MARSH DESIGN LIMITED

STRUCTURAL DESIGN CONSULTANTS & SURVEY REPORTS

The Stable Block, Buckden Mount
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Huddersfield
HD1 4DN
Company No: 457 2796
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STRUCTURAL CALCULATIONS

FOR

EXTRA CALCULATION RETAINING WALL FOR FRONT PROPERTY

FOR

MR & MRS. FLINT
33, CLOUGH DRIVE, FENAY BRIDGE,
HUDDERSFIELD, HD8 0JJ
OUR REF: MDL – 9871-002

REV.01: Issued for Building Control Approval Only
13th August 2024

Structural Notes:

These calculations are issued for building control approval only. Any structural construction works undertaken prior to approval being obtained are done so at risk by the client / contractor.

If any queries arise on site or if there are any doubts, then ask the structural engineer immediately for further guidance.

All CDM requirements are the responsibility of the client and principal contractor. We have not been engaged to undertake the role of principal designer.

It is the client's responsibility to ensure that all the requirements of the Party Wall Act are the met during entire construction period of the project.

The sketches and marked up drawings contained within these structural calculations are NOT setting out or construction drawings, and they must NOT be used for setting out of steelwork or foundations.

All setting out and positioning of steel beams is the full responsibility of the building contractor responsible for the works.

All stated dimensions are clear dimensions for calculation purposes only.

The builder must confirm the lengths of all beams, columns and other structural elements from his own site measurements allowing a minimum of 100mm end bearing at both ends of the beam.

The builder is responsible for all temporary propping works, for both internal and external works.

All beams must be supported on reinforced concrete padstones unless noted otherwise in the calculations.

Structural integrity and stability of all retained masonry piers or walls is to be confirmed after all openings have been broken out. This is generally undertaken by the building control inspector, but in certain instances approval by the appointed structural engineer may be necessary.

Upon commencement of the works, when the retained walls supporting the steelwork have been exposed, new masonry piers or steel columns maybe required to support the steel beams.

All steel work must be minimum grade BS EN 10025 S355.

All twin beams to be bolted together at both ends and maximum 1.0m centres using M16 bolts and 50 mm tubular spacers.

All welded, plate and bolted cleat connections details must be confirmed by the fabricator. Any beam connection details included within these calculations are indicative only.

All bolts to be grade 8.8, unless noted otherwise.

It is recommended that any exposed steelwork in external walls is galvanised, however other coating alternatives maybe used to satisfaction of building control inspector.

For fabricated beam & plate lintels, the support plate must be set out to suit the dimensions of the wall. This must be confirmed by the builder and fabricator from their own site measurements.

The width of all proprietary lintels must be confirmed on site by the builders – to suit the width of the cavity walls.

All timber to be minimum grade C24 unless noted otherwise.

Strengthening or underpinning of the existing foundations maybe required due to increased point loadings on the walls. Foundations must be exposed and checked on site prior to installations of the beams.

