



Associates

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Structural Calculations

**Proposed Private Gravity Burr Walls Adjacent to PROW
at a New Residential Development off
Britannia Road, Milnsbridge. HD3 4QB**

5879

October 2025

Contents

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1.0	Notes + Loadings
2.0	Wall Design

Notes on Calculations

All concrete to be C35/45
 GBP onto bedrock minimum > 150kN/m²
 Soil parameters to be used in the design of earth retaining elements
 $K_a = 0.33$
 $K_0 = 0.5$
 $\phi = 30$

Temporary Stability to be maintained at all times
 Analysis adopted using Tedds stepped masonry wall with density to suit concrete

Loadings

(Permanent) Graded Granular Backfill	19kN/m ³
(Variable) Construction Traffic	10kN/m ²
(Variable) Gardens	2.5kN/m ²
Ground Water – wall to be fully drained	

Wall Design

Wall Refs	Retaining Height	Drawing Ref	Section Refs
Wall 1	1600mm	5879-101	B-B + D-D
Wall 2	1765mm	5879-100	G-G
Wall 3	2125mm	5879-100	J-J + K-K
Wall 4	2890mm	5879-100	H-H



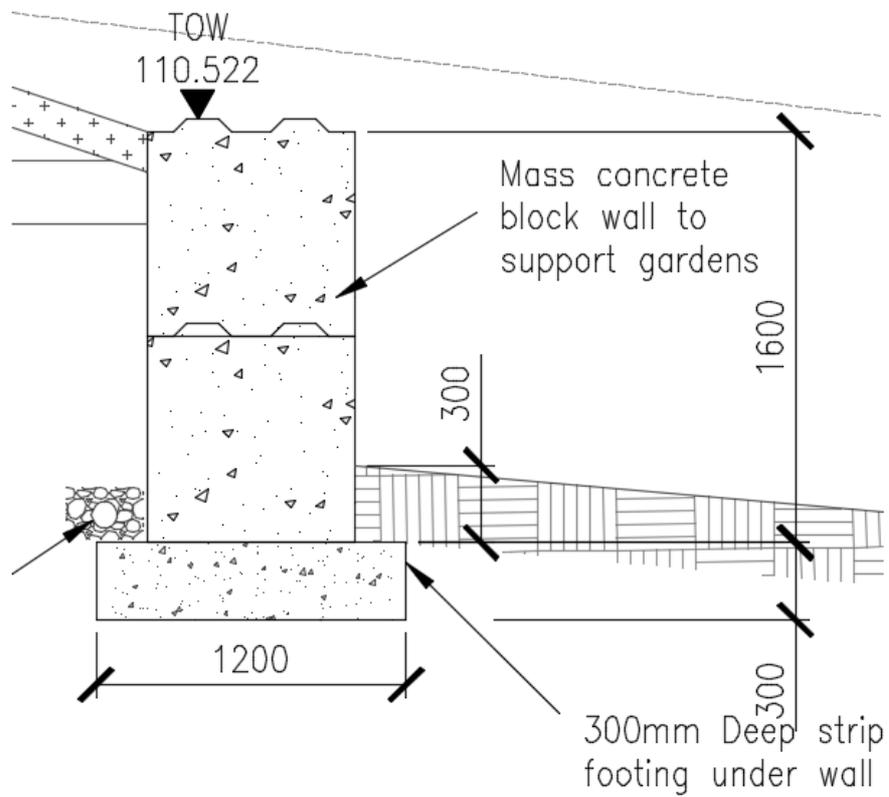
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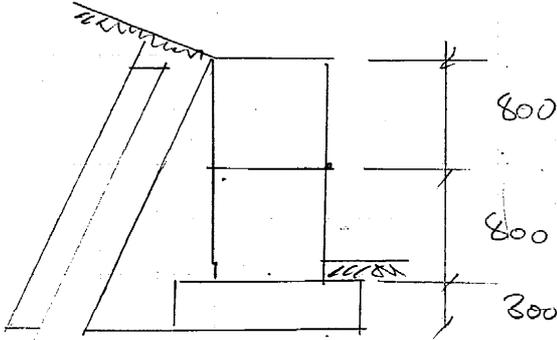
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Wall 1 Design



	Tim Anelay Associates Ltd. 11 Grange View, Crofton, Wakefield WF4 1RX Tel: 01924 865147 Mob: 07754 704748 Email: info@timanelayassociates.co.uk	PROJECT No.	CALCULATION SHEET No.
	PROJECT / ELEMENT	PREPARED BY:	DATE:
	WALL 1. - Gable	AN	TA

COMPACTED WITH WHACKER PLATE ONLY - GARDEN LOAD ONLY



$$\phi = 3^\circ$$

$$K_a = 0.41$$

$$E_{uh} = 19 \text{ kN/m}^3$$

$$C_{ov} = 25 \text{ kN/m}^3$$

$$S_{ov} = 2.50 \text{ kN/m}^2$$

CHECK TOP SECTION STABILITY

ONLY CHECK OVERTURNING - SHEAR IGNORED DUE TO INTERLOCKING

$$(D)_H = 0.410 \times 19 \times \frac{0.8^2}{2} \times 1.1 = 2.74 \text{ kN} \rightarrow \times \frac{0.8}{3} = 0.731 \text{ kNm} \curvearrowright$$

$$(L) = 0.410 \times 2.5 \times 0.8 \times 1.5 = 1.23 \text{ kN} \rightarrow \times \frac{0.8}{2} = 0.492 \text{ kNm} \curvearrowright$$

$$\text{RESTORING MOMENT} = 0.8 \times 0.8 \times 25 \times 0.9 \times 0.4 = 5.76 \text{ kNm} \curvearrowleft$$

$$FOS = 5.76 / (0.73 + 0.492) = 4.6 > 1.0 \checkmark$$

BOTTOM SECTION STABILITY

$$(D) = 0.410 \times 19 \times \frac{1.6^2}{2} \times 1.1 = 10.9 \text{ kN} \rightarrow \times \frac{1.6}{3} = 5.84 \text{ kNm} \curvearrowright$$

$$(L) = 0.410 \times 2.5 \times 1.6 \times 1.5 = 2.46 \text{ kN} \rightarrow \times \frac{1.6}{2} = 1.97 \text{ kNm} \curvearrowright$$

$$\text{RESTORING MOMENT} = 0.8 \times 1.6 \times 25 \times 0.9 \times 0.4 = 11.52 \text{ kNm} \curvearrowleft$$

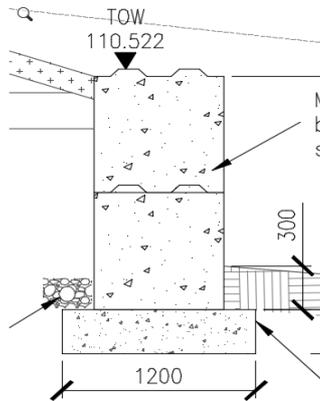
$$FOS = 1.47 > 1.0 \checkmark$$

$$\text{BASE SHEAR} = (0.8 \times 1.6 \times 25 \times 0.9) \times 0.5 = 14.4 \text{ kN}$$

$$FOS = 14.4 / 13.86 = 1.07 > 1.0 \text{ OK}$$

SEE EXCEL OUTPUT.

