C2C CONSULTING ENGINEERS LTD
CIVIL | STRUCTURAL | DESIGN

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Project				Job Ref.	
Land Adj. Meadow View, Well Lane, Gillow Heath				200120	
Section				Sheet no./rev.	
Basement retaining walls				1	
Calc. by	Date	Chk'd by	Date	App'd by	Date
T	09/06/2020				

Structural Calculations

For Retaining Wall

At

Land Adjacent Meadow View,
Well Lane,
Gillow Heath,
Staffordshire.
ST8 6QU

For

Mr & Mrs Beech

Project Title:	**Job No:**
Land adjacent Meadow View, Well Lane, Gillow Heath	200120
Calculations Prepared by: Tim Wright	Position: Associate Director
Signature:	Date: 15/09/2020

Calculations Sheets and Sketches Reviewed:

Reviewed by: Tim Wright	Job Title: Associate Director
Signature:	Date: 15/09/2020

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Reference	Section
1.0	Design Philosophy Statement
2.0	Loading, Assumptions & Observations
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1. DESIGN PHILOSOPHY STATEMENT.

C2C Consulting Engineers were instructed by Mr & Mrs Beech to carry out the structural design for the proposed new dwelling

IMPORTANT NOTE

Dimensions in these calculations are only approximate and the contractor must check the latest architectural drawings and measure up on site before ordering any materials.

STRUCTURAL SPECIFICATION

Ensure a copy of these calculations and supporting drawings and details are forwarded to Building Control and the Builder in advance of the works commencing.

It is recommended that full approval is obtained from Building Control for the structural proposals prior to ordering materials.

Actual beam lengths to be measured on site DO NOT use span lengths quoted in design calculations. Ensure length includes for bearings as specified on drawings.

Where long span beams are installed to support existing masonry walls the deflection, although within tolerance and cannot be avoided, can be moderate and minor cracking can show in the decoration above. This would tend to occur when props are removed and should be made good

1 General

No site survey has been undertaken to determine the condition and detail of the as built construction. The contractor shall notify the Engineer should there be any information contained within these calculations and details that are unclear or conflicts with the existing construction.

Traditional construction assumed with solid load bearing inner blockwork/ outer brickwork walls and timber floors

The condition of supporting brickwork and blockwork walls to be verified on site before ordering of materials. Any discrepancies are to be reported to the Engineer.

The structural design and enclosed calculations are based on the drawings and information provided by the Architect.

The structural information provided in the enclosed specification is in addition to that provided by the Architect.

2 Dimensions:

Prior to ordering materials all dimensions to be checked on site.

3 Building Regulation Approval:

It is recommended that full approval is obtained from Building Control for the structural proposals prior to ordering materials.

Where necessary existing foundations to be exposed and inspected by the Building Inspector.

4 Steel Fabrication:

All dimension to be checked / determined on site.

Where necessary all connections to be designed by the steel fabricator in accordance with BS 5950 to the loadings specified.

Load bearing site welding is to be avoided, bolted connections to be provided where possible. However non load bearing locating welds would be acceptable.

5 Proprietary Products:

All propriety manufacturers items [lintels, precast floors, trussed rafters, etc] to be installed in accordance with manufacturer's requirements.

6 Materials:

All materials and installation to comply with current British Standards, Building Regulations and Codes of Practice.

7 CDM Regulations:

Designer's risks have been considered during the preparation of the structural design and where possible risks have been designed out. Where residual risks remain these are highlighted on the supporting drawings and details.

Temporary works and propping of the existing structure shall consider the existing building loads and ensure stability is maintained at all times.

Installation of steel beams and heavy materials shall use mechanical handling [manual handling regulations].

The contractor is to have a co-ordinated construction plan and method statement for non-traditional works.

The contractor is to inform the designer should there be any changes to the construction that may impact on the design and CDM regulations.

