

 Vale Consultancy 29 Bocam Park Old Field Road, Pencoed Bridgend, CF35 5LJ	Project The Norton Tavern				Job no. 20391	
	Calcs for 3 Block legato wall				Start page no./Revision 1	
	Calcs by J	Calcs date 24/06/2026	Checked by	Checked date	Approved by	Approved date

RETAINING WALL ANALYSIS & DESIGN (EN1992/EN1996/EN1997)

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 2.9.22

Retaining wall details

Stem type	Cantilever
Stem height	$h_{\text{stem}} = 1800 \text{ mm}$
Stem thickness	$t_{\text{stem}} = 600 \text{ mm}$
Angle to rear face of stem	$\alpha = 90 \text{ deg}$
Stem density	$\gamma_{\text{stem}} = 25 \text{ kN/m}^3$
Base thickness	$t_{\text{base}} = 100 \text{ mm}$
Base density	$\gamma_{\text{base}} = 25 \text{ kN/m}^3$
Height of retained soil	$h_{\text{ret}} = 1800 \text{ mm}$
Angle of soil surface	$\beta = 10 \text{ deg}$
Depth of cover	$d_{\text{cover}} = 0 \text{ mm}$

Retained soil properties

Soil type	Very dense well graded sand
Moist density	$\gamma_{\text{mr}} = 18 \text{ kN/m}^3$
Saturated density	$\gamma_{\text{sr}} = 21 \text{ kN/m}^3$
Characteristic effective shear resistance angle	$\phi'_{\text{r,k}} = 46 \text{ deg}$
Characteristic wall friction angle	$\delta_{\text{r,k}} = 21 \text{ deg}$

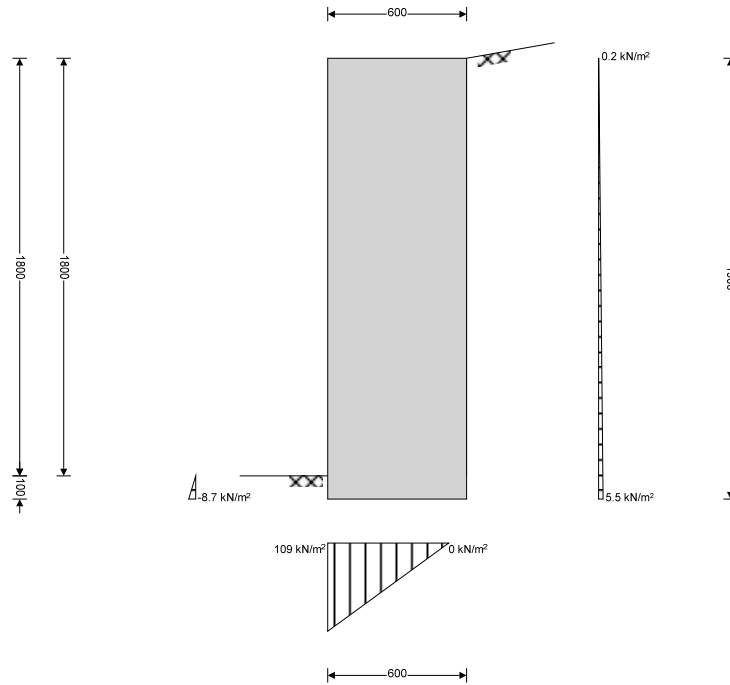
Base soil properties

Soil type	Medium dense well graded sand
Soil density	$\gamma_{\text{b}} = 18 \text{ kN/m}^3$
Characteristic effective shear resistance angle	$\phi'_{\text{b,k}} = 30 \text{ deg}$
Characteristic wall friction angle	$\delta_{\text{b,k}} = 15 \text{ deg}$
Characteristic base friction angle	$\delta_{\text{bb,k}} = 30 \text{ deg}$
Presumed bearing capacity	$P_{\text{bearing}} = 150 \text{ kN/m}^2$

Loading details

Variable surcharge load	Surcharge _Q = 1.5 kN/m ²
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General arrangement - sketch pressures relate to bearing check