Wall 1 Top



Properties

Angle of repose	30 °
ko	0.41 slope
Earth Density	19 kN/m ³
Surcharge	2.5 kN/m ²
Concrete Density	25 kN/m ³
Retained Height	0.8 m
Toe	0 m
Stem Width	0.8 m
Heel	0 m
Base	0 m

Ref	Load	Axial	Horizontal	l/a	Mr	Mo
W1 (backfill)		0		0.8	0.00	
W2 (stem)		14.4		0.4	5.76	
W3 (base)		0		0.4	0.00	

F1	Surcharge		1.23	0.40		0.49
F2	Dead		2.74	0.27		0.73

		14.4	3.97		5.76	1.22
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Overturning Check

Mo (overturning) / Mr (restoring)
FOS=

4.71

Sliding Check

Axial 14.4 kN/m
Horizontal 3.97 kN/m
FOS= 1.81

using friction coefficient = 0.5
not critical due to interlocking

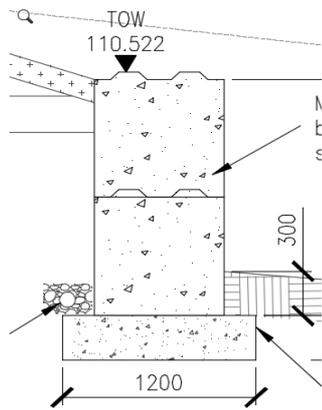
GBP Check

eccentricity Mr - Mo / Axial
GBP

0.32 m
30.47 kN/m²

PASS SAY OK

Wall 1 Base



Properties

Angle of repose	30 °
ko	0.41 slope
Earth Density	19 kN/m ³
Surcharge	2.5 kN/m ²
Concrete Density	25 kN/m ³
Retained Height	1.6 m
Toe	0 m
Stem Width	0.8 m
Heel	0 m
Base	0 m

Ref	Load	Axial	Horizontal	l/a	Mr	Mo
W1 (backfill)		0		0.8	0.00	
W2 (stem)		28.8		0.4	11.52	
W3 (base)		0		0.4	0.00	
F1	Surcharge		2.46	0.80		1.97
F2	Dead		10.97	0.53		5.85
		28.8	13.43		11.52	7.82

Overturning Check

Mo (overturning) / Mr (restoring)
FOS= **1.47**

Sliding Check

Axial 28.8 kN/m
Horizontal 13.43 kN/m
FOS= **1.07** using friction coefficient = 0.5

GBP Check

eccentricity Mr - Mo / Axial 0.13 m
GBP 149.36 kN/m² PASS SAY OK



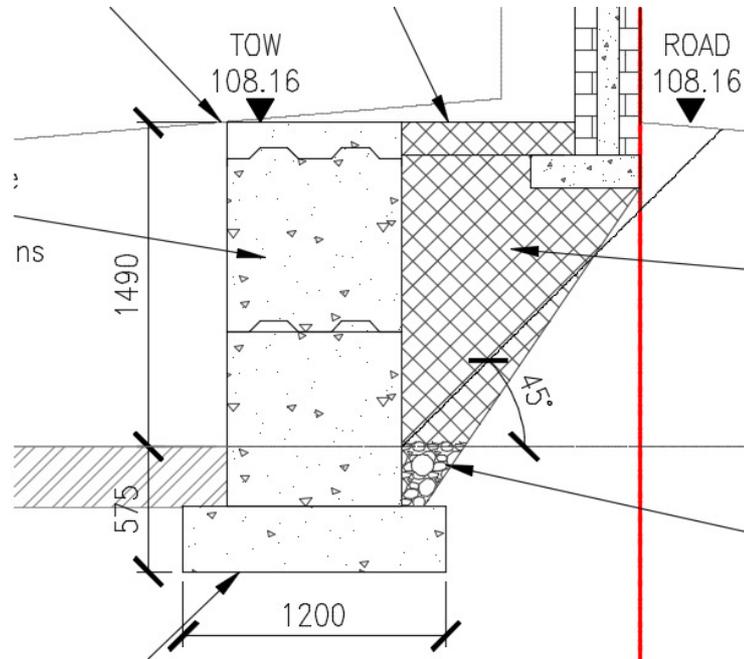
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Wall 2 Design



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RETAINING WALL ANALYSIS

In accordance with EN1997-1:2004 incorporating Corrigendum dated February 2009 and the UK National Annex incorporating Corrigendum No.1

Tedds calculation version 2.9.25

Analysis summary

Design summary

Overall design utilisation 0.983

Overall design status Pass

Description	Unit	Capacity	Applied	F o S	Result
Sliding stability	kN/m	36.6	35.9	1.017	PASS
Overturning stability	kNm/m	40	33	1.210	PASS
Bearing pressure	kN/m ²	150	115.9	1.294	PASS

Retaining wall details

Stem type	Cantilever with stepped rear face		
Stem height	$h_{\text{stem}} = 1765$ mm		
Number of steps	$N_{\text{steps}} = 3$		
Height step 1	$h_{s1} = 800$ mm	Thickness step 1	$t_{s1} = 800$ mm
Height step 2	$h_{s2} = 800$ mm	Thickness step 2	$t_{s2} = 800$ mm
Height step 3	$h_{s3} = 165$ mm	Thickness step 3	$t_{s3} = 800$ mm
Angle to rear face of stem	$\alpha = 90$ deg		
Stem density	$\gamma_{\text{stem}} = 25$ kN/m ³		
Toe length	$l_{\text{toe}} = 225$ mm		
Heel length	$l_{\text{heel}} = 225$ mm		
Base thickness	$t_{\text{base}} = 300$ mm		
Base density	$\gamma_{\text{base}} = 25$ kN/m ³		
Height of retained soil	$h_{\text{ret}} = 1490$ mm	Angle of soil surface	$\beta = 0$ deg
Depth of cover	$d_{\text{cover}} = 275$ mm		

