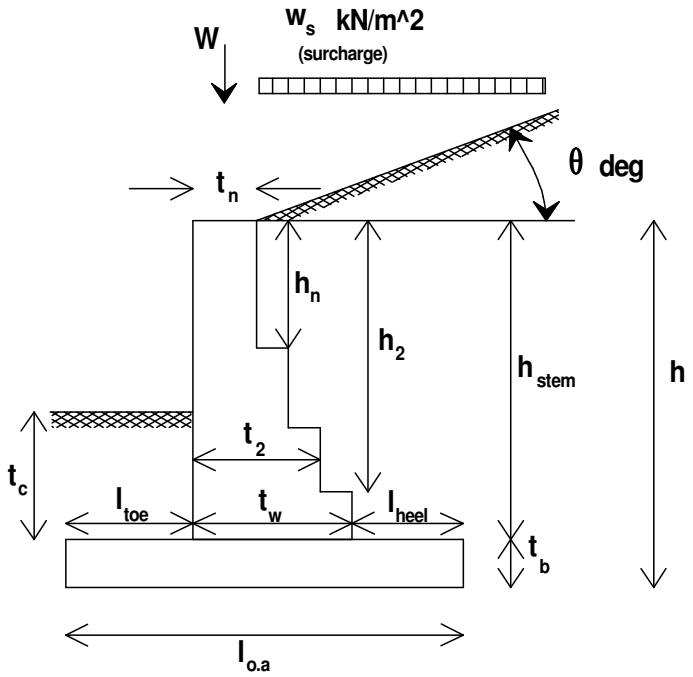

CANTILEVER MASONRY RETAINING WALL DESIGN (BS8110&BS5628) MASONRY CANTILEVER RETAINING WALL DESIGN TO CP2 & BS5628 (PART 1)

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

General Soil Data

Density of retained soil	γ_s = **16.0** kN/m^3
Angle of internal friction	ϕ = **45.0** °
Angle of soil surface	θ = **0.0** °
Ground cover over base at front of wall – if > 0mm, assumed permanent	t_c = **600** mm

Loads on wall and ground

Surcharge load (horizontal plan area)	w_s = **4.0** kN/m^2
Design vertical dead load on wall (unfactored)	W_v = **0.00** kN/m
Design vertical live load on wall (unfactored)	W_l = **0.00** kN/m

Stem details

Density of wall stem brickwork	γ_w = **22.0** kN/m^3
Wall base section thickness	t_w = **600.0** mm
Height retained	h = **1950** mm

Base details

Density of wall base	γ_b = **23.6** kN/m^3
Length of heel	l_{heel} = **600** mm

Length of toe l_{toe} = **300** mm

Base thickness t_b = **600** mm

Length of base $l_{o\_a} = l_{toe} + t_w + l_{heel}$ = **1500** mm

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

Height of wall stem $h_{stem} = h - t_b$ = **1350** mm

$h_{soil} = h + l_{heel} \times \tan(\theta)$ = **1950** mm

Load factors

Dead Load Factor γ_{f_d} = **1.40**

Imposed Load Factor γ_{f_i} = **1.60**

Coefficients using Rankine

Active coefficient (Sloping Surface) - no friction

$k_{a\_s} = (\cos(\theta) - \sqrt{((\cos(\theta))^2 - (\cos(\phi))^2}) / (\cos(\theta) + \sqrt{((\cos(\theta))^2 - (\cos(\phi))^2})$ = **0.172**

Active coefficient (level surface) $k_a = (1 - \sin(\phi)) / (1 + \sin(\phi))$ = **0.172**

Passive coefficient (level surface) $k_p = (1 + \sin(\phi)) / (1 - \sin(\phi))$ = **5.828**

At - rest coefficient $k_o = (1 - \sin(\phi))$ = **0.293**

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

At the virtual back of the wall (back of heel)

