

107 Dinas Baglan Road, Port Talbot

Parking Bay - Structural Calculations

06/07/2020

Solutions to Structures Ltd.

J.M. Davies

Project 107 Dinas Baglan Road, Port Talbot				Job Ref. 20-065	
Section Parking bay				Sheet no./rev. 2	
Calc. by JD	Date 06/07/2020	Chk'd by	Date	App'd by	Date

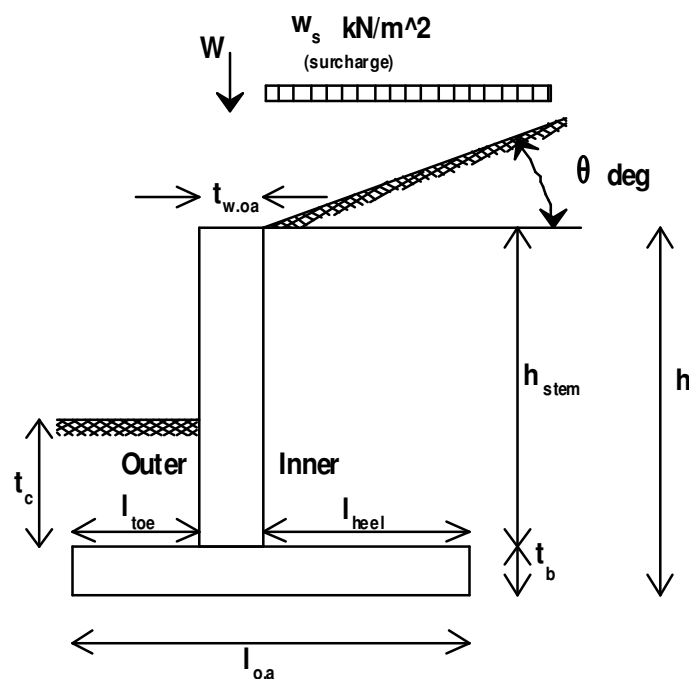


INTRODUCTION

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

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.



 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. 3	
	Calc. by JD	Date 06/07/2020	Chk'd by	Date	App'd by	Date

PROPPED CANTILEVER MASONRY RETAINING WALL DESIGN (BS8110&BS5628);PROPPED CANTILEVER MASONRY RETAINING WALL DESIGN TO CP2 & BS5628 (PART 1)

Note:-The wall is part of a structure restrained at the top by a concrete floor slab. Sliding & Overturning are therefore not critical and are thus not checked.

RETAINING WALL PRESSURES - GRANULAR FILL - NO WALL FRICTION – ASSUMED FULLY DRAINED

General Soil Data

- ; Density of retained soil; $\gamma_s = 18.0 \text{ kN/m}^3$
- ; Angle of internal friction; $\phi = 35.0^\circ$
- ; Angle of soil surface; $\theta = 0.0^\circ$
- ; Ground cover over base at front of wall
– if > 0mm, assumed permanent; $t_c = 0 \text{ mm}$

Loads on wall and ground

- ; Surcharge load (horizontal plan area); $w_s = 0.0 \text{ kN/m}^2$
- ; Design vertical dead load on wall (unfactored); $W_v = 5.00 \text{ kN/m}$
- ; Design vertical live load on wall (unfactored); $W_l = 2.50 \text{ kN/m}$

Stem details

- ; Density of wall stem brickwork; $\gamma_w = 21.0 \text{ kN/m}^3$
- ; Height retained; $h = 2800 \text{ mm}$
- ; Thickness of wall stem; $t_w = 1002 \text{ mm}$

Base details

- ; Density of wall base; $\gamma_b = 24.0 \text{ kN/m}^3$
- ; Length of heel; $l_{heel} = 150 \text{ mm}$
- ; Length of toe; $l_{toe} = 150 \text{ mm}$
- ; Base thickness; $t_b = 500 \text{ mm}$
- Length of Base; $l_{o_a} = l_{toe} + t_w + l_{heel} = 1302 \text{ mm}$

Height of active soil (at back of stem and heel)

