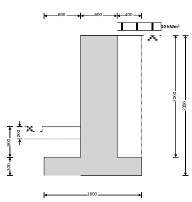
RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06



Wall details

Retaining wall type; **Unpropped cantilever**

Height of retaining wall stem; h_{stem} = **2000** mm

Thickness of wall stem; t_{wall} = **600** mm

Length of toe; l_{toe} = **600** mm

Length of heel; l_{heel} = **400** mm

Overall length of base; $l_{base} = l_{toe} + l_{heel} + t_{wall}$ = **1600** mm

Thickness of base; t_{base} = **300** mm

Depth of downstand; d_{ds} = **0** mm

Position of downstand; l_{ds} = **600** mm

Thickness of downstand; t_{ds} = **300** mm

Height of retaining wall; $h_{wall} = h_{stem} + t_{base} + d_{ds}$ = **2300** mm

Depth of cover in front of wall; d_{cover} = **500** mm

Depth of unplanned excavation; d_{exc} = **200** mm

Height of ground water behind wall; h_{water} = **0** mm

Height of saturated fill above base; $h_{sat} = \max(h_{water} - t_{base} - d_{ds}, 0\text{ mm})$ = **0** mm

Density of wall construction; γ_{wall} = **23.6** kN/m^3

Density of base construction; γ_{base} = **23.6** kN/m^3

Angle of rear face of wall; α = **90.0** deg

Angle of soil surface behind wall; β = **0.0** deg

Effective height at virtual back of wall; $h_{eff} = h_{wall} + l_{heel} \times \tan(\beta)$ = **2300** mm

Retained material details

Mobilisation factor; $M = \mathbf{1.5}$

Moist density of retained material; $\gamma_m = \mathbf{18.0}$ kN/m^3

Saturated density of retained material; $\gamma_s = \mathbf{21.0}$ kN/m^3

Design shear strength; $\phi' = \mathbf{24.2}$ deg

Angle of wall friction; $\delta = \mathbf{0.0}$ deg

Base material details

Moist density; $\gamma_{mb} = \mathbf{18.0}$ kN/m^3

Design shear strength; $\phi'_b = \mathbf{24.2}$ deg

Design base friction; $\delta_b = \mathbf{18.6}$ deg

Allowable bearing pressure; $P_{bearing} = \mathbf{150}$ kN/m^2

Using Coulomb theory

Active pressure coefficient for retained material

$$K_a = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))}]^2) = \mathbf{0.419}$$

Passive pressure coefficient for base material

$$K_p = \sin(90 - \phi'_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi'_b + \delta_b) \times \sin(\phi'_b) / (\sin(90 + \delta_b)))}]^2) = \mathbf{4.187}$$

At-rest pressure

At-rest pressure for retained material; $K_0 = 1 – \sin(\phi') = \mathbf{0.590}$

Loading details

Surcharge load on plan; Surcharge = **10.0** kN/m^2

Applied vertical dead load on wall; $W_{dead} = \mathbf{0.0}$ kN/m

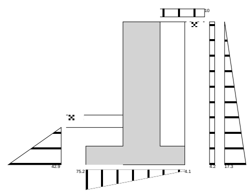
Applied vertical live load on wall; $W_{live} = \mathbf{0.0}$ kN/m

Position of applied vertical load on wall; $l_{load} = \mathbf{0}$ mm

Applied horizontal dead load on wall; $F_{dead} = \mathbf{0.0}$ kN/m

Applied horizontal live load on wall; $F_{live} = \mathbf{0.0}$ kN/m

Height of applied horizontal load on wall; $h_{load} = \mathbf{0}$ mm



Loads shown in kN/m, pressures shown in kN/m^2

Vertical forces on wall

Wall stem; $w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall}$ = **28.3** kN/m

Wall base; $w_{base} = l_{base} \times t_{base} \times \gamma_{base}$ = **11.3** kN/m

Surcharge; w_{sur} = Surcharge $\times\ l_{heel}$ = **4** kN/m

Moist backfill to top of wall; $w_{m\_w} = l_{heel} \times (h_{stem} - h_{sat}) \times \gamma_m$ = **14.4** kN/m

Soil in front of wall; $w_p = l_{toe} \times d_{cover} \times \gamma_{mb}$ = **5.4** kN/m