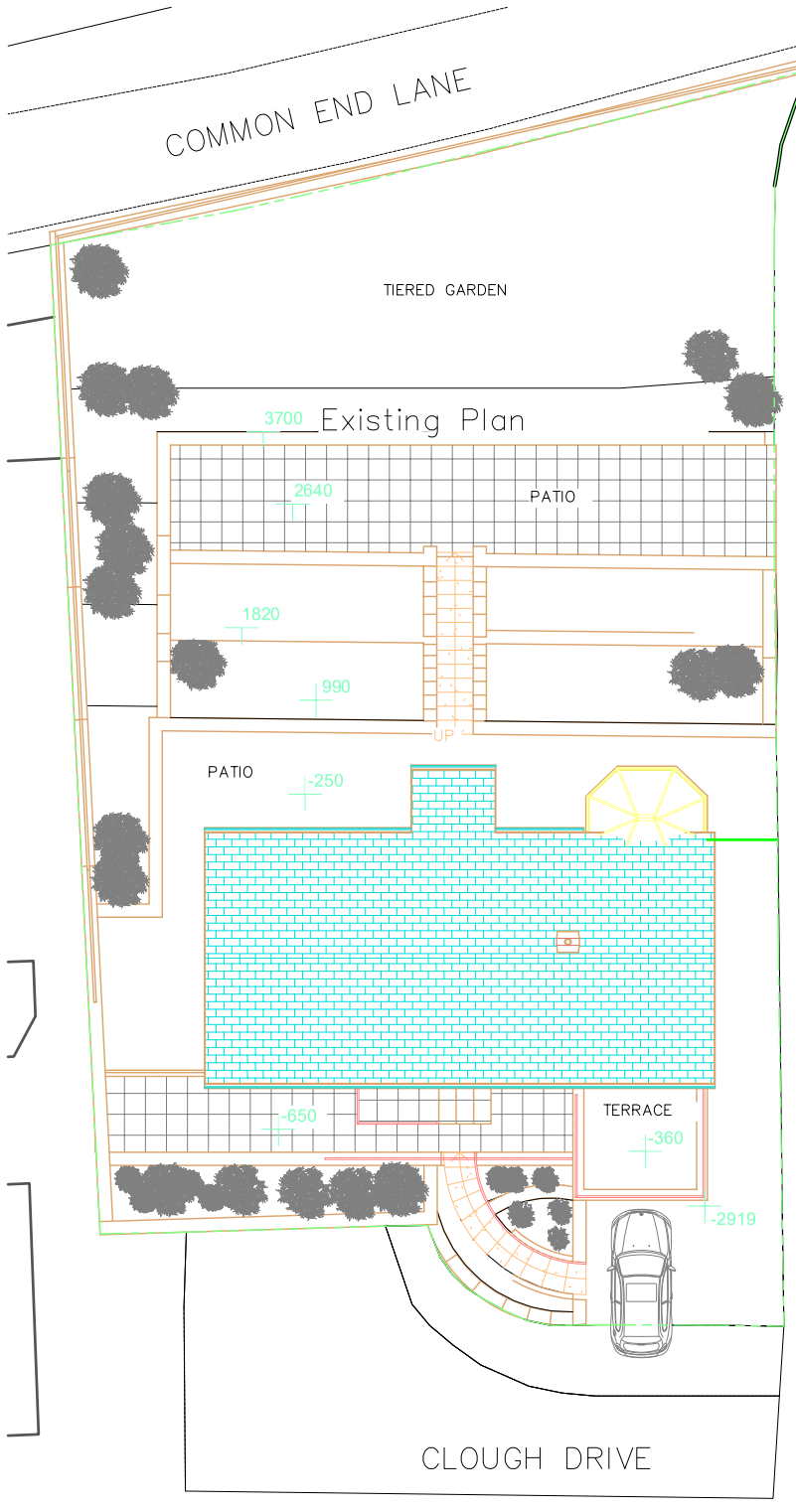
All new foundation sizes to be confirmed after excavations have started and underlying sub strata exposed.

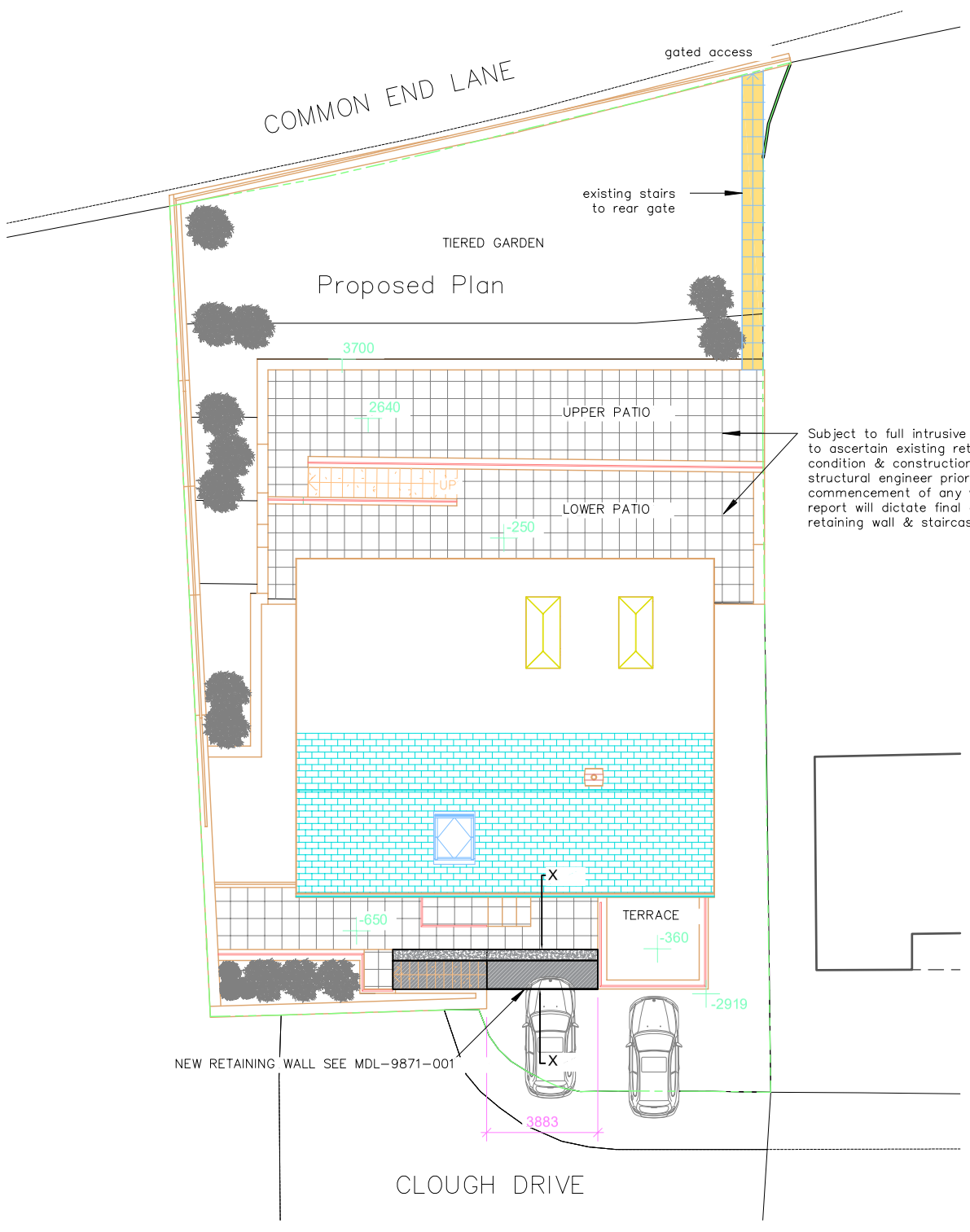
All ground conditions to approval of building inspector.