- Height of wall stem; $h_{stem} = h - t_b = 2300 \text{ mm}$

Warning the height of the stem is not a complete number of bricks

$$h_{soil} = h + l_{heel} \times \tan(\theta) = 2800 \text{ mm}$$

Load factors

- ; Dead Load Factor; $\gamma_{f_d} = 1.40$
- ; Imposed Load Factor; $\gamma_{f_i} = 1.60$

Coefficients using Rankine

Active coefficient (Sloping Surface) - no friction

$$k_{a_s} = (\cos(\theta) - \sqrt{((\cos(\theta))^2 - (\cos(\phi))^2)}) / (\cos(\theta) + \sqrt{((\cos(\theta))^2 - (\cos(\phi))^2)}) = 0.271$$

$$\text{Active coefficient (level surface); } k_a = (1 - \sin(\phi)) / (1 + \sin(\phi)) = 0.271$$

$$\text{Passive coefficient (level surface); } k_p = (1 + \sin(\phi)) / (1 - \sin(\phi)) = 3.690$$

$$\text{At - rest coefficient; } k_o = (1 - \sin(\phi)) = 0.426$$

 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. 4	
	Calc. by JD	Date 06/07/2020	Chk'd by	Date	App'd by	Date

For a one metre width - (Horizontal Components - Active Earth Pressures)

Surcharge

pressure; $p_s = k_{a,s} \times w_s = \mathbf{0.0 \text{ kN/m}^2}$
force; $F_s = (p_s \times h_{soil}) \times (\cos(\theta))^2 = \mathbf{0.0 \text{ kN/m}}$

Backfill

pressure; $p_a = k_{a,s} \times \gamma_s \times h_{soil} = \mathbf{13.7 \text{ kN/m}^2}$
force; $F_a = (p_a \times h_{soil} / 2) \times (\cos(\theta))^2 = \mathbf{19.1 \text{ kN/m}}$

Total horizontal force (unfactored); $F_t = F_s + F_a = \mathbf{19.1 \text{ kN/m}}$

Moments

Unfactored base moment; $M_{base} = - (2 \times F_a \times h_{soil} / 15 + F_s \times h_{soil} / 8) = \mathbf{-7.1 \text{ kNm/m}}$
Factored base moment; $M_{base_ult} = - (2 \times F_a \times h_{soil} \times \gamma_{f,d} / 15 + F_s \times h_{soil} \times \gamma_{f,i} / 8) = \mathbf{-10.0 \text{ kNm/m}}$
Unfactored span moment; $M_{span} = 0.0596 \times F_a \times h_{soil} + 0.07 \times F_s \times h_{soil} = \mathbf{3.2 \text{ kNm/m}}$
Factored span moment; $M_{span_ult} = 0.0596 \times F_a \times h_{soil} \times \gamma_{f,d} + 0.07 \times F_s \times h_{soil} \times \gamma_{f,i} = \mathbf{4.5 \text{ kNm/m}}$
Average load factor; $\gamma_{f_av} = M_{base_ult} / M_{base} = \mathbf{1.40}$

Shears

Unfactored shear at base; $F_{t_base} = 0.625 \times F_s + 0.8 \times F_a = \mathbf{15.3 \text{ kN/m}}$
Unfactored shear at top; $F_{t_top} = F_t - F_{t_base} = \mathbf{3.8 \text{ kN/m}}$

Stem loading using At Rest Earth Pressures

Surcharge

pressure; $p_{so_wall} = k_o \times w_s = \mathbf{0.0 \text{ kN/m}^2}$
force; $F_{so_wall} = p_{so_wall} \times h_{stem} = \mathbf{0.0 \text{ kN/m}}$

Backfill

pressure; $p_{o_wall} = k_o \times \gamma_s \times h_{stem} = \mathbf{17.7 \text{ kN/m}^2}$
force; $F_{o_wall} = p_{o_wall} \times h_{stem} / 2 = \mathbf{20.3 \text{ kN/m}}$

Total horizontal force (factored); $F_{t_ult_wall} = \gamma_{f,i} \times F_{so_wall} + \gamma_{f,d} \times F_{o_wall} = \mathbf{28.4 \text{ kN/m}}$