<u>All projects to have:</u>
All workers with the right skills, knowledge, training and experience
Contractors providing appropriate supervision, instruction and information
A written construction phase plan

<u>Projects where more than one contractor involved</u>
Principal designer and principle contractor must be appointed
Need a health and safety file

<u>Client must notify project to HSE</u>
If construction programme is longer than 30 working days and have more than 20 workers working simultaneously at any point or exceeds 500 person days.

8 Party Wall Act

Where works are being undertaken adjacent to an adjoining property in some cases the PARTY WALL ACT may apply.

In such instances the Architect should be consulted for advice and the correct procedure for notifying the owner of the adjoining property. Approval can take several weeks especially if agreement cannot be reached therefore the notice should be submitted well in advance of the works commencing on site.

If no Architect involved then refer to www.gov.uk/guidance/party-wall-etc-act-1996-guidance for example template notices.

2. LOADINGS, ASSUMPTIONS & OBSERVATIONS

LOADINGS

Pitched tiled roof = 0.85kN/m²

Concrete tiles = 0.60kN/m²
Battens & Felt = 0.1kN/m²
Timber rafters = 0.15kN/m²

Ceiling = 0.30kN/m²

Insulation = 0.15kN/m²
Soffite = 0.15 kN/m²
Roof live = 0.75kN/m²

Timber floor (Dead) = 0.5kN/m²

Boards and Joists = 0.35kN/m²
Soffite = 0.15kN/m²

Imposed = 1.5kN/m² Domestic loading BS6399 pt 1

Pre-Cast ground floor (Dead) = 3.8kN/m²

150mm Beam and block = 2.0kN/m²
75mm screed = 1.8kN/m²

Surcharge= 2.5kN/m²

ASSUMPTIONS

Ground bearing capacity = 100.0kN/m²

3. DESIGN CALCULATIONS

RETAINING WALL TO BASEMENT PERIMETER

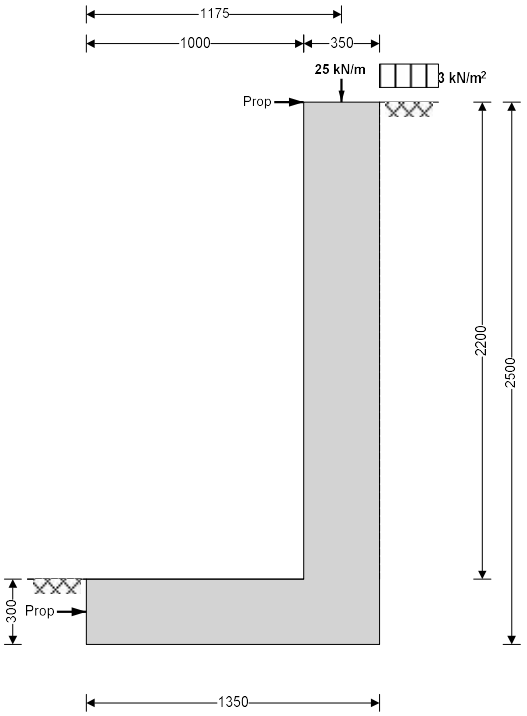
Retaining wall to be designed as propped in as built condition. The wall will therefore need to be propped during construction prior to installing beam and block ground floor, or the backfill not placed behind the wall untill after construction of ground floor.

LOADING	DEAD	LIVE
Beam and block ground floor	3.6 x 1.8 = 6.5kN/m	1.5 x 1.8 = 2.7kN/m
Cavity wall	4.0 x 3.8 = 15.2kN/m	
Surcharge landscape areas	2.5kN/m^2	

RETAINING WALL ANALYSIS & DESIGN (BS8002)

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.07



Wall details

Retaining wall type	**Cantilever propped at both**
Height of retaining wall stem	h_{stem} = **2200** mm
Thickness of wall stem	t_{wall} = **350** mm
Length of toe	l_{toe} = **1000** mm
Length of heel	l_{heel} = **0** mm
Overall length of base	$l_{base} = l_{toe} + l_{heel} + t_{wall}$ = **1350** mm
Thickness of base	t_{base} = **300** mm
Depth of downstand	d_{ds} = **0** mm

