

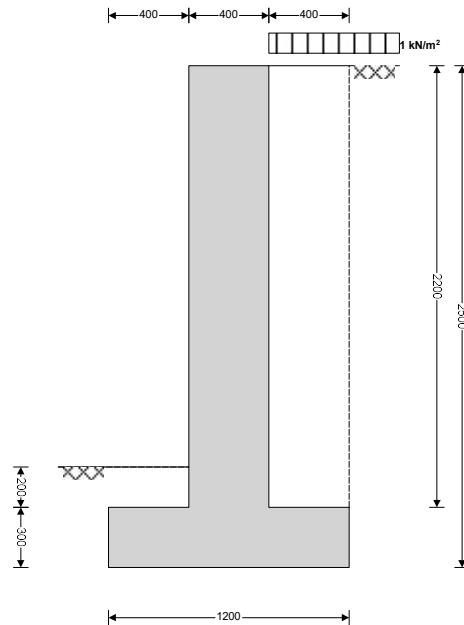
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RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.08



Wall details

Retaining wall type;
 Height of retaining wall stem;
 Thickness of wall stem;
 Length of toe;
 Length of heel;
 Overall length of base;
 Thickness of base;
 Depth of downstand;
 Position of downstand;
 Thickness of downstand;
 Height of retaining wall;
 Depth of cover in front of wall;
 Depth of unplanned excavation;
 Height of ground water behind wall;
 Height of saturated fill above base;
 Density of wall construction;
 Density of base construction;
 Angle of rear face of wall;
 Angle of soil surface behind wall;
 Effective height at virtual back of wall;

Unpropped cantilever

$h_{\text{stem}} = 2200 \text{ mm}$
 $t_{\text{wall}} = 400 \text{ mm}$
 $l_{\text{toe}} = 400 \text{ mm}$
 $l_{\text{heel}} = 400 \text{ mm}$
 $l_{\text{base}} = l_{\text{toe}} + l_{\text{heel}} + t_{\text{wall}} = 1200 \text{ mm}$
 $t_{\text{base}} = 300 \text{ mm}$
 $d_{\text{ds}} = 0 \text{ mm}$
 $l_{\text{ds}} = 500 \text{ mm}$
 $t_{\text{ds}} = 300 \text{ mm}$
 $h_{\text{wall}} = h_{\text{stem}} + t_{\text{base}} + d_{\text{ds}} = 2500 \text{ mm}$
 $d_{\text{cover}} = 200 \text{ mm}$
 $d_{\text{exc}} = 0 \text{ mm}$
 $h_{\text{water}} = 0 \text{ mm}$
 $h_{\text{sat}} = \max(h_{\text{water}} - t_{\text{base}} - d_{\text{ds}}, 0 \text{ mm}) = 0 \text{ mm}$
 $\gamma_{\text{wall}} = 23.6 \text{ kN/m}^3$
 $\gamma_{\text{base}} = 23.6 \text{ kN/m}^3$
 $\alpha = 90.0 \text{ deg}$
 $\beta = 0.0 \text{ deg}$
 $h_{\text{eff}} = h_{\text{wall}} + l_{\text{heel}} \times \tan(\beta) = 2500 \text{ mm}$

Retained material details

Mobilisation factor;
 Moist density of retained material;
 Saturated density of retained material;
 Design shear strength;

$M = 1.5$
 $\gamma_{\text{m}} = 18.0 \text{ kN/m}^3$
 $\gamma_{\text{s}} = 21.0 \text{ kN/m}^3$
 $\phi' = 24.2 \text{ deg}$

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Angle of wall friction;

$$\delta = 18.6 \text{ deg}$$

Base material details

Stiff or hard glacial clay

Moist density;

$$\gamma_{mb} = 17.5 \text{ kN/m}^3$$

Design shear strength;

$$\phi'_b = 24.2 \text{ deg}$$

Design base friction;

$$\delta_b = 18.6 \text{ deg}$$

Allowable bearing pressure;

$$P_{\text{bearing}} = 300 \text{ kN/m}^2$$

Using Coulomb theory

Active pressure coefficient for retained material

$$K_a = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))^2}] = 0.369$$

Passive pressure coefficient for base material

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

At-rest pressure

At-rest pressure for retained material;

$$K_0 = 1 - \sin(\phi') = 0.590$$

Loading details

Surcharge load on plan;

$$\text{Surcharge} = 1.0 \text{ kN/m}^2$$

Applied vertical dead load on wall;

$$W_{\text{dead}} = 0.0 \text{ kN/m}$$

Applied vertical live load on wall;

$$W_{\text{live}} = 0.0 \text{ kN/m}$$

Position of applied vertical load on wall;

$$l_{\text{load}} = 0 \text{ mm}$$

Applied horizontal dead load on wall;