Total vertical load; $W_{total} = w_{wall} + w_{base} + w_{sur} + w_{m\_w} + w_p$ = **63.4** kN/m

Horizontal forces on wall

Surcharge; $F_{sur} = K_a \times$ Surcharge $\times\ h_{eff}$ = **9.6** kN/m

Moist backfill above water table; $F_{m\_a} = 0.5 \times K_a \times \gamma_m \times (h_{eff} - h_{water})^2$ = **19.9** kN/m

Total horizontal load; $F_{total} = F_{sur} + F_{m\_a}$ = **29.6** kN/m

Calculate stability against sliding

Passive resistance of soil in front of wall; $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **12.9** kN/m

Resistance to sliding; $F_{res} = F_p + (W_{total} - w_{sur} - w_p) \times \tan(\delta_b)$ = **31.0** kN/m

PASS - Resistance force is greater than sliding force

Overturning moments

Surcharge; $M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **11.1** kNm/m

Moist backfill above water table; $M_{m\_a} = F_{m\_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **15.3** kNm/m

Total overturning moment; $M_{ot} = M_{sur} + M_{m\_a}$ = **26.3** kNm/m

Restoring moments

Wall stem; $M_{wall} = w_{wall} \times (l_{toe} + t_{wall} / 2)$ = **25.5** kNm/m

Wall base; $M_{base} = w_{base} \times l_{base} / 2$ = **9.1** kNm/m

Moist backfill; $M_{m\_r} = (w_{m\_w} \times (l_{base} - l_{heel} / 2) + w_{m\_s} \times (l_{base} - l_{heel} / 3)) =$ **20.2** kNm/m

Total restoring moment; $M_{rest} = M_{wall} + M_{base} + M_{m\_r} =$ **54.7** kNm/m

Check stability against overturning

Total overturning moment; $M_{ot} =$ **26.3** kNm/m

Total restoring moment; $M_{rest} =$ **54.7** kNm/m

PASS - Restoring moment is greater than overturning moment

Check bearing pressure

Surcharge; $M_{sur\_r} = w_{sur} \times (l_{base} - l_{heel} / 2) =$ **5.6** kNm/m

Soil in front of wall; $M_{p\_r} = w_p \times l_{toe} / 2 =$ **1.6** kNm/m

Total moment for bearing; $M_{total} = M_{rest} - M_{ot} + M_{sur\_r} + M_{p\_r} =$ **35.6** kNm/m

Total vertical reaction; $R = W_{total} =$ **63.4** kN/m

Distance to reaction; $x_{bar} = M_{total} / R =$ **561** mm

Eccentricity of reaction; $e = abs((l_{base} / 2) - x_{bar}) =$ **239** mm

Reaction acts within middle third of base

Bearing pressure at toe; $p_{toe} = (R / l_{base}) + (6 \times R \times e / l_{base}^2) =$ **75.2** kN/m^2

Bearing pressure at heel; $p_{heel} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) =$ **4.1** kN/m^2

PASS - Maximum bearing pressure is less than allowable bearing pressure

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor; γ_{f_d} = **1.4**

Live load factor; γ_{f_l} = **1.6**

Earth and water pressure factor; γ_{f_e} = **1.4**

Factored vertical forces on wall

Wall stem; $w_{wall\_f} = \gamma_{f\_d} \times h_{stem} \times t_{wall} \times \gamma_{wall}$ = **39.6** kN/m

Wall base; $w_{base\_f} = \gamma_{f\_d} \times l_{base} \times t_{base} \times \gamma_{base}$ = **15.9** kN/m

Surcharge; $w_{sur\_f} = \gamma_{f\_l} \times$ Surcharge $\times l_{heel}$ = **6.4** kN/m

Moist backfill to top of wall; $w_{m\_w\_f} = \gamma_{f\_d} \times l_{heel} \times (h_{stem} - h_{sat}) \times \gamma_m$ = **20.2** kN/m

Soil in front of wall; $w_{p\_f} = \gamma_{f\_d} \times l_{toe} \times d_{cover} \times \gamma_{mb}$ = **7.6** kN/m