Position of downstand	l_{ds} = **1000** mm
Thickness of downstand	t_{ds} = **300** mm
Height of retaining wall	$h_{wall} = h_{stem} + t_{base} + d_{ds}$ = **2500** mm
Depth of cover in front of wall	d_{cover} = **0** mm
Depth of unplanned excavation	d_{exc} = **0** mm
Height of ground water behind wall	h_{water} = **0** mm
Height of saturated fill above base	$h_{sat} = \max(h_{water} - t_{base} - d_{ds}, 0\ mm)$ = **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	$h_{eff} = h_{wall} + l_{heel} \times \tan(\beta)$ = **2500** mm

Retained material details

Mobilisation factor	M = **1.5**
Moist density of retained material	γ_m = **18.0** kN/m^3
Saturated density of retained material	γ_s = **21.0** kN/m^3
Design shear strength	ϕ' = **24.2** deg
Angle of wall friction	δ = **0.0** deg

Base material details

Moist density	γ_{mb} = **18.0** kN/m^3
Design shear strength	ϕ'_b = **24.2** deg
Design base friction	δ_b = **18.6** deg
Allowable bearing pressure	$P_{bearing}$ = **100** 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

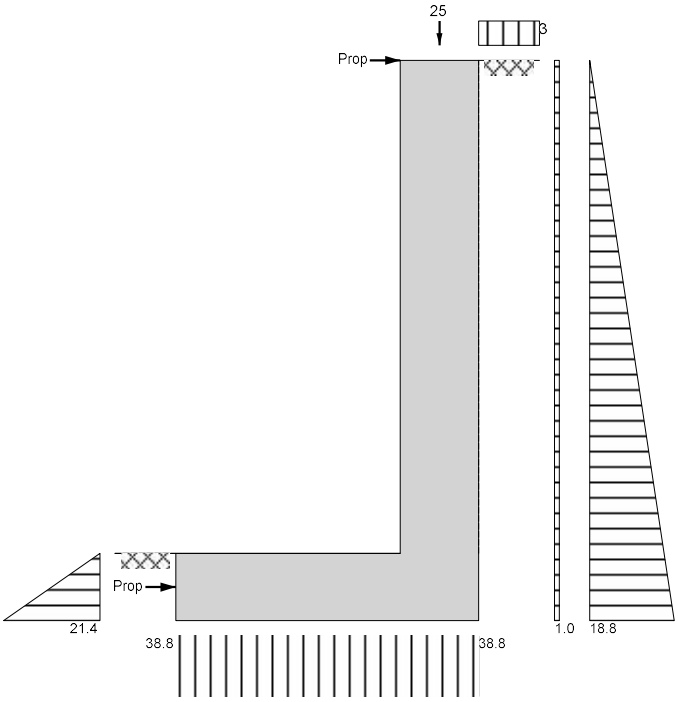
$$K_p = \sin(90 - \phi'_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi'_b + \delta_b) \times \sin(\phi'_b) / (\sin(90 + \delta_b)))}]^2) = \mathbf{4.187}$$

At-rest pressure

At-rest pressure for retained material	$K_0 = 1 - \sin(\phi')$ = **0.590**

Loading details

Surcharge load on plan	Surcharge = **2.5** kN/m^2
Applied vertical dead load on wall	W_{dead} = **22.0** kN/m
Applied vertical live load on wall	W_{live} = **2.7** kN/m
Position of applied vertical load on wall	l_{load} = **1175** mm
Applied horizontal dead load on wall	F_{dead} = **0.0** kN/m
Applied horizontal live load on wall	F_{live} = **0.0** kN/m
Height of applied horizontal load on wall	h_{load} = **0** mm