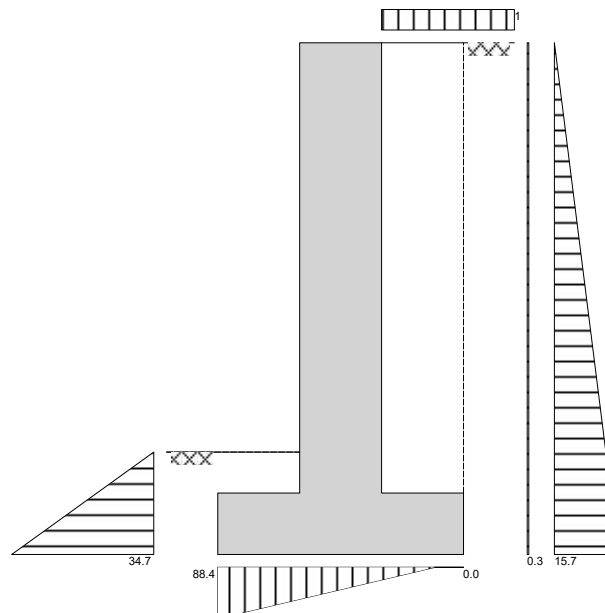
$$F_{\text{dead}} = 0.0 \text{ kN/m}$$

Applied horizontal live load on wall;

$$F_{\text{live}} = 0.0 \text{ kN/m}$$

Height of applied horizontal load on wall;

$$h_{\text{load}} = 0 \text{ mm}$$



Loads shown in kN/m, pressures shown in kN/m²

Vertical forces on wall

Wall stem;

$$W_{\text{wall}} = h_{\text{stem}} \times t_{\text{wall}} \times \gamma_{\text{wall}} = 20.8 \text{ kN/m}$$

Wall base;

$$W_{\text{base}} = l_{\text{base}} \times t_{\text{base}} \times \gamma_{\text{base}} = 8.5 \text{ kN/m}$$

Surcharge;

$$W_{\text{sur}} = \text{Surcharge} \times l_{\text{heel}} = 0.4 \text{ kN/m}$$

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Moist backfill to top of wall;

$$W_{m_w} = l_{heel} \times (h_{stem} - h_{sat}) \times \gamma_m = \mathbf{15.8 \text{ kN/m}}$$

Soil in front of wall;

$$W_p = l_{toe} \times d_{cover} \times \gamma_{mb} = \mathbf{1.4 \text{ kN/m}}$$

Total vertical load;

$$W_{total} = W_{wall} + W_{base} + W_{sur} + W_{m_w} + W_p = \mathbf{46.9 \text{ kN/m}}$$

Horizontal forces on wall

Surcharge;

$$F_{sur} = K_a \times \cos(90 - \alpha + \delta) \times \text{Surcharge} \times h_{eff} = \mathbf{0.9 \text{ kN/m}}$$

Moist backfill above water table;

$$F_{m_a} = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2 = \mathbf{19.7 \text{ kN/m}}$$

Total horizontal load;

$$F_{total} = F_{sur} + F_{m_a} = \mathbf{20.6 \text{ kN/m}}$$

Calculate stability against sliding

Passive resistance of soil in front of wall;

$$F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = \mathbf{8.7 \text{ kN/m}}$$

Resistance to sliding;

$$F_{res} = F_p + (W_{total} - W_{sur} - W_p) \times \tan(\delta_b) = \mathbf{23.9 \text{ kN/m}}$$

PASS - Resistance force is greater than sliding force

Overturning moments

Surcharge;

$$M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2 = \mathbf{1.1 \text{ kNm/m}}$$

Moist backfill above water table;

$$M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = \mathbf{16.4 \text{ kNm/m}}$$

Total overturning moment;

$$M_{ot} = M_{sur} + M_{m_a} = \mathbf{17.5 \text{ kNm/m}}$$

Restoring moments

Wall stem;

$$M_{wall} = W_{wall} \times (l_{toe} + t_{wall} / 2) = \mathbf{12.5 \text{ kNm/m}}$$