Foundations to be built on firm sub-strata with a minimum ground bearing pressure of 100 kN/m^2, to be confirmed on site by the building control inspector.

Depth of foundations to be confirmed on site considering any cellars, drains or trees which may be present.

Any temporary shoring works required to retain exposed earth are the full responsibility of the main contractor.





Subject to full intrusive investigation to ascertain existing retaining wall condition & construction by appointed structural engineer prior to commencement of any works. Findings in report will dictate final design of retaining wall & staircase accordingly

Rev	Date	by	Amendments
01	13/08/24	BRR	1st Issue

Job Number	Dwg Number
9871-002	001
Scale	Rev
1:50 @A3	02
By	Approved by
BRR	DSH

MR. & MRS. FLINT

33, CLOUGH DRIVE

STRUCTURE PLAN

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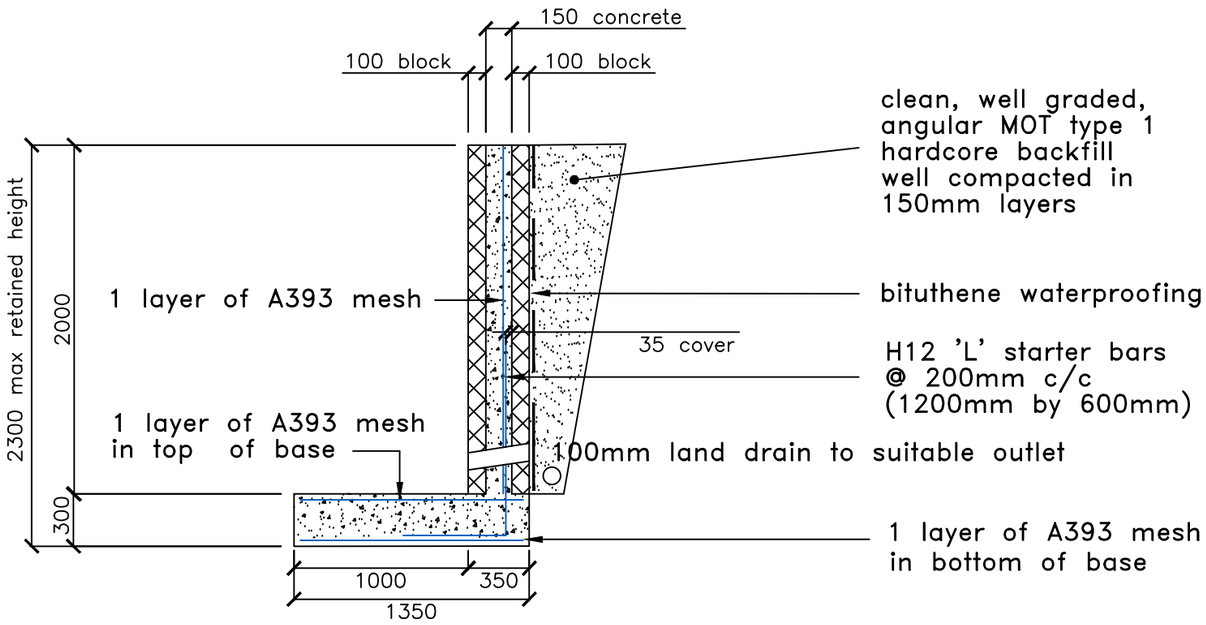
IF IN DOUBT ASK	DO NOT SCALE

