

Project Mass Masonry Retaining Wall Design									
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Structural Design for the design of various size mass masonry Retaining Walls

1 Introduction

The design of gargen retaining walls up to a maximum height of 1.5m

2 Design Parameters

Wall Construction: Concrete Blocks

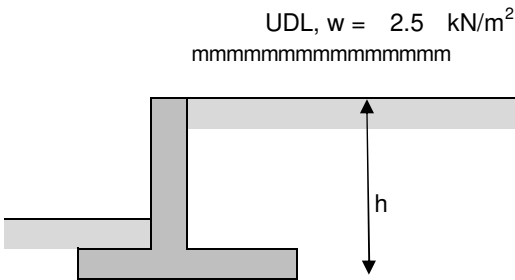
Wall Thickness: Walls of any thickness

(i) Retaining wall dimensions and details are shown on Standard detail retaining wall drawing. (ii) Maximum slope of retained material is 1 in 8. (iii) Retained granular material angle of internal friction (iv) Density of retained material (v) Blockwork Density (vi) Blockwork compressive strength (vii) Brickwork Density (viii) Brickwork Strength (ix) Mortar Class (cement:lime:sand) (x) Concrete foundations (xi) Surcharge loading (xii) Allowable Bearing Pressure (xiii) Concrete Density (xiv) Characteristic Initial Shear Strength of Masonry (BS 5628-1:2005 - Cl 21.1.2 - c) (xv) Basic flexural strength of blockwork, (From Table 3, BS5628:Pt 1:2005) (xvi) Dead load factor of safety (for blockwork flexural checks) (xvii) Level of Blockwork Manufacturing Control (xviii) Dead load factor of safety for general applied loads (ixx) Imposed (surcharge) load factor of safety for loads (xx) Overturning FOS 2.0 Sliding FOS 2.0	Θ = 7 degrees ψ = 35 degrees φ = 18 kN/m³ φ = 18 kN/m³ = 10.4 N/mm² φ = 20 kN/m³ = 20 N/mm² = (ii) = (1:0 to 1/4:3) Mass concrete = C16/20 Reinforced foundations = C28/35 = 2.5 kN/m² = 125 kN/m² = 24 kN/m³ f_{vko} = 0.35 N/mm² f_{kx} = 0.25 N/mm² γ_f = 0.9 γ_m = 3.5 γ_G = 1.4 γ_Q = 1.6
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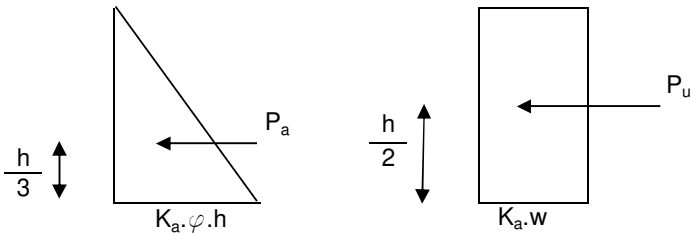
Only use (i), (ii) or (iii)

0.15 for mortar (iii) (iv)
0.35 for mortar (i) (ii)

3 Lateral Pressure on Retaining Walls



Pressures acting on wall are modelled as shown below:



Horizontal trust on wall = $P_a + P_u$

where $P_a = 0.5.K_a.\varphi.h^2$ (Earth Pressure)

$P_u = K_a.w.h$ (Surcharge Pressure)