Wall base;

$$M_{base} = W_{base} \times l_{base} / 2 = \mathbf{5.1 \text{ kNm/m}}$$

Moist backfill;

$$M_{m_r} = (W_{m_w} \times (l_{base} - l_{heel} / 2) + W_{m_s} \times (l_{base} - l_{heel} / 3)) = \mathbf{15.8 \text{ kNm/m}}$$

Total restoring moment;

$$M_{rest} = M_{wall} + M_{base} + M_{m_r} = \mathbf{33.4 \text{ kNm/m}}$$

Check stability against overturning

Total overturning moment;

$$M_{ot} = \mathbf{17.5 \text{ kNm/m}}$$

Total restoring moment;

$$M_{rest} = \mathbf{33.4 \text{ kNm/m}}$$

PASS - Restoring moment is greater than overturning moment

Check bearing pressure

Surcharge;

$$M_{sur_r} = W_{sur} \times (l_{base} - l_{heel} / 2) = \mathbf{0.4 \text{ kNm/m}}$$

Soil in front of wall;

$$M_{p_r} = W_p \times l_{toe} / 2 = \mathbf{0.3 \text{ kNm/m}}$$

Total moment for bearing;

$$M_{total} = M_{rest} - M_{ot} + M_{sur_r} + M_{p_r} = \mathbf{16.6 \text{ kNm/m}}$$

Total vertical reaction;

$$R = W_{total} = \mathbf{46.9 \text{ kN/m}}$$

Distance to reaction;

$$x_{bar} = M_{total} / R = \mathbf{354 \text{ mm}}$$

Eccentricity of reaction;

$$e = \text{abs}((l_{base} / 2) - x_{bar}) = \mathbf{246 \text{ mm}}$$

Reaction acts outside middle third of base

Bearing pressure at toe;

$$p_{toe} = R / (1.5 \times x_{bar}) = \mathbf{88.4 \text{ kN/m}^2}$$

Bearing pressure at heel;

$$p_{heel} = 0 \text{ kN/m}^2 = \mathbf{0 \text{ kN/m}^2}$$

PASS - Maximum bearing pressure is less than allowable bearing pressure

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RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.08

Ultimate limit state load factors

Dead load factor; $\gamma_{f_d} = 1.4$
 Live load factor; $\gamma_{f_l} = 1.6$
 Earth and water pressure factor; $\gamma_{f_e} = 1.4$

Factored vertical forces on wall

Wall stem; $W_{wall_f} = \gamma_{f_d} \times h_{stem} \times t_{wall} \times \gamma_{wall} = 29.1 \text{ kN/m}$
 Wall base; $W_{base_f} = \gamma_{f_d} \times l_{base} \times t_{base} \times \gamma_{base} = 11.9 \text{ kN/m}$
 Surcharge; $W_{sur_f} = \gamma_{f_l} \times \text{Surcharge} \times l_{heel} = 0.6 \text{ kN/m}$
 Moist backfill to top of wall; $W_{m_w_f} = \gamma_{f_d} \times l_{heel} \times (h_{stem} - h_{sat}) \times \gamma_m = 22.2 \text{ kN/m}$
 Soil in front of wall; $W_{p_f} = \gamma_{f_d} \times l_{toe} \times d_{cover} \times \gamma_{mb} = 2 \text{ kN/m}$
 Total vertical load; $W_{total_f} = W_{wall_f} + W_{base_f} + W_{sur_f} + W_{m_w_f} + W_{p_f} = 65.7 \text{ kN/m}$

Factored horizontal at-rest forces on wall

Surcharge; $F_{sur_f} = \gamma_{f_l} \times K_0 \times \text{Surcharge} \times h_{eff} = 2.4 \text{ kN/m}$
 Moist backfill above water table; $F_{m_a_f} = \gamma_{f_e} \times 0.5 \times K_0 \times \gamma_m \times (h_{eff} - h_{water})^2 = 46.5 \text{ kN/m}$
 Total horizontal load; $F_{total_f} = F_{sur_f} + F_{m_a_f} = 48.8 \text{ kN/m}$
 Passive resistance of soil in front of wall; $F_{p_f} = \gamma_{f_e} \times 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb} = 12.2 \text{ kN/m}$