Surcharge

pressure $p_s = k_{a\_s} \times w_s$ = **0.7** kN/m^2

force – horizontal $F_s = (p_s \times h_{soil}) \times (\cos(\theta))^2$ = **1.3** kN/m

overturning moment about toe $M_s = F_s \times h_{soil} / 2$ = **1.3** kNm/m

Backfill

pressure $p_a = k_{a\_s} \times \gamma_s \times h_{soil}$ = **5.4** kN/m^2

force – horizontal $F_a = (p_a \times h_{soil} / 2) \times (\cos(\theta))^2$ = **5.2** kN/m

overturning moment about the toe $M_a = F_a \times h_{soil} / 3$ = **3.4** kNm/m

Total horizontal force (unfactored) $F_t = F_s + F_a$ = **6.6** kN/m

Total horizontal force (factored) $F_{t\_ult} = \gamma_{f\_i} \times F_s + \gamma_{f\_d} \times F_a$ = **9.4** kN/m

Total overturning moment (unfactored) $M_t = M_s + M_a$ = **4.7** kNm/m

Total overturning moment (factored) $M_{t\_ult} = \gamma_{f\_i} \times M_s + \gamma_{f\_d} \times M_a$ = **6.8** kNm/m

Average load factor $\gamma_{f\_av} = M_{t\_ult} / M_t$ = **1.46**

STABILITY CHECKS

(Unfactored Loads - Active Soil Pressures)

1) SLIDING

Coefficient of friction $\mu = \tan(\phi) \times \text{factor} =$ **0.750** factor = **0.75**

Passive pressures in front of wall

Top of base $pp_1 = k_p \times t_c \times \gamma_s =$ **56.0** kN/m^2

Underside of base $pp_2 = k_p \times (t_c + t_b) \times \gamma_s =$ **111.9** kN/m^2

Total resistance

Base $PP_{base} = (pp_1 + pp_2) \times t_b / 2 =$ **50.4** kN/m

Passive resistance **Soil in front of wall assumed to resist sliding**

$P = PP_{base} \times \text{soil\_resists} =$ **50.4** kN/m

Factor of safety against sliding

Factor of safety required $FOS\_reqd_{sliding} =$ **2.00**

Length of heel provided $l_{heel} =$ **600** mm

Conservatively, it is assumed that the surcharge load does not provide downward pressure on the heel in the sliding calculation.

$FOS_{sliding} = ((((l_{heel} \times (\gamma_s \times (h_{stem} + l_{heel} \times \tan(\theta)/2) + \gamma_b \times t_b)) + l_{toe} \times \gamma_b \times t_b + W_v + (t_w \times (\gamma_w \times h_{stem} + \gamma_b \times t_b))) \times \mu) + P) / F_t$

$FOS_{sliding} =$ **13.629**

Factor of safety against sliding = 13.6 i.e. > 2.0 - OK

2) OVERTURNING

Factor of safety against overturning

Factor of safety required $FOS\_reqd_{o\_turn} =$ **2.00**

Length of toe provided $l_{toe} =$ **300** mm

Conservatively, it is assumed that the surcharge load does not provide downward pressure on the heel in the overturning calculation.

Taking Moments about front of the toe

$M_{r1} = (W_v + h_{stem} \times t_w \times \gamma_w) \times (l_{toe} + t_w / 2) =$ **10.7** kNm/m

$M_{r2} = l_{heel} \times h_{stem} \times \gamma_s \times (l_{toe} + t_w + l_{heel} / 2) =$ **15.6** kNm/m

$M_{r3} = (l_{toe} + t_w + l_{heel})^2 \times t_b \times \gamma_b / 2 =$ **15.9** kNm/m

$M_{r4} = l_{heel} \times l_{heel} \times \tan(\theta) / 2 \times \gamma_s \times (l_{toe} + t_w + l_{heel} \times 2/3) =$ **0.0** kNm/m

Resisting moment $M_r = M_{r1} + M_{r2} + M_{r3} + M_{r4} =$ **42.2** kNm/m

Factor of safety against overturning $FOS_{o\_turn} = M_r / \text{abs}(M_t) =$ **8.98**

Factor of safety against overturning = 9.0 i.e. > 2.0 - OK

Overall length of base $l_{o\_a} = l_{toe} + t_w + l_{heel} =$ **1.500** m

3) BEARING PRESSURE (INCLUDING LIVE LOADS AND TOE COVER)

Total overturning moment for bearing calculation M_t = **4.7** kNm/m

Total resisting moment for bearing calculation M_r = **42.2** kNm/m

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 = **57.3** kN/m

Eccentricity of vertical load

$$e_1 = (M_r - \text{abs}(M_t) + t_c \times l_{toe}^2 \times \gamma_s/2 + w_s \times l_{heel} \times (l_{toe} + t_w + l_{heel}/2) + W_l \times (l_{toe} + t_w/2)) / N = \mathbf{0.712}\ \text{m}$$

