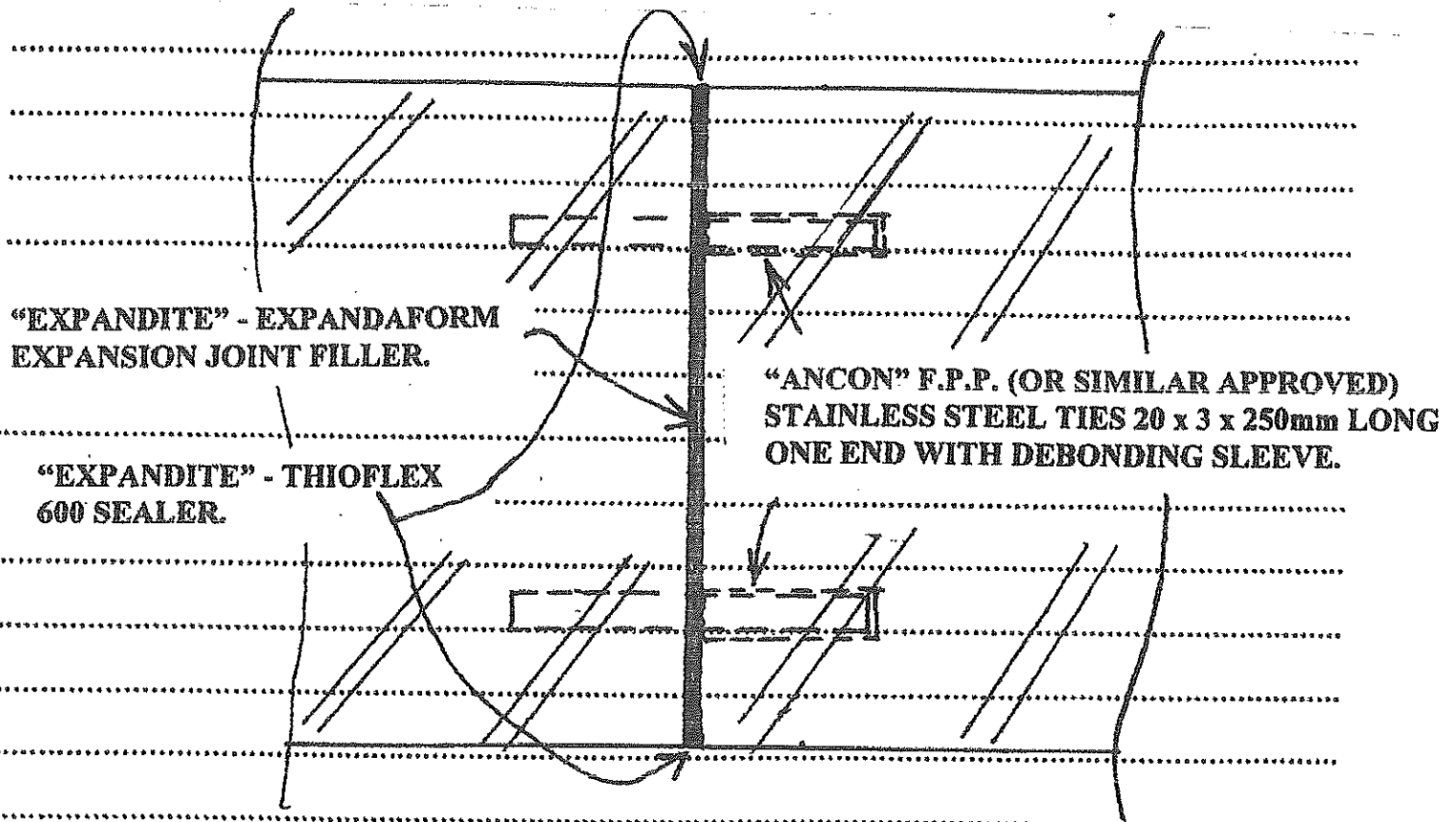
NEW DOMESTIC DWELLING @ 143, HIGH STREET, GLYNEATH. SA11 5DA.

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DATE:- DEC 2019.

EXPANSION / MOVEMENT JOINT DETAILS.

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PLAN.

(NOTE! THE NUMBER OF WALL TIES REQUIRED IS DEPENDENT UPON THE WIDTH OF THE WALL.)