2.3m HIGH WALL



SECTION X–X

Notes:
1. All concrete grade C35 minimum.
2. All re–bar cover 35mm.
3. 100mm perforated land drain behind wall encased in free draining material taken to suitable outlet.
4. Recommend bituthene type tanking behind wall to protect blockwork masonry from perishing.
5. All blockwork minimum 7.3 N/mm2.

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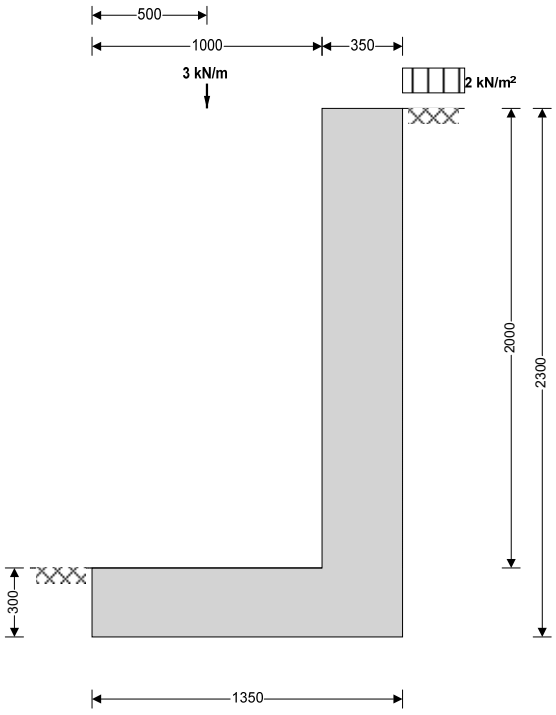
MarshDesignLtd STRUCTURAL ENGINEERS www.marshdesign.co.uk	Project: 33 Clough Drive				Job no.: MDL - 9871	
	Calcs for: Retaining Wall for Front House				Start page no./Revision: 1	
	Calcs by: BRR	Calcs date: 09/08/2024	Checked by: DSH	Checked date:	Approved by:	Approved date:

DESIGN RETAINING WALL FOR FRONT HOUSE 2.5M

RETAINING WALL ANALYSIS & DESIGN (BS8002)

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.08



Wall details

Retaining wall type	**Unpropped cantilever**
Height of retaining wall stem	h_{stem} = **2000** 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} = **300** 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} = **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	$h_{eff} = h_{wall} + l_{heel} \times \tan(\beta)$ = **2300** mm

Retained material details

Mobilisation factor	M = **1.5**
Moist density of retained material	γ_m = **17.5** kN/m^3
Saturated density of retained material	γ_s = **21.0** kN/m^3
Design shear strength	ϕ' = **27.5** deg
Angle of wall friction	δ = **21.3** deg

Base material details

Moist density	γ_{mb} = **17.5** kN/m^3
Design shear strength	ϕ'_b = **27.5** deg
Design base friction	δ_b = **21.3** deg
Allowable bearing pressure	$P_{bearing}$ = **100** kN/m^2

Using Coulomb theory

Active pressure coefficient for retained material

$$K_a = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))}]^2) = \mathbf{0.326}$$

Passive pressure coefficient for base material

$$K_p = \sin(90 - \phi'_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi'_b + \delta_b) \times \sin(\phi'_b) / (\sin(90 + \delta_b)))}]^2) = \mathbf{5.571}$$

