WHITE & LLOYD CONSULTING ENGINEERS	Job No.	Section	Sheet No.	Rev
	Engineer		Checked	
	Date		Rev. Date	

Project: 24 BURGESS HILL

Element: RETAINING WALL LOADING – WORST CASE

		DEAD (kN/m)	IMPOSED (kN/m)
EXISTING MASONRY WALL			
4.6 kN/m² × 6.5m	=	29.9	
TIMBER FLOORS			
0.96 kN/m² × 2.2m × 2	=	4.2	
1.5 kN/m² × 2.2m × 2	=		6.6
GROUND FLOOR			
5.0 kN/m² × 2.2m	=	11	
1.5 kN/m² × 2.2m	=		3.3
ROOF			
0.91 kN/m² × 4.0m	=	3.64	
0.75 kN/m² × 4.0m	=		3.0
TOTAL :		48.75 kN/m	12.9 kN/m

WATER TABLE @ 1m BGL

SURCHARGE = 10 kN/m²

RETAINING BASEMENT WALL ANALYSIS

In accordance with EN1997-1:2004 incorporating Corrigendum dated February 2009 and the UK national annex

Tedds calculation version 1.0.00

Design summary

Overall design status; PASS

Overall design utilisation; 0.971

Description	Unit	Provided	Required	Utilisation	Result
Bearing pressure	kN/m^2	100	62.09	0.621	PASS

Design - Combination 1.35G + 1.5Q + 1.5Qr

Description	Unit	Provided	Required	Utilisation	Result
Pure axial capacity	kN/m	5022.43	112.49	0.022	PASS
Bending capacity	kNm/m	56.53	-30.32	0.536	PASS
Shear axial capacity	kN/m	129.27	55.18	0.427	PASS
Foot. bending reinf.	mm^2/m	785	762	0.971	PASS
Foot. shear capacity	kN/m	111.24	89.99	0.809	PASS

Basement wall details

Stem height; h_{stem} = **2700** mm

Thickness of stem; t_{stem} = **300** mm

Stem area; $A_{stem} = h_{stem} \times t_{stem}$ = **810000** mm^2

Density; γ_{stem} = **25** kN/m^3

Fixity at base of the wall; Pinned

Angle to rear face of basement wall; α = **90**

Retained soil height; h_{ret} = **2700** mm

Backfill soil angle; β = **0**

Groundwater level; h_{water} = **1700** mm

Water density; γ_w = **9.8** kN/m^3

Strip footing details

Footing depth; $h_{footing}$ = **300** mm

Toe length; l_{toe} = **1200** mm

Heel length; l_{heel} = **0** mm

Total length; l_{total} = **1500** mm

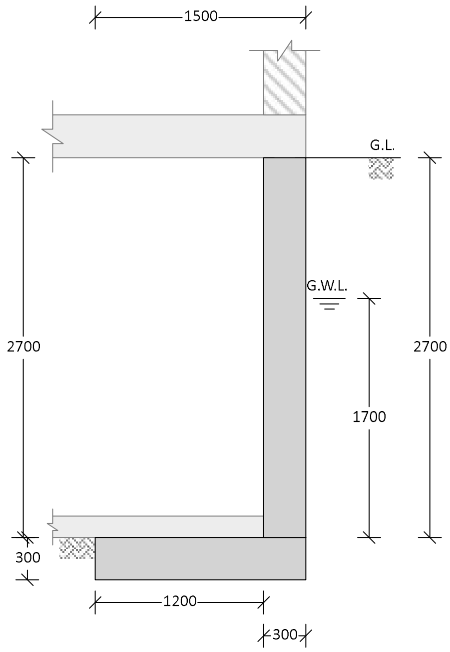
Footing area; $A_{footing} = l_{total} \times h_{footing}$ = **450000** mm^2

Density; $\gamma_{footing}$ = **25** kN/m^3

Footing rotation; Prevented

Total height; $h_{total} = h_{stem} + h_{footing}$ = **3000** mm

Effective soil height; $h_{eff} = h_{ret} + h_{footing}$ = **3000** mm



Loading details

Axial permanent load on top of wall ; P_G = **48.74** kN/m

Axial imposed load on top of wall ; P_Q = **12.9** kN/m

Imposed surcharge load; $p_{Q,sur}$ = **10** kN/m^2

Retained soil properties

Soil type; Firm clay

Moist soil height; h_{moist} = **1000** mm

Saturated soil height; h_{sat} = **1700** mm

Moist density; γ_{mr} = **19** kN/m^3

Saturated density; γ_{sr} = **19** kN/m^3

Characteristic effective shear resistance angle; $\phi'_{r.k}$ = **23.5** deg

Characteristic wall friction angle; $\delta_{r.k}$ = **9** deg

Base soil properties

Soil type; Stiff clay

Soil density; γ_b = **19** kN/m^3

Characteristic cohesion; $c'_{b.k}$ = **0** kN/m^2

Characteristic effective shear resistance angle; $\phi'_{b.k}$ = **23.5** deg

Using Coulomb theory

At rest pressure coefficient; $K_0 = 1 - \sin(\phi'_{r.k})$ = **0.601**

Lateral pressure

Permanent surcharge pressure; $p_{Q.Surch.Press} = K_0 \times \cos(\delta_{r.d}) \times p_{Q,sur}$ = **5.9** kN/m^2

