

Project					
Trefechan Mass Retaining Wall Design - 1 in 8 Slope					
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Structural Design for the design of various size mass masonry Retaining Walls

1 Introduction

Calculations by Pierre Grigorian BEng(Hons) CEng MStructE FICE

These calculations have been prepared for the design of mass masonry retaining walls for various heights up to a maximum retained height of 1.5m. The design is for typical garden type retaining walls.

The retaining walls below are designed for a max 1 in 8 slope behind the wall.

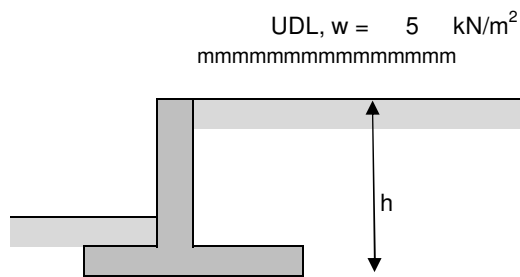
2 Design Parameters

(i) Retaining wall dimensions and details are shown on Standard detail retaining wall drawing.

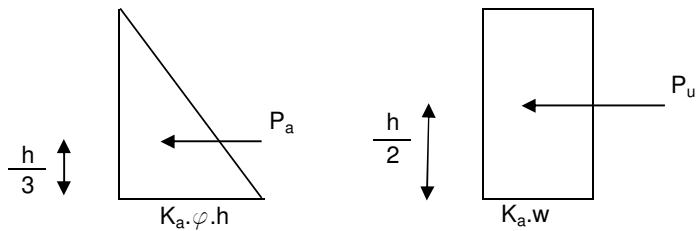
(ii) Maximum slope of retained material is 1 in 8.	$\Theta =$	7	degrees
(iii) Retained granular material angle of internal friction	$\vartheta =$	35	degrees
(iv) Density of retained material	$\varphi =$	18	kN/m ³
(v) Blockwork Density	$\varphi =$	18	kN/m ³
(vi) Blockwork compressive strength	$=$	7.3	N/mm ²
(vii) Brickwork Density	$\varphi =$	20	kN/m ³
(viii) Brickwork Strength	$=$	20	N/mm ²
(ix) Mortar Class (cement:lime:sand)	$=$	(i)	$= (1:0 \text{ to } 1/4:3)$ Only use (i), (ii) or (iii)
(x) Concrete foundations	$=$	C28/35	
(xi) Surcharge loading	$=$	5	kN/m ²
(xii) Allowable Bearing Pressure	$=$	50	kN/m ²
(xiii) Concrete Density	$=$	24	kN/m ³
(xiv) Characteristic Initial Shear Strength of Masonry (BS 5628-1:2005 - Cl 21.1.2 - c)	$f_{vko} =$	0.35	N/mm ² 0.15 for mortar (iii) (iv) 0.35 for mortar (i) (ii)
(xv) Basic flexural strength of blockwork, (From Table 3, BS5628:Pt 1:2005)	$f_{kx} =$	0.35	N/mm ²
(xvi) Dead load factor of safety (for blockwork flexural checks)	$\gamma_f =$	0.9	
(xvii) Level of Blockwork Manufacturing Control	$\gamma_m =$	3.5	
(xviii) Dead load factor of safety for general applied loads	$\gamma_G =$	1.4	
(ixx) Imposed (surcharge) load factor of safety for loads	$\gamma_Q =$	1.6	

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3 Lateral Pressure on Retaining Walls



Pressures acting on wall are modelled as shown below:



Horizontal thrust on wall = $P_a + P_u$

where $P_a = 0.5 \cdot K_a \cdot \phi \cdot h^2$ (Earth Pressure)

$P_u = K_a \cdot w \cdot h$ (Surcharge Pressure)

Active Earth pressure coefficient calculation

For $\theta = 7$ degrees and for $\psi = 35$ degrees

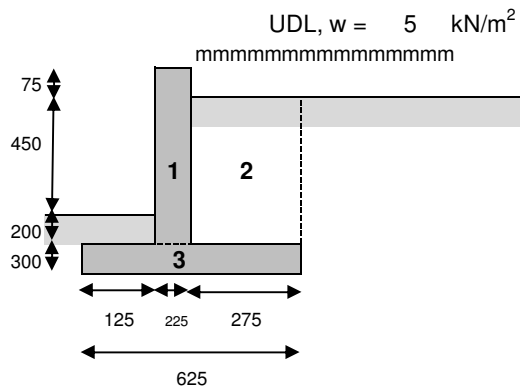
$$K_a = \cos \theta \times \frac{\cos \theta - (\cos^2 \theta - \cos^2 \psi)^{0.5}}{\cos \theta + (\cos^2 \theta - \cos^2 \psi)^{0.5}} \quad (\text{Rankine Coeffs with inclined backfills})$$

$$K_a = 0.276$$

$$K_a = 0.276$$

These values and formulas have been used in the calculations on the following pages