Total vertical load; $W_{total\_f} = w_{wall\_f} + w_{base\_f} + w_{sur\_f} + w_{m\_w\_f} + w_{p\_f}$ = **89.6** kN/m

Factored horizontal at-rest forces on wall

Surcharge; $F_{sur\_f} = \gamma_{f\_l} \times K_0 \times$ Surcharge $\times h_{eff}$ = **21.7** kN/m

Moist backfill above water table; $F_{m\_a\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times \gamma_m \times (h_{eff} - h_{water})^2$ = **39.3** kN/m

Total horizontal load; $F_{total\_f} = F_{sur\_f} + F_{m\_a\_f}$ = **61** kN/m

Passive resistance of soil in front of wall; $F_{p\_f} = \gamma_{f\_e} \times 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **18** kN/m

Factored overturning moments

Surcharge; $M_{sur\_f} = F_{sur\_f} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **25** kNm/m

Moist backfill above water table; $M_{m\_a\_f} = F_{m\_a\_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **30.2** kNm/m

Total overturning moment; $M_{ot\_f} = M_{sur\_f} + M_{m\_a\_f}$ = **55.1** kNm/m

Restoring moments

Wall stem; $M_{wall\_f} = w_{wall\_f} \times (l_{toe} + t_{wall} / 2)$ = **35.7** kNm/m

Wall base; $M_{base\_f} = w_{base\_f} \times l_{base} / 2$ = **12.7** kNm/m

Surcharge; $M_{sur\_r\_f} = w_{sur\_f} \times (l_{base} - l_{heel} / 2)$ = **9** kNm/m

Moist backfill; $M_{m\_r\_f} = (w_{m\_w\_f} \times (l_{base} - l_{heel} / 2) + w_{m\_s\_f} \times (l_{base} - l_{heel} / 3))$ = **28.2** kNm/m

Soil in front of wall; $M_{p\_r\_f} = w_{p\_f} \times l_{toe} / 2$ = **2.3** kNm/m

Total restoring moment; $M_{rest\_f} = M_{wall\_f} + M_{base\_f} + M_{sur\_r\_f} + M_{m\_r\_f} + M_{p\_r\_f}$ = **87.8** kNm/m

Factored bearing pressure

Total moment for bearing; $M_{total\_f} = M_{rest\_f} - M_{ot\_f}$ = **32.7** kNm/m

Total vertical reaction; $R_f = W_{total\_f}$ = **89.6** kN/m

Distance to reaction; $x_{bar\_f} = M_{total\_f} / R_f$ = **365** mm

Eccentricity of reaction; $e_f = \text{abs}((l_{base} / 2) - x_{bar\_f})$ = **435** mm

Reaction acts outside middle third of base

Bearing pressure at toe; $p_{toe\_f} = R_f / (1.5 \times x_{bar\_f})$ = **163.8** kN/m^2

Bearing pressure at heel; p_{heel_f} = 0 kN/m^2 = **0** kN/m^2

Rate of change of base reaction; rate = $p_{toe\_f} / (3 \times x_{bar\_f})$ = **149.66** kN/m^2/m

Bearing pressure at stem / toe; $p_{stem\_toe\_f} = \max(p_{toe\_f} - (\text{rate} \times l_{toe}), 0\ \text{kN/m}^2)$ = **74** kN/m^2

Bearing pressure at mid stem; $p_{stem\_mid\_f} = \max(p_{toe\_f} - (\text{rate} \times (l_{toe} + t_{wall} / 2)), 0\ \text{kN/m}^2)$ = **29.1** kN/m^2

Bearing pressure at stem / heel; $p_{stem\_heel\_f} = \max(p_{toe\_f} - (rate \times (l_{toe} + t_{wall})), 0\ kN/m^2) =$ **0** kN/m^2

Design of reinforced concrete retaining wall toe (BS 8002:1994)

Material properties

Characteristic strength of concrete; $f_{cu} =$ **40** N/mm^2

Characteristic strength of reinforcement; $f_y =$ **500** N/mm^2

Base details

Minimum area of reinforcement; k = **0.13** %

Cover to reinforcement in toe; $c_{toe} =$ **30** mm

Calculate shear for toe design

Shear from bearing pressure; $V_{toe\_bear} = (p_{toe\_f} + p_{stem\_toe\_f}) \times l_{toe} / 2 =$ **71.3** kN/m