Factored overturning moments

Surcharge; $M_{sur_f} = F_{sur_f} \times (h_{eff} - 2 \times d_{ds}) / 2 = 3 \text{ kNm/m}$
 Moist backfill above water table; $M_{m_a_f} = F_{m_a_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3 = 38.7 \text{ kNm/m}$
 Total overturning moment; $M_{ot_f} = M_{sur_f} + M_{m_a_f} = 41.7 \text{ kNm/m}$

Restoring moments

Wall stem; $M_{wall_f} = W_{wall_f} \times (l_{toe} + t_{wall} / 2) = 17.4 \text{ kNm/m}$
 Wall base; $M_{base_f} = W_{base_f} \times l_{base} / 2 = 7.1 \text{ kNm/m}$
 Surcharge; $M_{sur_f} = W_{sur_f} \times (l_{base} - l_{heel} / 2) = 0.6 \text{ kNm/m}$
 Moist backfill; $M_{m_r_f} = (W_{m_w_f} \times (l_{base} - l_{heel} / 2) + W_{m_s_f} \times (l_{base} - l_{heel} / 3)) = 22.2 \text{ kNm/m}$
 Soil in front of wall; $M_{p_r_f} = W_{p_f} \times l_{toe} / 2 = 0.4 \text{ kNm/m}$
 Total restoring moment; $M_{rest_f} = M_{wall_f} + M_{base_f} + M_{sur_f} + M_{m_r_f} + M_{p_r_f} = 47.8 \text{ kNm/m}$

Factored bearing pressure

Total moment for bearing; $M_{total_f} = M_{rest_f} - M_{ot_f} = 6.1 \text{ kNm/m}$
 Total vertical reaction; $R_f = W_{total_f} = 65.7 \text{ kN/m}$
 Distance to reaction; $X_{bar_f} = M_{total_f} / R_f = 93 \text{ mm}$
 Eccentricity of reaction; $e_f = \text{abs}((l_{base} / 2) - X_{bar_f}) = 507 \text{ mm}$

Reaction acts outside middle third of base

Bearing pressure at toe; $p_{toe_f} = R_f / (1.5 \times X_{bar_f}) = 471.2 \text{ kN/m}^2$
 Bearing pressure at heel; $p_{heel_f} = 0 \text{ kN/m}^2 = 0 \text{ kN/m}^2$
 Rate of change of base reaction; $\text{rate} = p_{toe_f} / (3 \times X_{bar_f}) = 1688.55 \text{ kN/m}^2/\text{m}$
 Bearing pressure at stem / toe; $p_{stem_toe_f} = \text{max}(p_{toe_f} - (\text{rate} \times l_{toe}), 0 \text{ kN/m}^2) = 0 \text{ kN/m}^2$
 Bearing pressure at mid stem; $p_{stem_mid_f} = \text{max}(p_{toe_f} - (\text{rate} \times (l_{toe} + t_{wall} / 2)), 0 \text{ kN/m}^2) = 0 \text{ kN/m}^2$
 Bearing pressure at stem / heel; $p_{stem_heel_f} = \text{max}(p_{toe_f} - (\text{rate} \times (l_{toe} + t_{wall})), 0 \text{ kN/m}^2) = 0 \text{ kN/m}^2$

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

Material properties

Characteristic strength of concrete; $f_{cu} = 35 \text{ N/mm}^2$
Characteristic strength of reinforcement; $f_y = 500 \text{ N/mm}^2$

Base details

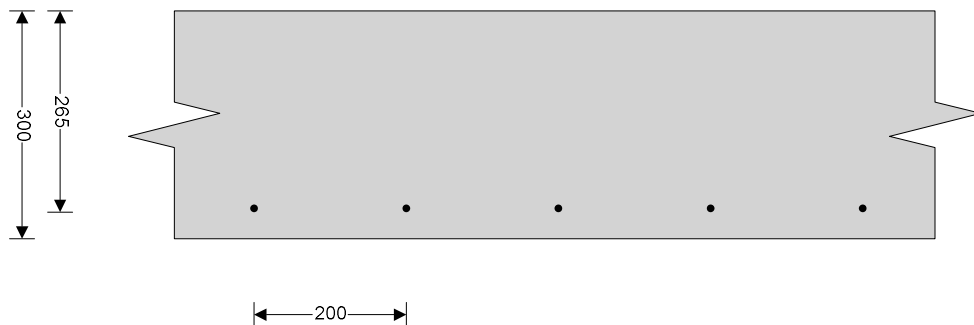
Minimum area of reinforcement; $k = 0.13 \%$
Cover to reinforcement in toe; $c_{toe} = 30 \text{ mm}$