Retained soil properties

Soil type	Medium dense well graded sand and gravel	
Moist density	$\gamma_{\text{mr}} = 20$ kN/m ³	
Saturated density	$\gamma_{\text{sr}} = 22.3$ kN/m ³	
Characteristic effective shear resistance angle		$\phi'_{r,k} = 30$ deg
Characteristic wall friction angle		$\delta_{r,k} = 15$ deg

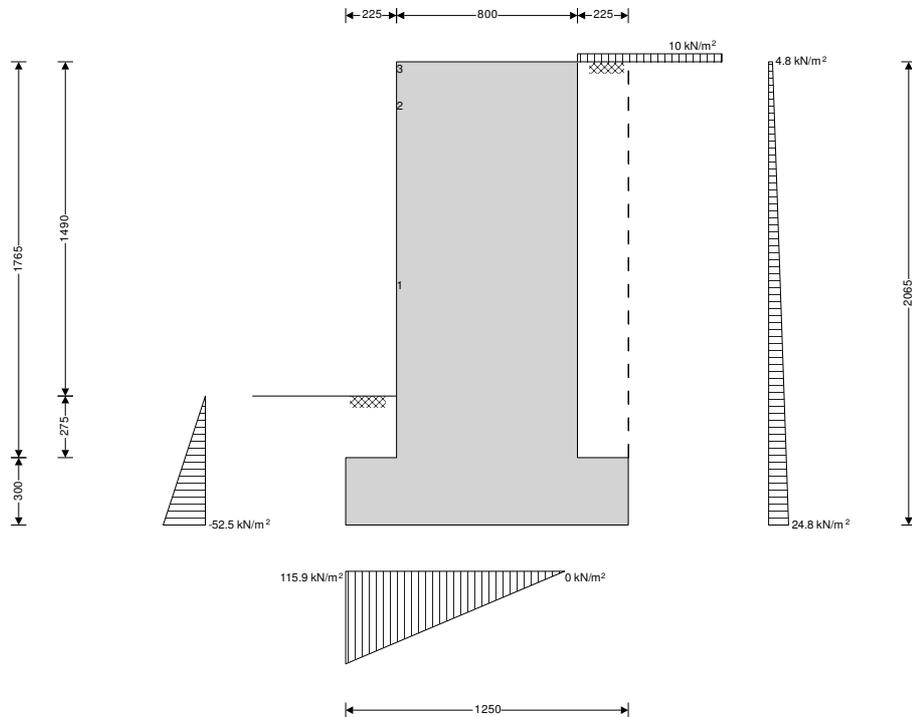
Base soil properties

Soil type	Medium dense well graded sand	
Soil density	$\gamma_b = 19$ kN/m ³	
Characteristic effective shear resistance angle		$\phi'_{b,k} = 30$ deg
Characteristic wall friction angle		$\delta_{b,k} = 15$ deg
Characteristic base friction angle		$\delta_{bb,k} = 30$ deg
Presumed bearing capacity	$P_{\text{bearing}} = 150$ kN/m ²	

Loading details

Permanent surcharge load Surcharge_G = 10 kN/m²

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General arrangement - sketch pressures relate to bearing check

Calculate retaining wall geometry

Base length	$l_{base} = 1250$ mm	Vertical distance	$X_{stem} = 625$ mm
Moist soil height	$h_{moist} = 1765$ mm	Vertical distance	$X_{base} = 625$ mm
Length of surcharge load	$l_{sur} = 225$ mm	Vertical distance	$X_{moist_v} = 1138$ mm
Vertical distance	$X_{sur_v} = 1138$ mm	Horizontal distance	$X_{moist_h} = 688$ mm
Effective height of wall	$h_{eff} = 2065$ mm	Vertical distance	$X_{pass_v} = 113$ mm
Horizontal distance	$X_{sur_h} = 1033$ mm	Horizontal distance	$X_{pass_h} = 192$ mm
Area of wall stem	$A_{stem} = 1.412$ m ²	Vertical distance	$X_{exc_v} = 113$ mm
Area of wall base	$A_{base} = 0.375$ m ²	Horizontal distance	$X_{exc_h} = 192$ mm
Area of moist soil	$A_{moist} = 0.397$ m ²		
Area of base soil	$A_{pass} = 0.062$ m ²		
Area of excavated base soil	$A_{exc} = 0.062$ m ²		

Using Coulomb theory

At rest pressure coefficient	$K_0 = 0.500$	Passive pressure coefficient	$K_P = 4.977$
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Bearing pressure check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{pass_v} = 56$ kN/m

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Horizontal forces on wall

Total $F_{total_h} = \max(F_{sur_h} + F_{moist_h} + F_{pass_h} - F_{total_v} \times \tan(\delta_{bb,k}), 0 \text{ kN/m}) = 0 \text{ kN/m}$

Moments on wall

Total $M_{total} = M_{stem} + M_{base} + M_{sur} + M_{moist} + M_{pass} = 18.1 \text{ kNm/m}$

Check bearing pressure

Bearing pressure at toe $q_{toe} = 115.9 \text{ kN/m}^2$ Bearing pressure at heel $q_{heel} = 0 \text{ kN/m}^2$

Factor of safety $FoS_{bp} = 1.294$

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

Design approach 1

Partial factors on actions - Table A.3 - Combination 1

Partial factor set A1

Permanent unfavourable action $\gamma_G = 1.35$ Permanent favourable action $\gamma_{Gf} = 1.00$

Variable unfavourable action $\gamma_Q = 1.50$ Variable favourable action $\gamma_{Qf} = 0.00$

Partial factors for soil parameters – Table A.4 - Combination 1

Soil parameter set M1

Angle of shearing resistance $\gamma_{\phi'} = 1.00$ Effective cohesion $\gamma_c = 1.00$

Weight density $\gamma_r = 1.00$

Retained soil properties

Design moist density $\gamma_{mr}' = 20 \text{ kN/m}^3$ Design saturated density $\gamma_{sr}' = 22.3 \text{ kN/m}^3$

Des. eff. shear resist. angle $\phi'_{r,d} = 30 \text{ deg}$ Design wall friction angle $\delta_{r,d} = 15 \text{ deg}$