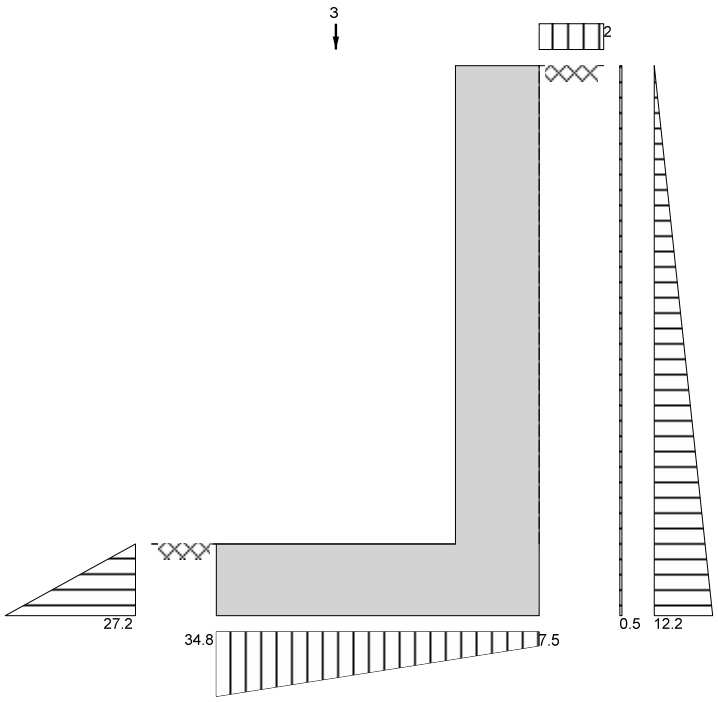
At-rest pressure

At-rest pressure for retained material	$K_0 = 1 - \sin(\phi')$ = **0.538**

Loading details

Surcharge load on plan	Surcharge = **1.5** kN/m^2
Applied vertical dead load on wall	W_{dead} = **2.5** kN/m
Applied vertical live load on wall	W_{live} = **0.0** kN/m
Position of applied vertical load on wall	l_{load} = **500** 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

MarshDesignLtd STRUCTURAL ENGINEERS www.marshdesign.co.uk	Project: 33 Clough Drive				Job no.: MDL - 9871	
	Calcs for: Retaining Wall for Front House				Start page no./Revision: 3	
	Calcs by: BRR	Calcs date: 09/08/2024	Checked by: DSH	Checked date:	Approved by:	Approved date:



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

Vertical forces on wall

Wall stem	$w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall}$ = **16.5** kN/m
Wall base	$w_{base} = l_{base} \times t_{base} \times \gamma_{base}$ = **9.6** kN/m
Applied vertical load	$W_v = W_{dead} + W_{live}$ = **2.5** kN/m
Total vertical load	$W_{total} = w_{wall} + w_{base} + W_v$ = **28.6** kN/m

Horizontal forces on wall

Surcharge	$F_{sur} = K_a \times \cos(90 - \alpha + \delta) \times \text{Surcharge} \times h_{eff}$ = **1** kN/m
Moist backfill above water table	$F_{m\_a} = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2$ = **14** kN/m
Total horizontal load	$F_{total} = F_{sur} + F_{m\_a}$ = **15.1** kN/m

Calculate stability against sliding

Passive resistance of soil in front of wall	$F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **4.1** kN/m
Resistance to sliding	$F_{res} = F_p + W_{total} \times \tan(\delta_b)$ = **15.2** kN/m

PASS - Resistance force is greater than sliding force

Overturning moments

Surcharge	$M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **1.2** kNm/m
Moist backfill above water table	$M_{m\_a} = F_{m\_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **10.8** kNm/m
Total overturning moment	$M_{ot} = M_{sur} + M_{m\_a}$ = **12** kNm/m

Restoring moments

Wall stem	$M_{wall} = w_{wall} \times (l_{toe} + t_{wall} / 2)$ = **19.4** kNm/m
Wall base	$M_{base} = w_{base} \times l_{base} / 2$ = **6.5** kNm/m
Design vertical load	$M_v = W_v \times l_{load}$ = **1.3** kNm/m
Total restoring moment	$M_{rest} = M_{wall} + M_{base} + M_v$ = **27.1** kNm/m

Check stability against overturning

Total overturning moment	M_{ot} = **12.0** kNm/m
Total restoring moment	M_{rest} = **27.1** kNm/m

PASS - Restoring moment is greater than overturning moment

Check bearing pressure

Total moment for bearing — $M_{total} = M_{rest} - M_{ot} =$ **15.1** kNm/m

Total vertical reaction — $R = W_{total} =$ **28.6** kN/m

Distance to reaction — $x_{bar} = M_{total} / R =$ **530** mm

Eccentricity of reaction — $e = abs((l_{base} / 2) - x_{bar}) =$ **145** mm

Reaction acts within middle third of base

Bearing pressure at toe — $p_{toe} = (R / l_{base}) + (6 \times R \times e / l_{base}^2) =$ **34.8** kN/m^2

Bearing pressure at heel — $p_{heel} = (R / l_{base}) - (6 \times R \times e / l_{base}^2) =$ **7.5** kN/m^2