Calculate shear for toe design

Shear from bearing pressure; $V_{toe_bear} = 3 \times p_{toe_f} \times X_{bar_f} / 2 = 65.7 \text{ kN/m}$
Shear from weight of base; $V_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times l_{toe} \times t_{base} = 4 \text{ kN/m}$
Shear from weight of soil; $V_{toe_wt_soil} = W_{p_f} - (\gamma_{f_d} \times \gamma_m \times l_{toe} \times d_{exc}) = 2 \text{ kN/m}$
Total shear for toe design; $V_{toe} = V_{toe_bear} - V_{toe_wt_base} - V_{toe_wt_soil} = 59.8 \text{ kN/m}$

Calculate moment for toe design

Moment from bearing pressure; $M_{toe_bear} = 3 \times p_{toe_f} \times X_{bar_f} \times (l_{toe} - X_{bar_f} + t_{wall} / 2) / 2 = 33.3 \text{ kNm/m}$
Moment from weight of base; $M_{toe_wt_base} = (\gamma_{f_d} \times \gamma_{base} \times t_{base} \times (l_{toe} + t_{wall} / 2)^2 / 2) = 1.8 \text{ kNm/m}$
Moment from weight of soil; $M_{toe_wt_soil} = (W_{p_f} - (\gamma_{f_d} \times \gamma_m \times l_{toe} \times d_{exc})) \times (l_{toe} + t_{wall}) / 2 = 0.8 \text{ kNm/m}$
Total moment for toe design; $M_{toe} = M_{toe_bear} - M_{toe_wt_base} - M_{toe_wt_soil} = 30.8 \text{ kNm/m}$



Check toe in bending

Width of toe; $b = 1000 \text{ mm/m}$
Depth of reinforcement; $d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2) = 265.0 \text{ mm}$
Constant; $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu}) = 0.013$

Compression reinforcement is not required

Lever arm; $z_{toe} = \min(0.5 + \sqrt{(0.25 - (\min(K_{toe}, 0.225) / 0.9))}, 0.95) \times d_{toe}$
 $z_{toe} = 252 \text{ mm}$

Area of tension reinforcement required; $A_{s_toe_des} = M_{toe} / (0.87 \times f_y \times z_{toe}) = 281 \text{ mm}^2/\text{m}$

Minimum area of tension reinforcement; $A_{s_toe_min} = k \times b \times t_{base} = 390 \text{ mm}^2/\text{m}$

Area of tension reinforcement required; $A_{s_toe_req} = \max(A_{s_toe_des}, A_{s_toe_min}) = 390 \text{ mm}^2/\text{m}$

Reinforcement provided;

A393 mesh

Area of reinforcement provided;

$A_{s_toe_prov} = 393 \text{ mm}^2/\text{m}$

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress; $v_{toe} = V_{toe} / (b \times d_{toe}) = 0.226 \text{ N/mm}^2$

Allowable shear stress; $v_{adm} = \min(0.8 \times \sqrt{f_{cu}} / 1 \text{ N/mm}^2, 5) \times 1 \text{ N/mm}^2 = 4.733 \text{ N/mm}^2$

PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

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Design concrete shear stress;

$$V_{c_toe} = 0.415 \text{ N/mm}^2$$

$V_{toe} < V_{c_toe}$ - No shear reinforcement required

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

Material properties

Characteristic strength of concrete;

$$f_{cu} = 35 \text{ N/mm}^2$$

Characteristic strength of reinforcement;

$$f_y = 500 \text{ N/mm}^2$$

Base details

Minimum area of reinforcement;

$$k = 0.13 \%$$

Cover to reinforcement in heel;

$$C_{heel} = 30 \text{ mm}$$

Calculate shear for heel design

Shear from weight of base;

$$V_{heel_wt_base} = \gamma_{f_d} \times \gamma_{base} \times l_{heel} \times t_{base} = 4 \text{ kN/m}$$