Active Earth pressure coefficient calculation

For $\Theta = 7$ degrees and for $\vartheta = 35$ degrees

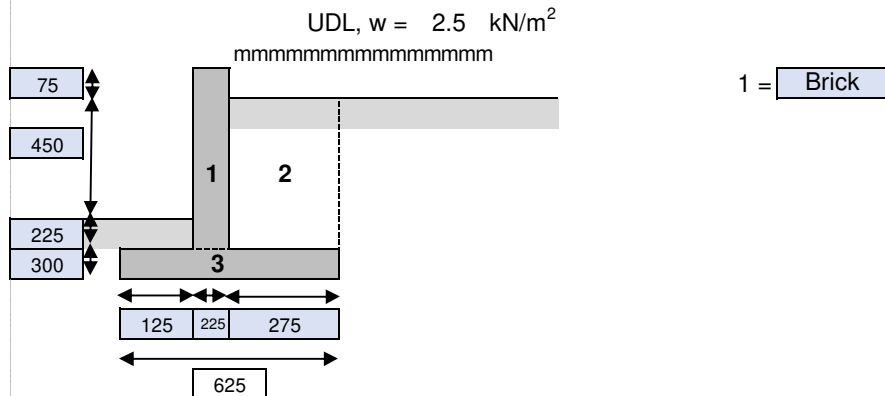
$$K_a = \cos \Theta \times \frac{\cos \Theta - (\cos^2 \Theta - \cos^2 \vartheta)^{0.5}}{\cos \Theta + (\cos^2 \Theta - \cos^2 \vartheta)^{0.5}} \qquad \text{(Rankine Coeffs with inclined backfills)}$$

$K_a = 0.276$

$K_a = 0.276$

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

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



$$P_a = 0.5 \cdot K_a \cdot \phi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 0.98^2 = 2.36 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 2.5 \times 0.98 = 0.67 \text{ kN/m}$$

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

Wall Element	Force (kN/m)	Lever Arm (m)	Moment (kNm/m)	
			Clockwise	Anticlockwise
1	0.750 x 0.225 x 20.0 = 3.375	0.238	0.802	
2	0.675 x 0.275 x 18.0 = 3.341	0.488	1.629	
3	0.625 x 0.300 x 24.0 = 4.500	0.313	1.406	
P _a	As calculated above = 2.36	0.325		0.768
P _u	As calculated above = 0.67	0.488		0.328
Totals	Horiz. = 3.036 kN Vert = 11.216 kN		3.837	1.096
Overturning Moment Sum =			2.741 kNm	

Check Overturning F.O.S = $\frac{3.837}{1.096} = 3.50 > 2.0$ **Therefore OK**

Therefore OK

Check Sliding F.O.S = $\frac{\text{Vert Load} \times \tan \theta}{\text{Horiz Load}} = \frac{11.22 \times 0.70}{3.036} = 2.587 > 2.0$ **Therefore OK**

Therefore OK

Check Ground Pressure

Reaction Lever Arm, y = $\frac{\text{Sum of Moments}}{\text{Vertical Reaction}} = \frac{2.741}{11.216} = 0.244 \text{ m}$ (dist from bottom left)

Distance from reaction to centre of foundation, e = $\frac{\text{Length of footing}}{2} - y = \frac{0.625}{2} - 0.244$

e = 0.068 m

Check Middle Third Rule: $\frac{L}{6} = \frac{0.625}{6} = 0.104 \text{ m} > 0.068 \text{ m}$ Therefore reaction lies in middle third

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

Maximum Ground Bearing Pressure, p_{max} = $\frac{11.216}{0.625} \times \frac{(1 + 6 \times 0.068)}{0.625} = 29.69 \text{ kN/m}^2$

< 125 kN/m²
< Allowable, therefore OK

Check Blockwork

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

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

$y_f = 0.9$ (It should be noted that this value of y_f should be used in calculating the design vertical load)

$$g_d = 0.9 \times 0.75 \text{ m} \times 18 \text{ kN/m}^3 = 12.15 \text{ kN/m}^2 = 0.012 \text{ N/mm}^2$$

Basic flexural strength of blockwork, $f_{kx} = 0.25 \text{ N/mm}^2$ (From Table 3, BS5628:Pt 1:2005)

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

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

$$M_R = \left[\frac{0.25}{3.5} + 0.012 \right] \times 8437500 = 705194.2 \text{ N.mm} = \mathbf{0.705 \text{ kNm}}$$