Calculate retaining wall geometry

Base length

$$l_{\text{base}} = t_{\text{stem}} = \mathbf{600 \text{ mm}}$$

Moist soil height

$$h_{\text{moist}} = h_{\text{soil}} = \mathbf{1800 \text{ mm}}$$

Length of surcharge load

$$l_{\text{sur}} = l_{\text{heel}} = \mathbf{0 \text{ mm}}$$

- Distance to vertical component

$$x_{\text{sur}_v} = l_{\text{base}} - l_{\text{heel}} / 2 = \mathbf{600 \text{ mm}}$$

Effective height of wall

$$h_{\text{eff}} = h_{\text{base}} + d_{\text{cover}} + h_{\text{ret}} + l_{\text{sur}} \times \tan(\beta) = \mathbf{1900 \text{ mm}}$$

- Distance to horizontal component

$$x_{\text{sur}_h} = h_{\text{eff}} / 2 = \mathbf{950 \text{ mm}}$$

Area of wall stem

$$A_{\text{stem}} = h_{\text{stem}} \times t_{\text{stem}} = \mathbf{1.08 \text{ m}^2}$$

- Distance to vertical component

$$x_{\text{stem}} = l_{\text{toe}} + t_{\text{stem}} / 2 = \mathbf{300 \text{ mm}}$$

Area of wall base

$$A_{\text{base}} = l_{\text{base}} \times t_{\text{base}} = \mathbf{0.06 \text{ m}^2}$$

- Distance to vertical component

$$x_{\text{base}} = l_{\text{base}} / 2 = \mathbf{300 \text{ mm}}$$

Using Coulomb theory

Active pressure coefficient

$$K_A = \sin(\alpha + \phi'_{r,k})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,k}) \times [1 + \sqrt{[\sin(\phi'_{r,k} + \delta_{r,k}) \times \sin(\phi'_{r,k} - \beta) / (\sin(\alpha - \delta_{r,k}) \times \sin(\alpha + \beta))]}]^2) = \mathbf{0.166}$$

Passive pressure coefficient

$$K_P = \sin(90 - \phi'_{b,k})^2 / (\sin(90 + \delta_{b,k}) \times [1 - \sqrt{[\sin(\phi'_{b,k} + \delta_{b,k}) \times \sin(\phi'_{b,k}) / (\sin(90 + \delta_{b,k}))]}]^2) = \mathbf{4.977}$$

Bearing pressure check

Vertical forces on wall

Wall stem

$$F_{\text{stem}} = A_{\text{stem}} \times \gamma_{\text{stem}} = \mathbf{27 \text{ kN/m}}$$

Wall base

$$F_{\text{base}} = A_{\text{base}} \times \gamma_{\text{base}} = \mathbf{1.5 \text{ kN/m}}$$

Total

$$F_{\text{total}_v} = F_{\text{stem}} + F_{\text{base}} = \mathbf{28.5 \text{ kN/m}}$$

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Horizontal forces on wall

Surcharge load	$F_{sur_h} = K_A \times \cos(\delta_{r,k}) \times \text{Surcharge}_Q \times h_{eff} = \mathbf{0.4 \text{ kN/m}}$
Moist retained soil	$F_{moist_h} = K_A \times \cos(\delta_{r,k}) \times \gamma_{mr} \times h_{eff}^2 / 2 = \mathbf{5 \text{ kN/m}}$
Base soil	$F_{pass_h} = -K_P \times \cos(\delta_{b,k}) \times \gamma_b \times (d_{cover} + h_{base})^2 / 2 = \mathbf{-0.4 \text{ kN/m}}$
Total	$F_{total_h} = \max(F_{sur_h} + F_{moist_h} + F_{pass_h} - F_{total_v} \times \tan(\delta_{bb,k}), 0 \text{ kN/m}) = \mathbf{0 \text{ kN/m}}$