Base soil properties

Design soil density $\gamma_b' = 19 \text{ kN/m}^3$ Des. eff. shear resist. angle $\phi'_{b,d} = 30 \text{ deg}$

Design wall friction angle $\delta_{b,d} = 15 \text{ deg}$ Design base friction angle $\delta_{bb,d} = 30 \text{ deg}$

Design effective cohesion $c'_{b,d} = 0 \text{ kN/m}^2$

Using Coulomb theory

At rest pressure coefficient $K_0 = 0.500$ Passive pressure coefficient $K_P = 4.977$

Sliding check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{exc_v} = 56 \text{ kN/m}$

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{moist_h} = 41.3 \text{ kN/m}$

Check stability against sliding

Resistance to sliding $F_{rest} = 47.5 \text{ kN/m}$ Factor of safety $FoS_{sl} = 1.15$

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{exc_v} = 56 \text{ kN/m}$

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{moist_h} + F_{exc_h} = 26.2 \text{ kN/m}$

Overturning moments on wall

Total $M_{total_OT} = M_{sur_OT} + M_{moist_OT} = 33 \text{ kNm/m}$

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Restoring moments on wall

Total $M_{total_R} = M_{stem_R} + M_{base_R} + M_{moist_R} + M_{exc_R} = 40 \text{ kNm/m}$

Check stability against overturning

Factor of safety $FoS_{ot} = 1.21$

PASS - Maximum restoring moment is greater than overturning moment

Design approach 1

Partial factors on actions - Table A.3 - Combination 2

Partial factor set A2

Permanent unfavourable action $\gamma_G = 1.00$ Permanent favourable

Variable unfavourable action $\gamma_Q = 1.30$ Variable favourable action $\gamma_{Qf} = 0.00$

Partial factors for soil parameters – Table A.4 - Combination 2

Soil parameter set M2

Angle of shearing resistance $\gamma_\psi = 1.25$ Effective cohesion $\gamma_{c'} = 1.25$

Weight density $\gamma_r = 1.00$

Retained soil properties

Design moist density $\gamma_{mr}' = 20 \text{ kN/m}^3$ Design saturated density $\gamma_{sr}' = 22.3 \text{ kN/m}^3$

Des. eff. shear resist. angle $\phi'_{r,d} = 24.8 \text{ deg}$ Design wall friction angle $\delta_{r,d} = 12.1 \text{ deg}$

Base soil properties

Design soil density $\gamma_b' = 19 \text{ kN/m}^3$ Des. eff. shear resist. angle $\phi'_{b,d} = 24.8 \text{ deg}$

Design wall friction angle $\delta_{b,d} = 12.1 \text{ deg}$ Design base friction angle $\delta_{bb,d} = 24.8 \text{ deg}$

Design effective cohesion $c'_{b,d} = 0 \text{ kN/m}^2$

Using Coulomb theory

At rest pressure coefficient $K_0 = 0.581$ Passive pressure coefficient $K_P = 3.473$

Sliding check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{exc_v} = 56 \text{ kN/m}$

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{moist_h} = 35.9 \text{ kN/m}$

Check stability against sliding

Resistance to sliding $F_{rest} = 36.6 \text{ kN/m}$ Factor of safety $FoS_{sl} = 1.017$

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{exc_v} = 56 \text{ kN/m}$

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{moist_h} + F_{exc_h} = 25.3 \text{ kN/m}$

Overturning moments on wall

Total $M_{total_OT} = M_{sur_OT} + M_{moist_OT} = 28.8 \text{ kNm/m}$

Restoring moments on wall

Total $M_{total_R} = M_{stem_R} + M_{base_R} + M_{moist_R} + M_{exc_R} = 39.1 \text{ kNm/m}$

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Check stability against overturning

Factor of safety $FoS_{ot} = 1.36$

PASS - Maximum restoring moment is greater than overturning moment



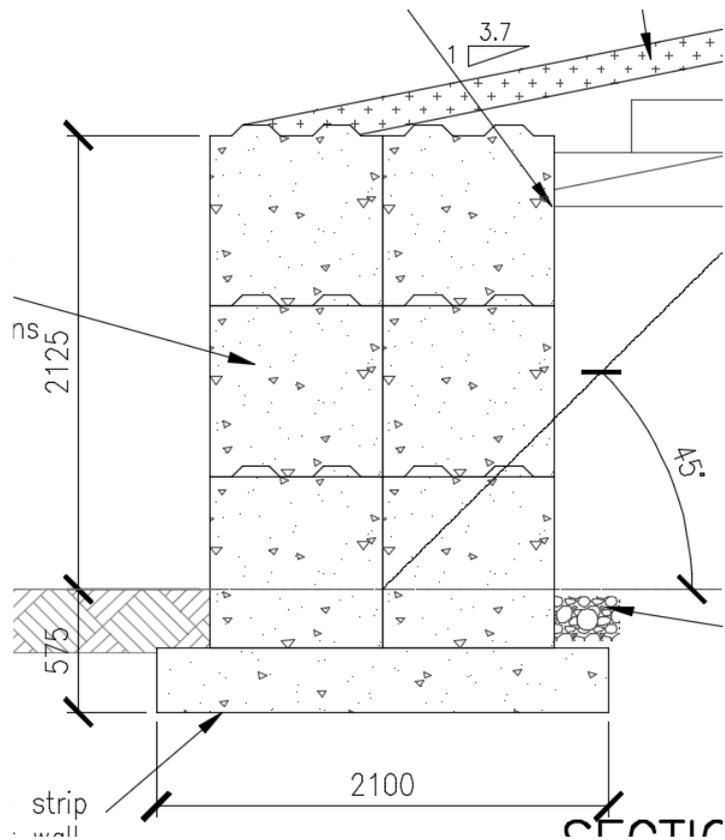
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Wall 3 Design



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RETAINING WALL ANALYSIS

In accordance with EN1997-1:2004 incorporating Corrigendum dated February 2009 and the UK National Annex incorporating Corrigendum No.1

Tedds calculation version 2.9.25

Analysis summary

Design summary

Overall design utilisation 0.999

Overall design status Pass

Description	Unit	Capacity	Applied	F o S	Result
Sliding stability	kN/m	69.4	69.3	1.001	PASS
Overturning stability	kNm/m	143.2	83.5	1.715	PASS
Bearing pressure	kN/m ²	150	124.8	1.202	PASS