Shear from weight of moist backfill;

$$V_{heel_wt_m} = w_{m_w_f} = 22.2 \text{ kN/m}$$

Shear from surcharge;

$$V_{heel_sur} = w_{sur_f} = 0.6 \text{ kN/m}$$

Total shear for heel design;

$$V_{heel} = V_{heel_wt_base} + V_{heel_wt_m} + V_{heel_sur} = 26.8 \text{ kN/m}$$

Calculate moment for heel design

Moment from weight of base;

$$M_{heel_wt_base} = (\gamma_{f_d} \times \gamma_{base} \times t_{base} \times (l_{heel} + t_{wall} / 2)^2 / 2) = 1.8 \text{ kNm/m}$$

Moment from weight of moist backfill;

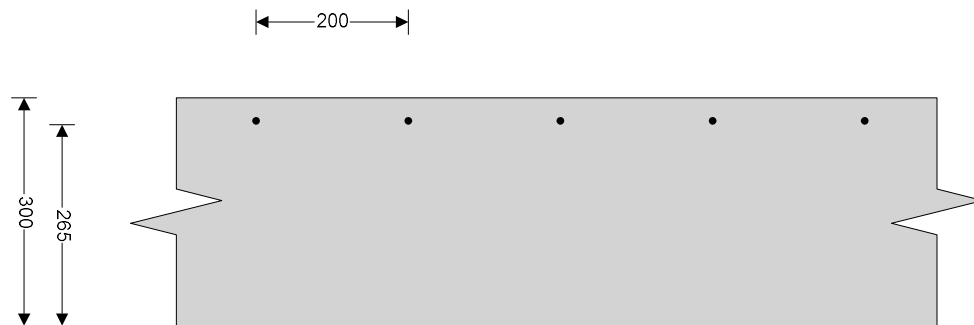
$$M_{heel_wt_m} = w_{m_w_f} \times (l_{heel} + t_{wall}) / 2 = 8.9 \text{ kNm/m}$$

Moment from surcharge;

$$M_{heel_sur} = w_{sur_f} \times (l_{heel} + t_{wall}) / 2 = 0.3 \text{ kNm/m}$$

Total moment for heel design;

$$M_{heel} = M_{heel_wt_base} + M_{heel_wt_m} + M_{heel_sur} = 10.9 \text{ kNm/m}$$



Check heel in bending

Width of heel;

$$b = 1000 \text{ mm/m}$$

Depth of reinforcement;

$$d_{heel} = t_{base} - C_{heel} - (\phi_{heel} / 2) = 265.0 \text{ mm}$$

Constant;

$$K_{heel} = M_{heel} / (b \times d_{heel}^2 \times f_{cu}) = 0.004$$

Compression reinforcement is not required

Lever arm;

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

$$Z_{heel} = 252 \text{ mm}$$

Area of tension reinforcement required;

$$A_{s_heel_des} = M_{heel} / (0.87 \times f_y \times Z_{heel}) = 100 \text{ mm}^2/\text{m}$$

Minimum area of tension reinforcement;

$$A_{s_heel_min} = k \times b \times t_{base} = 390 \text{ mm}^2/\text{m}$$

Area of tension reinforcement required;

$$A_{s_heel_req} = \text{Max}(A_{s_heel_des}, A_{s_heel_min}) = 390 \text{ mm}^2/\text{m}$$

Reinforcement provided;

$$\text{A393 mesh}$$

Area of reinforcement provided;

$$A_{s_heel_prov} = 393 \text{ mm}^2/\text{m}$$

PASS - Reinforcement provided at the retaining wall heel is adequate

Check shear resistance at heel

Design shear stress;

$$v_{heel} = V_{heel} / (b \times d_{heel}) = 0.101 \text{ N/mm}^2$$

Allowable shear stress;

$$v_{adm} = \min(0.8 \times \sqrt{f_{cu}} / 1 \text{ N/mm}^2, 5) \times 1 \text{ N/mm}^2 = 4.733 \text{ N/mm}^2$$

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PASS - Design shear stress is less than maximum shear stress