4 Wall Type "A" (Max retained height = 0.45 m)



$$P_a = 0.5 \cdot K_a \cdot \phi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 0.95^2 = 2.24 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 5.0 \times 0.95 = 1.31 \text{ kN/m}$$

Table of Forces and Moments taken about point at bottom left of footing

Wall Element	Force (kN)	Lever Arm (m)	Moment (kNm)
1	0.725 x 0.225 x 20.0 = 3.263	0.238	0.775
2	0.650 x 0.275 x 18.0 = 3.218	0.488	1.569
3	0.625 x 0.300 x 24.0 = 4.500	0.313	1.406
P _a	As calculated above = 2.243	0.3167	0.710
P _u	As calculated above = 1.312	0.475	0.623
Totals	Horiz. = 3.555 kN Vert = 10.980 kN		3.750 1.333

$$\text{Overturning Moment Sum} = 2.416 \text{ kNm}$$

Check Overturning F.O.S = $\frac{3.750}{1.333} = 2.81 > 2.0$ **Therefore OK** Therefore OK

Check Sliding F.O.S = $\frac{\text{Vert Load} \times \tan \Theta}{\text{Horiz Load}} = \frac{10.98 \times 0.70}{3.555} = 2.1629 > 2$ **Therefore OK** Therefore OK

Check Ground Pressure

Reaction Lever Arm, y = $\frac{\text{Sum of Moments}}{\text{Vertical Reaction}} = \frac{2.416}{10.980} = 0.2201 \text{ m}$ (dist from bottom left)

Distance from reaction to centre of foundation, e = $\frac{\text{Length of footing}}{2} - y = \frac{0.625}{2} - 0.2201$

$$e = 0.0924 \text{ m}$$

Check Middle Third Rule: $\frac{L}{6} = \frac{0.625}{6} = 0.1042 \text{ m} > 0.0924 \text{ m}$ Therefore reaction lies in middle third

Maximum Ground Bearing Pressure, p_{max} = $\frac{\text{Vert Reaction}}{\text{Footing Length}} \times \left[1 + \frac{6 \times e}{\text{Footing Length}} \right]$

Maximum Ground Bearing Pressure, p_{max} = $\frac{10.980}{0.625} \times \left(1 + \frac{6 \times 0.0924}{0.625} \right) = 33.157 \text{ kN/m}^2$
 < 50 kN/m²
 < Allowable, therefore OK

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Check Blockwork

$$\text{At base of wall } Z = \frac{b \times d^2}{6} = \frac{1000 \times 225^2}{6} = 8437500 \text{ mm}^3$$

$$\text{Self weight pressure (gd)} = \frac{\gamma_f \times \text{Density} \times \text{Thickness} \times \text{Height}}{\text{Thickness}} = \gamma_f \times \text{Density} \times \text{Height}$$

$$\gamma_f = 0.9 \quad (\text{It should be noted that this value of } \gamma_f \text{ should be used in calculating the design vertical load})$$

$$g_d = 0.9 \times 0.725 \text{ m} \times 18 \text{ kN/m}^3 = 11.745 \text{ kN/m}^2 = 0.0117 \text{ N/mm}^2$$

$$\text{Basic flexural strength of blockwork, } f_{kx} = 0.35 \text{ N/mm}^2 \quad (\text{From Table 3, BS5628:Pt 1:2005})$$

Blockwork moment Resistance with modified Blockwork flexural strength enhanced by dead weight:

$$M_R = \left[\frac{f_{kx}}{\gamma_m} + g_d \right] \times Z$$

$$M_R = \left[\frac{0.35}{3.5} + 0.0117 \right] \times 8437500 = 942848.438 \text{ N.mm} = \mathbf{0.943 \text{ kNm}}$$

Applied moment with appropriate load factors for dead and imposed loads

(Note that height h is height of masonry and excludes the depth of the footing, h = 0.65 m)

$$M_o = 1.4 \left[P_a \times \frac{h}{3} \right] + 1.6 \left[P_u \times \frac{h}{2} \right]$$

where the P_a and P_u for the blockwork height of 0.65 m only, and not the height from base

$$P_a = 0.5 \cdot K_a \cdot \gamma \cdot h^2 = 0.5 \times 0.276 \times 18 \times 0.65^2 = 1.05 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 5.0 \times 0.65 = 0.90 \text{ kN/m}$$

$$M_o = 1.4 \left[1.05 \times \frac{0.65}{3} \right] + 1.6 \left[0.90 \times \frac{0.65}{2} \right] = \mathbf{0.7852 \text{ kNm}}$$