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, $h = 0.675 \text{ m}$)

$$M_o = 1.4 \left[\text{Pa} \times \frac{h}{3} \right] + 1.6 \left[\text{Pu} \times \frac{h}{2} \right]$$

where the Pa and Pu for the blockwork height of 0.675 m only, and not the height from base

$$\begin{aligned} P_a &= 0.5 \cdot K_a \cdot \varphi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 0.675^2 = 1.13 \text{ kN/m} \\ P_u &= K_a \cdot w \cdot h = 0.276 \times 2.5 \times 0.675 = 0.47 \text{ kN/m} \end{aligned}$$

$$M_o = 1.4 \left[1.13 \times \frac{0.675}{3} \right] + 1.6 \left[0.47 \times \frac{0.675}{2} \right] = 0.608 \text{ kNm}$$

Therefore since $0.705 (M_R) > 0.608 (M_\theta)$ OK

OK

Check Shear at the Base of Blockwork Wall

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

$$\text{Applied Shear, } F_v = (1.4 \times 1.13) + (1.6 \times 0.47) = \mathbf{2.331 \text{ kN (ult)}}$$

Contact area at base of blockwork = 225 mm (x 1000mm width)

Therefore average applied shear stress = $\frac{2.331 \times 1000}{225 \times 1000} = 0.01 \text{ N/mm}^2$

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

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

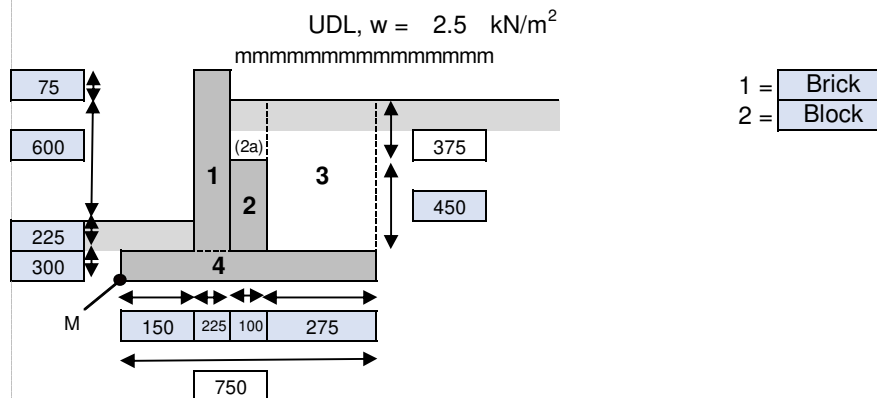
$$g_A = g_d = 0.012 \text{ N/mm}^2$$

$$f_v = 0.350 + (0.600 \times 0.012) = 0.357 \text{ N/mm}^2$$

Therefore since $0.357 (f_v) > 0.01 (F_v)$ OK

OK

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



$$P_a = 0.5 \cdot K_a \cdot \phi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 1.13^2 = \mathbf{3.15 \text{ kN/m}}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 2.5 \times 1.13 = \mathbf{0.78 \text{ kN/m}}$$

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

Wall Element	Force (kN/m)	Lever Arm (m)	Moment (kNm/m)	
			Clockwise	Anticlockwise
1	0.900 x 0.225 x 20.0 = 4.050	0.263	1.063	1.180
2	0.450 x 0.100 x 18.0 = 0.810	0.425	0.344	
2a	0.375 x 0.100 x 18.0 = 0.675	0.425	0.287	
3	0.825 x 0.275 x 18.0 = 4.084	0.613	2.501	
4	0.750 x 0.300 x 24.0 = 5.400	0.375	2.025	
P _a	As calculated above = 3.145	0.375		
P _u	As calculated above = 0.777	0.563	0.437	
Totals	Horiz. = 3.922 kN Vert = 15.019 kN		6.221	1.616
Overturning Moment Sum =			4.604 kNm	

<u>Check Overturning</u>	F.O.S =	$\frac{6.221}{1.616}$	=	3.85	>	2.0	Therefore OK
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Therefore OK

<u>Check Sliding</u>	F.O.S =	$\frac{\text{Vert Load} \times \tan \Theta}{\text{Horiz Load}} = \frac{15.02 \times 0.70}{3.922} = 2.681 > 2$	Therefore OK
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Therefore OK