PASS - Maximum bearing pressure is less than allowable bearing pressure

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.08

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	$w_{wall\_f} = \gamma_{f\_d} \times h_{stem} \times t_{wall} \times \gamma_{wall}$ = **23.1** 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	$W_{v\_f} = \gamma_{f\_d} \times W_{dead} + \gamma_{f\_l} \times W_{live}$ = **3.5** kN/m
Total vertical load	$W_{total\_f} = w_{wall\_f} + w_{base\_f} + W_{v\_f}$ = **40** kN/m

Factored horizontal at-rest forces on wall

Surcharge	$F_{sur\_f} = \gamma_{f\_l} \times K_0 \times \text{Surcharge} \times h_{eff}$ = **3** kN/m
Moist backfill above water table	$F_{m\_a\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times \gamma_m \times (h_{eff} - h_{water})^2$ = **34.9** kN/m
Total horizontal load	$F_{total\_f} = F_{sur\_f} + F_{m\_a\_f}$ = **37.9** kN/m
Passive resistance of soil in front of wall	$F_{p\_f} = \gamma_{f\_e} \times 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **5.7** kN/m

Factored overturning moments

Surcharge	$M_{sur\_f} = F_{sur\_f} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **3.4** kNm/m
Moist backfill above water table	$M_{m\_a\_f} = F_{m\_a\_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **26.7** kNm/m
Total overturning moment	$M_{ot\_f} = M_{sur\_f} + M_{m\_a\_f}$ = **30.2** kNm/m

Restoring moments

Wall stem	$M_{wall\_f} = w_{wall\_f} \times (l_{toe} + t_{wall} / 2)$ = **27.2** kNm/m
Wall base	$M_{base\_f} = w_{base\_f} \times l_{base} / 2$ = **9** kNm/m
Design vertical load	$M_{v\_f} = W_{v\_f} \times l_{load}$ = **1.8** kNm/m
Total restoring moment	$M_{rest\_f} = M_{wall\_f} + M_{base\_f} + M_{v\_f}$ = **38** kNm/m

Factored bearing pressure

Total moment for bearing	$M_{total\_f} = M_{rest\_f} - M_{ot\_f}$ = **7.8** kNm/m
Total vertical reaction	$R_f = W_{total\_f}$ = **40.0** kN/m
Distance to reaction	$x_{bar\_f} = M_{total\_f} / R_f$ = **195** mm
Eccentricity of reaction	$e_f = \text{abs}((l_{base} / 2) - x_{bar\_f})$ = **480** mm
	Reaction acts outside middle third of base
Bearing pressure at toe	$p_{toe\_f} = R_f / (1.5 \times x_{bar\_f})$ = **136.8** 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 = $p_{toe\_f} / (3 \times x_{bar\_f})$ = **233.95** kN/m^2/m
Bearing pressure at stem / toe	$p_{stem\_toe\_f} = \max(p_{toe\_f} - (\text{rate} \times l_{toe}), 0\ \text{kN/m}^2)$ = **0** kN/m^2
Bearing pressure at mid stem	$p_{stem\_mid\_f} = \max(p_{toe\_f} - (\text{rate} \times (l_{toe} + t_{wall} / 2)), 0\ \text{kN/m}^2)$ = **0** kN/m^2
Bearing pressure at stem / heel	$p_{stem\_heel\_f} = \max(p_{toe\_f} - (\text{rate} \times (l_{toe} + t_{wall})), 0\ \text{kN/m}^2)$ = **0** kN/m^2

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

Material properties

Characteristic strength of concrete	f_{cu} = **35** 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} = **35** mm

Calculate shear for toe design

Shear from bearing pressure $V_{toe\_bear} = 3 \times p_{toe\_f} \times x_{bar\_f} / 2 =$ **40** 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

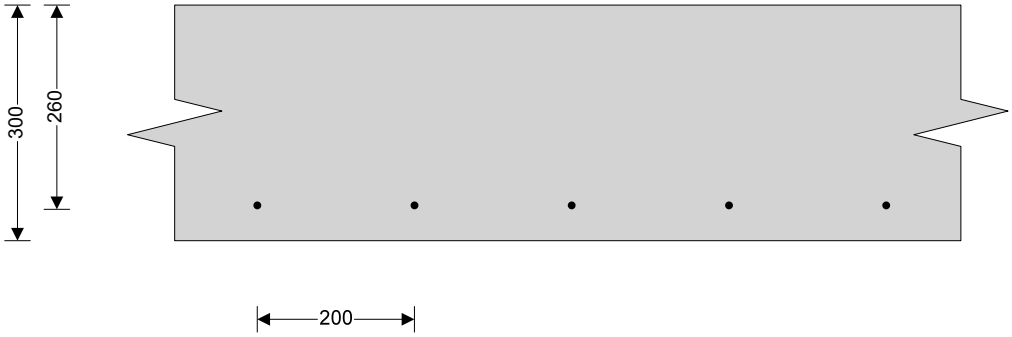
Total shear for toe design $V_{toe} = V_{toe\_bear} - V_{toe\_wt\_base} =$ **30.1** kN/m