NOTES.

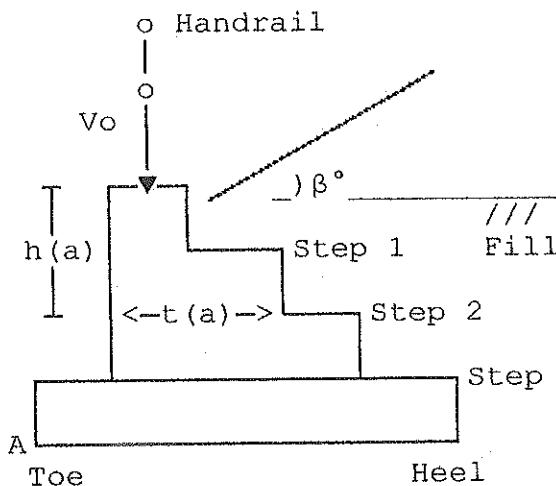
- WALLS CONSTRUCTED IN CLASS "A" CONCRETE BLOCK WORK, SHALL BE PROVIDED WITH MOVEMENT JOINTS AT A MAXIMUM OF 6.00m CENTRES, AS REQUIRED BY BS 5628 (USE OF MASONRY.)
- WALLS CONSTRUCTED IN CALCIUM SILICATE MASONRY, SHOULD BE PROVIDED WITH MOVEMENT JOINTS OF BETWEEN 7.5m AND 10.0m.
- MOVEMENT JOINTS SHOULD NOT EXCEED 10mm WIDTH AND BE SEALED.

Location: GARDEN WALLS

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

NOTE: As a masonry wall has limited capacity the design assumes 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 $\phi = 35^\circ$

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=1

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

Concrete Blocks Dimensions

Height $hb = 100 \text{ mm}$

Least horiz dimension $lhd = 225 \text{ mm}$

ratio height/least horiz dim $rb = hb / lhd = 100 / 225 = 0.4444$

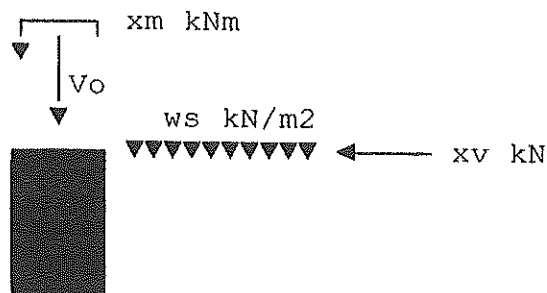
Compressive strength of blocks $po = 10.4 \text{ N/mm}^2$

Characteristic flexural strength for bed failure and leaf greater than 250mm thick - Table 3 $fb(a) = \text{TABLE 3.71 for } po = 10.4, \text{ mortar} = 1$
 $= 0.25 \text{ N/mm}^2$

Partial safety factor material $\gamma_{mam} = 3.5$

External loading

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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/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

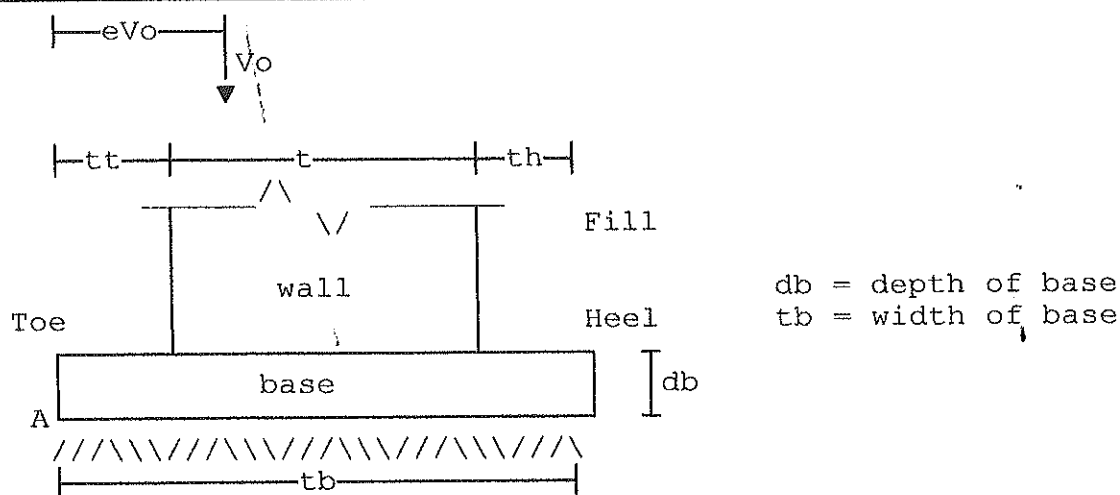
Step 1 Typical Analysis which is repeated for each step

