

RETAINING WALLS

PLOT 1 GREENACRES, HEOLGERRIG, MERTHYR TYDFIL

STRUCTURAL CALCULATIONS

Wall 1

Maximum height of wall = 1.2 m above finished ground level 1.6 m overall.

Density of earth = 18 kN/m³. Well drained cohesionless.

Angle of shearing resistance = 35°

$$\text{horizontal component} \\ k_a = \frac{1 - \sin \phi}{1 + \sin \phi} = 0.27$$

Co-efficient of friction between base and earth = 0.5

Safe ground bearing capacity = 100 kN/m²

Wall to be built of dense concrete blockwork with natural stone facing = 20kN/m³

Allow for surcharge = 10.0 kN/m²

Introduce free draining material to rear of wall.

Base of well compacted 30N/mm² concrete = 24kN/m³

Factor of Safety for Sliding to be minimum of 1.5 and Overturning to be minimum of 2.00

Vertical Loads

Part	Area m ²	density (kN/m ³)	Wt (kN)	lever arm	Moments about A
Base	0.3 x 0.900	24	6.48	0.450	2.916
Wall	0.4 x 0.800	20	6.4	0.450	2.880
	0.5 x 0.450	20	4.5	0.275	1.238
	0.4 x 0.225	20	1.8	0.162	0.292
Earth	0.050 x 1.3	18	1.17	0.788	0.922
	0.350 x 0.9	18	5.67	0.563	3.192
	0.225 x 0.4	18	1.62	0.312	0.505
Surcharge 10 kN =	0.625 x 10		6.25	0.587	3.669
			33.890		15.614
c.g. from A	=	$\frac{15.614}{33.890}$	= 0.461		

Horizontal Loads

$$P_{\text{earth}} = 18.00 \times 0.5 \times 1.6^2 \times 0.27 = 6.221 \text{ kN}$$

Moments about A

$$6.221 \times \frac{1.6}{3} \\ = 3.318 \text{ kN m}$$

$$P \text{ surcharge} = 10 \times 1.6 \times 0.27 = 4.320 \text{ kN}$$

Moments about A

$$4.320 \times \frac{1.6}{3}$$

$$= 2.304 \text{ kN m}$$

$$\text{Total Moment} = 3.318 + 2.304 = 5.622 \text{ kN m}$$

Overturning

$$F \text{ of S against overturning} = \frac{15.614}{5.622}$$

$$= 2.777 \quad \text{Therefore OK}$$

Resultant of Forces

$$x = \frac{5.622}{33.890}$$

$$= 0.166$$

$$\text{Distance from A} = 0.525 - 0.166 = 0.359$$

Eccentricity of load

$$e = 0.450 - 0.359 = 0.097 \quad L/6 = 0.9/6 = 0.150$$

Lies within middle third O.K.

Check Sliding

$$\text{FOS} = \frac{33.890 \times 0.5}{5.622} = 3.014 \quad \text{Therefore OK}$$

Bearing

Resultant of forces

$$\text{Distance from A} = \frac{\text{Restoring moment} - \text{Overturning moment}}{\text{Total Weight}}$$

$$= \frac{15.614 - 5.622}{33.890} = 295$$

$$e = \text{Base} / 2 - \text{offset from A} = 900 / 2 - 295$$

= -155 lies within middle third O.K.

Bearing Pressure / metre run

$$\frac{33.890}{1 \times 0.900} + \frac{33.890 \times 0.155}{1 \times 0.900^2} \times 6$$

$$37.656 \quad +/\quad 38.911$$

$$\text{Max} = 76.567 < 100 \quad \text{OK}$$

Check wall tension at each step (BS5628 Pt 1)

$$m = 3.5 f_k x = 0.25 \text{ N/mm}^2$$

Design moment of resistance = $(f_k x / m) Z$

$$\text{Overturning moment} = \frac{1}{2} \times 0.27 \times 18 \times h^2 \times h/3 \times 1.4 = 1.13 h^3$$

At 0.6 below top of wall

$$\text{BM} = 1.13 (0.6)^3 = 0.244 \text{ kNm}$$

$$gd = \frac{0.225 \times 0.6 \times 18 \times 0.9}{225} = 0.0097$$

$$\text{Des Moment} = (0.25/3.5 + gd) Z = (0.07 + gd) Z$$

$$= (0.07 + 0.0097) \frac{1000 \times 225^2}{6} \times 10^{-6}$$

$$= 0.672 \text{ kNm} > 0.244 \text{ kNm} \quad \text{OK}$$

At 1.2 below top of wall

$$\text{BM} = 1.13 (1.2)^3 = 1.953 \text{ kNm}$$

$$gd = \frac{0.450 \times 1.2 \times 18 \times 0.9}{450} = 0.019$$

$$\text{Des Moment} = (0.25/3.5 + gd) Z = (0.07 + gd) Z$$

$$= (0.07 + 0.019) \frac{1000 \times 450^2}{6} \times 10^{-6}$$

$$= 3.004 \text{ kNm} > 1.953 \text{ kNm} \quad \text{OK}$$

Wall 2

Maximum height of wall = 1.6 m above finished ground level 2.0 m overall.

