

107 Dinas Baglan Road, Port Talbot

Parking Bay - Structural Calculations

06/07/2020

Solutions to Structures Ltd.

J.M. Davies

 Solutions to Structures Ltd 44 Depot Road Port Talbot SA12 9BA	Project 107 Dinas Baglan Road, Port Talbot				Job Ref. 20-065	
	Section Parking bay				Sheet no./rev. 2	
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INTRODUCTION

Solutions to Structures Ltd. have been instructed to carry out the structural justification for the retaining works to the parking bay at the front of the above property.

The structure constructed of mass 7N Blockwork is seated on Mass Concrete strip foundations which are stepped to the sides of the structure to follow the adjacent ground levels.

Because of the returns to the main retaining section the side walls are considered for the reduced height behind the main wall

The structure is restrained at the top by the concrete slab of the car bay which bears on the walls.

The calculations are based on the rear wall section with stepped thicknesses as noted, ignoring the restraint provided by the return walls.

Loading to the tops of the walls are due to the self weight of the concrete slab and a domestic parking load

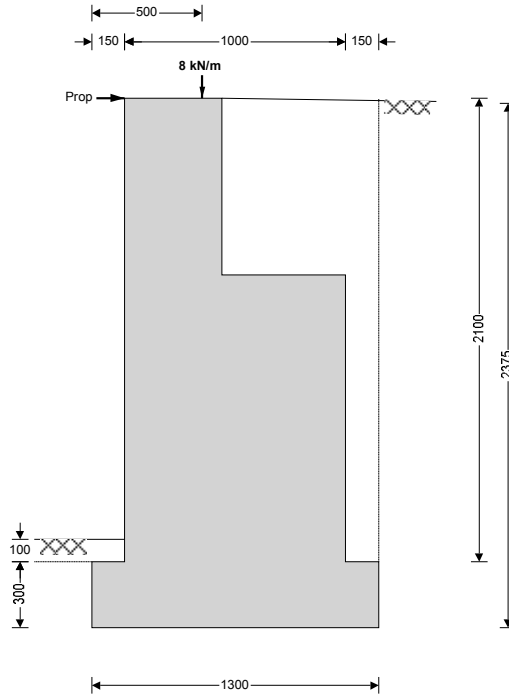
Loading		
SW	0.2x24=4.8	x1.4 = 6.8kN
Domestic parking	2.5	x1.6 = 4.0kN

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REAR SECTION

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.07



Wall details

Retaining wall type;
Number of steps;
Height of retaining 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;

Cantilever with stepped rear face propped at top

2

$h_{\text{stem}} = 2100 \text{ mm}$
 $l_{\text{toe}} = 150 \text{ mm}$
 $l_{\text{heel}} = 150 \text{ mm}$
 $l_{\text{base}} = l_{\text{toe}} + l_{\text{heel}} + t_{s1} = 1300 \text{ mm}$
 $t_{\text{base}} = 300 \text{ mm}$
 $d_{\text{ds}} = 0 \text{ mm}$
 $l_{\text{ds}} = 0 \text{ mm}$
 $t_{\text{ds}} = 300 \text{ mm}$
 $h_{\text{wall}} = h_{\text{stem}} + t_{\text{base}} + d_{\text{ds}} = 2400 \text{ mm}$
 $d_{\text{cover}} = 100 \text{ mm}$
 $d_{\text{exc}} = 100 \text{ mm}$
 $h_{\text{water}} = 0 \text{ mm}$
 $h_{\text{sat}} = \max(h_{\text{water}} - t_{\text{base}} - d_{\text{ds}}, 0 \text{ mm}) = 0 \text{ mm}$
 $\gamma_{\text{wall}} = 19.0 \text{ kN/m}^3$
 $\gamma_{\text{base}} = 24.0 \text{ kN/m}^3$
 $\alpha = 90.0 \text{ deg}$
 $\beta = -2.0 \text{ deg}$
 $h_{\text{eff}} = h_{\text{wall}} + (l_{\text{heel}} + t_{s1} - t_{s2}) \times \tan(\beta) = 2375 \text{ mm}$

Retained material details

Mobilisation factor;
 $M = 1.5$

Moist density of retained material;

$$\gamma_m = 18.0 \text{ kN/m}^3$$

Saturated density of retained material;

$$\gamma_s = 21.0 \text{ kN/m}^3$$

Design shear strength;

$$\phi' = 25.0 \text{ deg}$$

Angle of wall friction;

$$\delta = 0.0 \text{ deg}$$

Base material details

Moist density;

$$\gamma_{mb} = 18.0 \text{ kN/m}^3$$

Design shear strength;

$$\phi'_b = 25.8 \text{ deg}$$

Design base friction;

$$\delta_b = 19.9 \text{ deg}$$

Allowable bearing pressure;

$$P_{\text{bearing}} = 150 \text{ kN/m}^2$$

Using Coulomb theory

Active pressure coefficient for retained material

$$K_a = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))^2}] = 0.397$$

Passive pressure coefficient for base material

$$K_p = \sin(90 - \phi'_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi'_b + \delta_b) \times \sin(\phi'_b) / (\sin(90 + \delta_b)))^2}] = 4.785$$

At-rest pressure

At-rest pressure for retained material;

$$K_0 = 1 - \sin(\phi') = 0.577$$

Loading details

Surcharge load on plan;

$$\text{Surcharge} = 0.0 \text{ kN/m}^2$$

Applied vertical dead load on wall;

$$W_{\text{dead}} = 5.0 \text{ kN/m}$$

Applied vertical live load on wall;

$$W_{\text{live}} = 2.5 \text{ kN/m}$$

Position of applied vertical load on wall;

$$l_{\text{load}} = 500 \text{ mm}$$

Applied horizontal dead load on wall;