Therefore since $0.943 (M_R) > 0.7852 (M_o)$ OK

OK

Check Shear at the Base of Blockwork Wall

$$\text{Applied Shear, } F_v = (1.4 \times P_a) + (1.6 \times P_u)$$

$$\text{Applied Shear, } F_v = (1.4 \times 1.05) + (1.6 \times 0.90) = \mathbf{2.9059 \text{ kN (ult)}}$$

$$\text{Contact area at base of blockwork} = 225 \text{ mm} \quad (\times 1000 \text{ mm width})$$

$$\text{Therefore average applied shear stress} = \frac{2.9059 \times 1000}{225 \times 1000} = 0.0129 \text{ N/mm}^2$$

Shear resistance of blockwork in horizontal direction (cl. 21.1.1 BS 5628:pt1:2005)

$$f_v = f_{vko} + 0.6g_A \quad \text{where} \quad f_{vko} = 0.35 \text{ N/mm}^2$$

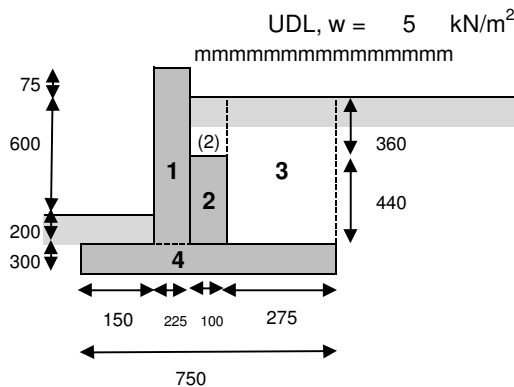
$$g_A = g_d = 0.0117 \text{ N/mm}^2$$

$$f_v = 0.350 + (0.600 \times 0.0117) = 0.357 \text{ N/mm}^2$$

Therefore since $0.357 (f_v) > 0.0129 (F_v)$ OK

OK

5 Wall Type "B" (Max retained height = 0.6 m)



$$P_a = 0.5 \cdot K_a \cdot \phi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 1.1^2 = 3.01 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 5.0 \times 1.1 = 1.52 \text{ kN/m}$$

Table of Forces and Moments taken about point at bottom left of footing

Wall Element	Force (kN)	Lever Arm (m)	Moment (kNm)	
			Clockwise	Anticlockwise
1	0.875 x 0.225 x 20.0 = 3.938	0.263	1.034	
2	0.800 x 0.100 x 18.0 = 1.440	0.425	0.612	
3	0.800 x 0.275 x 18.0 = 3.960	0.613	2.426	
4	0.750 x 0.300 x 24.0 = 5.400	0.375	2.025	
P_a	As calculated above = 3.007	0.3667		1.103
P_u	As calculated above = 1.519	0.55		0.835
Totals	Horiz. = 4.526 kN Vert = 14.738 kN		6.096	1.938

Overturning Moment Sum = 4.158 kNm

Check Overturning F.O.S = $\frac{6.096}{1.938} = 3.15 > 2.0$ **Therefore OK** Therefore OK

Check Sliding F.O.S = $\frac{\text{Vert Load} \times \tan \theta}{\text{Horiz Load}} = \frac{14.74 \times 0.70}{4.526} = 2.2801 > 2$ **Therefore OK** Therefore OK

Check Ground Pressure

Reaction Lever Arm, $y = \frac{\text{Sum of Moments}}{\text{Vertical Reaction}} = \frac{4.158}{14.738} = 0.2821 \text{ m}$ (dist from bottom left)

Distance from reaction to centre of foundation, $e = \frac{\text{Length of footing}}{2} - y = \frac{0.75}{2} - 0.2821$

$e = 0.0929 \text{ m}$

Check Middle Third Rule: $\frac{L}{6} = \frac{0.75}{6} = 0.125 \text{ m} > 0.0929 \text{ m}$ Therefore reaction lies in middle third

Maximum Ground Bearing Pressure, $p_{\max} = \frac{\text{Vert Reaction}}{\text{Footing Length}} \times \left[1 + \frac{6 \times e}{\text{Footing Length}} \right]$

Maximum Ground Bearing Pressure, $p_{\max} = \frac{14.738}{0.75} \times \left(1 + \frac{6 \times 0.0929}{0.75} \right) = 34.246 \text{ kN/m}^2$
 $< 50 \text{ kN/m}^2$
 $< \text{Allowable, therefore OK}$