Moments on wall

Wall stem	$M_{stem} = F_{stem} \times X_{stem} = \mathbf{8.1 \text{ kNm/m}}$
Wall base	$M_{base} = F_{base} \times X_{base} = \mathbf{0.5 \text{ kNm/m}}$
Surcharge load	$M_{sur} = -F_{sur_h} \times X_{sur_h} = \mathbf{-0.4 \text{ kNm/m}}$
Moist retained soil	$M_{moist} = -F_{moist_h} \times X_{moist_h} = \mathbf{-3.2 \text{ kNm/m}}$
Base soil	$M_{pass} = -F_{pass_h} \times X_{pass_h} = \mathbf{0 \text{ kNm/m}}$
Total	$M_{total} = M_{stem} + M_{base} + M_{sur} + M_{moist} + M_{pass} = \mathbf{5 \text{ kNm/m}}$

Check bearing pressure

Distance to reaction	$\bar{x} = M_{total} / F_{total_v} = \mathbf{174 \text{ mm}}$
Eccentricity of reaction	$e = \bar{x} - l_{base} / 2 = \mathbf{-126 \text{ mm}}$
Loaded length of base	$l_{load} = 3 \times \bar{x} = \mathbf{523 \text{ mm}}$
Bearing pressure at toe	$q_{toe} = 2 \times F_{total_v} / l_{load} = \mathbf{109 \text{ kN/m}^2}$
Bearing pressure at heel	$q_{heel} = \mathbf{0 \text{ kN/m}^2}$
Factor of safety	$FoS_{bp} = P_{bearing} / \max(q_{toe}, q_{heel}) = \mathbf{1.376}$

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	$\gamma_G = \mathbf{1.350}$
Permanent favourable action	$\gamma_{Gr} = \mathbf{1.000}$
Variable unfavourable action	$\gamma_Q = \mathbf{1.500}$
Variable favourable action	$\gamma_{Qr} = \mathbf{0.000}$

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

Soil parameter set	M1
Angle of shearing resistance	$\gamma_{\phi'} = \mathbf{1.00}$
Effective cohesion	$\gamma_{c'} = \mathbf{1.00}$
Weight density	$\gamma_{\gamma} = \mathbf{1.00}$

Retained soil properties

Design moist density	$\gamma_{mr}' = \gamma_{mr} / \gamma_{\gamma} = \mathbf{18 \text{ kN/m}^3}$
Design saturated density	$\gamma_{sr}' = \gamma_{sr} / \gamma_{\gamma} = \mathbf{21 \text{ kN/m}^3}$
Design effective shear resistance angle	$\phi'_{r,d} = \text{atan}(\tan(\phi'_{r,k}) / \gamma_{\phi'}) = \mathbf{46 \text{ deg}}$
Design wall friction angle	$\delta_{r,d} = \text{atan}(\tan(\delta_{r,k}) / \gamma_{\phi'}) = \mathbf{21 \text{ deg}}$

Base soil properties

Design soil density	$\gamma_{b'} = \gamma_b / \gamma_{\gamma} = \mathbf{18 \text{ kN/m}^3}$
Design effective shear resistance angle	$\phi'_{b,d} = \text{atan}(\tan(\phi'_{b,k}) / \gamma_{\phi'}) = \mathbf{30 \text{ deg}}$
Design wall friction angle	$\delta_{b,d} = \text{atan}(\tan(\delta_{b,k}) / \gamma_{\phi'}) = \mathbf{15 \text{ deg}}$
Design base friction angle	$\delta_{bb,d} = \text{atan}(\tan(\delta_{bb,k}) / \gamma_{\phi'}) = \mathbf{30 \text{ deg}}$
Design effective cohesion	$c'_{b,d} = c'_{b,k} / \gamma_{c'} = \mathbf{0 \text{ kN/m}^2}$

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Using Coulomb theory

Active pressure coefficient

$$K_A = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times [1 + \sqrt{[\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))]}]^2) = \mathbf{0.166}$$

Passive pressure coefficient

$$K_P = \sin(90 - \phi'_{b,d})^2 / (\sin(90 + \delta_{b,d}) \times [1 - \sqrt{[\sin(\phi'_{b,d} + \delta_{b,d}) \times \sin(\phi'_{b,d}) / (\sin(90 + \delta_{b,d}))]}]^2) = \mathbf{4.977}$$