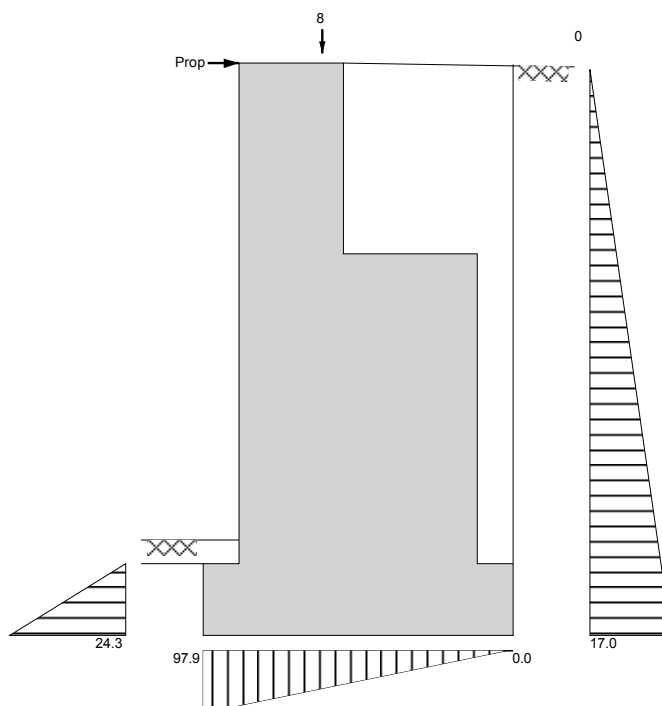
$$F_{\text{dead}} = 0.0 \text{ kN/m}$$

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

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Vertical forces on wall

Wall step no. 2;

$$w_{\text{step2}} = h_{s2} \times t_{s2} \times \gamma_{\text{wall}} = \mathbf{6.7 \text{ kN/m}}$$

Wall step no. 1;

$$w_{\text{step1}} = h_{s1} \times t_{s1} \times \gamma_{\text{wall}} = \mathbf{24.7 \text{ kN/m}}$$

Wall base;

$$w_{\text{base}} = l_{\text{base}} \times t_{\text{base}} \times \gamma_{\text{base}} = \mathbf{9.4 \text{ kN/m}}$$

Moist backfill to step no. 2;

$$w_{m_w2} = (l_{\text{heel}} + t_{s1} - t_{s2}) \times h_{s2} \times \gamma_m = \mathbf{10.2 \text{ kN/m}}$$

Moist backfill to step no. 1;

$$w_{m_w1} = (l_{\text{heel}} + t_{s1} - t_{s1}) \times h_{s1} \times \gamma_m = \mathbf{3.5 \text{ kN/m}}$$

Soil in front of wall;

$$w_p = l_{\text{toe}} \times d_{\text{cover}} \times \gamma_m = \mathbf{0.3 \text{ kN/m}}$$

Applied vertical load;

$$W_v = W_{\text{dead}} + W_{\text{live}} = \mathbf{7.5 \text{ kN/m}}$$

Total vertical load;

$$W_{\text{total}} = w_{\text{step2}} + w_{\text{step1}} + w_{\text{base}} + w_{m_w2} + w_{m_w1} + w_p + W_v = \mathbf{62.3 \text{ kN/m}}$$

Horizontal forces on wall

Moist backfill above water table;

$$F_{m_a} = 0.5 \times K_a \times \gamma_m \times (h_{\text{eff}} - h_{\text{water}})^2 = \mathbf{20.2 \text{ kN/m}}$$

Total horizontal load;

$$F_{\text{total}} = F_{m_a} = \mathbf{20.2 \text{ kN/m}}$$

Calculate propping force

Passive resistance of soil in front of wall;

$$F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{\text{cover}} + t_{\text{base}} + d_{\text{ds}} - d_{\text{exc}})^2 \times \gamma_{\text{mb}} = \mathbf{3.6 \text{ kN/m}}$$

Propping force;

$$F_{\text{prop}} = \max(F_{\text{total}} - F_p - (W_{\text{total}} - w_p - W_{\text{live}}) \times \tan(\delta_b), 0 \text{ kN/m})$$

$$F_{\text{prop}} = \mathbf{0.0 \text{ kN/m}}$$

Overturning moments

Moist backfill above water table;

$$M_{m_a} = F_{m_a} \times (h_{\text{eff}} + 2 \times h_{\text{water}} - 3 \times d_{\text{ds}}) / 3 = \mathbf{16 \text{ kNm/m}}$$

Total overturning moment;

$$M_{\text{ot}} = M_{m_a} = \mathbf{16 \text{ kNm/m}}$$

Restoring moments

Wall step no. 2;

$$M_{\text{step2}} = w_{\text{step2}} \times (l_{\text{toe}} + t_{s2} / 2) = \mathbf{2.5 \text{ kNm/m}}$$

Wall step no. 1;

$$M_{\text{step1}} = w_{\text{step1}} \times (l_{\text{toe}} + t_{s1} / 2) = \mathbf{16.1 \text{ kNm/m}}$$

Wall base;

$$M_{\text{base}} = w_{\text{base}} \times l_{\text{base}} / 2 = \mathbf{6.1 \text{ kNm/m}}$$