Calculate moment for toe design

Moment from bearing pressure $M_{toe\_bear} = 3 \times p_{toe\_f} \times x_{bar\_f} \times (l_{toe} - x_{bar\_f} + t_{wall} / 2) / 2 =$ **39.2** kNm/m

Moment from weight of base $M_{toe\_wt\_base} = (\gamma_{f\_d} \times \gamma_{base} \times t_{base} \times (l_{toe} + t_{wall} / 2)^2 / 2) =$ **6.8** kNm/m

Total moment for toe design $M_{toe} = M_{toe\_bear} - M_{toe\_wt\_base} =$ **32.4** kNm/m



Check toe in bending

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

Depth of reinforcement $d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2) =$ **260.0** mm

Constant $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu}) =$ **0.014**

Compression reinforcement is not required

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

$z_{toe} =$ **247** mm

Area of tension reinforcement required $A_{s\_toe\_des} = M_{toe} / (0.87 \times f_y \times z_{toe}) =$ **301** mm²/m

Minimum area of tension reinforcement $A_{s\_toe\_min} = k \times b \times t_{base} =$ **390** mm²/m

Area of tension reinforcement required $A_{s\_toe\_req} = \max(A_{s\_toe\_des}, A_{s\_toe\_min}) =$ **390** mm²/m

Reinforcement provided **A393 mesh**

Area of reinforcement provided $A_{s\_toe\_prov} =$ **393** mm²/m

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress $v_{toe} = V_{toe} / (b \times d_{toe}) =$ **0.116** N/mm²

Allowable shear stress $v_{adm} = \min(0.8 \times \sqrt{}(f_{cu} / 1\ N/mm^2), 5) \times 1\ N/mm^2 =$ **4.733** N/mm²

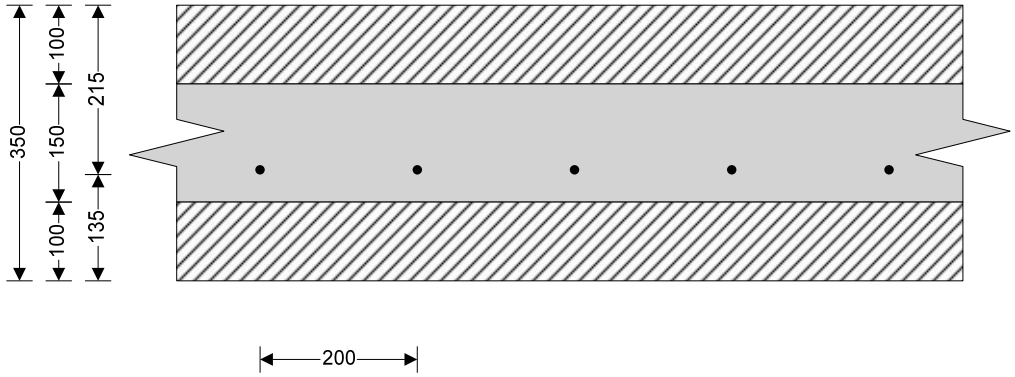
PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress $v_{c\_toe} =$ **0.419** N/mm²

$v_{toe} < v_{c\_toe}$ - 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} = **215** 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 $\times (h_{eff} - t_{base} - d_{ds})$ = **2.6** kN/m
Moist backfill above water table	$F_{s\_m\_a\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2$ = **26.4** kN/m

Calculate shear for stem design

Shear at base of stem	$V_{stem} = F_{s\_sur\_f} + F_{s\_m\_a\_f}$ = **29** kN/m

Calculate moment for stem design

Surcharge	$M_{s\_sur} = F_{s\_sur\_f} \times (h_{stem} + t_{base}) / 2$ = **3** kNm/m
Moist backfill above water table	$M_{s\_m\_a} = F_{s\_m\_a\_f} \times (2 \times h_{sat} + h_{eff} - d_{ds} + t_{base} / 2) / 3$ = **21.5** kNm/m
Total moment for stem design	$M_{stem} = M_{s\_sur} + M_{s\_m\_a}$ = **24.5** kNm/m

Check maximum design moment for wall stem

Width of wall	b = **1000** mm/m
Maximum design moment	$M_{d\_stem} = 0.4 \times f_k \times b \times d_{stem}^2 / \gamma_{mm}$ = **51.5** kNm/m
	PASS - Applied moment is less than maximum design moment