Base of Wall (Negative Moments) - Outer Face

$M_{base_wall} = F_{so_wall} \times h_{stem} / 8 + 2 \times F_{o_wall} \times h_{stem} / 15 = \mathbf{6.2 \text{ kNm/m}}$
 $M_{base_wall_ult} = F_{so_wall} \times h_{stem} \times \gamma_{f,i} / 8 + 2 \times F_{o_wall} \times h_{stem} \times \gamma_{f,d} / 15 = \mathbf{8.7 \text{ kNm/m}}$
Shear at Base of Wall; $F_{base_wall_ult} = 0.625 \times F_{so_wall} \times \gamma_{f,i} + 0.8 \times F_{o_wall} \times \gamma_{f,d} = \mathbf{22.7 \text{ kN/m}}$

Mid Height of Wall (Positive Moments) - Inner Face

$M_{span_wall} = F_{o_wall} \times h_{stem} \times 0.0596 + F_{so_wall} \times h_{stem} \times 0.07 = \mathbf{2.8 \text{ kNm/m}}$
 $M_{span_wall_ult} = F_{o_wall} \times h_{stem} \times \gamma_{f,d} \times 0.0596 + F_{so_wall} \times h_{stem} \times \gamma_{f,i} \times 0.07 = \mathbf{3.9 \text{ kNm/m}}$

Shear at Top of Wall; $F_{top_wall_ult} = F_{t_ult_wall} - F_{base_wall_ult} = \mathbf{5.7 \text{ kN/m}}$

Stem details

Thickness of wall stem; $t_w = \mathbf{440 \text{ mm}}$
Height of wall stem; $h_{stem} = \mathbf{750 \text{ mm}}$
Thickness of wall stem; $t_w = \mathbf{665 \text{ mm}}$
Height of wall stem; $h_{stem} = \mathbf{1000 \text{ mm}}$

 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. 5	
	Calc. by JD	Date 06/07/2020	Chk'd by	Date	App'd by	Date

Thickness of wall stem; $t_w = 1002 \text{ mm}$
Height of wall stem; $h_{\text{stem}} = 2300 \text{ mm}$

STEM DESIGN CHECKS - TENSION ALLOWED

Moment of Resistance - Tension Allowed

;Thickness of wall stem; $t_w = 440 \text{ mm}$
;Material safety factor for brickwork; $\gamma_m = 3.50$
;Characteristic brickwork flexural stress; $f_{kx} = 0.15 \text{ N/mm}^2$
;Partial safety factor for design dead load; $\gamma_{fd} = 0.90$

Modified stress; $f_{kx1} = f_{kx} + \gamma_{fd} \times ((\gamma_w \times h_{\text{stem}} \times t_w + W_v) / t_w) \times \gamma_m = 0.235 \text{ N/mm}^2$

Moment of resistance; $M_{R_base} = (t_w^2 / 6) \times (f_{kx1} / \gamma_m) = 2.17 \text{ kNm/m}$

Maximum base moment; $M_{\text{stem_base}} = \text{abs}(M_{\text{base_wall_ult}}) = 2.11 \text{ kNm/m}$

;Wall thickness OK - MR > factored moments at step

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

Modified stress; $f_{kx1_span} = f_{kx} + \gamma_{fd} \times ((\gamma_w \times h_{\text{stem}} / 2 \times t_w + W_v) / t_w) \times \gamma_m = 0.207 \text{ N/mm}^2$

Moment of resistance; $M_{R_span} = (t_w^2 / 6) \times (f_{kx1_span} / \gamma_m) = 4.35 \text{ kNm/m}$

Maximum moment; $M_{\text{span}} = \text{abs}(M_{\text{span_wall_ult}}) = 3.90 \text{ kNm/m}$

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

Base Moment of Resistance - Tension Allowed

;Thickness of wall stem; $t_w = 1002 \text{ mm}$
;Material safety factor for brickwork; $\gamma_m = 3.50$
;Characteristic brickwork flexural stress; $f_{kx} = 0.15 \text{ N/mm}^2$
;Partial safety factor for design dead load; $\gamma_{fd} = 0.90$