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Check Blockwork

$$\text{At base of wall } Z = \frac{b \times d^2}{6} = \frac{1000 \times 325^2}{6} = 17604167 \text{ mm}^3$$

$$\text{Self weight pressure (gd)} = \frac{\gamma_f \times \text{Density} \times \text{Thickness} \times \text{Height}}{\text{Thickness}} = \gamma_f \times \text{Density} \times \text{Height}$$

$$\gamma_f = 0.9 \quad (\text{It should be noted that this value of } \gamma_f \text{ should be used in calculating the design vertical load})$$

$$g_d = 0.9 \times 0.8 \text{ m} \times 18 \text{ kN/m}^3 = 12.96 \text{ kN/m}^2 = 0.013 \text{ N/mm}^2$$

$$\text{Basic flexural strength of blockwork, } f_{kx} = 0.35 \text{ N/mm}^2 \quad (\text{From Table 3, BS5628:Pt 1:2005})$$

Blockwork moment Resistance with modified Blockwork flexural strength enhanced by dead weight:

$$M_R = \left[\frac{f_{kx}}{\gamma_m} + g_d \right] \times Z$$

$$M_R = \left[\frac{0.35}{3.5} + 0.013 \right] \times 17604167 = 1988566.67 \text{ N.mm} = \mathbf{1.989 \text{ kNm}}$$

Applied moment with appropriate load factors for dead and imposed loads

(Note that height h is height of masonry and excludes the depth of the footing, h = 0.8 m)

$$M_o = 1.4 \left[P_a \times \frac{h}{3} \right] + 1.6 \left[P_u \times \frac{h}{2} \right]$$

where the P_a and P_u for the blockwork height of 0.8 m only, and not the height from base

$$P_a = 0.5 \cdot K_a \cdot \gamma \cdot h^2 = 0.5 \times 0.276 \times 18 \times 0.8^2 = 1.59 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 5.0 \times 0.8 = 1.10 \text{ kN/m}$$

$$M_o = 1.4 \left[1.59 \times \frac{0.8}{3} \right] + 1.6 \left[1.10 \times \frac{0.8}{2} \right] = \mathbf{1.3007 \text{ kNm}}$$

Therefore since $1.989 (M_R) > 1.3007 (M_o)$ OK

OK

Check Shear at the Base of Blockwork Wall

$$\text{Applied Shear, } F_v = (1.4 \times P_a) + (1.6 \times P_u)$$

$$\text{Applied Shear, } F_v = (1.4 \times 1.59) + (1.6 \times 1.10) = \mathbf{3.994 \text{ kN (ult)}}$$

$$\text{Contact area at base of blockwork} = 225 \text{ mm} \quad (\times 1000 \text{ mm width})$$

$$\text{Therefore average applied shear stress} = \frac{3.994 \times 1000}{225 \times 1000} = 0.0178 \text{ N/mm}^2$$

Shear resistance of blockwork in horizontal direction (cl. 21.1.1 BS 5628:pt1:2005)

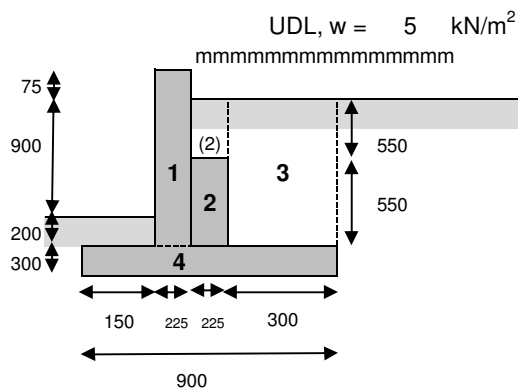
$$f_v = f_{vko} + 0.6g_A \quad \text{where} \quad f_{vko} = 0.35 \text{ N/mm}^2$$

$$g_A = g_d = 0.013 \text{ N/mm}^2$$

$$f_v = 0.350 + (0.600 \times 0.013) = 0.358 \text{ N/mm}^2$$

Therefore since $0.358 (f_v) > 0.0178 (F_v)$ OK

6 Wall Type "C" (Max retained height = 0.9 m)



$$P_a = 0.5 \cdot K_a \cdot \phi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 1.4^2 = 4.87 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 5.0 \times 1.4 = 1.93 \text{ kN/m}$$

Table of Forces and Moments taken about point at bottom left of footing

Wall Element	Force (kN)	Lever Arm (m)	Moment (kNm)	
			Clockwise	Anticlockwise
1	1.175 x 0.225 x 20.0 = 5.288	0.263	1.388	
2	1.100 x 0.225 x 18.0 = 4.455	0.488	2.172	
3	1.100 x 0.300 x 18.0 = 5.940	0.750	4.455	
4	0.900 x 0.300 x 24.0 = 6.480	0.450	2.916	
P _a	As calculated above = 4.871	0.4667		2.273
P _u	As calculated above = 1.933	0.7		1.353
Totals	Horiz. = 6.804 kN Vert = 22.163 kN		10.931	3.626

$$\text{Overturning Moment Sum} = 7.305 \text{ kNm}$$

Check Overturning F.O.S = $\frac{10.931}{3.626} = 3.01 > 2.0$ **Therefore OK** Therefore OK