Sliding check

Vertical forces on wall

Wall stem

$$F_{stem} = \gamma Gf \times A_{stem} \times \gamma_{stem} = \mathbf{27 \text{ kN/m}}$$

Wall base

$$F_{base} = \gamma Gf \times A_{base} \times \gamma_{base} = \mathbf{1.5 \text{ kN/m}}$$

Total

$$F_{total_v} = F_{stem} + F_{base} = \mathbf{28.5 \text{ kN/m}}$$

Horizontal forces on wall

Surcharge load

$$F_{sur_h} = K_A \times \cos(\delta_{r,d}) \times \gamma_Q \times \text{Surcharge}_Q \times h_{eff} = \mathbf{0.7 \text{ kN/m}}$$

Moist retained soil

$$F_{moist_h} = \gamma_G \times K_A \times \cos(\delta_{r,d}) \times \gamma_{mr}' \times h_{eff}^2 / 2 = \mathbf{6.8 \text{ kN/m}}$$

Total

$$F_{total_h} = F_{sur_h} + F_{moist_h} = \mathbf{7.4 \text{ kN/m}}$$

Check stability against sliding

Base soil resistance

$$F_{exc_h} = \gamma Gf \times K_P \times \cos(\delta_{b,d}) \times \gamma_{b'}' \times (h_{pass} + h_{base})^2 / 2 = \mathbf{0.4 \text{ kN/m}}$$

Base friction

$$F_{friction} = F_{total_v} \times \tan(\delta_{bb,d}) = \mathbf{16.5 \text{ kN/m}}$$

Resistance to sliding

$$F_{rest} = F_{exc_h} + F_{friction} = \mathbf{16.9 \text{ kN/m}}$$

Factor of safety

$$FoS_{sl} = F_{rest} / F_{total_h} = \mathbf{2.27}$$

PASS - Resistance to sliding is greater than sliding force

Overturning check

Vertical forces on wall

Wall stem

$$F_{stem} = \gamma Gf \times A_{stem} \times \gamma_{stem} = \mathbf{27 \text{ kN/m}}$$

Wall base

$$F_{base} = \gamma Gf \times A_{base} \times \gamma_{base} = \mathbf{1.5 \text{ kN/m}}$$

Total

$$F_{total_v} = F_{stem} + F_{base} = \mathbf{28.5 \text{ kN/m}}$$

Horizontal forces on wall

Surcharge load

$$F_{sur_h} = K_A \times \cos(\delta_{r,d}) \times \gamma_Q \times \text{Surcharge}_Q \times h_{eff} = \mathbf{0.7 \text{ kN/m}}$$

Moist retained soil

$$F_{moist_h} = \gamma_G \times K_A \times \cos(\delta_{r,d}) \times \gamma_{mr}' \times h_{eff}^2 / 2 = \mathbf{6.8 \text{ kN/m}}$$

Base soil

$$F_{exc_h} = -\gamma Gf \times K_P \times \cos(\delta_{b,d}) \times \gamma_{b'}' \times (h_{pass} + h_{base})^2 / 2 = \mathbf{-0.4 \text{ kN/m}}$$

Total

$$F_{total_h} = F_{sur_h} + F_{moist_h} + F_{exc_h} = \mathbf{7 \text{ kN/m}}$$

Overturning moments on wall

Surcharge load

$$M_{sur_OT} = F_{sur_h} \times x_{sur_h} = \mathbf{0.6 \text{ kNm/m}}$$

Moist retained soil

$$M_{moist_OT} = F_{moist_h} \times x_{moist_h} = \mathbf{4.3 \text{ kNm/m}}$$

Total

$$M_{total_OT} = M_{sur_OT} + M_{moist_OT} = \mathbf{4.9 \text{ kNm/m}}$$

Restoring moments on wall

Wall stem

$$M_{stem_R} = F_{stem} \times x_{stem} = \mathbf{8.1 \text{ kNm/m}}$$

Wall base

$$M_{base_R} = F_{base} \times x_{base} = \mathbf{0.5 \text{ kNm/m}}$$

Base soil

$$M_{exc_R} = -F_{exc_h} \times x_{exc_h} = \mathbf{0 \text{ kNm/m}}$$

Total

$$M_{total_R} = M_{stem_R} + M_{base_R} + M_{exc_R} = \mathbf{8.6 \text{ kNm/m}}$$