Retaining wall details

Stem type	Cantilever with stepped rear face		
Stem height	$h_{\text{stem}} = 2400$ mm		
Number of steps	$N_{\text{steps}} = 3$		
Height step 1	$h_{s1} = 800$ mm	Thickness step 1	$t_{s1} = 1600$ mm
Height step 2	$h_{s2} = 800$ mm	Thickness step 2	$t_{s2} = 1600$ mm
Height step 3	$h_{s3} = 800$ mm	Thickness step 3	$t_{s3} = 1600$ mm
Angle to rear face of stem	$\alpha = 90$ deg		
Stem density	$\gamma_{\text{stem}} = 25$ kN/m ³		
Toe length	$l_{\text{toe}} = 250$ mm		
Heel length	$l_{\text{heel}} = 250$ mm		
Base thickness	$t_{\text{base}} = 300$ mm		
Base density	$\gamma_{\text{base}} = 25$ kN/m ³		
Height of retained soil	$h_{\text{ret}} = 2125$ mm	Angle of soil surface	$\beta = 15$ deg
Depth of cover	$d_{\text{cover}} = 275$ mm		

Retained soil properties

Soil type	Medium dense well graded sand and gravel	
Moist density	$\gamma_{\text{mr}} = 19$ kN/m ³	
Saturated density	$\gamma_{\text{sr}} = 22.3$ kN/m ³	
Characteristic effective shear resistance angle		$\phi'_{r,k} = 30$ deg
Characteristic wall friction angle		$\delta_{r,k} = 15$ deg

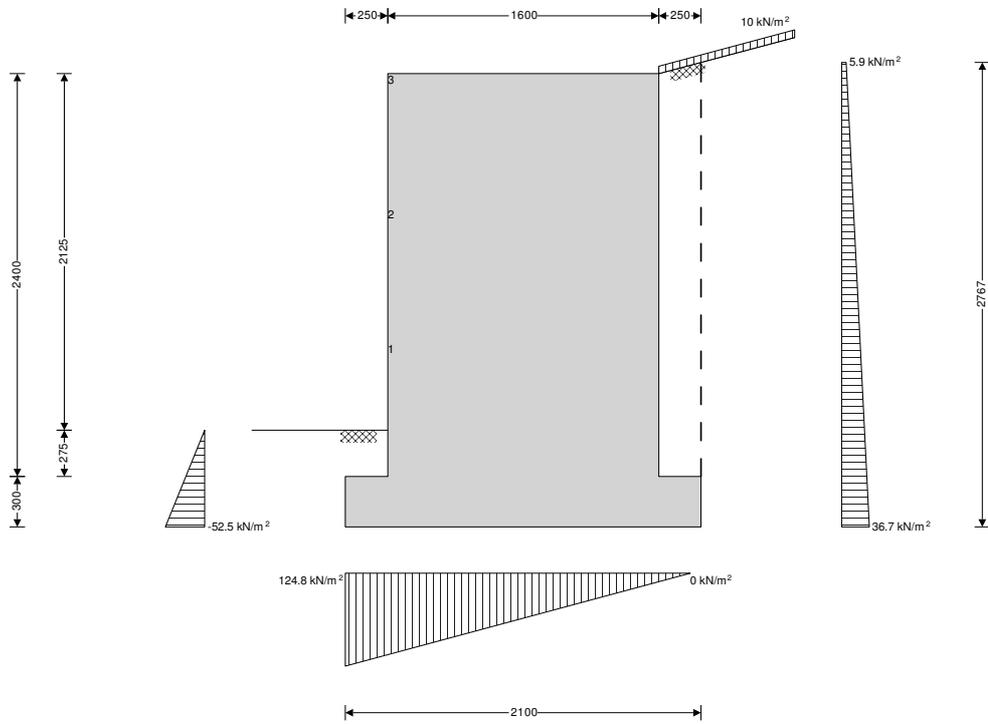
Base soil properties

Soil type	Medium dense well graded sand	
Soil density	$\gamma_b = 19$ kN/m ³	
Characteristic effective shear resistance angle		$\phi'_{b,k} = 30$ deg
Characteristic wall friction angle		$\delta_{b,k} = 15$ deg
Characteristic base friction angle		$\delta_{bb,k} = 30$ deg
Presumed bearing capacity	$P_{\text{bearing}} = 150$ kN/m ²	

Loading details

Permanent surcharge load Surcharge_G = 10 kN/m²

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General arrangement - sketch pressures relate to bearing check

Calculate retaining wall geometry

Base length	$l_{base} = 2100$ mm	Vertical distance	$X_{stem} = 1050$ mm
Moist soil height	$h_{moist} = 2400$ mm	Vertical distance	$X_{base} = 1050$ mm
Length of surcharge load	$l_{sur} = 250$ mm	Vertical distance	$X_{moist_v} = 1976$ mm
Vertical distance	$X_{sur_v} = 1975$ mm	Horizontal distance	$X_{moist_h} = 922$ mm
Effective height of wall	$h_{eff} = 2767$ mm	Vertical distance	$X_{pass_v} = 125$ mm
Horizontal distance	$X_{sur_h} = 1383$ mm	Horizontal distance	$X_{pass_h} = 192$ mm
Area of wall stem	$A_{stem} = 3.84$ m ²	Vertical distance	$X_{exc_v} = 125$ mm
Area of wall base	$A_{base} = 0.63$ m ²	Horizontal distance	$X_{exc_h} = 192$ mm
Area of moist soil	$A_{moist} = 0.608$ m ²		
Area of base soil	$A_{pass} = 0.069$ m ²		
Area of excavated base soil	$A_{exc} = 0.069$ m ²		

Using Coulomb theory

At rest pressure coefficient	$K_0 = 0.608$	Passive pressure coefficient	$K_P = 4.977$
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Bearing pressure check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{pass_v} = 127.1$ kN/m

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Horizontal forces on wall

Total $F_{total_h} = \max(F_{sur_h} + F_{moist_h} + F_{pass_h} - F_{total_v} \times \tan(\delta_{bb,k}), 0 \text{ kN/m}) = 0 \text{ kN/m}$

Moments on wall

Total $M_{total} = M_{stem} + M_{base} + M_{sur} + M_{moist} + M_{pass} = 86.3 \text{ kNm/m}$

Check bearing pressure

Bearing pressure at toe $q_{toe} = 124.8 \text{ kN/m}^2$ Bearing pressure at heel $q_{heel} = 0 \text{ kN/m}^2$