Check Sliding F.O.S = $\frac{\text{Vert Load} \times \tan \theta}{\text{Horiz Load}} = \frac{22.16 \times 0.70}{6.804} = 2.2808 > 2$ **Therefore OK** Therefore OK

Check Ground Pressure

$$\text{Reaction Lever Arm, } y = \frac{\text{Sum of Moments}}{\text{Vertical Reaction}} = \frac{7.305}{22.163} = 0.3296 \text{ m} \quad (\text{dist from bottom left})$$

$$\text{Distance from reaction to centre of foundation, } e = \frac{\text{Length of footing}}{2} - y = \frac{0.9}{2} - 0.3296$$

$$e = 0.1204 \text{ m}$$

Check Middle Third Rule: $\frac{L}{6} = \frac{0.9}{6} = 0.15 \text{ m} > 0.1204 \text{ m}$ Therefore reaction lies in middle third

$$\text{Maximum Ground Bearing Pressure, } p_{\max} = \frac{\text{Vert Reaction}}{\text{Footing Length}} \times \left[1 + \frac{6 \times e}{\text{Footing Length}} \right]$$

$$\text{Maximum Ground Bearing Pressure, } p_{\max} = \frac{22.163}{0.9} \times \left(1 + \frac{6 \times 0.1204}{0.9} \right) = 44.392 \text{ kN/m}^2 < 50 \text{ kN/m}^2 < \text{Allowable, therefore OK}$$

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Check Blockwork

$$\text{At base of wall } Z = \frac{b \times d^2}{6} = \frac{1000 \times 450^2}{6} = 33750000 \text{ mm}^3$$

$$\text{Self weight pressure (gd)} = \frac{\gamma_f \times \text{Density} \times \text{Thickness} \times \text{Height}}{\text{Thickness}} = \gamma_f \times \text{Density} \times \text{Height}$$

$$\gamma_f = 0.9 \quad (\text{It should be noted that this value of } \gamma_f \text{ should be used in calculating the design vertical load})$$

$$g_d = 0.9 \times 1.1 \text{ m} \times 18 \text{ kN/m}^3 = 17.82 \text{ kN/m}^2 = 0.0178 \text{ N/mm}^2$$

$$\text{Basic flexural strength of blockwork, } f_{kx} = 0.35 \text{ N/mm}^2 \quad (\text{From Table 3, BS5628:Pt 1:2005})$$

Blockwork moment Resistance with modified Blockwork flexural strength enhanced by dead weight:

$$M_R = \left[\frac{f_{kx}}{\gamma_m} + g_d \right] \times Z$$

$$M_R = \left[\frac{0.35}{3.5} + 0.0178 \right] \times 33750000 = 3976425 \text{ N.mm} = \mathbf{3.976 \text{ kNm}}$$

Applied moment with appropriate load factors for dead and imposed loads

(Note that height h is height of masonry and excludes the depth of the footing, h = 1.1 m)

$$M_o = 1.4 \left[P_a \times \frac{h}{3} \right] + 1.6 \left[P_u \times \frac{h}{2} \right]$$

where the P_a and P_u for the blockwork height of 1.1 m only, and not the height from base

$$P_a = 0.5 \cdot K_a \cdot \gamma \cdot h^2 = 0.5 \times 0.276 \times 18 \times 1.1^2 = 3.01 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 5.0 \times 1.1 = 1.52 \text{ kN/m}$$

$$M_o = 1.4 \left[3.01 \times \frac{1.1}{3} \right] + 1.6 \left[1.52 \times \frac{1.1}{2} \right] = \mathbf{2.8801 \text{ kNm}}$$

Therefore since $3.976 (M_R) > 2.8801 (M_o)$ OK

OK

Check Shear at the Base of Blockwork Wall

$$\text{Applied Shear, } F_v = (1.4 \times P_a) + (1.6 \times P_u)$$

$$\text{Applied Shear, } F_v = (1.4 \times 3.01) + (1.6 \times 1.52) = \mathbf{6.64 \text{ kN (ult)}}$$

$$\text{Contact area at base of blockwork} = 225 \text{ mm} \quad (\times 1000 \text{ mm width})$$

$$\text{Therefore average applied shear stress} = \frac{6.64 \times 1000}{225 \times 1000} = 0.0295 \text{ N/mm}^2$$