Shear from weight of base; $V_{toe\_wt\_base} = \gamma_{f\_d} \times \gamma_{base} \times l_{toe} \times t_{base} =$ **5.9** kN/m

Shear from weight of soil; $V_{toe\_wt\_soil} = w_{p\_f} - (\gamma_{f\_d} \times \gamma_m \times l_{toe} \times d_{exc}) =$ **4.5** kN/m

Total shear for toe design; $V_{toe} = V_{toe\_bear} - V_{toe\_wt\_base} - V_{toe\_wt\_soil} =$ **60.9** kN/m

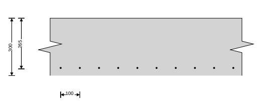
Calculate moment for toe design

Moment from bearing pressure; $M_{toe\_bear} = (2 \times p_{toe\_f} + p_{stem\_mid\_f}) \times (l_{toe} + t_{wall} / 2)^2 / 6 =$ **48.2** kNm/m

Moment from weight of base; $M_{toe\_wt\_base} = (\gamma_{f\_d} \times \gamma_{base} \times t_{base} \times (l_{toe} + t_{wall} / 2)^2 / 2) =$ **4** kNm/m

Moment from weight of soil; $M_{toe\_wt\_soil} = (w_{p\_f} - (\gamma_{f\_d} \times \gamma_m \times l_{toe} \times d_{exc})) \times (l_{toe} + t_{wall}) / 2 =$ **2.7** kNm/m

Total moment for toe design; $M_{toe} = M_{toe\_bear} - M_{toe\_wt\_base} - M_{toe\_wt\_soil} =$ **41.4** kNm/m



Check toe in bending

Width of toe; b = **1000** mm/m

Depth of reinforcement; $d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2) =$ **265.0** mm

Constant; $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu}) =$ **0.015**

Compression reinforcement is not required

Lever arm; $z_{toe} = \min(0.5 + \sqrt{(0.25 - (\min(K_{toe}, 0.225) / 0.9))}, 0.95) \times d_{toe}$

$z_{toe} =$ **252** mm

Area of tension reinforcement required; $A_{s\_toe\_des} = M_{toe} / (0.87 \times f_y \times z_{toe}) =$ **378** mm^2/m

Minimum area of tension reinforcement; $A_{s\_toe\_min} = k \times b \times t_{base} =$ **390** mm^2/m

Area of tension reinforcement required; $A_{s\_toe\_req} = \mathrm{Max}(A_{s\_toe\_des}, A_{s\_toe\_min}) =$ **390** mm^2/m

Reinforcement provided; **10 mm dia.bars @ 100 mm centres**

Area of reinforcement provided; $A_{s\_toe\_prov}$ = **785** mm^2/m

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress; $v_{toe} = V_{toe} / (b \times d_{toe})$ = **0.230** N/mm^2

Allowable shear stress; $v_{adm} = \min(0.8 \times \sqrt{(f_{cu} / 1\ N/mm^2)}, 5) \times 1\ N/mm^2$ = **5.000** N/mm^2

PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress; v_{c_toe} = **0.546** N/mm^2

$v_{toe} < v_{c\_toe}$ - No shear reinforcement required

<u>Design of reinforced concrete retaining wall heel (BS 8002:1994)</u>

Material properties

Characteristic strength of concrete; f_{cu} = **40** N/mm^2

Characteristic strength of reinforcement; f_y = **500** N/mm^2

Base details

Minimum area of reinforcement; k = **0.13** %

Cover to reinforcement in heel; c_{heel} = **30** mm

Calculate shear for heel design

Shear from weight of base; $V_{heel\_wt\_base} = \gamma_{f\_d} \times \gamma_{base} \times l_{heel} \times t_{base}$ = **4** kN/m

Shear from weight of moist backfill; $V_{heel\_wt\_m} = w_{m\_w\_f}$ = **20.2** kN/m

Shear from surcharge; $V_{heel\_sur} = w_{sur\_f}$ = **6.4** kN/m

Total shear for heel design; $V_{heel} = V_{heel\_wt\_base} + V_{heel\_wt\_m} + V_{heel\_sur}$ = **30.5** kN/m