Factor of safety $FoS_{bp} = 1.202$

PASS - Allowable bearing pressure exceeds maximum applied bearing pressure

Design approach 1

Partial factors on actions - Table A.3 - Combination 1

Partial factor set A1

Permanent unfavourable action $\gamma_G = 1.35$ Permanent favourable action $\gamma_{Gf} = 1.00$

Variable unfavourable action $\gamma_Q = 1.50$ Variable favourable action $\gamma_{Qf} = 0.00$

Partial factors for soil parameters – Table A.4 - Combination 1

Soil parameter set M1

Angle of shearing resistance $\gamma_{\phi'} = 1.00$ Effective cohesion $\gamma_c = 1.00$

Weight density $\gamma_r = 1.00$

Retained soil properties

Design moist density $\gamma_{mr}' = 19 \text{ kN/m}^3$ Design saturated density $\gamma_{sr}' = 22.3 \text{ kN/m}^3$

Des. eff. shear resist. angle $\phi'_{r,d} = 30 \text{ deg}$ Design wall friction angle $\delta_{r,d} = 15 \text{ deg}$

Base soil properties

Design soil density $\gamma_b' = 19 \text{ kN/m}^3$ Des. eff. shear resist. angle $\phi'_{b,d} = 30 \text{ deg}$

Design wall friction angle $\delta_{b,d} = 15 \text{ deg}$ Design base friction angle $\delta_{bb,d} = 30 \text{ deg}$

Design effective cohesion $c'_{b,d} = 0 \text{ kN/m}^2$

Using Coulomb theory

At rest pressure coefficient $K_0 = 0.608$ Passive pressure coefficient $K_P = 4.977$

Sliding check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{exc_v} = 127.1 \text{ kN/m}$

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{moist_h} = 79.6 \text{ kN/m}$

Check stability against sliding

Resistance to sliding $F_{rest} = 88.5 \text{ kN/m}$ Factor of safety $FoS_{sl} = 1.112$

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{exc_v} = 127.1 \text{ kN/m}$

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{moist_h} + F_{exc_h} = 64.5 \text{ kN/m}$

Overturning moments on wall

Total $M_{total_OT} = M_{sur_OT} + M_{moist_OT} = 83.5 \text{ kNm/m}$

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Restoring moments on wall

Total $M_{total_R} = M_{stem_R} + M_{base_R} + M_{moist_R} + M_{exc_R} = 143.2$ kNm/m

Check stability against overturning

Factor of safety $FoS_{ot} = 1.715$

PASS - Maximum restoring moment is greater than overturning moment

Design approach 1

Partial factors on actions - Table A.3 - Combination 2

Partial factor set A2

Permanent unfavourable action $\gamma_G = 1.00$ Permanent favourable

action $\gamma_{Gf} = 1.00$

Variable unfavourable action $\gamma_Q = 1.30$ Variable favourable action $\gamma_{Qf} = 0.00$

Partial factors for soil parameters – Table A.4 - Combination 2

Soil parameter set M2

Angle of shearing resistance $\gamma_\psi = 1.25$ Effective cohesion $\gamma_{c'} = 1.25$

Weight density $\gamma_f = 1.00$

Retained soil properties

Design moist density $\gamma_{mr}' = 19$ kN/m³ Design saturated density $\gamma_{sr}' = 22.3$ kN/m³

Des. eff. shear resist. angle $\phi'_{r,d} = 24.8$ deg Design wall friction angle $\delta_{r,d} = 12.1$ deg

Base soil properties

Design soil density $\gamma_b' = 19$ kN/m³ Des. eff. shear resist. angle $\phi'_{b,d} = 24.8$ deg

Design wall friction angle $\delta_{b,d} = 12.1$ deg Design base friction angle $\delta_{bb,d} = 24.8$ deg

Design effective cohesion $c'_{b,d} = 0$ kN/m²

Using Coulomb theory

At rest pressure coefficient $K_0 = 0.706$ Passive pressure coefficient $K_P = 3.473$

Sliding check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{exc_v} = 127.1$ kN/m

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{moist_h} = 69.3$ kN/m

Check stability against sliding

Resistance to sliding $F_{rest} = 69.4$ kN/m Factor of safety $FoS_{sl} = 1.001$

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{exc_v} = 127.1$ kN/m

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{moist_h} + F_{exc_h} = 58.7$ kN/m

Overturning moments on wall

Total $M_{total_OT} = M_{sur_OT} + M_{moist_OT} = 72.7$ kNm/m

Restoring moments on wall

Total $M_{total_R} = M_{stem_R} + M_{base_R} + M_{moist_R} + M_{exc_R} = 142.4$ kNm/m

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Check stability against overturning

Factor of safety

FoS_{ot} = **1.957**

PASS - Maximum restoring moment is greater than overturning moment



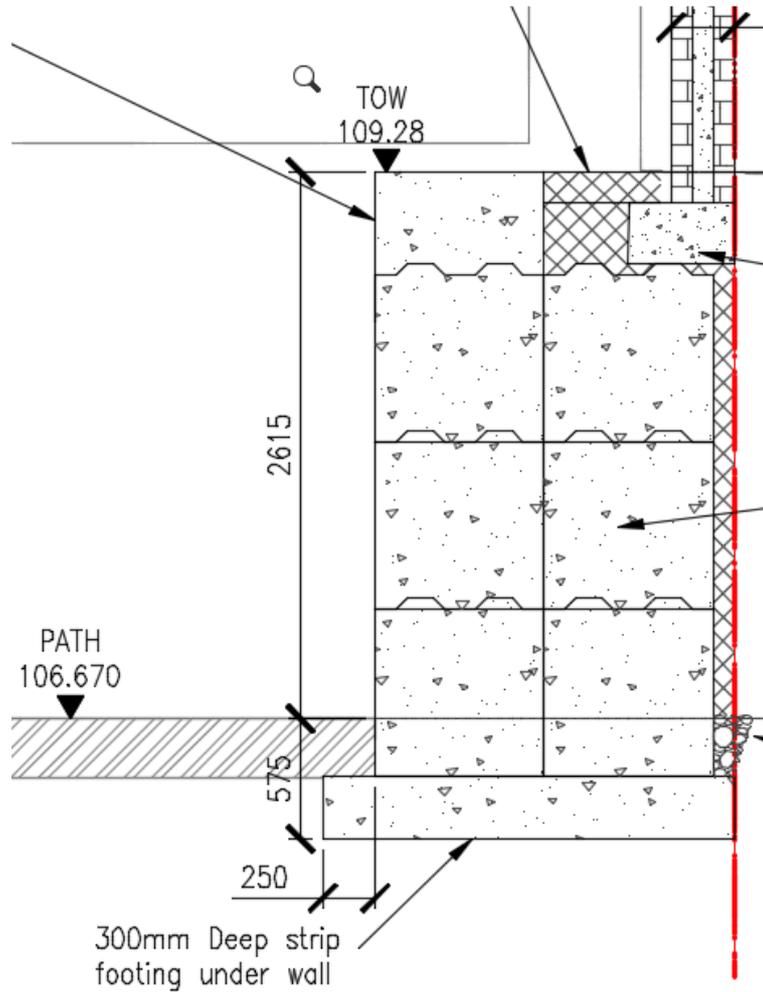
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Wall 4 Design



