

VALE DESIGN PARTNERSHIP LTD.
Chartered Civil and Structural Engineers

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Project No. 10059x
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 Prepared by KRD
 Date April 2021

proposed two-storey detached development at Plot 6, Sandbrook Place, Bryntirion Road, Merthyr Tydfil, CF47 0EW.

Code Ref.	Calculations	Output
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Design Data and Assumptions for Earth Retaining Walls

- 1 Specific weight of backfill material is assumed to be 18.0 kN/m^3 . A nominal garden surcharge loading of 2.5 kN/m^2 has been adopted in the design of the retaining walls.
- 2 Internal 'angle of friction' 'B' is assumed to be 35° and the Slope of retained ground 'A' is not to exceed 35°
- 3 Rankin's factor =
$$\frac{\cos A - (\cos^2 A - \cos^2 B)^{1/2}}{\cos A + (\cos^2 A - \cos^2 B)^{1/2}} \times \cos^2 A$$
 - 3.1 for ground slope $A = 0^\circ$ and angle of internal friction $B = 35^\circ$
 Rankin's factor = $\frac{1.000 - (1.000 - 0.671)^{1/2}}{1.000 + (1.000 - 0.671)^{1/2}} \times 1.000 = 0.27$
 - 3.2 for ground slope $A = 20^\circ$ and angle of internal friction $B = 35^\circ$
 Rankin's factor = $\frac{0.940 - (0.883 - 0.671)^{1/2}}{0.940 + (0.883 - 0.671)^{1/2}} \times 0.883 = 0.30$
 - 3.3 for ground slope $A = 35^\circ$ and angle of internal friction $B = 35^\circ$
 Rankin's factor = $\frac{0.819 - (0.671 - 0.671)^{1/2}}{0.819 + (0.671 - 0.671)^{1/2}} \times 0.671 = 0.67$
- 4 The retaining wall is to be backfilled with a single size granular material incorporating a suitable land drainage system.
 (i.e. hydrostatic water pressure is assumed to be zero.)
- 5 Retaining wall 'Type 1' is to be constructed with Grade 7.0 N/mm^2 dense concrete blockwork bonded with 1 : $\frac{1}{4}$: 3 cement/sand mortar.
- 6 Retaining wall 'Type 2' is to comprise gabion baskets filled with hand-placed stones.
- 7 Specific weight of the blockwork earth-retaining wall walls is taken to be 22.25 kN/m^3
- 8 Specific weight of concrete base is taken to be 24.0 kN/m^3
- 9 Specific weight of 'gabion' baskets containing say 30% voids in stones is assumed to be 15 kN/m^3 .
- 10 The following partial factors of safety for loading will be adopted in the determination of loads acting on the masonry retaining walls:-
 - 10.1 active earth pressures - 1.35
 - 10.2 surcharge loads - 1.50
 - 10.3 passive earth pressures - 1.00
- 11 The following partial of safety for stability will be adopted in the determination of a suitable section for a garden retaining wall:-
 - 11.1 sliding resistance (friction only) - 1.50
 - 11.2 sliding resistance (friction and passive) - 2.00
 - 11.3 overturning (serviceability loadings) - 2.00

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Calculations

Output

Design of 'Free-Standing' Earth-Retaining Wall - Type 1

0.80m depth

$$MO = \frac{0.80^3}{6} \times (18 \times 1.35) \times 0.27 + \frac{0.80^2}{2} \times (2.5 \times 1.50) \times 0.27$$

$$= 0.56 + 0.34 = 0.90 \text{ kN.m}$$

adopt 225mm thick masonry section

$$\text{Section ht} \times \text{width} \times \text{density} = \text{Wt.} \times L_a = MR$$

$$225\text{mm wall } 1.40 \times 0.225 \times 20.25 = 6.38 \times 0.112 = 0.71$$

$$\frac{6.38 \text{ kN}}{0.64 \text{ kN.m}}$$

$$x = \frac{0.90 - 0.71}{6.38} = +0.033 \quad ; \quad ecc = +0.033 + 0.112 = +0.145\text{m}$$

resultant vertical force is outside wall

$$\text{extreme fibre stresses} = \frac{6.38 \times 10^3}{225 \times 1000} \left(1 \pm \frac{145 \times 6}{225} \right)$$

$$= 0.0255 (1 \pm 3.87) \text{ N/mm}^2$$

$$\text{maximum compression} = +0.124 \text{ N/mm}^2$$

$$\text{maximum tension} = -0.073 \text{ N/mm}^2 \quad (\text{ok})$$

225mm thick concrete masonry section will be adequate for walls up to 0.80m depth below ground level