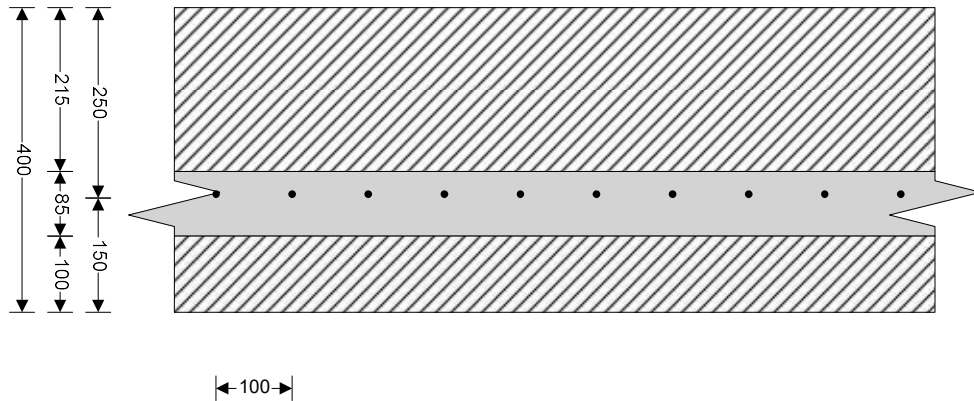
From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress;

$$v_{c_heel} = 0.415 \text{ N/mm}^2$$

$v_{heel} < v_{c_heel}$ - No shear reinforcement required

Design of cavity reinforced masonry retaining wall stem - BS5628-2:2000



Wall details

Thickness of outer leaf of wall;

$$t_{outer} = 215 \text{ mm}$$

Thickness of inner leaf of wall;

$$t_{inner} = 100 \text{ mm}$$

Thickness of reinforced cavity;

$$t_{cavity} = t_{wall} - t_{outer} - t_{inner} = 85 \text{ mm}$$

Depth of stem reinforcement;

$$d_{stem} = 250 \text{ mm}$$

Masonry details

Masonry type;

Aggregate concrete blocks no voids

Compressive strength of units;

$$p_{unit} = 7.3 \text{ N/mm}^2$$

Mortar designation;

(ii)

Category of manufacturing control of units;

Category II

Partial safety factor for material strength;

$$\gamma_{mm} = 2.3$$

Characteristic compressive strength of masonry

Least horizontal dimension of masonry units;

$$b_{unit} = 100.0 \text{ mm}$$

Height of masonry units;

$$h_{unit} = 215.0 \text{ mm}$$

Ratio of height to least horizontal dimension;

$$\text{ratio} = h_{unit} / b_{unit} = 2.2$$

From BS5628:2 Table 3d, mortar ii

Characteristic compressive strength;

$$f_k = 6.4 \text{ N/mm}^2$$

Factored horizontal at-rest forces on stem

Surcharge;

$$F_{s_sur_f} = \gamma_{f_l} \times K_0 \times \text{Surcharge} \times (h_{eff} - t_{base} - d_{ds}) = 2.1 \text{ kN/m}$$

Moist backfill above water table;

$$F_{s_m_a_f} = 0.5 \times \gamma_{f_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2 = 36 \text{ kN/m}$$

Calculate shear for stem design

Shear at base of stem;

$$V_{stem} = F_{s_sur_f} + F_{s_m_a_f} = 38.1 \text{ kN/m}$$

Calculate moment for stem design

Surcharge;

$$M_{s_sur} = F_{s_sur_f} \times (h_{stem} + t_{base}) / 2 = 2.6 \text{ kNm/m}$$

Moist backfill above water table;

$$M_{s_m_a} = F_{s_m_a_f} \times (2 \times h_{sat} + h_{eff} - d_{ds} + t_{base} / 2) / 3 = 31.8 \text{ kNm/m}$$

Total moment for stem design;

$$M_{stem} = M_{s_sur} + M_{s_m_a} = 34.4 \text{ kNm/m}$$

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Check maximum design moment for wall stem

Width of wall;

$$b = 1000 \text{ mm/m}$$

Maximum design moment;

$$M_{d_stem} = 0.4 \times f_k \times b \times d_{stem}^2 / \gamma_{mm} = 69.6 \text{ kNm/m}$$

PASS - Applied moment is less than maximum design moment

Check wall stem in bending

Moment of resistance factor;

$$Q = M_{stem} / d_{stem}^2 = 0.550 \text{ N/mm}^2$$

$$Q = 2 \times c \times (1 - c) \times f_k / \gamma_{mm}$$

Lever arm factor;

$$c = 0.889$$

Lever arm;

$$Z_{stem} = \min(0.95, c) \times d_{stem} = 222.2 \text{ mm}$$

Area of tension reinforcement required;

$$A_{s_stem_des} = M_{stem} \times \gamma_{ms} / (f_y \times Z_{stem}) = 356 \text{ mm}^2/\text{m}$$