Shear resistance of blockwork in horizontal direction (cl. 21.1.1 BS 5628:pt1:2005)

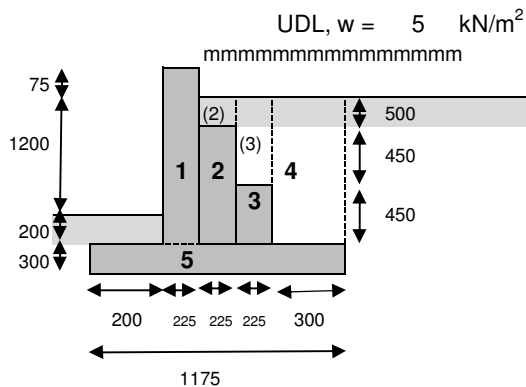
$$f_v = f_{vko} + 0.6g_A \quad \text{where} \quad f_{vko} = 0.35 \text{ N/mm}^2$$

$$g_A = g_d = 0.0178 \text{ N/mm}^2$$

$$f_v = 0.350 + (0.600 \times 0.0178) = 0.361 \text{ N/mm}^2$$

Therefore since $0.361 (f_v) > 0.0295 (F_v)$ OK

7 Wall Type "D" (Max retained height = 1.2 m)



$$P_a = 0.5 \cdot K_a \cdot \phi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 1.7^2 = 7.18 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 5.0 \times 1.7 = 2.35 \text{ kN/m}$$

Table of Forces and Moments taken about point at bottom left of footing

Wall Element	Force (kN)	Lever Arm (m)	Moment (kNm)	
			Clockwise	Anticlockwise
1	1.475 x 0.225 x 20.0 = 6.638	0.313	2.074	
2	1.400 x 0.225 x 18.0 = 5.670	0.538	3.048	
3	1.400 x 0.225 x 18.0 = 5.670	0.763	4.323	
4	1.400 x 0.300 x 18.0 = 7.560	1.025	7.749	
5	1.175 x 0.300 x 24.0 = 8.460	0.588	4.970	
P _a	As calculated above = 7.182	0.5667		4.070
P _u	As calculated above = 2.347	0.85		1.995
Totals	Horiz. = 9.529 kN Vert = 33.998 kN		22.164	6.065

Overturning Moment Sum = 16.099 kNm

Check Overturning F.O.S = $\frac{22.164}{6.065} = 3.65 > 2.0$ **Therefore OK** Therefore OK

Check Sliding F.O.S = $\frac{\text{Vert Load} \times \tan \theta}{\text{Horiz Load}} = \frac{34.00 \times 0.70}{9.529} = 2.4981 > 2$ **Therefore OK** Therefore OK

Check Ground Pressure

Reaction Lever Arm, y = $\frac{\text{Sum of Moments}}{\text{Vertical Reaction}} = \frac{16.099}{33.998} = 0.4735 \text{ m}$ (dist from bottom left)

Distance from reaction to centre of foundation, e = $\frac{\text{Length of footing}}{2} - y = \frac{1.175}{2} - 0.4735$
 $e = 0.114 \text{ m}$

Check Middle Third Rule: $\frac{L}{6} = \frac{1.175}{6} = 0.1958 \text{ m} > 0.114 \text{ m}$ Therefore reaction lies in middle third

Maximum Ground Bearing Pressure, p_{max} = $\frac{\text{Vert Reaction}}{\text{Footing Length}} \times \left[1 + \frac{6 \times e}{\text{Footing Length}} \right]$

Maximum Ground Bearing Pressure, p_{max} = $\frac{33.998}{1.175} \times \left(1 + \frac{6 \times 0.114}{1.175} \right) = 45.77 \text{ kN/m}^2$
 $< 50 \text{ kN/m}^2$
 < Allowable, therefore OK

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Check Blockwork

$$\text{At base of wall } Z = \frac{b \times d^2}{6} = \frac{1000 \times 675^2}{6} = 75937500 \text{ mm}^3$$

$$\text{Self weight pressure (gd)} = \frac{\gamma_f \times \text{Density} \times \text{Thickness} \times \text{Height}}{\text{Thickness}} = \gamma_f \times \text{Density} \times \text{Height}$$

$$\gamma_f = 0.9 \quad (\text{It should be noted that this value of } \gamma_f \text{ should be used in calculating the design vertical load})$$

$$g_d = 0.9 \times 1.4 \text{ m} \times 18 \text{ kN/m}^3 = 22.68 \text{ kN/m}^2 = 0.0227 \text{ N/mm}^2$$

$$\text{Basic flexural strength of blockwork, } f_{kx} = 0.35 \text{ N/mm}^2 \quad (\text{From Table 3, BS5628:Pt 1:2005})$$