Check stability against overturning

Factor of safety

$$FoS_{ot} = M_{total_R} / M_{total_OT} = \mathbf{1.741}$$

PASS - Maximum restoring moment is greater than overturning moment

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Design approach 1

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

Partial factor set	A2
Permanent unfavourable action	$\gamma_G = 1.000$
Permanent favourable action	$\gamma_{Gf} = 1.000$
Variable unfavourable action	$\gamma_Q = 1.300$
Variable favourable action	$\gamma_{Qf} = 0.000$

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

Soil parameter set	M2
Angle of shearing resistance	$\gamma_{\phi'} = 1.25$
Effective cohesion	$\gamma_{c'} = 1.25$
Weight density	$\gamma_\gamma = 1.00$

Retained soil properties

Design moist density	$\gamma_{mr}' = \gamma_{mr} / \gamma_\gamma = 18 \text{ kN/m}^3$
Design saturated density	$\gamma_{sr}' = \gamma_{sr} / \gamma_\gamma = 21 \text{ kN/m}^3$
Design effective shear resistance angle	$\phi'_{r,d} = \text{atan}(\tan(\phi'_{r,k}) / \gamma_{\phi'}) = 39.6 \text{ deg}$
Design wall friction angle	$\delta_{r,d} = \text{atan}(\tan(\delta_{r,k}) / \gamma_{\phi'}) = 17.1 \text{ deg}$

Base soil properties

Design soil density	$\gamma_b' = \gamma_b / \gamma_\gamma = 18 \text{ kN/m}^3$
Design effective shear resistance angle	$\phi'_{b,d} = \text{atan}(\tan(\phi'_{b,k}) / \gamma_{\phi'}) = 24.8 \text{ deg}$
Design wall friction angle	$\delta_{b,d} = \text{atan}(\tan(\delta_{b,k}) / \gamma_{\phi'}) = 12.1 \text{ deg}$
Design base friction angle	$\delta_{bb,d} = \text{atan}(\tan(\delta_{bb,k}) / \gamma_{\phi'}) = 24.8 \text{ deg}$
Design effective cohesion	$c'_{b,d} = c'_{b,k} / \gamma_{c'} = 0 \text{ kN/m}^2$

Using Coulomb theory

Active pressure coefficient	$K_A = \sin(\alpha + \phi'_{r,d})^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_{r,d}) \times [1 + \sqrt{[\sin(\phi'_{r,d} + \delta_{r,d}) \times \sin(\phi'_{r,d} - \beta) / (\sin(\alpha - \delta_{r,d}) \times \sin(\alpha + \beta))]}]^2) = 0.224$
Passive pressure coefficient	$K_P = \sin(90 - \phi'_{b,d})^2 / (\sin(90 + \delta_{b,d}) \times [1 - \sqrt{[\sin(\phi'_{b,d} + \delta_{b,d}) \times \sin(\phi'_{b,d}) / (\sin(90 + \delta_{b,d}))]}]^2) = 3.473$

Sliding check

Vertical forces on wall

Wall stem	$F_{\text{stem}} = \gamma_{Gf} \times A_{\text{stem}} \times \gamma_{\text{stem}} = 27 \text{ kN/m}$
Wall base	$F_{\text{base}} = \gamma_{Gf} \times A_{\text{base}} \times \gamma_{\text{base}} = 1.5 \text{ kN/m}$
Total	$F_{\text{total}_v} = F_{\text{stem}} + F_{\text{base}} = 28.5 \text{ kN/m}$

Horizontal forces on wall

Surcharge load	$F_{\text{sur}_h} = K_A \times \cos(\delta_{r,d}) \times \gamma_Q \times \text{Surcharge}_Q \times h_{\text{eff}} = 0.8 \text{ kN/m}$
Moist retained soil	$F_{\text{moist}_h} = \gamma_G \times K_A \times \cos(\delta_{r,d}) \times \gamma_{mr}' \times h_{\text{eff}}^2 / 2 = 7 \text{ kN/m}$
Total	$F_{\text{total}_h} = F_{\text{sur}_h} + F_{\text{moist}_h} = 7.8 \text{ kN/m}$