$e = l_{o\_a} / 2 - e_1$ = **0.038** m

Resultant lies inside middle third

Maximum bearing pressure $p_{max} = \text{if}(\text{abs}(e)<(l_{o\_a}/6)\ ,\ \sigma_{max2}\ ,\ \sigma_{max1})$ = **44.0** kN/m²

Permissible bearing pressure $p_{bearing}$ = **150** kN/m²

Maximum bearing pressure is 44 kN/m² i.e. < Allowable - OK

DESIGN BASE PRESSURES BASED UPON AT REST EARTH PRESSURES

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

Surcharge

pressure	$p_{so} = k_o \times w_s$ = **1.2** kN/m²
force	$F_{so} = p_{so} \times h$ = **2.3** kN/m
moment	$M_{so} = F_{so} \times h / 2$ = **2.2** kNm/m

Backfill

pressure	$p_o = k_o \times \gamma_s \times h$ = **9.1** kN/m²
force	$F_o = p_o \times h / 2$ = **8.9** kN/m
moment	$M_o = F_o \times h / 3$ = **5.8** kNm/m

Total horizontal force (unfactored) $F_{t\_o} = F_{so} + F_o$ = **11.2** kN/m

Total horizontal force (factored) $F_{t\_ult\_o} = \gamma_{f\_i} \times F_{so} + \gamma_{f\_d} \times F_o$ = **16.1** kN/m

Total moment (unfactored) $M_{t\_o} = M_{so} + M_o$ = **8.0** kNm/m

Total horizontal force (factored) $M_{t\_ult\_o} = \gamma_{f\_i} \times M_{so} + \gamma_{f\_d} \times M_o$ = **11.7** kNm/m

Average load factor $\gamma_{f\_av} = M_{t\_ult\_o} / M_{t\_o}$ = **1.46**

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 = **57.3** kN/m

Total resistance moment (no live loads included or toe cover)

M_r = **42.174** kNm/m

Eccentricity of vertical load

$$e_1 = (M_r - M_{t\_o} + t_c \times l_{toe}^2 \times \gamma_s/2 + w_s \times l_{heel} \times (l_{toe} + t_w + l_{heel}/2) + W_l \times (l_{toe} + t_w/2)) / N = \mathbf{0.654} \text{ m}$$

$$e = l_{o\_a} / 2 - e_1 = \mathbf{0.096} \text{ m}$$

Resultant lies inside middle third

1) Resultant outside middle third **This Section is Invalid as Resultant is within Middle Third**

$$\sigma_{max1} = (2 \times N) / (3 \times (l_{o\_a} / 2 - \text{abs}(e))) = \mathbf{58} \text{ kN/m}^2$$

$$l_{b1} = (N \times 2 / \sigma_{max1}) = \mathbf{1.962} \text{ m}$$

2) Resultant inside middle third

$$\sigma_{max2} = N / l_{o\_a} + 6 \times N \times \text{abs}(e) / l_{o\_a}^2 = \mathbf{53} \text{ kN/m}^2$$

$$\sigma_{min2} = N / l_{o\_a} - 6 \times N \times \text{abs}(e) / l_{o\_a}^2 = \mathbf{24} \text{ kN/m}^2$$

$$l_{b2} = l_{o\_a} = \mathbf{1.500} \text{m}$$

Pressures under the base

$$\sigma_{max} = \text{if}(\text{abs}(e) < l_{o\_a} / 6, \sigma_{max2}, \sigma_{max1}) = \mathbf{52.9} \text{ kN/m}^2$$

$$\sigma_{min} = \text{if}(\text{abs}(e) < l_{o\_a} / 6, \sigma_{min2}, 0 \text{ kN/m}^2) = \mathbf{23.5} \text{ kN/m}^2$$

Bearing length $l_p = \text{if}(\text{abs}(e) < (l_{o\_a} / 6) , l_{b2} , l_{b1}) = \mathbf{1.500}$ m