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

Vertical forces on wall

Wall stem	$w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall}$ = **18.2** kN/m
Wall base	$w_{base} = l_{base} \times t_{base} \times \gamma_{base}$ = **9.6** kN/m
Applied vertical load	$W_v = W_{dead} + W_{live}$ = **24.7** kN/m
Total vertical load	$W_{total} = w_{wall} + w_{base} + W_v$ = **52.4** kN/m

Horizontal forces on wall

Surcharge	$F_{sur} = K_a \times \text{Surcharge} \times h_{eff}$ = **2.6** kN/m
Moist backfill above water table	$F_{m_a} = 0.5 \times K_a \times \gamma_m \times (h_{eff} - h_{water})^2$ = **23.5** kN/m
Total horizontal load	$F_{total} = F_{sur} + F_{m_a}$ = **26.2** kN/m

Calculate total propping force

Passive resistance of soil in front of wall	$F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **3.2** kN/m
Propping force	$F_{prop} = \max(F_{total} - F_p - (W_{total} - W_{live}) \times \tan(\delta_b), 0 \text{ kN/m})$
	F_{prop} = **6.2** kN/m

Overturning moments

Surcharge	$M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **3.3** kNm/m
Moist backfill above water table	$M_{m_a} = F_{m_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **19.6** kNm/m
Total overturning moment	$M_{ot} = M_{sur} + M_{m_a}$ = **22.9** kNm/m

Restoring moments

Wall stem	$M_{wall} = w_{wall} \times (l_{toe} + t_{wall} / 2)$ = **21.4** kNm/m
Wall base	$M_{base} = w_{base} \times l_{base} / 2$ = **6.5** kNm/m
Design vertical dead load	$M_{dead} = W_{dead} \times l_{load}$ = **25.9** kNm/m
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_{dead}$ = **53.7** kNm/m

Check bearing pressure

Total vertical reaction	$R = W_{total}$ = **52.4** kN/m
Distance to reaction	$x_{bar} = l_{base} / 2$ = **675** mm

Eccentricity of reaction $e = abs((l_{base} / 2) - x_{bar}) = \mathbf{0}$ mm

Reaction acts within middle third of base

Bearing pressure at toe $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) = \mathbf{38.8}$ kN/m^2

Bearing pressure at heel $p_{heel} = (R / l_{base}) + (6 \times R \times e / l_{base}^2) = \mathbf{38.8}$ kN/m^2

PASS - Maximum bearing pressure is less than allowable bearing pressure

Calculate propping forces to top and base of wall

Propping force to top of wall

$F_{prop_top} = (M_{ot} - M_{rest} + R \times l_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = \mathbf{1.572}$ kN/m

Propping force to base of wall $F_{prop_base} = F_{prop} - F_{prop_top} = \mathbf{4.636}$ kN/m

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.07

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 — $w_{wall_f} = \gamma_{f_d} \times h_{stem} \times t_{wall} \times \gamma_{wall}$ = **25.4** kN/m

Wall base — $w_{base_f} = \gamma_{f_d} \times l_{base} \times t_{base} \times \gamma_{base}$ = **13.4** kN/m

Applied vertical load — $W_{v_f} = \gamma_{f_d} \times W_{dead} + \gamma_{f_l} \times W_{live}$ = **35.1** kN/m

Total vertical load — $W_{total_f} = w_{wall_f} + w_{base_f} + W_{v_f}$ = **73.9** kN/m

Factored horizontal at-rest forces on wall

Surcharge — $F_{sur_f} = \gamma_{f_l} \times K_0 \times \text{Surcharge} \times h_{eff}$ = **5.9** 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** kN/m

Total horizontal load — $F_{total_f} = F_{sur_f} + F_{m_a_f}$ = **52.4** kN/m

Calculate total propping force

Passive resistance of soil in front of wall — $F_{p_f} = \gamma_{f_e} \times 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **4.5** kN/m

Propping force — $F_{prop_f} = \max(F_{total_f} - F_{p_f} - (W_{total_f} - \gamma_{f_l} \times W_{live}) \times \tan(\delta_b), 0\ \text{kN/m})$