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RETAINING WALL ANALYSIS

In accordance with EN1997-1:2004 incorporating Corrigendum dated February 2009 and the UK National Annex incorporating Corrigendum No.1

Tedds calculation version 2.9.25

Analysis summary

Design summary

Overall design utilisation 1.102

Overall design status Fail

Description	Unit	Capacity	Applied	F o S	Result
Sliding stability	kN/m	74.4	73	1.019	PASS
Overturning stability	kNm/m	149.1	100.2	1.488	PASS
Bearing pressure	kN/m ²	150	165.3	0.907	FAIL

Retaining wall details

Stem type	Cantilever with stepped rear face		
Stem height	$h_{\text{stem}} = 2890$ mm		
Number of steps	$N_{\text{steps}} = 4$		
Height step 1	$h_{s1} = 800$ mm	Thickness step 1	$t_{s1} = 1600$ mm
Height step 2	$h_{s2} = 800$ mm	Thickness step 2	$t_{s2} = 1600$ mm
Height step 3	$h_{s3} = 800$ mm	Thickness step 3	$t_{s3} = 1600$ mm
Height step 4	$h_{s4} = 490$ mm	Thickness step 4	$t_{s4} = 1600$ mm
Angle to rear face of stem	$\alpha = 90$ deg		
Stem density	$\gamma_{\text{stem}} = 25$ kN/m ³		
Toe length	$l_{\text{toe}} = 250$ mm		
Heel length	$l_{\text{heel}} = 100$ mm		
Base thickness	$t_{\text{base}} = 300$ mm		
Base density	$\gamma_{\text{base}} = 25$ kN/m ³		
Height of retained soil	$h_{\text{ret}} = 2615$ mm	Angle of soil surface	$\beta = 0$ deg
Depth of cover	$d_{\text{cover}} = 275$ mm		

Retained soil properties

Soil type	Medium dense well graded sand and gravel		
Moist density	$\gamma_{\text{mr}} = 19$ kN/m ³		
Saturated density	$\gamma_{\text{sr}} = 22.3$ kN/m ³		
Characteristic effective shear resistance angle		$\phi'_{r,k} = 30$ deg	
Characteristic wall friction angle		$\delta_{r,k} = 15$ deg	

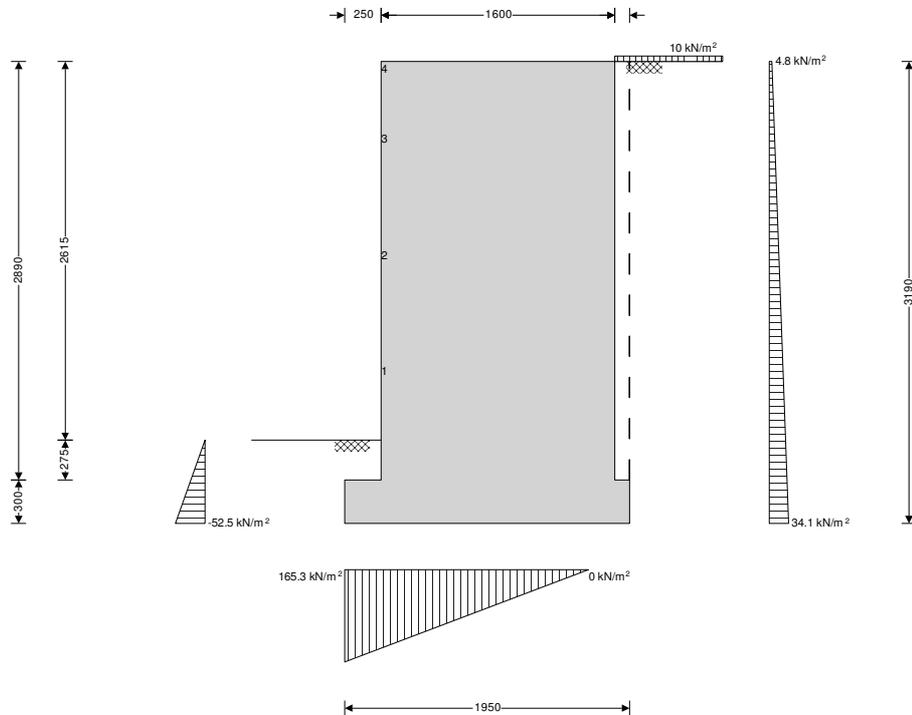
Base soil properties

Soil type	Medium dense well graded sand		
Soil density	$\gamma_b = 19$ kN/m ³		
Characteristic effective shear resistance angle		$\phi'_{b,k} = 30$ deg	
Characteristic wall friction angle		$\delta_{b,k} = 15$ deg	
Characteristic base friction angle		$\delta_{bb,k} = 30$ deg	
Presumed bearing capacity	$P_{\text{bearing}} = 150$ kN/m ²		

Loading details

Permanent surcharge load Surcharge_G = 10 kN/m²

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General arrangement - sketch pressures relate to bearing check