Pressures under the heel/stem interface

$$l_{p\_heel} = l_p - l_{toe} - t_w = \mathbf{0.600} \text{ m}$$

$$\sigma_{heel} = \max (((\sigma_{max} - \sigma_{min}) \times l_{p\_heel} / l_p) + \sigma_{min} , 0 \text{ kN/m}^2) = \mathbf{35.3} \text{ kN/m}^2$$

Pressures under the toe/stem interface

$$\sigma_{toe} = ((\sigma_{max} - \sigma_{min}) \times (l_{p\_heel} + t_w) / l_p) + \sigma_{min} = \mathbf{47.0} \text{ kN/m}^2$$

BASE DESIGN - HEEL

Shears and Moments

Vertical load downward $w_{ult\_heel} = (h_{stem} \times \gamma_s + \gamma_b \times t_b) \times \gamma_{f\_d} + w_s \times \gamma_{f\_i} = \mathbf{56.5} \text{ kN/m}^2$

$$w_{ult\_heel1} = (l_{heel} \times \tan(\theta)/2 \times \gamma_s) \times \gamma_{f\_d} = \mathbf{0.0} \text{ kN/m}^2$$

Ultimate Shear (at wall face)

downward $V_{ult\_pos\_heel} = (w_{ult\_heel} + w_{ult\_heel1}) \times l_{heel} = \mathbf{33.9}$ kN/m

upward

$V_{ult\_neg\_heel} = (\sigma_{min} \times \max(l_{p\_heel}, 0\ mm) + (\sigma_{heel} - \sigma_{min}) \times (\max(l_{p\_heel}, 0\ mm))^2 / (2 \times l_{p\_heel})) \times \gamma_{f\_av}$

$V_{ult\_neg\_heel}$ = **25.7** kN/m

Nett Ultimate Shear $V_{ult\_heel} = abs(V_{ult\_pos\_heel} - V_{ult\_neg\_heel})$ = **8.2** kN/m

Ultimate Moment (at centre of wall)

clockwise $M_{ult\_pos\_heel} = w_{ult\_heel} \times l_{heel} \times (l_{heel} + t_w)/2 + w_{ult\_heel1} \times l_{heel} \times (2 \times l_{heel} / 3 + t_w/2)$ = **20.3** kNm/m

anticlockwise

$M_{ult\_neg\_heel} = ((\sigma_{min} \times l_{p\_heel} \times (l_{p\_heel} + t_w) / 2) + (\sigma_{heel} - \sigma_{min}) / 2 \times l_{p\_heel} \times (l_{p\_heel} / 3 + t_w / 2)) \times \gamma_{f\_av}$

$M_{ult\_neg\_heel}$ = **14.9** kNm/m

Nett Ultimate Moment $M_{ult\_heel} = abs(M_{ult\_pos\_heel} - M_{ult\_neg\_heel})$ = **5.4** kNm/m

HEEL REINFORCEMENT - MESH

Tension Reinforcement

Cover to bars in the top of the heel c_{r_heel} = **50** mm

Effective depth to bars $d_{heel} = t_b - c_{r\_heel} - (6mm)$ = **544** mm

Assume the base is a cantilevered slab

Characteristic strength of reinforcement f_y = **460** N/mm²

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

Area of reinforcement required

$K_{heel} = abs(M_{ult\_heel}) / (d_{heel}^2 \times f_{cu})$ = **0.001** K' = 0.156

Compression steel not required

Lever arm $z_{heel} = \min ((0.95 \times d_{heel}), (d_{heel} \times (0.5 + \sqrt{(0.25 - K_{heel}/0.9)})))$ = **517** mm

Reinforcement required $A_{s\_heel} = abs(M_{ult\_heel}) / (1/\gamma_{ms} \times f_y \times z_{heel})$ = **24** mm²/m

Minimum reinforcement $A_{s\_min\_heel} = if(f_y == 460\ N/mm^2, 0.0013 \times t_b, 0.0024 \times t_b)$ = **780** mm²/m