1.30m depth

$$MO = \frac{1.30^3}{6} \times (18 \times 1.35) \times 0.27 + \frac{1.30^2}{2} \times (2.5 \times 1.50) \times 0.27$$

$$= 2.40 + 0.90 = 3.30 \text{ kN.m}$$

adopt 450mm thick masonry section

$$\text{Section ht} \times \text{width} \times \text{density} = \text{Wt.} \times L_a = MR$$

$$225\text{mm wall } 1.40 \times 0.225 \times 20.25 = 6.38 \times 0.112 = 0.71$$

$$450\text{mm wall } 0.50 \times 0.450 \times 20.25 = 4.56 \times 0.225 = 1.03$$

$$225\text{mm fill } 0.80 \times 0.225 \times 18.00 = 3.24 \times 0.337 = 1.09$$

$$\text{surcharge } 0.225 \times 2.50 = 0.56 \times 0.337 = 0.19$$

$$\frac{14.74 \text{ kN}}{3.02 \text{ kN.m}}$$

$$x = \frac{3.30 - 3.02}{14.74} = +0.019\text{m} \quad ; \quad ecc = +0.019 + 0.225 = +0.244\text{m}$$

resultant vertical force is outside wall

$$\text{extreme fibre stresses} = \frac{14.74 \times 10^3}{450 \times 1000} \left(1 \pm \frac{244 \times 6}{450} \right)$$

$$= 0.0328 (1 \pm 3.25) \text{ N/mm}^2$$

$$\text{maximum compression} = +0.145 \text{ N/mm}^2$$

$$\text{maximum tension} = -0.077 \text{ N/mm}^2 \quad (\text{ok})$$

450mm thick concrete blockwork section will be adequate for walls up to 1.30m depth below ground level

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Design of 'Free-Standing' Earth-Retaining Wall - Type 1

1.80m depth

$$MO = \frac{1.80^3}{6} \times (18 \times 1.35) \times 0.27 + \frac{1.80^2}{2} \times (2.5 \times 1.50) \times 0.27$$

$$= 6.50 + 1.65 = 8.15 \text{ kN.m}$$

adopt 675mm thick masonry section

Section ht x width x density = Wt. x La = MR

225mm wall 1.40 x 0.225 x 20.25 = 6.38 x 0.112 = 0.71

450mm wall 0.50 x 0.450 x 20.25 = 4.56 x 0.225 = 1.03

675mm wall 0.50 x 0.675 x 20.25 = 6.83 x 0.337 = 2.30

225mm fill 0.80 x 0.225 x 18.00 = 3.24 x 0.337 = 1.09

225mm fill 1.30 x 0.225 x 18.00 = 5.27 x 0.562 = 2.96

surcharge 0.450 x 2.50 = 1.13 x 0.450 = 0.51

27.41kN 8.60kN.m

$x = \frac{8.15}{27.41} - \frac{8.60}{27.41} = -0.016\text{m}$: ecc = -0.016 + 0.337 = +0.321m

resultant vertical force is outside wall

extreme fibre stresses = $\frac{27.41 \times 10^3}{675 \times 1000} (1 \pm \frac{321 \times 6}{675})$

$= 0.0406 (1 \pm 2.85) \text{ N/mm}^2$

maximum compression = +0.160 N/mm²

maximum tension = -0.075 N/mm² (ok)

675mm thick concrete blockwork section will be adequate for walls up to 1.80m depth below ground level

Stability @ 2.10 depth

$P = \frac{2.10^2}{2} \times 18 \times 0.27 + 2.10 \times 2.5 \times 0.27 = 10.7 + 1.4 = 12.1 \text{ kN}$

$MO = \frac{2.10^3}{6} \times 18 \times 0.27 + \frac{2.10^2}{2} \times 2.5 \times 0.27 = 7.50 + 1.50 = 9.0 \text{ kN.m}$

adopt 1075mm wide x 200mm deep m.c. base - 200mm heel + 200mm toe

Section ht x width x density = Wt. x La = MR

225mm wall 1.40 x 0.225 x 22.5 = 7.1 x 0.312 = 2.2

450mm wall 0.50 x 0.450 x 22.5 = 5.1 x 0.425 = 2.2

675mm wall 0.60 x 0.675 x 22.5 = 9.1 x 0.537 = 4.9

225mm fill 0.80 x 0.225 x 18.0 = 3.2 x 0.537 = 1.7

225mm fill 1.30 x 0.225 x 18.0 = 5.3 x 0.762 = 4.0

surcharge 0.650 x 2.5 = 1.6 x 0.725 = 1.2

base slab 0.20 x 1.075 x 25.0 = 5.4 x 0.537 = 2.9

36.8kN 19.1kN.m

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Design of 'Free-Standing' Earth-Retaining Wall - Type 1