Proposed height at step	$h(1) = 0.6$ m
Proposed thickness at step	$t(1) = 0.225$ m
Moment at height h earth	$m_e = c_e * w_e * h(a)^3 / 6 = 0.271 * 18 * 0.6^3 / 6$ $= 0.1756$ kNm
surcharge	$m_s = c_e * w_s * h(a)^2 / 2 = 0.271 * 1.5 * 0.6^2 / 2$ $= 0.0732$ kNm
Ultimate moment at height h	$m_u = m_e * \gamma_{mae} + m_s * \gamma_{mas} + (x_m + x_v * h(a)) * \gamma_{max}$ $= 0.1756 * 1.4 + 0.0732 * 1.6 + (0 + 0 * 0.6) * 1.6$ $= 0.3629$
Section modulus at thickness t	$z = t(a)^2 / 6 = 0.225^2 / 6 = 0.0084$ m ³
Weight/unit area at depth h	$g_d = (w_s + w_e * h(a) + V_o / t(a)) * \gamma_{maf} / 1000$ $= (1.5 + 18 * 0.6 + 0 / 0.225) * 0.9 / 1000$ $= 0.0111$ N/mm ²
Moment of resistance	$m_r = (f_b(1) / \gamma_{mam} + g_d) * z * 1000$ $= (0.25 / 3.5 + 0.0111) * 0.0084 * 1000$ $= 0.6961$ kNm
Applied moment less than moment of resistance ($0.3629 \leq 0.6961$) therefore section is satisfactory.	

Step 1	width	0.225 m
	height	0.6 m

Step height (m)	Step thickness (m)	Ultimate Moments (kNm)	
		Resistance	Applied
0.6	0.225	0.6961	0.3629
1.3	0.45	3.167	3.05
2.3	1	18.34	15.57

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 m
Thickness of wall	t=1 m
Height of wall	h=2.3 m
Width of base	tb=t+tt+th=1+0.15+0.15=1.3
Depth of base	db=0.225 m
Overall depth	od=h+db=2.3+0.225=2.525 m
Weight of fill and wall	wf=we*(t+th)*h=18*(1+0.15)*2.3 =47.61 kN
Eccentricity from A (fill & wall)	ef=tt+(t+th)/2=0.15+(1+0.15)/2 =0.725 m
Density of base	denb=21 kN/m ³
Weight of base	wb=tb*db*denb=1.3*0.225*21 =6.143 kN
Earth horizontal force	sfe=ce*we*od ² /2=0.271*18*2.525 ² /2 =15.55 kN
Moment due to earth pressure	me=sfe*od/3=15.55*2.525/3 =13.09 kNm
Surcharge horizontal force	sfs=ws*ce*od=1.5*0.271*2.525 =1.026 kN
Moment due to surcharge	ms=sfs*od/2=1.026*2.525/2 =1.296 kNm

Wall shear

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Horizontal shear force $usf = (sfe * \gamma_{mae}) + (sfs * \gamma_{mas})$
 $= (15.55 * 1.4) + (1.026 * 1.6)$
 $= 23.41 \text{ kN}$

Shear stress at bottom of wall $uss = usf / (t(\text{steps}) * 1000)$
 $= 23.41 / (1 * 1000)$
 $= 0.0234 \text{ N/mm}^2$

Weight at bottom of step 1 $uwt = t(a) * we * h(a) * \gamma_{maf}$
 $= 0.225 * 18 * 0.6 * 0.9$
 $= 2.187 \text{ kN}$

Weight at bottom of step 2 $uwt = uwt + (t(a) * we * h(a) * \gamma_{maf})$
 $= 2.187 + (0.45 * 18 * 1.3 * 0.9)$
 $= 11.66 \text{ kN}$