$A_{s\_req\_heel} = \max(A_{s\_heel}, A_{s\_min\_heel})$ = **780** mm²/m

Tension steel provided

Use C785 Mesh ***$A_{s\_prov\_heel} = A_{sl\_heel}$ = 785 mm²/m***

Area of main tension steel provided in heel sufficient

Heel - Check min and max areas of steel

Total area of concrete $A_c = t_b$ = **600000** mm²/m

Minimum percentage area of reinforcement k = **0.13** %

Minimum area of steel required $A_{s\_min} = k \times A_c$ = **780** mm²/m

Maximum area of steel allowed $A_{s\_max} = 4\ \% \times A_c$ = **24000** mm²/m

Area of main steel provided OK

Heel Distribution Steel

Minimum percentage of distribution reinforcement k_1 = **0.13** %

Minimum Area Required $A_{s\_dist\_req} = k_1 \times A_c$ = **780** mm²/m

Area Provided $A_{s\_dist\_base} = A_{st\_heel}$ = **71** mm²/m

Less than min area of distribution steel

CHECK OF NOMINAL COVER

Cover to outer tension reinforcement

$c_{heel} = t_b - d_{heel} - d_{sl\_heel} / 2$ = **51.0** mm

Permissible minimum nominal cover to all reinforcement (Table 3.4)

c_{min_heel} = **35** mm

Cover over outer steel OK (top of heel)

HEEL SHEAR RESISTANCE – AT WALL FACE

Applied shear stress at wall face

$v_{heel} = V_{ult\_heel} / d_{heel}$ = **0.02** N/mm²

Check shear stress to clause 3.4.5.2 (BS8110:Pt 1)

$v_{allowable}$ = min ((0.8 N$^{1/2}$/mm) × $\sqrt{(f_{cu})}$, 5 N/mm²) = **4.73** N/mm²

Shear stress < maximum - OK

Shear stresses to clause 3.4.5.4 (BS8110:Pt1)

Allowable shear stress

v_{c_heel} = **0.37** N/mm²

No shear reinforcement required

BASE DESIGN - TOE

Shears and Moments

Conservatively all soil overburden on the toe is ignored

Ultimate Shear (conservatively - at face of wall)

$V_{ult\_toe} = ((\sigma_{toe} \times l_{toe}) + (((\sigma_{max} - \sigma_{toe}) / 2) \times l_{toe})) \times \gamma_{f\_av} - l_{toe} \times t_b \times \gamma_b \times \gamma_{f\_d}$ = **15.9** kN/m

Ultimate Moment (at centre of wall)

$M_{ult\_toe} = ((\sigma_{toe} \times l_{toe} \times (l_{toe} + t_w)/2) + (\sigma_{max} - \sigma_{toe})/2 \times l_{toe} \times (2 \times l_{toe}/3 + t_w/2)) \times \gamma_{f\_av} - l_{toe} \times t_b \times \gamma_b \times \gamma_{f\_d} \times (l_{toe}/2 + t_w/2)$

M_{ult_toe} = **7.2** kNm/m

TOE REINFORCEMENT - MESH

Tension Reinforcement

Cover to bars in the bottom of the toe c_{r_toe} = **50** mm

Effective depth to bars $d_{toe} = t_b - c_{r\_toe}$ - (6mm) = **544** mm

Assume the base is a cantilevered slab

Characteristic strength of reinforcement f_y = **460** N/mm²

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

Area of reinforcement required

K_{toe} = abs (M_{ult_toe}) / ($d_{toe}^2 \times f_{cu}$) = **0.001** K' = 0.156

Compression steel not required

Lever arm z_{toe} = min ((0.95 × d_{toe}),(d_{toe}×(0.5+√(0.25-K_{toe}/0.9)))) = **517** mm

Reinforcement required A_{s_toe} = abs(M_{ult_toe}) / (1/γ_{ms} × f_y × z_{toe}) = **32** mm²/m

Minimum reinforcement $A_{s\_min\_toe}$ = if(f_y == 460 N/mm²,0.0013×t_b,0.0024×t_b) = **780** mm²/m