Check stability against sliding

Base soil resistance	$F_{\text{exc}_h} = \gamma_{Gf} \times K_P \times \cos(\delta_{b,d}) \times \gamma_b' \times (h_{\text{pass}} + h_{\text{base}})^2 / 2 = 0.3 \text{ kN/m}$
Base friction	$F_{\text{friction}} = F_{\text{total}_v} \times \tan(\delta_{bb,d}) = 13.2 \text{ kN/m}$
Resistance to sliding	$F_{\text{rest}} = F_{\text{exc}_h} + F_{\text{friction}} = 13.5 \text{ kN/m}$
Factor of safety	$\text{FoS}_{\text{sl}} = F_{\text{rest}} / F_{\text{total}_h} = 1.735$

PASS - Resistance to sliding is greater than sliding force

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Overturning check

Vertical forces on wall

Wall stem	$F_{\text{stem}} = \gamma G \times A_{\text{stem}} \times \gamma_{\text{stem}} = \mathbf{27 \text{ kN/m}}$
Wall base	$F_{\text{base}} = \gamma G \times A_{\text{base}} \times \gamma_{\text{base}} = \mathbf{1.5 \text{ kN/m}}$
Total	$F_{\text{total}_v} = F_{\text{stem}} + F_{\text{base}} = \mathbf{28.5 \text{ kN/m}}$

Horizontal forces on wall

Surcharge load	$F_{\text{sur}_h} = K_A \times \cos(\delta_{r,d}) \times \gamma_Q \times \text{Surcharge}_Q \times h_{\text{eff}} = \mathbf{0.8 \text{ kN/m}}$
Moist retained soil	$F_{\text{moist}_h} = \gamma_G \times K_A \times \cos(\delta_{r,d}) \times \gamma_{\text{mr}}' \times h_{\text{eff}}^2 / 2 = \mathbf{7 \text{ kN/m}}$
Base soil	$F_{\text{exc}_h} = -\gamma G \times K_P \times \cos(\delta_{b,d}) \times \gamma_b' \times (h_{\text{pass}} + h_{\text{base}})^2 / 2 = \mathbf{-0.3 \text{ kN/m}}$
Total	$F_{\text{total}_h} = F_{\text{sur}_h} + F_{\text{moist}_h} + F_{\text{exc}_h} = \mathbf{7.5 \text{ kN/m}}$

Overturning moments on wall

Surcharge load	$M_{\text{sur}_OT} = F_{\text{sur}_h} \times X_{\text{sur}_h} = \mathbf{0.8 \text{ kNm/m}}$
Moist retained soil	$M_{\text{moist}_OT} = F_{\text{moist}_h} \times X_{\text{moist}_h} = \mathbf{4.4 \text{ kNm/m}}$
Total	$M_{\text{total}_OT} = M_{\text{sur}_OT} + M_{\text{moist}_OT} = \mathbf{5.2 \text{ kNm/m}}$

Restoring moments on wall

Wall stem	$M_{\text{stem}_R} = F_{\text{stem}} \times X_{\text{stem}} = \mathbf{8.1 \text{ kNm/m}}$
Wall base	$M_{\text{base}_R} = F_{\text{base}} \times X_{\text{base}} = \mathbf{0.5 \text{ kNm/m}}$
Base soil	$M_{\text{exc}_R} = -F_{\text{exc}_h} \times X_{\text{exc}_h} = \mathbf{0 \text{ kNm/m}}$
Total	$M_{\text{total}_R} = M_{\text{stem}_R} + M_{\text{base}_R} + M_{\text{exc}_R} = \mathbf{8.6 \text{ kNm/m}}$

Check stability against overturning

Factor of safety	$FoS_{ot} = M_{\text{total}_R} / M_{\text{total}_OT} = \mathbf{1.656}$
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PASS - Maximum restoring moment is greater than overturning moment