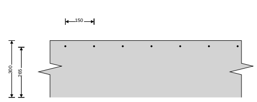
Calculate moment for heel design

Moment from weight of base; $M_{heel\_wt\_base} = (\gamma_{f\_d} \times \gamma_{base} \times t_{base} \times (l_{heel} + t_{wall} / 2)^2 / 2)$ = **2.4** kNm/m

Moment from weight of moist backfill; $M_{heel\_wt\_m} = w_{m\_w\_f} \times (l_{heel} + t_{wall}) / 2$ = **10.1** kNm/m

Moment from surcharge; $M_{heel\_sur} = w_{sur\_f} \times (l_{heel} + t_{wall}) / 2$ = **3.2** kNm/m

Total moment for heel design; $M_{heel} = M_{heel\_wt\_base} + M_{heel\_wt\_m} + M_{heel\_sur}$ = **15.7** kNm/m



Check heel in bending

Width of heel; b = **1000** mm/m

Depth of reinforcement; $d_{heel} = t_{base} - c_{heel} - (\phi_{heel} / 2)$ = **265.0** mm

Constant; $K_{heel} = M_{heel} / (b \times d_{heel}^2 \times f_{cu})$ = **0.006**

Compression reinforcement is not required

Lever arm; $z_{heel} = \min(0.5 + \sqrt{(0.25 - (\min(K_{heel}, 0.225) / 0.9))},0.95) \times d_{heel}$

z_{heel} = **252** mm

Area of tension reinforcement required; $A_{s\_heel\_des} = M_{heel} / (0.87 \times f_y \times z_{heel})$ = **143** mm^2/m

Minimum area of tension reinforcement; $A_{s\_heel\_min} = k \times b \times t_{base}$ = **390** mm^2/m

Area of tension reinforcement required; $A_{s\_heel\_req} = Max(A_{s\_heel\_des}, A_{s\_heel\_min})$ = **390** mm^2/m

Reinforcement provided; **10 mm dia.bars @ 150 mm centres**

Area of reinforcement provided; $A_{s\_heel\_prov}$ = **524** mm^2/m

PASS - Reinforcement provided at the retaining wall heel is adequate

Check shear resistance at heel

Design shear stress; $v_{heel} = V_{heel} / (b \times d_{heel})$ = **0.115** N/mm^2

Allowable shear stress; $v_{adm} = \min(0.8 \times \sqrt{(f_{cu} / 1 N/mm^2)}, 5) \times 1 N/mm^2$ = **5.000** N/mm^2

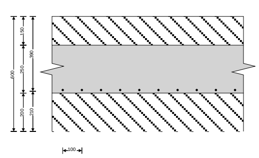
PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress; v_{c_heel} = **0.477** N/mm^2

$v_{heel} < v_{c\_heel}$ - No shear reinforcement required

<u>Design of cavity reinforced masonry retaining wall stem - BS5628-2:2000</u>



Wall details

Thickness of outer leaf of wall; t_{outer} = **150** mm

Thickness of inner leaf of wall; t_{inner} = **200** mm

Thickness of reinforced cavity; $t_{cavity} = t_{wall} - t_{outer} - t_{inner}$ = **250** mm

Depth of stem reinforcement; d_{stem} = **390** mm

Masonry details

Masonry type; **Aggregate concrete blocks no voids**

Compressive strength of units; p_{unit} = **10.0** N/mm^2
Mortar designation; **(ii)**
Category of manufactoring control of units; **Category I**
Partial safety factor for material strength; γ_{mm} = **2.0**

Characteristic compressive strength of masonry
Least horizontal dimension of masonry units; b_{unit} = **100.0** mm
Height of masonry units; h_{unit} = **215.0** mm
Ratio of height to least horizontal dimension; ratio = h_{unit} / b_{unit} = **2.2**

From BS5628:2 Table 3d, mortar ii

Characteristic compressive strength; f_k = **8.1** N/mm^2

Factored horizontal at-rest forces on stem
Surcharge; $F_{s\_sur\_f} = \gamma_{f\_l} \times K_0 \times$ Surcharge $\times (h_{eff} - t_{base} - d_{ds})$ = **18.9** kN/m
Moist backfill above water table; $F_{s\_m\_a\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2$ = **29.7** kN/m