F_{prop_f} = **24.4** kN/m

Factored overturning moments

Surcharge — $M_{sur_f} = F_{sur_f} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **7.4** 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** kNm/m

Total overturning moment — $M_{ot_f} = M_{sur_f} + M_{m_a_f}$ = **46.1** kNm/m

Restoring moments

Wall stem — $M_{wall_f} = w_{wall_f} \times (l_{toe} + t_{wall} / 2)$ = **29.9** kNm/m

Wall base — $M_{base_f} = w_{base_f} \times l_{base} / 2$ = **9** kNm/m

Design vertical load — $M_{v_f} = W_{v_f} \times l_{load}$ = **41.3** kNm/m

Total restoring moment — $M_{rest_f} = M_{wall_f} + M_{base_f} + M_{v_f}$ = **80.2** kNm/m

Factored bearing pressure

Total vertical reaction — $R_f = W_{total_f}$ = **73.9** kN/m

Distance to reaction — $x_{bar_f} = l_{base} / 2$ = **675** mm

Eccentricity of reaction — $e_f = \text{abs}((l_{base} / 2) - x_{bar_f})$ = **0** mm

Reaction acts within middle third of base

Bearing pressure at toe — $p_{toe_f} = (R_f / l_{base}) - (6 \times R_f \times e_f / l_{base}^2)$ = **54.8** kN/m^2

Bearing pressure at heel — $p_{heel_f} = (R_f / l_{base}) + (6 \times R_f \times e_f / l_{base}^2)$ = **54.8** kN/m^2

Rate of change of base reaction — $\text{rate} = (p_{toe_f} - p_{heel_f}) / l_{base}$ = **0.00** kN/m^2/m

Bearing pressure at stem / toe — $p_{stem_toe_f} = \max(p_{toe_f} - (\text{rate} \times l_{toe}), 0\ \text{kN/m}^2)$ = **54.8** kN/m^2

Bearing pressure at mid stem — $p_{stem_mid_f} = \max(p_{toe_f} - (\text{rate} \times (l_{toe} + t_{wall} / 2)), 0\ \text{kN/m}^2)$ = **54.8** kN/m^2

Bearing pressure at stem / heel — $p_{stem_heel_f} = \max(p_{toe_f} - (\text{rate} \times (l_{toe} + t_{wall})), 0\ \text{kN/m}^2)$ = **54.8** kN/m^2

Calculate propping forces to top and base of wall

Propping force to top of wall

$F_{prop_top_f} = (M_{ot_f} - M_{rest_f} + R_f \times l_{base} / 2 - F_{prop_f} \times t_{base} / 2) / (h_{stem} + t_{base} / 2)$ = **5.172** kN/m

Propping force to base of wall — $F_{prop_base_f} = F_{prop_f} - F_{prop_top_f}$ = **19.268** kN/m

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 — $V_{toe_bear} = (p_{toe_f} + p_{stem_toe_f}) \times l_{toe} / 2$ = **54.8** kN/m

Shear from weight of base — $V_{toe_wt_base} = \gamma_{f_d} \times \gamma_{base} \times l_{toe} \times t_{base}$ = **9.9** kN/m

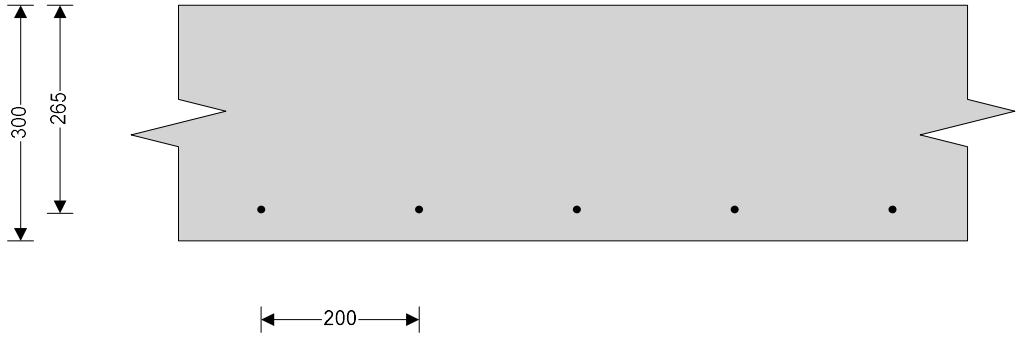
Total shear for toe design — $V_{toe} = V_{toe_bear} - V_{toe_wt_base}$ = **44.9** kN/m