$A_{s\_req\_toe}$ = max(A_{s_toe}, $A_{s\_min\_toe}$) = **780** mm²/m

Tension steel provided

Use C785 Mesh ***$A_{s\_prov\_toe}$ = A_{sl_toe} = 785 mm²/m***

Area of main tension steel provided in toe sufficient

Toe - Check min and max areas of steel

Total area of concrete A_c = t_b = **600000** mm²/m

Minimum percentage area of reinforcement k = **0.13** %

Minimum area of steel required A_{s_min} = k × A_c = **780** mm²/m

Maximum area of steel allowed A_{s_max} = 4 % × A_c = **24000** mm²/m

Area of main steel provided OK

Toe Distribution Steel

Minimum percentage of distribution reinforcement k_1 = **0.13** %

Minimum Area Required $A_{s\_dist\_req}$ = k_1 × A_c = **780** mm²/m

Area Provided $A_{s\_dist\_base}$ = A_{st_toe} = **71** mm²/m

Less than min area of distribution steel

CHECK OF NOMINAL COVER

Cover to outer tension reinforcement

c_{toe} = t_b - d_{toe} - d_{sl_toe} / 2 = **51.0** mm

Permissible minimum nominal cover to all reinforcement (Table 3.4)

c_{min_toe} = **35** mm

Cover over outer steel OK (bottom of toe)

TOE SHEAR RESISTANCE

Applied shear stress

v_{toe} = V_{ult_toe} / d_{toe} = **0.03** N/mm²

Check shear stress to clause 3.4.5.2 (BS8110:Pt 1)

$v_{allowable}$ = min ((0.8 N$^{1/2}$/mm) × √(f_{cu}), 5 N/mm²) = **4.73** N/mm²

Shear stress < maximum - OK

Shear stresses to clause 3.4.5.4 (BS8110:Pt 1)

Allowable shear stress

v_{c_toe} = **0.37** N/mm^2

No shear reinforcement required

STEM DESIGN

Width of base of wall t_w = **600.0** mm

Height of stem of wall h_{stem} = **1350** mm

DESIGN OF WALL SECTION 1 (AT REST PRESSURES)

Wall base section thickness t_w = **600.0** mm

Depth from top of wall to base

h_{stem} = **1350** mm

Applied moment at base of section

$M_{base} = (k_o \times w_s \times h_{stem}^2 / 2) \times \gamma_{f\_i} + (k_o \times \gamma_s \times h_{stem}^3 / 6) \times \gamma_{f\_d}$ = **4.4** kNm/m

Applied shear force at base of section

$F_{base} = (k_o \times w_s \times h_{stem}) \times \gamma_{f\_i} + (k_o \times \gamma_s \times h_{stem}^2 / 2) \times \gamma_{f\_d}$ = **8.5** kN/m

CHECK RESISTANCE TO MOMENT WITHOUT FLEXURAL STRENGTH **(BS5628:PT 1:CL 36.5.3)**

Compressive strength (Table 2) f_k = **7.00** N/mm^2

Design vertical load per unit length of wall $n_{w\_base} = \gamma_{fd} \times (W_v + t_w \times h_{stem} \times \gamma_w)$ = **16.0** kN/m

Moment of resistance $M_{RC\_base} = (n_{w\_base} / 2) \times (t_w - (n_{w\_base} \times \gamma_m / f_k))$ = **4.7** kNm/m

Wall bending - OK

STEM SHEAR (BS5628:PT 1:CL 33)

Mortar designation Mortar = **"iii"**

Design dead load at the base of the wall $V_{base} = W_v + t_w \times h_{stem} \times \gamma_w$ = **17.82** kN/m

Design vertical dead load per unit area $g_{A\_base} = V_{base} \times \gamma_{fd} / t_w$ = **0.03** N/mm^2

Characteristic shear strength of masonry

$f_{v\_i} = \min(1.75 \text{ N/mm}^2, 0.35 \text{ N/mm}^2 + (0.6 \times g_{A\_base}))$ = **0.37** 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** N/mm^2

f_v = if((Mortar == "i")||(Mortar == "ii"), f_{v_i}, f_{v_iii}) = **0.17** N/mm^2

Ref BS 5628 Pt 1: Clause 25

Shear stress $v_{base} = F_{base} / t_w$ = **0.01** N/mm^2

Partial safety factor for shear γ_{mv} = **2.5**

Wall base shear OK

DESIGN OF WALL SECTION 2 (AT REST PRESSURES)

Wall section thickness t_{wall_2} = **890.0** mm

Depth from top of wall to base of section

h_{wall_2} = **1200** mm

Applied moment at base of section

$M_{wall\_2} = (k_o \times w_s \times h_{wall\_2}^2 / 2) \times \gamma_{f\_i} + (k_o \times \gamma_s \times h_{wall\_2}^3 / 6) \times \gamma_{f\_d}$ = **3.2** kNm/m