Check wall stem in bending

Moment of resistance factor	$Q = M_{stem} / d_{stem}^2$ = **0.530** N/mm^2
	$Q = 2 \times c \times (1 - c) \times f_k / \gamma_{mm}$

Lever arm factor	c = **0.893**
Lever arm	z_{stem} = min(0.95, c) × d_{stem} = **192.1** mm
Area of tension reinforcement required	$A_{s\_stem\_des}$ = M_{stem} × γ_{ms} / (f_y × z_{stem}) = **294** mm²/m
Minimum area of tension reinforcement	$A_{s\_stem\_min}$ = k × b × t_{wall} = **455** mm²/m
Area of tension reinforcement required	$A_{s\_stem\_req}$ = Max($A_{s\_stem\_des}$, $A_{s\_stem\_min}$) = **455** mm²/m
Reinforcement provided	**12 mm dia.bars @ 200 mm centres**
Area of reinforcement provided	$A_{s\_stem\_prov}$ = π × ϕ_{stem}^2 / (4 × s_{stem}) = **565** 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 × d_{stem}) = **0.135** N/mm²
Basic characteristic shear strength of masonry	f_{vbas} = min[0.35 + (17.5 × $A_{s\_stem\_prov}$ / (b × d_{stem})), 0.7] × 1 N/mm²
	f_{vbas} = **0.396** N/mm²
Shear span	a = M_{stem} / V_{stem} = **846.4** mm
Characteristic shear strength of masonry	f_v = Min(f_{vbas} × max(2.5 - 0.25 × (a / d_{stem}), 1), 1.75 N/mm²)
	f_v = **0.600** N/mm²
Allowable shear stress	v_{adm} = f_v / γ_{mv} = **0.300** N/mm²
	PASS - Design shear stress is less than maximum shear stress

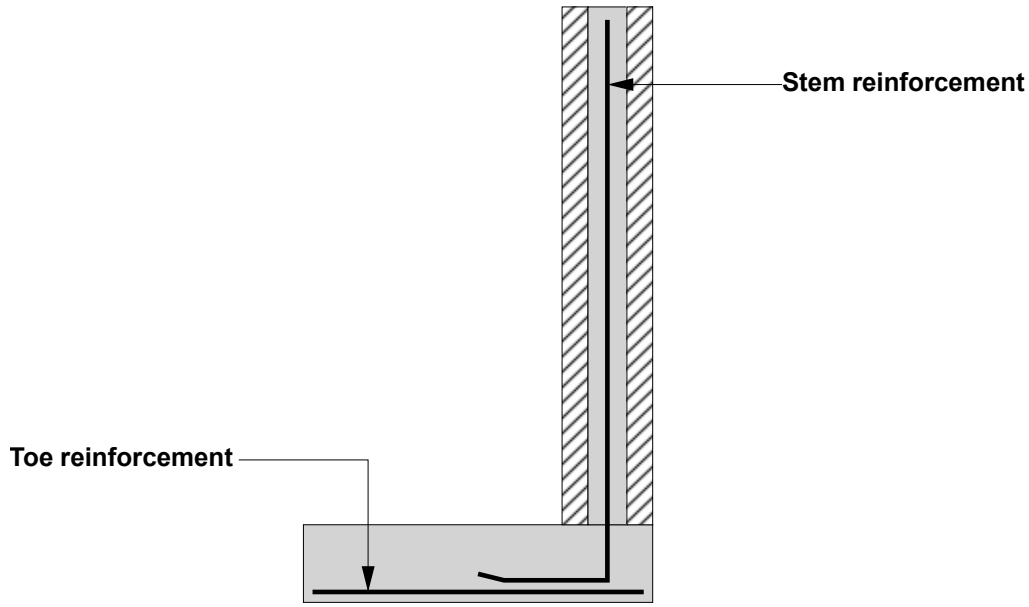
Check limiting dimensions

Limiting span/effective depth ratio	$ratio_{max}$ = **18.00**
Actual span/effective depth ratio	$ratio_{act}$ = (h_{stem} + d_{stem} / 2) / d_{stem} = **9.80**
	PASS - Span to depth ratio is acceptable

Axial load check

Factored axial load on wall	N_{wall} = ([t_{wall} × h_{stem} × γ_{wall} + W_{dead}] × γ_{f_d}) + (W_{live} × γ_{f_l}) = **26.6** kN/m
Limiting axial load	N_{limit} = 0.1 × f_k × 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 - 12 mm dia.@ 200 mm centres - (565 mm^2/m)