Density of earth = 18 kN/m³. Well drained cohesionless.

Angle of shearing resistance = 35°

$$\text{horizontal component} \\ k_a = \frac{1 - \sin \phi}{1 + \sin \phi} = 0.27$$

Co-efficient of friction between base and earth = 0.5

Safe ground bearing capacity = 100 kN/m²

Wall to be built of dense concrete blockwork with natural stone facing = 20kN/m³

Allow for surcharge = 10.0 kN/m²

Introduce free draining material to rear of wall.

Base of well compacted 30N/mm² concrete = 24kN/m³

Factor of Safety for Sliding to be minimum of 1.5 and Overturning to be minimum of 2.00

Vertical Loads

Part	Area m ²	density (kN/m ³)	Wt (kN)	lever arm	Moments about A
Base	0.3 x 1.050	24	7.56	0.525	3.969
Wall	0.6 x 1.000	20	12.0	0.500	6.000
	0.6 x 0.550	20	6.6	0.275	1.815
	0.5 x 0.325	20	3.25	0.162	0.520
Earth	0.050 x 1.7	18	1.53	0.788	1.206
	0.450 x 1.1	18	8.91	0.563	5.016
	0.175 x 0.5	18	1.58	0.312	0.491
Surcharge 10 kN = 0.725 x 10			7.25	0.587	4.256
			48.680		23.273
c.g. from A	=	$\frac{23.273}{48.680}$	= 0.478		

Horizontal Loads

$$P_{\text{earth}} = 18.00 \times 0.5 \times 1.6^2 \times 0.27 = 6.221 \text{ kN}$$

Moments about A

$$6.221 \times \frac{2.0}{3}$$

$$= 4.173 \text{ kN m}$$

$$P_{\text{surcharge}} = 10 \times 1.6 \times 0.27 = 4.320 \text{ kN}$$

Moments about A

$$4.320 \times \frac{2.0}{3}$$

$$= 2.880 \text{ kN m}$$

$$\text{Total Moment} = 4.320 + 2.880 = 7.200 \text{ kN m}$$

Overturning

$$\text{F of S against overturning} = \frac{23.273}{7.200}$$

$$= 3.232 \quad \text{Therefore OK}$$

Resultant of Forces

$$x = \frac{7.200}{48.680}$$

$$= 0.147$$

$$\text{Distance from A} = 0.525 - 0.147 = 0.378$$

Eccentricity of load

$$e = 0.525 - 0.378 = 0.147$$

$$L/6 = 1.050 / 6 = 0.175$$

Lies within middle third O.K.

Check Sliding

$$\text{FOS} = \frac{48.680 \times 0.5}{7.200} = 3.381 \quad \text{Therefore OK}$$

Bearing

Resultant of forces

$$\text{Distance from A} = \frac{\text{Restoring moment} - \text{Overturning moment}}{\text{Total Weight}}$$

$$= \frac{23.273 - 7.200}{48.680} = 330$$

$$e = \text{Base} / 2 - \text{offset from A} = 1050 / 2 - 330$$

= -195 Outside middle third. Check Bearing Pressure.

Bearing Pressure / metre run

$$\frac{48.680}{1 \times 1.050} + \frac{48.680 \times 0.195}{1 \times 1.050^2} \times 6$$

$$43.362 \quad +/\quad 51.636$$

$$\text{Max} = 94.99 < 100 \quad \text{Therefore O.K.}$$

Check wall tension at each step (BS5628 Pt 1)

$$m = 3.5 f_k x = 0.25 \text{ N/mm}^2$$

Design moment of resistance = $(f_k x / m) Z$

$$\text{Overturning moment} = \frac{1}{2} \times 0.27 \times 18 \times h^2 \times h/3 \times 1.4 = 1.13 h^3$$

At 0.6 below top of wall

$$\text{BM} = 1.13 (0.6)^3 = 0.244 \text{ kNm}$$

$$gd = \frac{0.225 \times 0.6 \times 18 \times 0.9}{225} = 0.0097$$

$$\text{Des Moment} = (0.25/3.5 + gd) Z = (0.07 + gd) Z$$

$$= (0.07 + 0.0097) \frac{1000 \times 225^2}{6} \times 10^{-6}$$

$$= 0.672 \text{ kNm} > 0.244 \text{ kNm} \quad \text{OK}$$

At 1.2 below top of wall

$$\text{BM} = 1.13 (1.2)^3 = 1.953 \text{ kNm}$$

$$gd = \frac{0.450 \times 1.2 \times 18 \times 0.9}{450} = 0.019$$

$$\text{Des Moment} = (0.25/3.5 + gd) Z = (0.07 + gd) Z$$

$$= (0.07 + 0.019) \frac{1000 \times 450^2}{6} \times 10^{-6}$$

$$= 3.004 \text{ kNm} > 1.953 \text{ kNm} \quad \text{OK}$$