Blockwork moment Resistance with modified Blockwork flexural strength enhanced by dead weight:

$$M_R = \left[\frac{f_{kx}}{\gamma_m} + g_d \right] \times Z$$

$$M_R = \left[\frac{0.35}{3.5} + 0.0227 \right] \times 75937500 = 9316012.5 \text{ N.mm} = \mathbf{9.316 \text{ kNm}}$$

Applied moment with appropriate load factors for dead and imposed loads

(Note that height h is height of masonry and excludes the depth of the footing, h = 1.4 m)

$$M_o = 1.4 \left[P_a \times \frac{h}{3} \right] + 1.6 \left[P_u \times \frac{h}{2} \right]$$

where the P_a and P_u for the blockwork height of 1.4 m only, and not the height from base

$$P_a = 0.5 \cdot K_a \cdot \gamma \cdot h^2 = 0.5 \times 0.276 \times 18 \times 1.4^2 = 4.87 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 5.0 \times 1.4 = 1.93 \text{ kN/m}$$

$$M_o = 1.4 \left[4.87 \times \frac{1.4}{3} \right] + 1.6 \left[1.93 \times \frac{1.4}{2} \right] = \mathbf{5.3473 \text{ kNm}}$$

Therefore since $9.316 (M_R) > 5.3473 (M_o)$ OK

OK

Check Shear at the Base of Blockwork Wall

$$\text{Applied Shear, } F_v = (1.4 \times P_a) + (1.6 \times P_u)$$

$$\text{Applied Shear, } F_v = (1.4 \times 4.87) + (1.6 \times 1.93) = \mathbf{9.9122 \text{ kN (ult)}}$$

$$\text{Contact area at base of blockwork} = 225 \text{ mm} \quad (\times 1000 \text{ mm width})$$

$$\text{Therefore average applied shear stress} = \frac{9.9122 \times 1000}{225 \times 1000} = 0.0441 \text{ N/mm}^2$$

Shear resistance of blockwork in horizontal direction (cl. 21.1.1 BS 5628:pt1:2005)

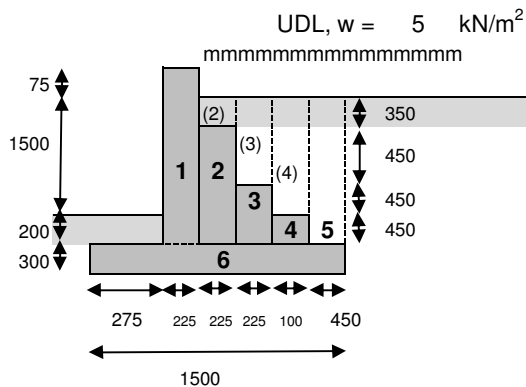
$$f_v = f_{vko} + 0.6g_A \quad \text{where} \quad f_{vko} = 0.35 \text{ N/mm}^2$$

$$g_A = g_d = 0.0227 \text{ N/mm}^2$$

$$f_v = 0.350 + (0.600 \times 0.0227) = 0.364 \text{ N/mm}^2$$

Therefore since $0.364 (f_v) > 0.0441 (F_v)$ OK

8 Wall Type "E" (Max retained height = 1.5 m)



$$P_a = 0.5 \cdot K_a \cdot \phi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 2^2 = 9.94 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 5.0 \times 2 = 2.76 \text{ kN/m}$$

Table of Forces and Moments taken about point at bottom left of footing

Wall Element	Force (kN)	Lever Arm (m)	Moment (kNm)	
			Clockwise	Anticlockwise
1	1.775 x 0.225 x 20.0 = 7.988	0.388	3.095	
2	1.700 x 0.225 x 18.0 = 6.885	0.613	4.217	
3	1.700 x 0.225 x 18.0 = 6.885	0.838	5.766	
4	1.700 x 0.100 x 18.0 = 3.060	1.000	3.060	
5	1.700 x 0.300 x 18.0 = 9.180	1.275	11.705	
6	1.500 x 0.300 x 24.0 = 10.800	0.750	8.100	
P _a	As calculated above = 9.941	0.6667		6.627
P _u	As calculated above = 2.761	1		2.761
Totals	Horiz. = 12.702 kN Vert = 44.798 kN		35.943	9.389

Overturning Moment Sum = 26.554 kNm

Check Overturning F.O.S = $\frac{35.943}{9.389} = 3.83 > 2.0$ **Therefore OK** Therefore OK

Check Sliding F.O.S = $\frac{\text{Vert Load} \times \tan \theta}{\text{Horiz Load}} = \frac{44.80 \times 0.70}{12.702} = 2.4695 > 2$ **Therefore OK** Therefore OK