Calculate moment for toe design

Moment from bearing pressure — $M_{toe_bear} = (2 \times p_{toe_f} + p_{stem_mid_f}) \times (l_{toe} + t_{wall} / 2)^2 / 6$ = **37.8** kNm/m

Moment from weight of base — $M_{toe_wt_base} = (\gamma_{f_d} \times \gamma_{base} \times t_{base} \times (l_{toe} + t_{wall} / 2)^2 / 2)$ = **6.8** kNm/m

Total moment for toe design — $M_{toe} = M_{toe_bear} - M_{toe_wt_base}$ = **31** 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 — $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu})$ = **0.011**

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 — $A_{s_toe_des} = M_{toe} / (0.87 \times f_y \times z_{toe})$ = **283** 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 — $A_{s_toe_req} = \max(A_{s_toe_des}, A_{s_toe_min})$ = **390** mm^2/m

Reinforcement provided — **A393 mesh**

Area of reinforcement provided — $A_{s_toe_prov}$ = **393** mm^2/m

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress — $v_{toe} = V_{toe} / (b \times d_{toe})$ = **0.169** N/mm^2

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

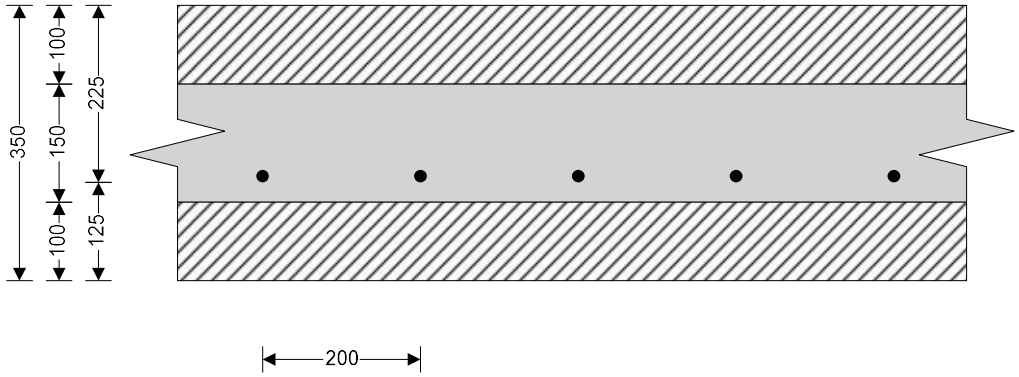
PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress — v_{c_toe} = **0.434** N/mm^2

$v_{toe} < v_{c_toe}$ - 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} = **100** mm
Thickness of inner leaf of wall	t_{inner} = **100** mm
Thickness of reinforced cavity	$t_{cavity} = t_{wall} - t_{outer} - t_{inner}$ = **150** mm
Depth of stem reinforcement	d_{stem} = **225** mm

Masonry details

Masonry type	**Aggregate concrete blocks no voids**
Compressive strength of units	p_{unit} = **7.3** N/mm^2
Mortar designation	**(ii)**
Category of manufactoring control of units	**Category II**
Partial safety factor for material strength	γ_{mm} = **2.3**

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 = **6.4** N/mm^2

Factored horizontal at-rest forces on stem

Surcharge	$F_{s_sur_f} = \gamma_{f_l} \times K_0 \times$ Surcharge $\times (h_{eff} - t_{base} - d_{ds})$ = **5.2** 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** kN/m