Moist backfill to step no. 2;

$$M_{m_w2} = w_{m_w2} \times (l_{\text{base}} - (l_{\text{heel}} + t_{s1} - t_{s2}) / 2) = \mathbf{9.7 \text{ kNm/m}}$$

Moist backfill to step no. 1;

$$M_{m_w1} = w_{m_w1} \times (l_{\text{base}} - (l_{\text{heel}} + t_{s1} - t_{s1}) / 2) = \mathbf{4.3 \text{ kNm/m}}$$

Soil in front of wall;

$$M_{p_r} = w_p \times l_{\text{toe}} / 2 = \mathbf{0 \text{ kNm/m}}$$

Design vertical load;

$$M_v = W_v \times l_{\text{load}} = \mathbf{3.8 \text{ kNm/m}}$$

Total restoring moment;

$$M_{\text{rest}} = M_{\text{step2}} + M_{\text{step1}} + M_{\text{base}} + M_{m_w2} + M_{m_w1} + M_{p_r} + M_v = \mathbf{42.3 \text{ kNm/m}}$$

kNm/m

Check bearing pressure

Total moment for bearing;

$$M_{\text{total}} = M_{\text{rest}} - M_{\text{ot}} = \mathbf{26.4 \text{ kNm/m}}$$

Total vertical reaction;

$$R = W_{\text{total}} = \mathbf{62.3 \text{ kN/m}}$$

Distance to reaction;

$$x_{\text{bar}} = M_{\text{total}} / R = \mathbf{424 \text{ mm}}$$

Eccentricity of reaction;

$$e = \text{abs}((l_{\text{base}} / 2) - x_{\text{bar}}) = \mathbf{226 \text{ mm}}$$

Bearing pressure at toe;

$$p_{\text{toe}} = R / (1.5 \times x_{\text{bar}}) = \mathbf{97.9 \text{ kN/m}^2}$$

Bearing pressure at heel;

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

PASS - Maximum bearing pressure is less than allowable bearing pressure

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Stem details

Thickness of wall stem;	$t_w = 440$ mm
Height of wall stem;	$h_{stem} = 750$ mm
Thickness of wall stem;	$t_w = 665$ mm
Height of wall stem;	$h_{stem} = 1000$ mm
Thickness of wall stem;	$t_w = 1002$ mm
Height of wall stem;	$h_{stem} = 2300$ mm

STEM DESIGN CHECKS - TENSION ALLOWED

Moment of Resistance - Tension Allowed

;Thickness of wall stem;	$t_w = 440$ mm
;Material safety factor for brickwork;	$\gamma_m = 3.50$
;Characteristic brickwork flexural stress;	$f_{kx} = 0.15$ N/mm ²
;Partial safety factor for design dead load;	$\gamma_{fd} = 0.90$
Modified stress;	$f_{kx1} = f_{kx} + \gamma_{fd} \times ((\gamma_w \times h_{stem} \times t_w + W_v) / t_w) \times \gamma_m = 0.235$ N/mm ²
Moment of resistance;	$M_{R_base} = (t_w^2 / 6) \times (f_{kx1} / \gamma_m) = 2.17$ kNm/m
Maximum base moment;	$M_{stem_base} = \text{abs}(M_{base_wall_ult}) = 2.11$ kNm/m

;Wall thickness OK - MR > factored moments at step

Mid Height Moment of Resistance - Tension Allowed 665mm Thick Section

Modified stress;	$f_{kx1_span} = f_{kx} + \gamma_{fd} \times ((\gamma_w \times h_{stem} / 2 \times t_w + W_v) / t_w) \times \gamma_m = 0.207$ N/mm ²
Moment of resistance;	$M_{R_span} = (t_w^2 / 6) \times (f_{kx1_span} / \gamma_m) = 4.35$ kNm/m
Maximum moment;	$M_{span} = \text{abs}(M_{span_wall_ult}) = 3.90$ kNm/m

;Wall thickness OK - MR > factored moments at mid height

Base Moment of Resistance - Tension Allowed

;Thickness of wall stem;	$t_w = 1002$ mm
;Material safety factor for brickwork;	$\gamma_m = 3.50$
;Characteristic brickwork flexural stress;	$f_{kx} = 0.15$ N/mm ²
;Partial safety factor for design dead load;	$\gamma_{fd} = 0.90$
Modified stress;	$f_{kx1} = f_{kx} + \gamma_{fd} \times ((\gamma_w \times h_{stem} \times t_w + W_v) / t_w) \times \gamma_m = 0.318$ N/mm ²
Moment of resistance;	$M_{R_base} = (t_w^2 / 6) \times (f_{kx1} / \gamma_m) = 15.21$ kNm/m
Maximum base moment;	$M_{stem_base} = \text{abs}(M_{base_wall_ult}) = 8.72$ kNm/m

;Wall thickness OK - MR > factored moments at base height

Stem Shear at base of wall (BS5628:Pt 1:Cl 33)

; Mortar designation;	Mortar = "ii"
Design dead load at the base of the wall;	$V_{base} = W_v + t_w \times h_{stem} \times \gamma_w = 53.42$ kN/m
;; Design vertical dead load per unit area;	$g_{A_base} = V_{base} \times \gamma_{fd} / t_w = 0.05$ N/mm ²

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Characteristic shear strength of masonry

$f_{v_i} = \min(1.75 \text{ N/mm}^2, 0.35 \text{ N/mm}^2 + (0.6 \times g_{A_base})) = \mathbf{0.38 \text{ N/mm}^2}$