Check Ground Pressure

Reaction Lever Arm, y = $\frac{\text{Sum of Moments}}{\text{Vertical Reaction}} = \frac{26.554}{44.798} = 0.5928 \text{ m}$ (dist from bottom left)

Distance from reaction to centre of foundation, e = $\frac{\text{Length of footing}}{2} - y = \frac{1.5}{2} - 0.5928$
 e = 0.1572 m

Check Middle Third Rule: $\frac{L}{6} = \frac{1.5}{6} = 0.25 \text{ m} > 0.1572 \text{ m}$ Therefore reaction lies in middle third

Maximum Ground Bearing Pressure, p_{max} = $\frac{\text{Vert Reaction}}{\text{Footing Length}} \times \left[1 + \frac{6 \times e}{\text{Footing Length}} \right]$

Maximum Ground Bearing Pressure, p_{max} = $\frac{44.798}{1.5} \times \left(1 + \frac{6 \times 0.1572}{1.5} \right) = 48.649 \text{ kN/m}^2$
 < 50 kN/m²
 < Allowable, therefore OK

Project					
Trefechan Mass Retaining Wall Design - 1 in 8 Slope					
Date	Calc by	Checked	Job no.	Sheet no.	
Aug-21	PHG	WW	1914	12	

Check Blockwork

$$\text{At base of wall } Z = \frac{b \times d^2}{6} = \frac{1000 \times 675^2}{6} = 75937500 \text{ mm}^3$$

$$\text{Self weight pressure (gd)} = \frac{\gamma_f \times \text{Density} \times \text{Thickness} \times \text{Height}}{\text{Thickness}} = \gamma_f \times \text{Density} \times \text{Height}$$

$$\gamma_f = 0.9 \quad (\text{It should be noted that this value of } \gamma_f \text{ should be used in calculating the design vertical load})$$

$$g_d = 0.9 \times 1.7 \text{ m} \times 18 \text{ kN/m}^3 = 27.54 \text{ kN/m}^2 = 0.0275 \text{ N/mm}^2$$

$$\text{Basic flexural strength of blockwork, } f_{kx} = 0.35 \text{ N/mm}^2 \quad (\text{From Table 3, BS5628:Pt 1:2005})$$

Blockwork moment Resistance with modified Blockwork flexural strength enhanced by dead weight:

$$M_R = \left[\frac{f_{kx}}{\gamma_m} + g_d \right] \times Z$$

$$M_R = \left[\frac{0.35}{3.5} + 0.0275 \right] \times 75937500 = 9685068.75 \text{ N.mm} = \mathbf{9.685 \text{ kNm}}$$

Applied moment with appropriate load factors for dead and imposed loads

(Note that height h is height of masonry and excludes the depth of the footing, h = 1.7 m)

$$M_o = 1.4 \left[P_a \times \frac{h}{3} \right] + 1.6 \left[P_u \times \frac{h}{2} \right]$$

where the P_a and P_u for the blockwork height of 1.7 m only, and not the height from base

$$P_a = 0.5 \cdot K_a \cdot \gamma \cdot h^2 = 0.5 \times 0.276 \times 18 \times 1.7^2 = 7.18 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 5.0 \times 1.7 = 2.35 \text{ kN/m}$$

$$M_o = 1.4 \left[7.18 \times \frac{1.7}{3} \right] + 1.6 \left[2.35 \times \frac{1.7}{2} \right] = \mathbf{8.8901 \text{ kNm}}$$

Therefore since $9.685 (M_R) > 8.8901 (M_o)$ OK

OK

Check Shear at the Base of Blockwork Wall

$$\text{Applied Shear, } F_v = (1.4 \times P_a) + (1.6 \times P_u)$$

$$\text{Applied Shear, } F_v = (1.4 \times 7.18) + (1.6 \times 2.35) = \mathbf{13.811 \text{ kN (ult)}}$$

$$\text{Contact area at base of blockwork} = 225 \text{ mm} \quad (\times 1000 \text{ mm width})$$

$$\text{Therefore average applied shear stress} = \frac{13.811 \times 1000}{225 \times 1000} = 0.0614 \text{ N/mm}^2$$

Shear resistance of blockwork in horizontal direction (cl. 21.1.1 BS 5628:pt1:2005)

$$f_v = f_{vko} + 0.6g_A \quad \text{where} \quad f_{vko} = 0.35 \text{ N/mm}^2$$

$$g_A = g_d = 0.0275 \text{ N/mm}^2$$

$$f_v = 0.350 + (0.600 \times 0.0275) = 0.367 \text{ N/mm}^2$$

Therefore since $0.367 (f_v) > 0.0614 (F_v)$ OK