Check Ground Pressure

$$\text{Reaction Lever Arm, } y = \frac{\text{Sum of Moments}}{\text{Vertical Reaction}} = \frac{4.604}{15.019} = 0.307 \text{ m} \quad (\text{dist from bottom left})$$

$$\text{Distance from reaction to centre of foundation, } e = \frac{\text{Length of footing}}{2} - y = \frac{0.75}{2} - 0.307$$

$$e = 0.068 \text{ m}$$

Check Middle Third Rule: $\frac{L}{6} = \frac{0.75}{6} = 0.125 \text{ m} > 0.068 \text{ m}$ Therefore reaction lies in middle third

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

$$\text{Maximum Ground Bearing Pressure, } p_{\max} = \frac{15.019}{0.75} \times \frac{(1 + 6 \times 0.068)}{0.75} = \mathbf{30.99 \text{ kN/m}^2}$$

$< 125 \text{ kN/m}^2$
 $< \text{Allowable, therefore OK}$

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Check Blockwork

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

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

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

$$g_d = 0.9 \times 0.825 \text{ m} \times 18 \text{ kN/m}^3 = 13.37 \text{ kN/m}^2 = 0.013 \text{ N/mm}^2$$

$$\text{Basic flexural strength of blockwork, } f_{kx} = 0.25 \text{ N/mm}^2 \quad (\text{From Table 3, BS5628:Pt 1:2005})$$

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

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

$$M_R = \left[\frac{0.25}{3.5} + 0.013 \right] \times 17604167 = 1492720.2 \text{ N.mm} = \mathbf{1.493 \text{ kNm}}$$

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 = 0.825 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 Pa and Pu for the blockwork height of 0.825 m only, and not the height from base

$$P_a = 0.5 K_a \cdot \varphi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 0.825^2 = 1.69 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 2.5 \times 0.825 = 0.57 \text{ kN/m}$$

$$M_o = 1.4 \left[1.69 \times \frac{0.825}{3} \right] + 1.6 \left[0.57 \times \frac{0.825}{2} \right] = \mathbf{1.027 \text{ kNm}}$$

Therefore since $1.493 (M_R) > 1.027 (M_o)$ **OK**

OK

Check Shear at the Base of Blockwork Wall

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

$$\text{Applied Shear, } F_v = (1.4 \times 1.69) + (1.6 \times 0.57) = \mathbf{3.279 \text{ kN (ult)}}$$

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

$$\text{Therefore average applied shear stress} = \frac{3.279 \times 1000}{225 \times 1000} = 0.015 \text{ N/mm}^2$$

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 $0.358 (f_v) > 0.015 (F_v)$ **OK**

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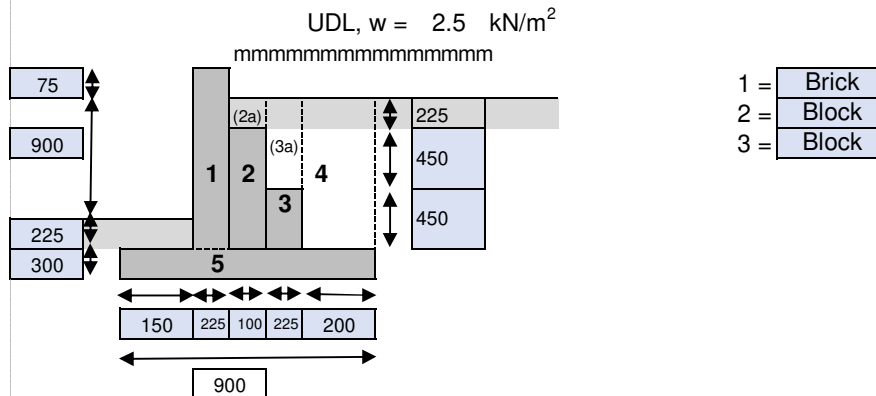
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6 Wall Type "C" (Max retained height = 0.9 m)



$$P_a = 0.5 \cdot K_a \cdot \phi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 1.43^2 = 5.05 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 2.5 \times 1.43 = 0.98 \text{ kN/m}$$