Calculate shear for stem design

Surcharge	$V_{s_sur_f} = 5 \times F_{s_sur_f} / 8$ = **3.2** kN/m
Moist backfill above water table	$V_{s_m_a_f} = F_{s_m_a_f} \times b_l \times ((5 \times L^2) - b_l^2) / (5 \times L^3)$ = **27.8** kN/m
Total shear for stem design	$V_{stem} = V_{s_sur_f} + V_{s_m_a_f}$ = **31** kN/m

Calculate moment for stem design

Surcharge	$M_{s_sur} = F_{s_sur_f} \times L / 8$ = **1.5** kNm/m
Moist backfill above water table	$M_{s_m_a} = F_{s_m_a_f} \times b_l \times ((5 \times L^2) - (3 \times b_l^2)) / (15 \times L^2)$ = **12.5** kNm/m
Total moment for stem design	$M_{stem} = M_{s_sur} + M_{s_m_a}$ = **14** kNm/m

Calculate moment for wall design

Surcharge	$M_{w_sur} = 9 \times F_{s_sur_f} \times L / 128$ = **0.9** kNm/m
Moist backfill above water table	$M_{w_m_a} = F_{s_m_a_f} \times 0.577 \times b_l \times [(b_l^3 + 5 \times a_l \times L^2)/(5 \times L^3) - 0.577^2/3]$ = **5.3** kNm/m
Total moment for wall design	$M_{wall} = M_{w_sur} + M_{w_m_a}$ = **6.2** kNm/m

Check maximum design moment for wall stem

Width of wall — b = **1000** mm/m

Maximum design moment — $M_{d_stem} = 0.4 \times f_k \times b \times d_{stem}^2 / \gamma_{mm}$ = **56.3** kNm/m

PASS - Applied moment is less than maximum design moment

Check wall stem in bending

Moment of resistance factor — $Q = M_{stem} / d_{stem}^2$ = **0.277** N/mm²

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

Lever arm factor — c = **0.947**

Lever arm — $z_{stem} = \min(0.95, c) \times d_{stem}$ = **213.2** mm

Area of tension reinforcement required — $A_{s_stem_des} = M_{stem} \times \gamma_{ms} / (f_y \times z_{stem})$ = **151** mm²/m

Minimum area of tension reinforcement — $A_{s_stem_min} = k \times b \times t_{wall}$ = **455** mm²/m

Area of tension reinforcement required — $A_{s_stem_req} = \text{Max}(A_{s_stem_des}, A_{s_stem_min})$ = **455** mm²/m

Reinforcement provided — **16 mm dia.bars @ 200 mm centres**

Area of reinforcement provided — $A_{s_stem_prov}$ = **1005** mm²/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress — $v_{stem} = V_{stem} / (b \times d_{stem})$ = **0.138** N/mm²

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/mm²

f_{vbas} = **0.428** N/mm²

Shear span — $a = M_{stem} / V_{stem}$ = **452.4** mm

Characteristic shear strength of masonry — $f_v = \text{Min}(f_{vbas} \times \max(2.5 - 0.25 \times (a / d_{stem}), 1), 1.75$ N/mm²)

f_v = **0.855** N/mm²

Allowable shear stress — $v_{adm} = f_v / \gamma_{mv}$ = **0.428** N/mm²

PASS - Design shear stress is less than maximum shear stress

Check maximum design moment for mid height of wall

Width of wall — b = **1000** mm/m

Depth of reinforcement — $d_{wall} = t_{wall} - d_{stem}$ = **125** mm

Maximum design moment — $M_{d_wall} = 0.4 \times f_k \times b \times d_{wall}^2 / \gamma_{mm}$ = **17.4** kNm/m