$f_{v_{iii}} = \min(1.4 \text{ N/mm}^2, 0.15 \text{ N/mm}^2 + (0.6 \times g_{A_base})) = \mathbf{0.18 \text{ N/mm}^2}$

$f_{v_base} = \text{if}((\text{Mortar} == \text{"i"}) || (\text{Mortar} == \text{"ii"}), f_{v_i}, f_{v_{iii}}) = \mathbf{0.38 \text{ N/mm}^2}$

Ref BS 5628 Pt 1: Clause 25

Shear stresses;

$v_{base} = F_{base_wall_ult} / t_w = \mathbf{0.02 \text{ N/mm}^2}$

;Partial safety factor for shear;

$\gamma_{mv} = \mathbf{2.5}$

Wall base shear OK

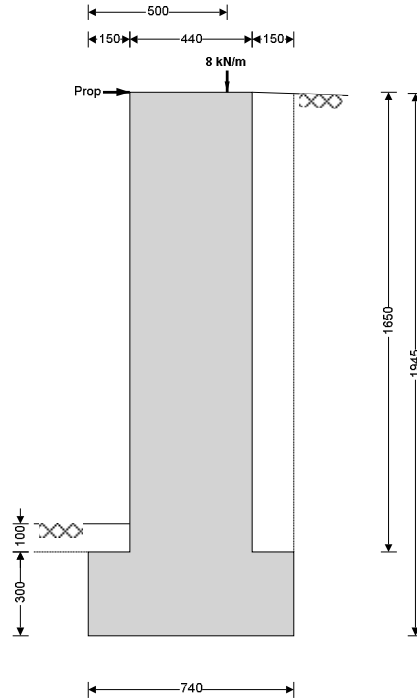
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SIDE WALLS

Maximum height taken behind base of rear wall

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.07



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;

Cantilever propped at top

$h_{\text{stem}} = 1650 \text{ mm}$
 $t_{\text{wall}} = 440 \text{ mm}$
 $l_{\text{toe}} = 150 \text{ mm}$
 $l_{\text{heel}} = 150 \text{ mm}$
 $l_{\text{base}} = l_{\text{toe}} + l_{\text{heel}} + t_{\text{wall}} = 740 \text{ mm}$
 $t_{\text{base}} = 300 \text{ mm}$
 $d_{\text{ds}} = 0 \text{ mm}$
 $l_{\text{ds}} = 0 \text{ mm}$
 $t_{\text{ds}} = 300 \text{ mm}$
 $h_{\text{wall}} = h_{\text{stem}} + t_{\text{base}} + d_{\text{ds}} = 1950 \text{ mm}$
 $d_{\text{cover}} = 100 \text{ mm}$
 $d_{\text{exc}} = 100 \text{ mm}$
 $h_{\text{water}} = 0 \text{ mm}$
 $h_{\text{sat}} = \max(h_{\text{water}} - t_{\text{base}} - d_{\text{ds}}, 0 \text{ mm}) = 0 \text{ mm}$
 $\gamma_{\text{wall}} = 19.0 \text{ kN/m}^3$
 $\gamma_{\text{base}} = 24.0 \text{ kN/m}^3$
 $\alpha = 90.0 \text{ deg}$
 $\beta = -2.0 \text{ deg}$
 $h_{\text{eff}} = h_{\text{wall}} + l_{\text{heel}} \times \tan(\beta) = 1945 \text{ mm}$

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Retained material details

Mobilisation factor;	$M = 1.5$
Moist density of retained material;	$\gamma_m = 18.0 \text{ kN/m}^3$
Saturated density of retained material;	$\gamma_s = 21.0 \text{ kN/m}^3$
Design shear strength;	$\phi' = 25.0 \text{ deg}$
Angle of wall friction;	$\delta = 0.0 \text{ deg}$

Base material details

Moist density;	$\gamma_{mb} = 18.0 \text{ kN/m}^3$
Design shear strength;	$\phi'_b = 25.8 \text{ deg}$
Design base friction;	$\delta_b = 19.9 \text{ deg}$
Allowable bearing pressure;	$P_{\text{bearing}} = 150 \text{ kN/m}^2$

Using Coulomb theory

Active pressure coefficient for retained material

$$K_a = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))}]^2) = 0.397$$

Passive pressure coefficient for base material

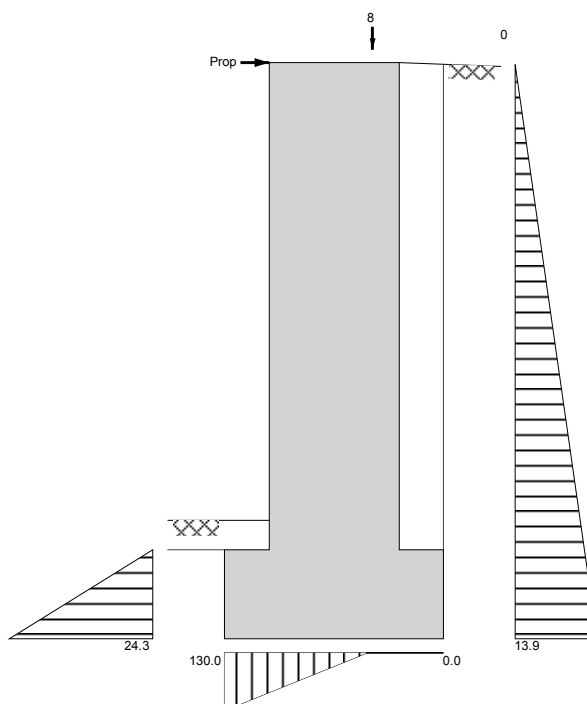
$$K_p = \sin(90 - \phi'_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi'_b + \delta_b) \times \sin(\phi'_b) / (\sin(90 + \delta_b)))}]^2) = 4.785$$