Minimum area of tension reinforcement;

$$A_{s_stem_min} = k \times b \times t_{wall} = 520 \text{ mm}^2/\text{m}$$

Area of tension reinforcement required;

$$A_{s_stem_req} = \text{Max}(A_{s_stem_des}, A_{s_stem_min}) = 520 \text{ mm}^2/\text{m}$$

Reinforcement provided;

B785 mesh

Area of reinforcement provided;

$$A_{s_stem_prov} = \pi \times \phi_{stem}^2 / (4 \times S_{stem}) = 785 \text{ mm}^2/\text{m}$$

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress;

$$v_{stem} = V_{stem} / (b \times d_{stem}) = 0.152 \text{ N/mm}^2$$

Basic characteristic shear strength of masonry;

$$f_{vbas} = \min[0.35 + (17.5 \times A_{s_stem_prov} / (b \times d_{stem})), 0.7] \times 1 \text{ N/mm}^2$$

$$f_{vbas} = 0.405 \text{ N/mm}^2$$

Shear span;

$$a = M_{stem} / V_{stem} = 903.3 \text{ mm}$$

Characteristic shear strength of masonry;

$$f_v = \text{Min}(f_{vbas} \times \max(2.5 - 0.25 \times (a / d_{stem}), 1), 1.75 \text{ N/mm}^2)$$

$$f_v = 0.647 \text{ N/mm}^2$$

Allowable shear stress;

$$v_{adm} = f_v / \gamma_{mv} = 0.323 \text{ N/mm}^2$$

PASS - Design shear stress is less than maximum shear stress

Check limiting dimensions

Limiting span/effective depth ratio;

$$\text{ratio}_{\max} = 18.00$$

Actual span/effective depth ratio;

$$\text{ratio}_{\text{act}} = (h_{stem} + d_{stem} / 2) / d_{stem} = 9.30$$

PASS - Span to depth ratio is acceptable

Axial load check

Factored axial load on wall;

$$N_{wall} = ([t_{wall} \times h_{stem} \times \gamma_{wall} + W_{dead}] \times \gamma_{f_d}) + (W_{live} \times \gamma_{f_l}) = 29.1 \text{ kN/m}$$

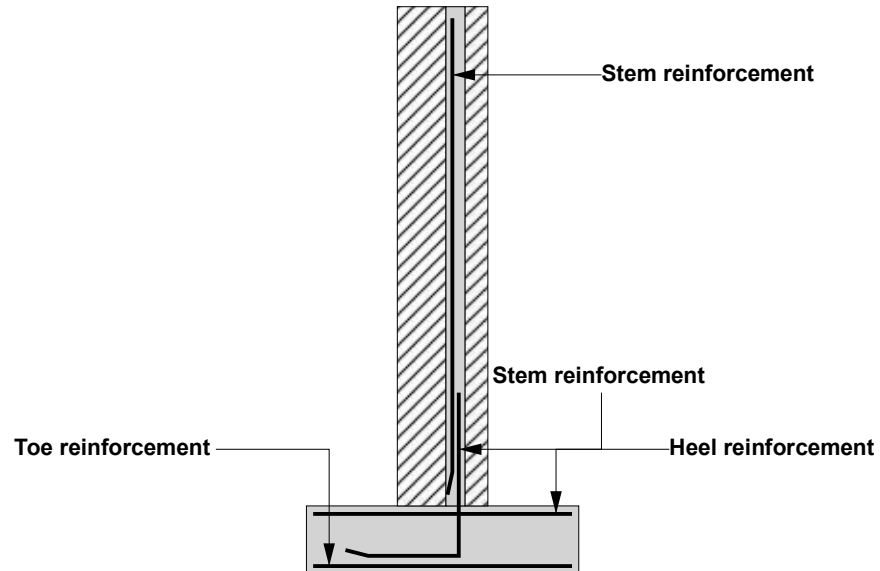
Limiting axial load;

$$N_{limit} = 0.1 \times f_k \times t_{wall} = 256.0 \text{ kN/m}$$

Applied axial load may be ignored - calculations valid

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Indicative retaining wall reinforcement diagram



Toe mesh - A393 - (393 mm²/m)
 Heel mesh - A393 - (393 mm²/m)
 Stem mesh - B785 - (785 mm²/m)