PASS - Applied moment is less than maximum design moment

Check mid height of wall in bending

Moment of resistance factor — $Q = M_{wall} / d_{wall}^2$ = **0.397** N/mm²

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

Lever arm factor — c = **0.923**

Lever arm — $z_{wall} = \min(0.95, c) \times d_{wall}$ = **115.3** mm

Area of tension reinforcement required — $A_{s_wall_des} = M_{wall} \times \gamma_{ms} / (f_y \times z_{wall})$ = **124** mm²/m

Minimum area of tension reinforcement — $A_{s_wall_min} = k \times b \times t_{wall}$ = **455** mm²/m

Area of tension reinforcement required — $A_{s_wall_req} = \text{Max}(A_{s_wall_des}, A_{s_wall_min})$ = **455** mm²/m

Reinforcement provided — **B785 mesh**

Area of reinforcement provided — $A_{s_wall_prov}$ = **785** mm²/m

PASS - Reinforcement provided to the retaining wall at mid height is adequate

Check limiting dimensions

Limiting span/effective depth ratio — ratio_{max} = **35.00**

Actual span/effective depth ratio — $\text{ratio}_{act} = (h_{stem} + d_{stem} / 2) / d_{stem}$ = **10.28**

PASS - Span to depth ratio is acceptable

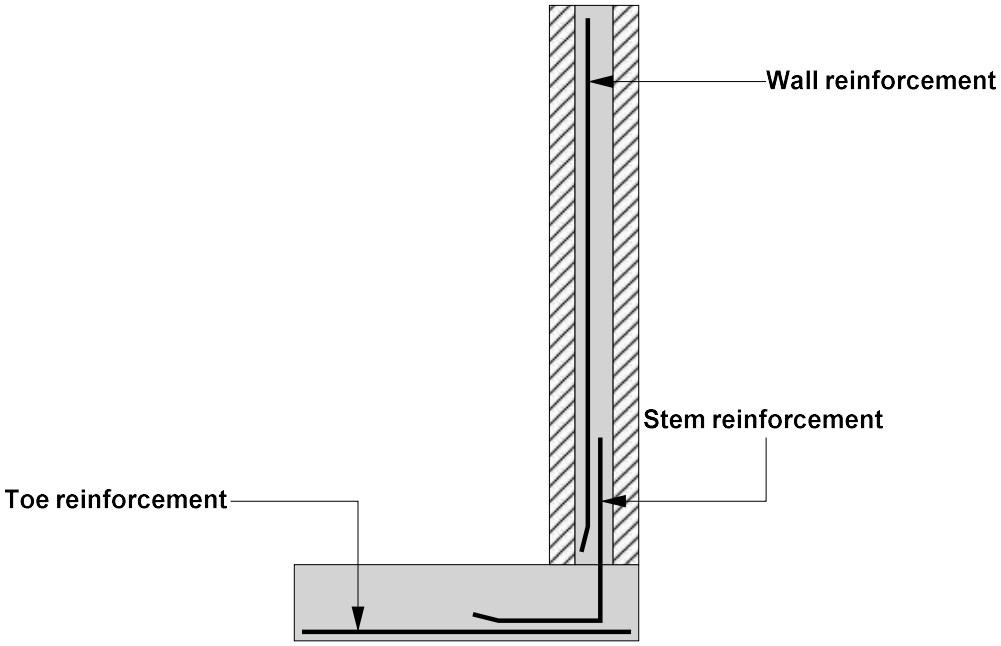
Axial load check

Factored axial load on wall $N_{wall} = ([t_{wall} \times h_{stem} \times \gamma_{wall} + W_{dead}] \times \gamma_{f_d}) + (W_{live} \times \gamma_{f_l}) =$ **60.6** kN/m

Limiting axial load $N_{limit} = 0.1 \times f_k \times t_{wall} =$ **224.0** kN/m

Applied axial load may be ignored - calculations valid

Indicative retaining wall reinforcement diagram



Toe mesh - A393 - (393 mm^2/m)
Stem bars - 16 mm dia.@ 200 mm centres - (1005 mm^2/m)
Wall mesh - B785 - (785 mm^2/m)