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

Wall Element	Force (kN/m)	Lever Arm (m)	Moment (kNm/m)
1	$1.200 \times 0.225 \times 20.0 = 5.400$	0.263	1.418
2	$0.900 \times 0.100 \times 18.0 = 1.620$	0.425	0.689
2a	$0.225 \times 0.100 \times 18.0 = 0.405$	0.425	0.172
3	$0.450 \times 0.225 \times 18.0 = 1.823$	0.588	1.071
3a	$0.675 \times 0.225 \times 18.0 = 2.734$	0.900	2.460
4	$1.125 \times 0.200 \times 18.0 = 4.050$	0.800	3.240
5	$0.900 \times 0.300 \times 24.0 = 6.480$	0.450	2.916
P_a	As calculated above = 5.047	0.475	2.397
P_u	As calculated above = 0.984	0.713	0.701
Totals	Horiz. = 6.030 kN Vert = 22.511 kN		11.965 3.098

Overturning Moment Sum = 8.867 kNm

Check Overturning F.O.S = $\frac{11.965}{3.098} = 3.86 > 2.0$ **Therefore OK**

Therefore OK

Check Sliding F.O.S = $\frac{\text{Vert Load} \times \tan \theta}{\text{Horiz Load}} = \frac{22.51 \times 0.70}{6.030} = 2.614 > 2$ **Therefore OK**

Therefore OK

Check Ground Pressure

Reaction Lever Arm, $y = \frac{\text{Sum of Moments}}{\text{Vertical Reaction}} = \frac{8.867}{22.511} = 0.394 \text{ m}$ (dist from bottom left)

Distance from reaction to centre of foundation, $e = \frac{\text{Length of footing}}{2} - y = \frac{0.9}{2} - 0.394$
 $e = 0.056 \text{ m}$

Check Middle Third Rule: $\frac{L}{6} = \frac{0.9}{6} = 0.15 \text{ m} > 0.056 \text{ m}$ **Therefore reaction lies in middle third**

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

Maximum Ground Bearing Pressure, $p_{\max} = \frac{22.511}{0.9} \times \frac{(1 + 6 \times 0.056)}{0.9} = 34.367 \text{ kN/m}^2$
 $< 125 \text{ kN/m}^2$
< Allowable, therefore OK

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Check Blockwork

At base of wall Z = $\frac{b \times d^2}{6} = \frac{1000 \times 550^2}{6} = 50416667 \text{ mm}^3$

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

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

$g_d = 0.9 \times 1.125 \text{ m} \times 18 \text{ kN/m}^3 = 18.23 \text{ kN/m}^2 = 0.018 \text{ N/mm}^2$

Basic flexural strength of blockwork, $f_{kx} = 0.25 \text{ N/mm}^2$ (From Table 3, BS5628:Pt 1:2005)

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

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

$M_R = \left[\frac{0.25}{3.5} + 0.018 \right] \times 50416667 = 4520034.2 \text{ N.mm} = \mathbf{4.520 \text{ kNm}}$

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 = 1.125 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 1.125 m only, and not the height from base

$P_a = 0.5 \cdot K_a \cdot \varphi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 1.125^2 = 3.15 \text{ kN/m}$
 $P_u = K_a \cdot w \cdot h = 0.276 \times 2.5 \times 1.125 = 0.78 \text{ kN/m}$

$M_o = 1.4 \left[3.15 \times \frac{1.125}{3} \right] + 1.6 \left[0.78 \times \frac{1.125}{2} \right] = \mathbf{2.35 \text{ kNm}}$

Therefore since 4.520 (M_R) > 2.35 (M_o) OK

Check Shear at the Base of Blockwork Wall

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

Applied Shear, $F_v = (1.4 \times 3.15) + (1.6 \times 0.78) = \mathbf{5.646 \text{ kN (ult)}}$

Contact area at base of blockwork = 225 mm (x 1000mm width)