Calculate shear for stem design
Shear at base of stem; $V_{stem} = F_{s\_sur\_f} + F_{s\_m\_a\_f}$ = **48.6** kN/m

Calculate moment for stem design
Surcharge; $M_{s\_sur} = F_{s\_sur\_f} \times (h_{stem} + t_{base}) / 2$ = **21.7** kNm/m
Moist backfill above water table; $M_{s\_m\_a} = F_{s\_m\_a\_f} \times (2 \times h_{sat} + h_{eff} - d_{ds} + t_{base} / 2) / 3$ = **24.3** kNm/m
Total moment for stem design; $M_{stem} = M_{s\_sur} + M_{s\_m\_a}$ = **46** kNm/m

Check maximum design moment for wall stem
Width of wall; b = **1000** mm/m
Maximum design moment; $M_{d\_stem} = 0.4 \times f_k \times b \times d_{stem}^2 / \gamma_{mm}$ = **247.7** kNm/m

PASS - Applied moment is less than maximum design moment

Check wall stem in bending
Moment of resistance factor; $Q = M_{stem} / d_{stem}^2$ = **0.302** N/mm^2
$Q = 2 \times c \times (1 - c) \times f_k / \gamma_{mm}$
Lever arm factor; c = **0.961**
Lever arm; $z_{stem} = \min(0.95, c) \times d_{stem}$ = **370.5** mm
Area of tension reinforcement required; $A_{s\_stem\_des} = M_{stem} \times \gamma_{ms} / (f_y \times z_{stem})$ = **286** mm^2/m
Minimum area of tension reinforcement; $A_{s\_stem\_min} = k \times b \times t_{wall}$ = **780** mm^2/m
Area of tension reinforcement required; $A_{s\_stem\_req} = \text{Max}(A_{s\_stem\_des}, A_{s\_stem\_min})$ = **780** mm^2/m
Reinforcement provided; **12 mm dia.bars @ 100 mm centres**
Area of reinforcement provided; $A_{s\_stem\_prov} = \pi \times \phi_{stem}^2 / (4 \times s_{stem})$ = **1131** mm^2/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem
Design shear stress; $v_{stem} = V_{stem} / (b \times d_{stem})$ = **0.125** N/mm^2
Basic characteristic shear strength of masonry; $f_{vbas} = \min[0.35 + (17.5 \times A_{s\_stem\_prov} / (b \times d_{stem})), 0.7] \times 1$ N/mm^2
f_{vbas} = **0.401** N/mm^2
Shear span; $a = M_{stem} / V_{stem}$ = **946.1** mm
Characteristic shear strength of masonry; $f_v = \text{Min}(f_{vbas} \times \max(2.5 - 0.25 \times (a / d_{stem}), 1), 1.75\ \text{N/mm}^2)$

f_v = **0.759** N/mm^2

Allowable shear stress; $v_{adm} = f_v / \gamma_{mv}$ = **0.379** N/mm^2

PASS - Design shear stress is less than maximum shear stress

Check limiting dimensions

Limiting span/effective depth ratio; $ratio_{max}$ = **18.00**

Actual span/effective depth ratio; $ratio_{act} = (h_{stem} + d_{stem} / 2) / d_{stem}$ = **5.63**

PASS - Span to depth ratio is acceptable

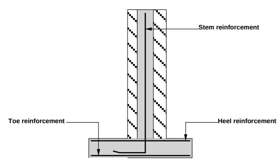
Axial load check

Factored axial load on wall; $N_{wall} = ([t_{wall} \times h_{stem} \times \gamma_{wall} + W_{dead}] \times \gamma_{f\_d}) + (W_{live} \times \gamma_{f\_l})$ = **39.6**
kN/m

Limiting axial load; $N_{limit} = 0.1 \times f_k \times t_{wall}$ = **488.5** kN/m

Applied axial load may be ignored - calculations valid

Indicative retaining wall reinforcement diagram



Toe bars - 10 mm dia.@ 100 mm centres - (785 mm^2/m)
Heel bars - 10 mm dia.@ 150 mm centres - (524 mm^2/m)
Stem bars - 12 mm dia.@ 100 mm centres - (1131 mm^2/m)