At-rest pressure

At-rest pressure for retained material;	$K_0 = 1 - \sin(\phi') = 0.577$
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Loading details

Surcharge load on plan;	Surcharge = 0.0 kN/m^2
Applied vertical dead load on wall;	$W_{\text{dead}} = 5.0 \text{ kN/m}$
Applied vertical live load on wall;	$W_{\text{live}} = 2.5 \text{ kN/m}$
Position of applied vertical load on wall;	$l_{\text{load}} = 500 \text{ mm}$
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;	$h_{\text{load}} = 0 \text{ mm}$



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

Vertical forces on wall

Wall stem;

$$w_{\text{wall}} = h_{\text{stem}} \times t_{\text{wall}} \times \gamma_{\text{wall}} = \mathbf{13.8 \text{ kN/m}}$$

Wall base;

$$w_{\text{base}} = l_{\text{base}} \times t_{\text{base}} \times \gamma_{\text{base}} = \mathbf{5.3 \text{ kN/m}}$$

Moist backfill to top of wall;

$$w_{\text{m}_w} = l_{\text{heel}} \times (h_{\text{stem}} - h_{\text{sat}}) \times \gamma_m = \mathbf{4.5 \text{ kN/m}}$$

Soil in front of wall;

$$w_p = l_{\text{toe}} \times d_{\text{cover}} \times \gamma_{\text{mb}} = \mathbf{0.3 \text{ kN/m}}$$

Applied vertical load;

$$W_v = W_{\text{dead}} + W_{\text{live}} = \mathbf{7.5 \text{ kN/m}}$$

Total vertical load;

$$W_{\text{total}} = w_{\text{wall}} + w_{\text{base}} + w_{\text{m}_w} + w_p + W_v = \mathbf{31.3 \text{ kN/m}}$$

Horizontal forces on wall

Moist backfill above water table;

$$F_{\text{m}_a} = 0.5 \times K_a \times \gamma_m \times (h_{\text{eff}} - h_{\text{water}})^2 = \mathbf{13.5 \text{ kN/m}}$$

Total horizontal load;

$$F_{\text{total}} = F_{\text{m}_a} = \mathbf{13.5 \text{ kN/m}}$$

Calculate propping force

Passive resistance of soil in front of wall;

$$F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{\text{cover}} + t_{\text{base}} + d_{\text{ds}} - d_{\text{exc}})^2 \times \gamma_{\text{mb}} = \mathbf{3.6 \text{ kN/m}}$$

Propping force;

$$F_{\text{prop}} = \max(F_{\text{total}} - F_p - (W_{\text{total}} - w_p - W_{\text{live}}) \times \tan(\delta_b), 0 \text{ kN/m})$$

$$F_{\text{prop}} = \mathbf{0.0 \text{ kN/m}}$$

Overturning moments

Moist backfill above water table;

$$M_{\text{m}_a} = F_{\text{m}_a} \times (h_{\text{eff}} + 2 \times h_{\text{water}} - 3 \times d_{\text{ds}}) / 3 = \mathbf{8.8 \text{ kNm/m}}$$

Total overturning moment;

$$M_{\text{ot}} = M_{\text{m}_a} = \mathbf{8.8 \text{ kNm/m}}$$

Restoring moments

Wall stem;

$$M_{\text{wall}} = w_{\text{wall}} \times (l_{\text{toe}} + t_{\text{wall}} / 2) = \mathbf{5.1 \text{ kNm/m}}$$

Wall base;

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

Moist backfill;

$$M_{\text{m}_r} = (w_{\text{m}_w} \times (l_{\text{base}} - l_{\text{heel}} / 2) + w_{\text{m}_s} \times (l_{\text{base}} - l_{\text{heel}} / 3)) = \mathbf{3 \text{ kNm/m}}$$

Soil in front of wall;

$$M_{\text{p}_r} = w_p \times l_{\text{toe}} / 2 = \mathbf{0 \text{ kNm/m}}$$

Design vertical load;

$$M_v = W_v \times l_{\text{load}} = \mathbf{3.8 \text{ kNm/m}}$$

Total restoring moment;

$$M_{\text{rest}} = M_{\text{wall}} + M_{\text{base}} + M_{\text{m}_r} + M_{\text{p}_r} + M_v = \mathbf{13.8 \text{ kNm/m}}$$

Check bearing pressure

Total moment for bearing;

$$M_{\text{total}} = M_{\text{rest}} - M_{\text{ot}} = \mathbf{5 \text{ kNm/m}}$$

Total vertical reaction;

$$R = W_{\text{total}} = \mathbf{31.3 \text{ kN/m}}$$

Distance to reaction;

$$x_{\text{bar}} = M_{\text{total}} / R = \mathbf{161 \text{ mm}}$$

Eccentricity of reaction;

$$e = \text{abs}((l_{\text{base}} / 2) - x_{\text{bar}}) = \mathbf{209 \text{ mm}}$$

Bearing pressure at toe;

$$p_{\text{toe}} = R / (1.5 \times x_{\text{bar}}) = \mathbf{130 \text{ kN/m}^2}$$

Bearing pressure at heel;

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

PASS - Maximum bearing pressure is less than allowable bearing pressure

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PROPPED CANTILEVER MASONRY RETAINING WALL DESIGN TO CP2 & BS5628 (PART 1)