Therefore average applied shear stress = $\frac{5.646 \times 1000}{225 \times 1000} = 0.025 \text{ N/mm}^2$

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

$f_v = f_{vko} + 0.6g_A$ where $f_{vko} = 0.35 \text{ N/mm}^2$
 $g_A = g_d = 0.018 \text{ N/mm}^2$

$f_v = 0.350 + (0.600 \times 0.018) = 0.361 \text{ N/mm}^2$

Therefore since 0.361 (f_v) > 0.025 (F_v) OK

OK

OK

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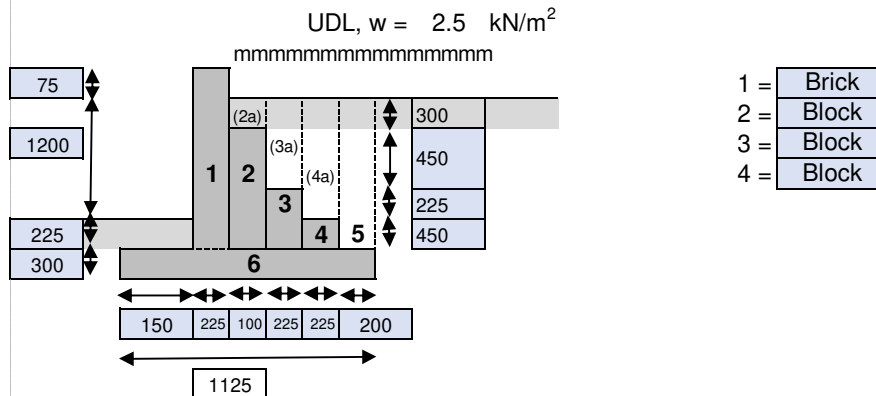
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7 Wall Type "D" (Max retained height = 1.2 m)



$$P_a = 0.5 \cdot K_a \cdot \phi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 1.73^2 = 7.40 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 2.5 \times 1.73 = 1.19 \text{ kN/m}$$

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

Wall Element	Force (kN/m)	Lever Arm (m)	Moment (kNm/m)
1	$1.500 \times 0.225 \times 20.0 = 6.750$	0.263	1.772
2	$1.125 \times 0.100 \times 18.0 = 2.025$	0.425	0.861
3	$0.675 \times 0.225 \times 18.0 = 2.734$	0.588	1.606
4	$0.450 \times 0.225 \times 18.0 = 1.823$	0.813	1.481
5	$1.425 \times 0.200 \times 18.0 = 5.130$	1.025	5.258
6	$1.125 \times 0.300 \times 24.0 = 8.100$	0.563	4.556
2a 3a 4a	As calculated		5.222
P_a	As calculated above = 7.395	0.575	4.252
P_u	As calculated above = 1.191	0.863	1.027
Totals	Horiz. = 8.586 kN Vert = 26.561 kN		20.756 5.279

Overturning Moment Sum = 15.477 kNm

Check Overturning F.O.S = $\frac{20.756}{5.279} = 3.93 > 2.0$ **Therefore OK**

Therefore OK

Check Sliding F.O.S = $\frac{\text{Vert Load} \times \tan \theta}{\text{Horiz Load}} = \frac{26.56 \times 0.70}{8.586} = 2.166 > 2$ **Therefore OK**

Therefore OK

Check Ground Pressure

Reaction Lever Arm, $y = \frac{\text{Sum of Moments}}{\text{Vertical Reaction}} = \frac{15.477}{26.561} = 0.583 \text{ m}$ (dist from bottom left)

Distance from reaction to centre of foundation, $e = \frac{\text{Length of footing}}{2} - y = \frac{1.125}{2} - 0.583$
 $e = -0.02 \text{ m}$

Check Middle Third Rule: $\frac{L}{6} = \frac{1.125}{6} = 0.188 \text{ m} > -0.02 \text{ m}$ **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, $p_{\max} = \frac{26.561}{1.125} \times \left(1 + \frac{6 \times -0.02}{1.125} \right) = 21.07 \text{ kN/m}^2$
 $< 125 \text{ kN/m}^2$
< Allowable, therefore OK