Weight at bottom of step 3 $uwt = uwt + (t(a) * we * h(a) * \gamma_{maf})$
 $= 11.66 + (1 * 18 * 2.3 * 0.9)$
 $= 48.92 \text{ kN}$

Weight per. unit area $ga = (uwt + Vo) / (t(\text{steps}) * 1000)$
 $= (48.92 + 0) / (1 * 1000)$
 $= 0.0489 \text{ N/mm}^2$

Permissible shear stress $fv = 0.35 + 0.6 * ga = 0.35 + 0.6 * 0.0489$
 $= 0.3794 \text{ N/mm}^2$

Applied shear less than shear resistance ($0.0234 \leq 0.3794$)
therefore section is satisfactory.

Overturning

Overturning moment about A $om = me + ms + (xm + xv * od)$
 $= 13.09 + 1.296 + (0 + 0 * 2.525)$
 $= 14.38 \text{ kNm}$

Restoring moment abt A fill/wall
base $rmf = wf * ef = 47.61 * 0.725 = 34.52 \text{ kNm}$
surcharge $rmb = wb * tb / 2 = 6.143 * 1.3 / 2 = 3.993 \text{ kNm}$
 $rms = ws * (t + th) * ef = 1.5 * (1 + 0.15) * 0.725$
 $= 1.251$

vertical load $rmVo = Vo * eVo = 0 * 0 = 0 \text{ kNm}$
total $rm = rmf + rmb + rms + rmVo$
 $= 34.52 + 3.993 + 1.251 + 0$
 $= 39.76$

Factor of safety $fso = rm / om = 39.76 / 14.38 = 2.764$

Sliding (passive resistance will be ignored)

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

Sliding force $sf = sfe + sfs + xv = 15.55 + 1.026 + 0$
 $= 16.58$

Details of bearing strata:
Angle of friction $\phi_{ib} = 40^\circ$
Soil cohesion $c_u = 0 \text{ kN/m}^2$
Coefficient of friction $cf = \tan(\text{RAD}(\phi_{ib} * 2/3))$
 $= \tan(\text{RAD}(40 * 2/3))$
 $= 0.5022$

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Resisting force
fill $rff = wf * cf = 47.61 * 0.5022 = 23.91$ kN
base $rfb = wb * cf + tb * cu / 2$
 $= 6.143 * 0.5022 + 1.3 * 0 / 2$
 $= 3.085$ kN
surcharge $rfs = ws * (t + th) * cf = 1.5 * (1 + 0.15) * 0.5022$
 $= 0.8663$ kN
total $rf = rff + rfb + rfs = 23.91 + 3.085 + 0.8663$
 $= 27.86$ kN
Factor of safety $fss = rf / sf = 27.86 / 16.58 = 1.681$

Bearing pressure

Weight of surcharge $sw = ws * (t + th) = 1.5 * (1 + 0.15)$
 $= 1.725$ kN

Moments about centre of base $m = om + (wf + sw) * (tb / 2 - ef) + Vo * (tb / 2 - eVo)$
 $= 14.38 + (47.61 + 1.725) * (1.3 / 2 - 0.725)$
 $+ 0 * (1.3 / 2 - 0)$
 $= 10.68$ kNm

Section modulus of base $zb = tb^2 / 6 = 1.3^2 / 6 = 0.2817$ m³

Total weight $tw = wf + sw + wb + Vo = 47.61 + 1.725 + 6.143 + 0$
 $= 55.48$ kN

Pressure due to weight $pw = tw / tb = 55.48 / 1.3 = 42.68$ kN/m²

Pressure due to moment (+/-) $pm = m / zb = 10.68 / 0.2817 = 37.93$ kN/m²

Maximum pressure $pmax = pw + pm = 42.68 + 37.93 = 80.6$ kN/m²

Minimum pressure $pmin = pw - pm = 42.68 - 37.93 = 4.746$ kN/m²

DESIGN SUMMARY

Wall height	2.3 m		
Step height (m)	Step thickness (m)	Ultimate Moments (kNm) Resistance	Applied
0.6	0.225	0.6961	0.3629
1.3	0.45	3.167	3.05
2.3	1	18.34	15.57

Summary of stability check

Factor of safety overturning 2.764
Factor of safety sliding 1.681
Maximum base pressure 80.6 kN/m²

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