STEM DESIGN CHECKS - TENSION ALLOWED

Stem Base section ;440mm thick and 1650mm from base to the top of the wall

Base Moment of Resistance - Tension Allowed

;Thickness of wall stem; $t_w = 440$ mm

;Material safety factor for brickwork; $\gamma_m = 3.50$

;Characteristic brickwork flexural stress; $f_{kx} = 0.15$ N/mm²

;Partial safety factor for design dead load; $\gamma_{fd} = 0.90$

Modified stress; $f_{kx1} = f_{kx} + \gamma_{fd} \times ((\gamma_w \times h_{stem} \times t_w + W_v) / t_w) \times \gamma_m = 0.276$ N/mm²

Moment of resistance; $M_{R_base} = (t_w^2 / 6) \times (f_{kx1} / \gamma_m) = 2.54$ kNm/m

Maximum base moment; $M_{stem_base} = \text{abs}(M_{base_wall_ult}) = 2.42$ kNm/m

;Wall thickness OK - MR > factored moments at base height

Stem Shear at base of wall (BS5628:Pt 1:Cl 33)

; Mortar designation; Mortar = "iii"

Design dead load at the base of the wall; $V_{base} = W_v + t_w \times h_{stem} \times \gamma_w = 17.54$ kN/m

; Design vertical dead load per unit area; $g_{A_base} = V_{base} \times \gamma_{fd} / t_w = 0.04$ N/mm²

Characteristic shear strength of masonry

$$f_{v_i} = \min(1.75 \text{ N/mm}^2, 0.35 \text{ N/mm}^2 + (0.6 \times g_{A_base})) = 0.37 \text{ N/mm}^2$$

$$f_{v_iii} = \min(1.4 \text{ N/mm}^2, 0.15 \text{ N/mm}^2 + (0.6 \times g_{A_base})) = 0.17 \text{ N/mm}^2$$

$$f_{v_base} = \text{if}((\text{Mortar} == "i") || (\text{Mortar} == "ii"), f_{v_i}, f_{v_iii}) = 0.17 \text{ N/mm}^2$$

Ref BS 5628 Pt 1: Clause 25

Shear stresses; $v_{base} = F_{base_wall_ult} / t_w = 0.02$ N/mm²

;Partial safety factor for shear; $\gamma_{mv} = 2.5$

Wall base shear OK

Mid Span Moment of Resistance - Tension Allowed

Modified stress; $f_{kx1_span} = f_{kx} + \gamma_{fd} \times ((\gamma_w \times h_{stem}/2 \times t_w + W_v) / t_w) \times \gamma_m = 0.231$ N/mm²

Moment of resistance; $M_{R_span} = (t_w^2 / 6) \times (f_{kx1_span} / \gamma_m) = 2.13$ kNm/m

Maximum base moment; $M_{span} = \text{abs}(M_{span_wall_ult}) = 1.08$ kNm/m

;Wall thickness OK - MR > factored moments at mid height

Stem shear at top of wall (BS5628:Pt 1:Cl 33)

Design dead load at the top of the wall; $V_{top} = W_v = 5.00$ kN/m

; Design vertical dead load per unit area; $g_{A_top} = V_{top} \times \gamma_{fd} / t_w = 0.01$ N/mm²

Characteristic shear strength of masonry

$$f_{v_i_top} = \min(1.75 \text{ N/mm}^2, 0.35 \text{ N/mm}^2 + (0.6 \times g_{A_top})) = 0.36 \text{ N/mm}^2$$

$$f_{v_iii_top} = \min(1.4 \text{ N/mm}^2, 0.15 \text{ N/mm}^2 + (0.6 \times g_{A_top})) = 0.16 \text{ N/mm}^2$$

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$f_{v_top} = \text{if}((\text{Mortar} == \text{"i"}) || (\text{Mortar} == \text{"ii"}), f_{v_i_top}, f_{v_iii_top}) = 0.16 \text{ N/mm}^2$

Ref BS 5628 Pt 1: Clause 25

Shear stresses;
 $v_{top} = F_{top_wall_ult} / t_w = 0.01 \text{ N/mm}^2$
;Partial safety factor for shear;
 $\gamma_{mv} = 2.5$

Top of wall shear OK

;
;

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RC SLAB DESIGN (BS8110:PART1:1997)

TEDDS calculation version 1.0.04

TWO WAY SPANNING SLAB DEFINITION – SIMPLY SUPPORTED

; Overall depth of slab; $h = 200$ mm

Outer sagging steel

; Cover to outer tension reinforcement resisting sagging; $c_{sag} = 40$ mm

; Trial bar diameter; $D_{tryx} = 10$ mm

Depth to outer tension steel (resisting sagging)

$$d_x = h - c_{sag} - D_{tryx}/2 = 155 \text{ mm}$$

Inner sagging steel

; Trial bar diameter; $D_{tryy} = 10$ mm

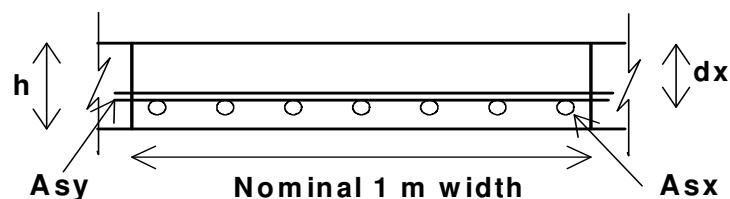
Depth to inner tension steel (resisting sagging)

$$d_y = h - c_{sag} - D_{tryx} - D_{tryy}/2 = 145 \text{ mm}$$

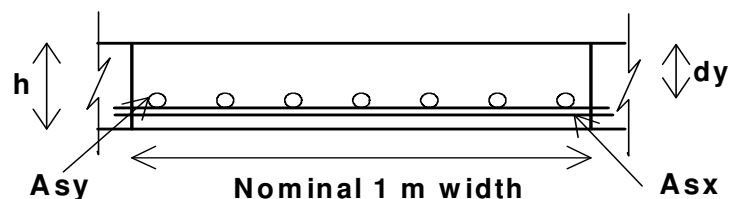
Materials

; Characteristic strength of reinforcement; $f_y = 500$ N/mm²

; Characteristic strength of concrete; $f_{cu} = 35$ N/mm²



Shorter Span



Longer Span

Two-way spanning slab (simple)