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Check Blockwork

$$\text{At base of wall } Z = \frac{b \times d^2}{6} = \frac{1000 \times 775^2}{6} = 100104167 \text{ mm}^3$$

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

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

$$g_d = 0.9 \times 1.425 \text{ m} \times 18 \text{ kN/m}^3 = 23.09 \text{ kN/m}^2 = 0.023 \text{ N/mm}^2$$

$$\text{Basic flexural strength of blockwork, } f_{kx} = 0.25 \text{ N/mm}^2 \quad (\text{From Table 3, BS5628:Pt 1:2005})$$

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

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

$$M_R = \left[\frac{0.25}{3.5} + 0.023 \right] \times 100104167 = 9461202.3 \text{ N.mm} = \mathbf{9.461 \text{ kNm}}$$

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 = 1.425 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 Pa and Pu for the blockwork height of 1.425 m only, and not the height from base

$$P_a = 0.5 K_a \cdot \varphi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 1.425^2 = 5.05 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 2.5 \times 1.425 = 0.98 \text{ kN/m}$$

$$M_o = 1.4 \left[5.05 \times \frac{1.425}{3} \right] + 1.6 \left[0.98 \times \frac{1.425}{2} \right] = \mathbf{4.477 \text{ kNm}}$$

Therefore since $9.461 (M_R) > 4.477 (M_o)$ **OK**

OK

Check Shear at the Base of Blockwork Wall

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

$$\text{Applied Shear, } F_v = (1.4 \times 5.05) + (1.6 \times 0.98) = \mathbf{8.639 \text{ kN (ult)}}$$

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

$$\text{Therefore average applied shear stress} = \frac{8.639 \times 1000}{225 \times 1000} = 0.038 \text{ N/mm}^2$$

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

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

$$g_A = g_d = 0.023 \text{ N/mm}^2$$

$$f_v = 0.350 + (0.600 \times 0.023) = 0.364 \text{ N/mm}^2$$

Therefore since $0.364 (f_v) > 0.038 (F_v)$ **OK**

Mass Masonry Retaining Wall Design

Dec '24

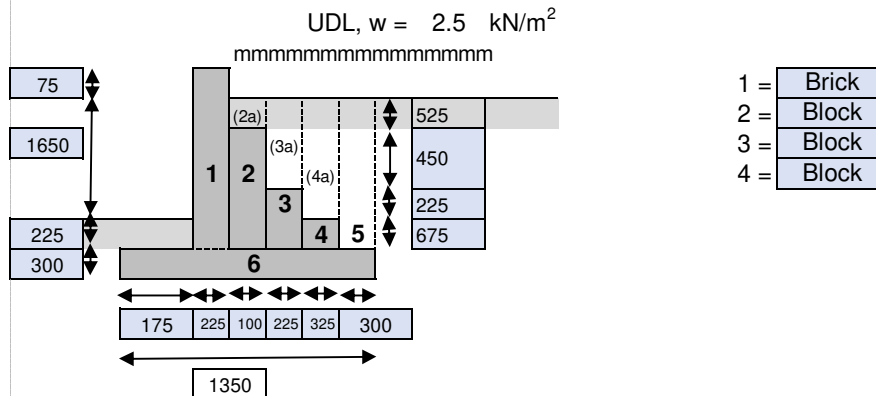
WW

PHG

2109

9

8 Wall Type "E" (Max retained height = 1.65 m)



$$P_a = 0.5 \cdot K_a \cdot \phi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 2.18^2 = 11.76 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 2.5 \times 2.18 = 1.50 \text{ kN/m}$$