Calculate retaining wall geometry

Base length	$l_{base} = 1950$ mm	Vertical distance	$X_{stem} = 1050$ mm
Moist soil height	$h_{moist} = 2890$ mm	Vertical distance	$X_{base} = 975$ mm
Length of surcharge load	$l_{sur} = 100$ mm	Vertical distance	$X_{moist_v} = 1900$ mm
Vertical distance	$X_{sur_v} = 1900$ mm	Horizontal distance	$X_{moist_h} = 1063$ mm
Effective height of wall	$h_{eff} = 3190$ mm	Vertical distance	$X_{pass_v} = 125$ mm
Horizontal distance	$X_{sur_h} = 1595$ mm	Horizontal distance	$X_{pass_h} = 192$ mm
Area of wall stem	$A_{stem} = 4.624$ m ²	Vertical distance	$X_{exc_v} = 125$ mm
Area of wall base	$A_{base} = 0.585$ m ²	Horizontal distance	$X_{exc_h} = 192$ mm
Area of moist soil	$A_{moist} = 0.289$ m ²		
Area of base soil	$A_{pass} = 0.069$ m ²		
Area of excavated base soil	$A_{exc} = 0.069$ m ²		

Using Coulomb theory

At rest pressure coefficient	$K_0 = 0.500$	Passive pressure coefficient	$K_P = 4.977$
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Bearing pressure check

Vertical forces on wall

Total	$F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{pass_v} = 138$ kN/m
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Horizontal forces on wall

Total $F_{total_h} = \max(F_{sur_h} + F_{moist_h} + F_{pass_h} - F_{total_v} \times \tan(\delta_{bb,k}), 0 \text{ kN/m}) = 0 \text{ kN/m}$

Moments on wall

Total $M_{total} = M_{stem} + M_{base} + M_{sur} + M_{moist} + M_{pass} = 76.8 \text{ kNm/m}$

Check bearing pressure

Bearing pressure at toe $q_{toe} = 165.3 \text{ kN/m}^2$ Bearing pressure at heel $q_{heel} = 0 \text{ kN/m}^2$

Factor of safety $FoS_{bp} = 0.907$

FAIL - Maximum applied bearing pressure exceeds allowable bearing pressure

Design approach 1

Partial factors on actions - Table A.3 - Combination 1

Partial factor set A1

Permanent unfavourable action $\gamma_G = 1.35$ Permanent favourable action $\gamma_{Gf} = 1.00$

Variable unfavourable action $\gamma_Q = 1.50$ Variable favourable action $\gamma_{Qf} = 0.00$

Partial factors for soil parameters – Table A.4 - Combination 1

Soil parameter set M1

Angle of shearing resistance $\gamma_{\phi'} = 1.00$ Effective cohesion $\gamma_c = 1.00$

Weight density $\gamma_r = 1.00$

Retained soil properties

Design moist density $\gamma_{mr}' = 19 \text{ kN/m}^3$ Design saturated density $\gamma_{sr}' = 22.3 \text{ kN/m}^3$

Des. eff. shear resist. angle $\phi'_{r,d} = 30 \text{ deg}$ Design wall friction angle $\delta_{r,d} = 15 \text{ deg}$

Base soil properties

Design soil density $\gamma_b' = 19 \text{ kN/m}^3$ Des. eff. shear resist. angle $\phi'_{b,d} = 30 \text{ deg}$

Design wall friction angle $\delta_{b,d} = 15 \text{ deg}$ Design base friction angle $\delta_{bb,d} = 30 \text{ deg}$

Design effective cohesion $c'_{b,d} = 0 \text{ kN/m}^2$

Using Coulomb theory

At rest pressure coefficient $K_0 = 0.500$ Passive pressure coefficient $K_P = 4.977$

Sliding check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{exc_v} = 138 \text{ kN/m}$

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{moist_h} = 83.8 \text{ kN/m}$

Check stability against sliding

Resistance to sliding $F_{rest} = 94.8 \text{ kN/m}$ Factor of safety $FoS_{sl} = 1.131$

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{exc_v} = 138 \text{ kN/m}$

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{moist_h} + F_{exc_h} = 68.7 \text{ kN/m}$

Overturning moments on wall

Total $M_{total_OT} = M_{sur_OT} + M_{moist_OT} = 100.2 \text{ kNm/m}$

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Restoring moments on wall

Total $M_{total_R} = M_{stem_R} + M_{base_R} + M_{moist_R} + M_{exc_R} = 149.1$ kNm/m

Check stability against overturning

Factor of safety $FoS_{ot} = 1.488$

PASS - Maximum restoring moment is greater than overturning moment

Design approach 1

Partial factors on actions - Table A.3 - Combination 2

Partial factor set A2

Permanent unfavourable action $\gamma_G = 1.00$ Permanent favourable

action $\gamma_{Gf} = 1.00$

Variable unfavourable action $\gamma_Q = 1.30$ Variable favourable action $\gamma_{Qf} = 0.00$

Partial factors for soil parameters – Table A.4 - Combination 2

Soil parameter set M2

Angle of shearing resistance $\gamma_{\psi} = 1.25$ Effective cohesion $\gamma_{c'} = 1.25$

Weight density $\gamma_f = 1.00$

Retained soil properties

Design moist density $\gamma_{mr}' = 19$ kN/m³ Design saturated density $\gamma_{sr}' = 22.3$ kN/m³

Des. eff. shear resist. angle $\phi'_{r,d} = 24.8$ deg Design wall friction angle $\delta_{r,d} = 12.1$ deg

Base soil properties

Design soil density $\gamma_b' = 19$ kN/m³ Des. eff. shear resist. angle $\phi'_{b,d} = 24.8$ deg

Design wall friction angle $\delta_{b,d} = 12.1$ deg Design base friction angle $\delta_{bb,d} = 24.8$ deg

Design effective cohesion $c'_{b,d} = 0$ kN/m²

Using Coulomb theory

At rest pressure coefficient $K_0 = 0.581$ Passive pressure coefficient $K_P = 3.473$

Sliding check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{exc_v} = 138$ kN/m

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{moist_h} = 73$ kN/m

Check stability against sliding

Resistance to sliding $F_{rest} = 74.4$ kN/m Factor of safety $FoS_{sl} = 1.019$

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Total $F_{total_v} = F_{stem} + F_{base} + F_{sur_v} + F_{moist_v} + F_{exc_v} = 138$ kN/m

Horizontal forces on wall

Total $F_{total_h} = F_{sur_h} + F_{moist_h} + F_{exc_h} = 62.3$ kN/m

Overturning moments on wall

Total $M_{total_OT} = M_{sur_OT} + M_{moist_OT} = 87.3$ kNm/m

Restoring moments on wall

Total $M_{total_R} = M_{stem_R} + M_{base_R} + M_{moist_R} + M_{exc_R} = 148.3$ kNm/m

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Check stability against overturning

Factor of safety $FoS_{ot} = 1.699$

PASS - Maximum restoring moment is greater than overturning moment