MAXIMUM DESIGN MOMENTS

; Length of shorter side of slab; $l_x = 2.100$ m

; Length of longer side of slab; $l_y = 4.300$ m

; Design ultimate load per unit area; $n_s = 11.0$ kN/m²

Moment coefficients

$$\alpha_{sx} = (l_y / l_x)^4 / (8 \times (1 + (l_y / l_x)^4)) = 0.118$$

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$$\alpha_{sy} = (l_y / l_x)^2 / (8 \times (1 + (l_y / l_x)^4)) = 0.028$$

Maximum moments per unit width - simply supported slabs

$$m_{sx} = \alpha_{sx} \times n_s \times l_x^2 = 5.7 \text{ kNm/m}$$

$$m_{sy} = \alpha_{sy} \times n_s \times l_x^2 = 1.4 \text{ kNm/m}$$

CONCRETE SLAB DESIGN – SAGGING – OUTER LAYER OF STEEL (CL 3.5.4)

; Design sagging moment (per m width of slab); $m_{sx} = 5.7 \text{ kNm/m}$

; Moment Redistribution Factor; $\beta_{bx} = 1.0$

Area of reinforcement required

$$K_x = \text{abs}(m_{sx}) / (d_x^2 \times f_{cu}) = 0.007$$

$$K'_x = \min(0.156, (0.402 \times (\beta_{bx} - 0.4)) - (0.18 \times (\beta_{bx} - 0.4)^2)) = 0.156$$

Outer compression steel not required to resist sagging

Concrete Slab Design - Sagging - Inner layer of steel (cl. 3.5.4)

; Design sagging moment (per m width of slab); $m_{sy} = 1.4 \text{ kNm/m}$

; Moment Redistribution Factor; $\beta_{by} = 1.0$

Area of reinforcement required

$$K_y = \text{abs}(m_{sy}) / (d_y^2 \times f_{cu}) = 0.002$$

$$K'_y = \min(0.156, (0.402 \times (\beta_{by} - 0.4)) - (0.18 \times (\beta_{by} - 0.4)^2)) = 0.156$$

Inner compression steel not required to resist sagging

Two way Spanning Slab requiring tension steel only - mesh (sagging)

$$z_x = \min((0.95 \times d_x), (d_x \times (0.5 + \sqrt{(0.25 - K_x/0.9)}))) = 147 \text{ mm}$$

$$\text{Neutral axis depth; } x_x = (d_x - z_x) / 0.45 = 17 \text{ mm}$$

$$z_y = \min((0.95 \times d_y), (d_y \times (0.5 + \sqrt{(0.25 - K_y/0.9)}))) = 138 \text{ mm}$$

$$\text{Neutral axis depth; } x_y = (d_y - z_y) / 0.45 = 16 \text{ mm}$$

Area of outer tension steel required

$$A_{sx_req} = \text{abs}(m_{sx}) / (1/\gamma_{ms} \times f_y \times z_x) = 90 \text{ mm}^2/\text{m}$$

Area of inner tension steel required

$$A_{sy_req} = \text{abs}(m_{sy}) / (1/\gamma_{ms} \times f_y \times z_y) = 23 \text{ mm}^2/\text{m}$$

Tension steel;

Provide A393 Mesh; tension steel resisting sagging

$$A_{sx_prov} = A_{sl} = 393 \text{ mm}^2/\text{m}; A_{sy_prov} = A_{st} = 393 \text{ mm}^2/\text{m}$$

$$D_x = d_{sl} = 10 \text{ mm}; D_y = d_{st} = 10 \text{ mm}$$

Area of tension steel provided sufficient to resist sagging

Check min and max areas of steel resisting sagging

$$\text{Total area of concrete; } A_c = h = 200000 \text{ mm}^2/\text{m}$$

; Minimum % reinforcement; $k = 0.13 \%$

$$A_{st_min} = k \times A_c = 260 \text{ mm}^2/\text{m}$$

$$A_{st_max} = 4 \% \times A_c = 8000 \text{ mm}^2/\text{m}$$

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Steel defined:

; Outer steel resisting sagging; $A_{sx_prov} = 393 \text{ mm}^2/\text{m}$

Area of outer steel provided (sagging) OK

; Inner steel resisting sagging; $A_{sy_prov} = 393 \text{ mm}^2/\text{m}$

Area of inner steel provided (sagging) OK

SHEAR RESISTANCE OF CONCRETE SLABS (CL 3.5.5)

Outer tension steel resisting sagging moments

; Depth to tension steel from compression face; $d_x = 155 \text{ mm}$

; Area of tension reinforcement provided (per m width of slab); $A_{sx_prov} = 393 \text{ mm}^2/\text{m}$