Modified stress; $f_{kx1} = f_{kx} + \gamma_{fd} \times ((\gamma_w \times h_{\text{stem}} \times t_w + W_v) / t_w) \times \gamma_m = 0.318 \text{ N/mm}^2$

Moment of resistance; $M_{R_base} = (t_w^2 / 6) \times (f_{kx1} / \gamma_m) = 15.21 \text{ kNm/m}$

Maximum base moment; $M_{\text{stem_base}} = \text{abs}(M_{\text{base_wall_ult}}) = 8.72 \text{ kNm/m}$

;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; $V_{\text{base}} = W_v + t_w \times h_{\text{stem}} \times \gamma_w = 53.42 \text{ kN/m}$

:: Design vertical dead load per unit area; $g_{A_base} = V_{\text{base}} \times \gamma_{fd} / t_w = 0.05 \text{ N/mm}^2$

Characteristic shear strength of masonry

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

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

 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. 6	
	Calc. by JD	Date 06/07/2020	Chk'd by	Date	App'd by	Date

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

Ref BS 5628 Pt 1: Clause 25

Shear stresses;

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

;Partial safety factor for shear;

$$\gamma_{mv} = 2.5$$

Wall base shear OK

STABILITY CHECKS

(Unfactored Loads - Active Soil Pressures)

Note:- Sliding and Overturning are Not Critical where the Wall is part of a balanced structure

;Length of heel provided;

$$l_{heel} = 150 \text{ mm}$$

;Length of toe provided;

$$l_{toe} = 150 \text{ mm}$$

Overall Length Of Base;

$$l_{o_a} = l_{toe} + t_w + l_{heel} = 1.302 \text{ m}$$

1) BEARING PRESSURE

Total vertical load on base

$$N = t_w \times h_{stem} \times \gamma_w + (h_{stem} + l_{heel} \times \tan(\theta) / 2) \times l_{heel} \times \gamma_s + t_c \times l_{toe} \times \gamma_s + l_{o_a} \times t_b \times \gamma_b + W_v + w_s \times l_{heel} + W_l$$

$$N = 77.8 \text{ kN/m}$$

Restoring moment

$$M_{r1} = (W_l + W_v + h_{stem} \times t_w \times \gamma_w) \times (l_{toe} + t_w / 2) = 36.4 \text{ kNm/m}$$

$$M_{r2} = (l_{heel} \times (h_{stem} \times \gamma_s + w_s) \times (l_{toe} + t_w + l_{heel} / 2)) = 7.6 \text{ kNm/m}$$

$$M_{r3} = l_{toe}^2 \times t_c \times \gamma_s / 2 = 0.0 \text{ kNm/m}$$

$$M_{r4} = ((l_{toe} + t_w + l_{heel})^2 \times t_b \times \gamma_b / 2) = 10.2 \text{ kNm/m}$$

$$M_{r5} = (l_{heel}^2 \times \tan(\theta) / 2) \times (l_{toe} + t_w + l_{heel} \times 2/3) \times \gamma_s = 0.0 \text{ kNm/m}$$

Restoring Moment; $M_r = M_{r1} + M_{r2} + M_{r3} + M_{r4} + M_{r5} = 54.2 \text{ kNm/m}$

Eccentricity of vertical load

$$e_1 = (M_r - \text{abs}(M_{base})) / N = 0.605 \text{ m}$$

$$e = l_{o_a} / 2 - e_1 = 0.046 \text{ m}$$

Resultant lies inside middle third

Maximum bearing pressure; $p_{max} = \text{if}(\text{abs}(e) < (l_{o_a} / 6), \sigma_{max2}, \sigma_{max1}) = 72.3 \text{ kN/m}^2$

;Permissible bearing pressure; $p_{bearing} = 150 \text{ kN/m}^2$

Maximum bearing pressure is 72 kN/m² i.e. < Allowable - OK



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. 7	
Calc. by JD	Date 06/07/2020	Chk'd by	Date	App'd by	Date

Stem details - 7.3N/mm² Dense aggregate blockwork

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

Base - 500mm thick Mass concrete base with 150mm projection to toe and heel.