Applied shear force at base of section

$F_{wall\_2} = (k_o \times w_s \times h_{wall\_2}) \times \gamma_{f\_i} + (k_o \times \gamma_s \times h_{wall\_2}^2 / 2) \times \gamma_{f\_d}$ = **7.0** kN/m

CHECK RESISTANCE TO MOMENT WITHOUT FLEXURAL STRENGTH **(BS5628:PT 1:CL 36.5.3)**

Compressive strength (Table 2) f_k = **7.00** N/mm^2

Design vertical load per unit length of wall $n_{w\_wall\_2} = \gamma_{fd} \times (W_v + t_{wall\_2} \times h_{wall\_2} \times \gamma_w)$ = **21.1** kN/m

Moment of resistance $M_{RC\_wall\_2} = (n_{w\_wall\_2} / 2) \times (t_{wall\_2} - (n_{w\_wall\_2} \times \gamma_m / f_k))$ = **9.3** kNm/m

Wall bending - OK

STEM SHEAR (BS5628:PT 1:CL 33)

Mortar designation Mortar = **"iii"**

Design dead load at the base of the wall $V_{wall\_2} = W_v + t_{wall\_2} \times h_{wall\_2} \times \gamma_w$ = **23.50** kN/m

Design vertical dead load per unit area $g_{A\_wall\_2} = V_{wall\_2} \times \gamma_{fd} / t_{wall\_2}$ = **0.02** N/mm^2

Characteristic shear strength of masonry

f_{v_i} = min(1.75 N/mm^2, 0.35 N/mm^2 + (0.6 × $g_{A\_wall\_2}$)) = **0.36** N/mm^2

f_{v_iii} = min(1.4 N/mm^2, 0.15 N/mm^2 + (0.6 × $g_{A\_wall\_2}$)) = **0.16** N/mm^2

f_v = if((Mortar == "i")||(Mortar == "ii"), f_{v_i}, f_{v_iii}) = **0.16** N/mm^2

Ref BS 5628 Pt 1: Clause 25

Shear stress $v_{wall\_2} = F_{wall\_2} / t_{wall\_2}$ = **0.01** N/mm^2

Partial safety factor for shear γ_{mv} = **2.5**

Wall section base shear OK

DESIGN OF WALL SECTION 3 (AT REST PRESSURES)

Wall section thickness t_{wall_3} = **1115.0** mm

Depth from top of wall to base of section

h_{wall_3} = **825** mm

Applied moment at base of section

$M_{wall\_3} = (k_o \times w_s \times h_{wall\_3}^2 / 2) \times \gamma_{f\_i} + (k_o \times \gamma_s \times h_{wall\_3}^3 / 6) \times \gamma_{f\_d}$ = **1.3** kNm/m

Applied shear force at base of section

$F_{wall\_3} = (k_o \times w_s \times h_{wall\_3}) \times \gamma_{f\_i} + (k_o \times \gamma_s \times h_{wall\_3}^2 / 2) \times \gamma_{f\_d}$ = **3.8** kN/m

CHECK RESISTANCE TO MOMENT WITHOUT FLEXURAL STRENGTH **(BS5628:PT 1:CL 36.5.3)**

Compressive strength (Table 2) f_k = **7.00** N/mm^2

Design vertical load per unit length of wall $n_{w\_wall\_3} = \gamma_{fd} \times (W_v + t_{wall\_3} \times h_{wall\_3} \times \gamma_w)$ = **18.2** kN/m

Moment of resistance $M_{RC\_wall\_3} = (n_{w\_wall\_3} / 2) \times (t_{wall\_3} - (n_{w\_wall\_3} \times \gamma_m / f_k))$ = **10.1** kNm/m

Wall bending - OK

STEM SHEAR (BS5628:PT 1:CL 33)

Mortar designation Mortar = **"iii"**

Design dead load at the base of the wall $V_{wall\_3} = W_v + t_{wall\_3} \times h_{wall\_3} \times \gamma_w$ = **20.24** kN/m

Design vertical dead load per unit area $g_{A\_wall\_3} = V_{wall\_3} \times \gamma_{fd} / t_{wall\_3}$ = **0.02** N/mm^2