; Design ultimate shear force (per m width of slab); $V_x = 22 \text{ kN/m}$

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

Applied shear stress

$$v_x = V_x / d_x = 0.14 \text{ N/mm}^2$$

Check shear stress to clause 3.5.5.2

$$v_{allowable} = \min((0.8 \text{ N}^{1/2}/\text{mm}) \times \sqrt{f_{cu}}, 5 \text{ N/mm}^2) = 4.73 \text{ N/mm}^2$$

Shear stress - OK

Shear stresses to clause 3.5.5.3

Design shear stress

$$f_{cu_ratio} = \text{if } (f_{cu} > 40 \text{ N/mm}^2, 40/25, f_{cu}/(25 \text{ N/mm}^2)) = 1.400$$

$$v_{cx} = 0.79 \text{ N/mm}^2 \times \min(3, 100 \times A_{sx_prov} / d_x)^{1/3} \times \max(0.67, (400 \text{ mm} / d_x)^{1/4}) / 1.25 \times f_{cu_ratio}^{1/3}$$

$$v_{cx} = 0.57 \text{ N/mm}^2$$

Applied shear stress

$$v_x = 0.14 \text{ N/mm}^2$$

No shear reinforcement required

SHEAR RESISTANCE OF CONCRETE SLABS (CL 3.5.5)

Inner tension steel resisting sagging moments

; Depth to tension steel from compression face; $d_y = 145 \text{ mm}$

; Area of tension reinforcement provided (per m width of slab); $A_{sy_prov} = 393 \text{ mm}^2/\text{m}$

; Design ultimate shear force (per m width of slab); $V_y = 22 \text{ kN/m}$

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

Applied shear stress

$$v_y = V_y / d_y = 0.15 \text{ N/mm}^2$$

Check shear stress to clause 3.5.5.2

$$v_{allowable} = \min((0.8 \text{ N}^{1/2}/\text{mm}) \times \sqrt{f_{cu}}, 5 \text{ N/mm}^2) = 4.73 \text{ N/mm}^2$$

Shear stress - OK

Shear stresses to clause 3.5.5.3

Design shear stress

$$f_{cu_ratio} = \text{if } (f_{cu} > 40 \text{ N/mm}^2, 40/25, f_{cu}/(25 \text{ N/mm}^2)) = 1.400$$

$$v_{cy} = 0.79 \text{ N/mm}^2 \times \min(3, 100 \times A_{sy_prov} / d_y)^{1/3} \times \max(0.67, (400 \text{ mm} / d_y)^{1/4}) / 1.25 \times f_{cu_ratio}^{1/3}$$

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$$v_{cy} = 0.59 \text{ N/mm}^2$$

Applied shear stress

$$v_y = 0.15 \text{ N/mm}^2$$

No shear reinforcement required

CONCRETE SLAB DEFLECTION CHECK (CL 3.5.7)

- ; Slab span length; $l_x = 2.100 \text{ m}$
- ; Design ultimate moment in shorter span per m width; $m_{sx} = 6 \text{ kNm/m}$
- ; Depth to outer tension steel; $d_x = 155 \text{ mm}$

Tension steel

- ; Area of outer tension reinforcement provided; $A_{sx_prov} = 393 \text{ mm}^2/\text{m}$
- ; Area of tension reinforcement required; $A_{sx_req} = 90 \text{ mm}^2/\text{m}$
- ; Moment Redistribution Factor; $\beta_{bx} = 1.00$

Modification Factors

; Basic span / effective depth ratio (Table 3.9); $\text{ratio}_{\text{span_depth}} = 20$

The modification factor for spans in excess of 10m (ref. cl 3.4.6.4) has not been included.

$$; f_s = 2 \times f_y \times A_{sx_req} / (3 \times A_{sx_prov} \times \beta_{bx}) = 76.0 \text{ N/mm}^2$$

$$\text{factor}_{\text{tens}} = \min (2, 0.55 + (477 \text{ N/mm}^2 - f_s) / (120 \times (0.9 \text{ N/mm}^2 + m_{sx} / d_x^2))) = 2.000$$

Calculate Maximum Span

This is a simplified approach and further attention should be given where special circumstances exist. Refer to clauses 3.4.6.4 and 3.4.6.7.

$$\text{Maximum span; } l_{\text{max}} = \text{ratio}_{\text{span_depth}} \times \text{factor}_{\text{tens}} \times d_x = 6.20 \text{ m}$$

Check the actual beam span

$$\text{Actual span/depth ratio; } l_x / d_x = 13.55$$

$$\text{Span depth limit; } \text{ratio}_{\text{span_depth}} \times \text{factor}_{\text{tens}} = 40.00$$

Span/Depth ratio check satisfied

CHECK OF NOMINAL COVER (SAGGING) – (BS8110:PT 1, TABLE 3.4)

- ; Slab thickness; $h = 200 \text{ mm}$
- ; Effective depth to bottom outer tension reinforcement; $d_x = 155.0 \text{ mm}$

$$; \text{Diameter of tension reinforcement; } D_x = 10 \text{ mm}$$

$$; \text{Diameter of links; } L_{\text{dix}} = 0 \text{ mm}$$

Cover to outer tension reinforcement

$$c_{\text{tenx}} = h - d_x - D_x / 2 = 40.0 \text{ mm}$$

Nominal cover to links steel

$$c_{\text{nomx}} = c_{\text{tenx}} - L_{\text{dix}} = 40.0 \text{ mm}$$

Permissible minimum nominal cover to all reinforcement (Table 3.4)

$$; c_{\text{min}} = 40 \text{ mm}$$

Cover over steel resisting sagging OK



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