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

Wall Element	Force (kN/m)	Lever Arm (m)	Moment (kNm/m)
1	$1.950 \times 0.225 \times 20.0 = 8.775$	0.288	2.523
2	$1.350 \times 0.100 \times 18.0 = 2.430$	0.450	1.094
3	$0.900 \times 0.225 \times 18.0 = 3.645$	0.613	2.233
4	$0.675 \times 0.325 \times 18.0 = 3.949$	0.888	3.505
5	$1.875 \times 0.300 \times 18.0 = 10.125$	1.200	12.150
6	$1.350 \times 0.300 \times 24.0 = 9.720$	0.675	6.561
2a 3a 4a	As calculated		9.074
P_a	As calculated above = 11.757	0.725	8.524
P_u	As calculated above = 1.501	1.088	1.633
Totals	Horiz. = 13.258 kN Vert = 38.644 kN		37.139 10.156

Overturning Moment Sum = 26.982 kNm

Check Overturning F.O.S = $\frac{37.139}{10.156} = 3.66 > 2.0$ **Therefore OK**

Therefore OK

Check Sliding F.O.S = $\frac{\text{Vert Load} \times \tan \theta}{\text{Horiz Load}} = \frac{38.64 \times 0.70}{13.258} = 2.041 > 2$ **Therefore OK**

Therefore OK

Check Ground Pressure

Reaction Lever Arm, $y = \frac{\text{Sum of Moments}}{\text{Vertical Reaction}} = \frac{26.982}{38.644} = 0.698 \text{ m}$ (dist from bottom left)

Distance from reaction to centre of foundation, $e = \frac{\text{Length of footing}}{2} - y = \frac{1.35}{2} - 0.698$
 $e = -0.023 \text{ m}$

Check Middle Third Rule: $\frac{L}{6} = \frac{1.35}{6} = 0.225 \text{ m} > -0.023 \text{ m}$ **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, $p_{\max} = \frac{38.644}{1.35} \times \left(1 + \frac{6 \times -0.023}{1.35} \right) = 25.67 \text{ kN/m}^2$
 $< 125 \text{ kN/m}^2$
< Allowable, therefore OK

Project									
Mass Masonry Retaining Wall Design									
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Check Blockwork

$$\text{At base of wall } Z = \frac{b \times d^2}{6} = \frac{1000 \times 875^2}{6} = 127604167 \text{ mm}^3$$

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

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

$$g_d = 0.9 \times 1.875 \text{ m} \times 18 \text{ kN/m}^3 = 30.38 \text{ kN/m}^2 = 0.03 \text{ N/mm}^2$$

$$\text{Basic flexural strength of blockwork, } f_{kx} = 0.25 \text{ N/mm}^2 \quad (\text{From Table 3, BS5628:Pt 1:2005})$$

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

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

$$M_R = \left[\frac{0.25}{3.5} + 0.03 \right] \times 127604167 = 12990560 \text{ N.mm} = \mathbf{12.991 \text{ kNm}}$$

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 = 1.875 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 Pa and Pu for the blockwork height of 1.875 m only, and not the height from base

$$P_a = 0.5 K_a \cdot \varphi \cdot h^2 = 0.5 \times 0.276 \times 18 \times 1.875^2 = 8.74 \text{ kN/m}$$

$$P_u = K_a \cdot w \cdot h = 0.276 \times 2.5 \times 1.875 = 1.29 \text{ kN/m}$$

$$M_o = 1.4 \left[8.74 \times \frac{1.875}{3} \right] + 1.6 \left[1.29 \times \frac{1.875}{2} \right] = \mathbf{9.587 \text{ kNm}}$$

Therefore since $12.991 (M_R) > 9.587 (M_o)$ **OK**

OK

Check Shear at the Base of Blockwork Wall

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

$$\text{Applied Shear, } F_v = (1.4 \times 8.74) + (1.6 \times 1.29) = \mathbf{14.3 \text{ kN (ult)}}$$

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

$$\text{Therefore average applied shear stress} = \frac{14.3 \times 1000}{225 \times 1000} = 0.064 \text{ N/mm}^2$$

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

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

$$g_A = g_d = 0.03 \text{ N/mm}^2$$

$$f_v = 0.350 + (0.600 \times 0.03) = 0.368 \text{ N/mm}^2$$

Therefore since $0.368 (f_v) > 0.064 (F_v)$ **OK**