Stability @ 2.10 depth

$$\text{frictional resistance} = 36.8 \times 0.50 = 18.4 \text{ kN}$$

$$F \text{ of } S \text{ sliding} = 18.4 / 12.1 = 1.52$$

$$F \text{ of } S \text{ overturning} = 19.1 / 9.0 = 2.12$$

$$x = \frac{9.0 - 19.1}{36.8} = -0.274 \text{ m} \quad : \quad ecc = -0.274 + 0.537 = +0.263 \text{ m}$$

resultant vertical force is outside mid 3rd

effective base length = $3 \times 0.263 = 0.789 \text{ m}$

maximum bearing pressure $\frac{2 \times 36.8}{0.789} = 95 \text{ kN/m}^2$ (ok)

1075mm long x 200mm deep concrete base slab will be adequate

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Typical Cross-Sections through Masonry Earth-Retaining Walls
(not to scale)

Design of Gabion Earth-Retaining System - Type 2

A 1.00m depth - level backfilling

$$MO = \frac{1.0^3}{6} \times (18 \times 1.35) \times 0.27 + \frac{1.0^2}{2} \times (2.5 \times 1.50) \times 0.27 = 1.09 + 0.51 = 1.60 \text{ kNm}$$

adopt 1000mm wide basket system

$$\text{section} \quad ht \times width \times sp. wt. = Wt. \times L_a = MR$$

$$1000\text{mm wall} \quad 1.00 \times 1.00 \times 15.0 = 15.0 \times 0.50 = 7.50$$

$$15.0 \text{ kN/m} \quad 7.50 \text{ kN.m/m}$$

1000mm wide basket system will be adequate for retention up to 1.00m depth below ground level - F of S overturning > 2.5 (ok)

B 2.00m depth - level backfilling

$$MO = \frac{2.0^3}{6} \times (18 \times 1.35) \times 0.27 + \frac{2.0^2}{2} \times (2.5 \times 1.5) \times 0.27 = 8.75 + 2.05 = 10.80 \text{ kNm}$$

adopt 1500mm wide basket system - top basket offset by 300mm

$$\text{section} \quad ht \times width \times sp. wt. = Wt. \times L_a = MR$$

$$1000\text{mm wall} \quad 1.00 \times 1.00 \times 15.0 = 15.0 \times 0.80 = 12.00$$

$$1500\text{mm wall} \quad 1.00 \times 1.50 \times 15.0 = 22.5 \times 0.75 = 15.88$$

$$37.5 \text{ kN/m} \quad 27.88 \text{ kN.m/m}$$

1500mm wide basket system will be adequate for retention up to 2.00m depth below ground level - F of S overturning > 2.5 (ok)

Typical Cross-Section through Gabion Earth-Retaining System

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(not to scale)

Design of Underpinned Edge-Strip Foundations

UD Loading on strips	unfactored	factored
4.00m roof and loft floor	6.60	9.80
1.5m ground floor slab	10.00	13.00
3.6m external wall	18.40	25.20
allowance for s.wt. edge strips	8.00	10.00
allowance for s.wt. underpinning	<u>22.00</u>	<u>32.00</u>
total loading	<u>65.00kN/m</u>	<u>90.00kN/m</u>

Adopt 2.0m deep x 1250mm wide MC strips

$$\text{Nett Bearing Pressure (unfactored)} = \frac{65.00}{1.25 \times 1.00} = 52 \text{ kN/m}^2 \quad (\text{ok})$$

Stability @ 2.00 depth

$$P = \frac{2.00^2}{2} \times 18 \times 0.27 = 9.7 \text{ kN}$$

$$MO = \frac{2.00^3}{6} \times 18 \times 0.27 = 6.5 \text{ kN.m}$$

adopt 1500mm wide x 2000mm deep m.c. strip

Section	Wt. x L_a	=	MR
foundation	43kN x 1.00m	=	43kN.m
mass concrete	<u>22kN</u> x 0.75m	=	<u>17kN.m</u>
	<u>65kN</u>		<u>60kN.m</u>

$$x = \frac{6.5 - 60}{65} = -0.823 \text{ m} \quad : \quad \text{ecc} = -0.823 + 0.750 = +0.072 \text{ m}$$

resultant vertical force is inside mid 3rd

$$\text{maximum bearing pressure} = \frac{65}{1.5 \times 1.0} \left(1 + \frac{0.072 \times 6}{1.5} \right) = 43 \times 1.29 = 55 \text{ kN/m}^2$$

1500mm wide concrete underpinning will be adequate