Characteristic shear strength of masonry

f_{v_i} = min(1.75 N/mm^2, 0.35 N/mm^2 + (0.6 × $g_{A\_wall\_3}$)) = **0.36** N/mm^2

f_{v_iii} = min(1.4 N/mm^2, 0.15 N/mm^2 + (0.6 × $g_{A\_wall\_3}$)) = **0.16** N/mm^2

f_v = if((Mortar == "i")||(Mortar == "ii"), f_{v_i}, f_{v_iii}) = **0.16** N/mm^2

Ref BS 5628 Pt 1: Clause 25

Shear stress $v_{wall\_3} = F_{wall\_3} / t_{wall\_3}$ = **0.00** N/mm^2

Partial safety factor for shear γ_{mv} = **2.5**

Wall section base shear OK

DESIGN OF WALL SECTION 4 (AT REST PRESSURES)

Wall section thickness t_{wall_4} = **1227.5** mm

Depth from top of wall to base of section

h_{wall_4} = **600** mm

Applied moment at base of section

$M_{wall\_4} = (k_o \times w_s \times h_{wall\_4}^2 / 2) \times \gamma_{f\_i} + (k_o \times \gamma_s \times h_{wall\_4}^3 / 6) \times \gamma_{f\_d}$ = **0.6** kNm/m

Applied shear force at base of section

$F_{wall\_4} = (k_o \times w_s \times h_{wall\_4}) \times \gamma_{f\_i} + (k_o \times \gamma_s \times h_{wall\_4}^2 / 2) \times \gamma_{f\_d}$ = **2.3** kN/m

CHECK RESISTANCE TO MOMENT WITHOUT FLEXURAL STRENGTH **(BS5628:PT 1:CL 36.5.3)**

Compressive strength (Table 2) f_k = **7.00** N/mm^2

Design vertical load per unit length of wall $n_{w\_wall\_4} = \gamma_{fd} \times (W_v + t_{wall\_4} \times h_{wall\_4} \times \gamma_w)$ = **14.6** kN/m

Moment of resistance $M_{RC\_wall\_4} = (n_{w\_wall\_4} / 2) \times (t_{wall\_4} - (n_{w\_wall\_4} \times \gamma_m / f_k))$ = **8.9** kNm/m

Wall bending - OK

STEM SHEAR (BS5628:PT 1:CL 33)

Mortar designation Mortar = **"iii"**

Design dead load at the base of the wall $V_{wall\_4} = W_v + t_{wall\_4} \times h_{wall\_4} \times \gamma_w$ = **16.20** kN/m

Design vertical dead load per unit area $g_{A\_wall\_4} = V_{wall\_4} \times \gamma_{fd} / t_{wall\_4} =$ **0.01** N/mm^2

Characteristic shear strength of masonry

$f_{v\_i} = \min(1.75\ N/mm^2, 0.35\ N/mm^2 + (0.6 \times g_{A\_wall\_4})) =$ **0.36** N/mm^2

$f_{v\_iii} = \min(1.4\ N/mm^2, 0.15\ N/mm^2 + (0.6 \times g_{A\_wall\_4})) =$ **0.16** N/mm^2

$f_v =$ if((Mortar == "i")||(Mortar == "ii"), f_{v_i}, f_{v_iii}) = **0.16** N/mm^2

Ref BS 5628 Pt 1: Clause 25

Shear stress $v_{wall\_4} = F_{wall\_4} / t_{wall\_4} =$ **0.00** N/mm^2

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

Wall section base shear OK

SUMMARY OF RESULTS

Wall Dimensions

Masonry Compressive Strength	**Masonry Compressive Strength - 7.0 N/mm^2**
Stem Base section	**600mm thick and 1350mm from base to the top of the wall**
Section 2	**890mm thick and 1200mm from base of section 2 to the top of the wall**
Section 3	**1115mm thick and 825mm from base of section 3 to the top of the wall**
Section 4	**1228mm thick and 600mm from base of section 4 to the top of the wall**

Base Top Reinforcement - Mesh

Heel (Top) Reinforcement	**Provide C785 Mesh (Top)**

Base Bottom Reinforcement - Mesh

Toe (Bottom) Reinforcement	**Provide C785 Mesh (Bottom)**