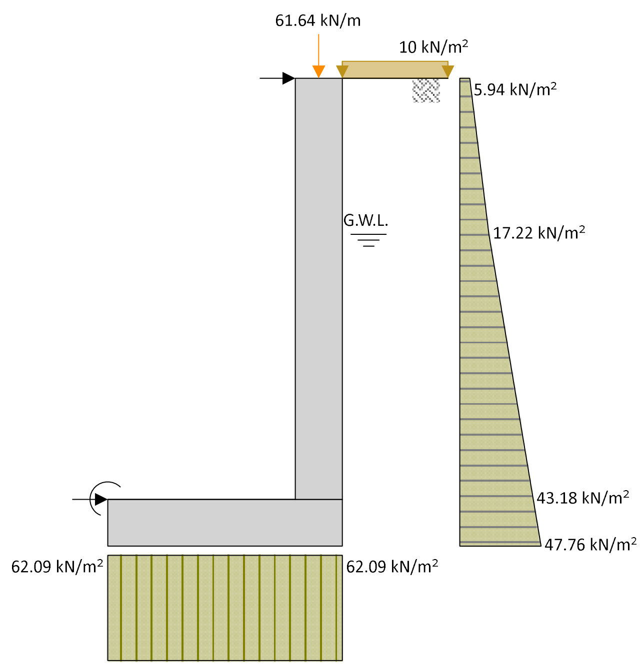
Imposed surcharge pressure; $p_{G.Surch.Press} = K_0 \times \cos(\delta_{r.d}) \times p_{G,sur}$ = **0** kN/m^2

Soil pressure at top of retained soil $p_{Soil.Top}$ = **0** kN/m^2

Soil pressure at groundwater level $p_{Soil.WaterLevel} = K_0 \times \cos(\delta_{r.d}) \times h_{moist} \times \gamma_{mr}$ = **11.3** kN/m^2

Soil pressure at footing; $p_{Soil.Footing} = K_0 \times \cos(\delta_{r.d}) \times (h_{moist} \times \gamma_{mr} + (h_{ret} + h_{footing} - h_{moist}) \times (\gamma_{sr} - \gamma_w))$ = **22.2** kN/m^2

Water pressure at footing; $p_{Water.Footing} = \gamma_w \times (h_{water} + h_{footing}) = \mathbf{19.6}$ kN/m²



Reactions at base of stem (from 2D analysis model)

Axial $R_{V.StemBase} = \mathbf{81.89}$ kN/m

Shear $R_{H.StemBase} = \mathbf{39.98}$ kN/m

Moment $R_{M.StemBase} = \mathbf{0}$ kNm/m

Bearing pressure check

Vertical forces

Stem; $F_{V.Stem} = A_{stem} \times \gamma_{stem} = \mathbf{20.25}$ kN/m

Footing; $F_{V.Footing} = A_{footing} \times \gamma_{footing} = \mathbf{11.25}$ kN/m

Retained soil; $F_{V.Soil} = h_{moist} \times l_{heel} \times \gamma_{mr} + h_{sat} \times l_{heel} \times (\gamma_{sr} - \gamma_w) = \mathbf{0}$ kN/m

Applied axial loads; $F_{V.Applied} = P_G + P_Q = \mathbf{61.64}$ kN/m

Total; $F_{V.Total} = F_{V.Stem} + F_{V.Footing} + F_{V.Soil} + F_{V.Applied} = \mathbf{93.14}$ kN/m

Horizontal forces

Stem; $F_{H.Stem} = R_{H.StemBase} = \mathbf{39.98}$ kN/m

Retained soil; $F_{H.Soil} = (p_{Soil.WallBase} + 0.5 \times (p_{Soil.Footing} - p_{Soil.WallBase})) \times h_{footing} = \mathbf{6.41}$ kN/m

Distance; $D_{FH.Soil} = h_{footing} \times (2 / 3 \times p_{Soil.WallBase} + p_{Soil.Footing} / 3) / (p_{Soil.WallBase} + p_{Soil.Footing}) = \mathbf{0.148}$ m

Surcharge load; $F_{H.Surch} = p_{Q.Surch.Press} \times h_{footing} = \mathbf{1.78}$ kN/m

Water; $F_{H.Water} = (p_{Water.WallBase} + 0.5 \times (p_{Water.Footing} - p_{Water.WallBase})) \times h_{footing} = \mathbf{5.44}$ kN/m

Distance; $D_{FH.Water} = h_{footing} \times (2 / 3 \times p_{Water.WallBase} + p_{Water.Footing} / 3) / (p_{Water.WallBase} + p_{Water.Footing}) = \mathbf{0.146}$ m

Prop; $F_{H.Prop} = F_{H.Stem} + F_{H.Soil} + F_{H.Surch} = \mathbf{48.18}$ kN/m

Total; $F_{H.Total} = F_{H.Stem} + F_{H.Soil} + F_{H.Surch} - F_{H.Prop} = \mathbf{0}$ kN/m

Moments

Stem; $M_{Stem} = R_{V.StemBase} \times (l_{toe} + t_{stem} / 2) - R_{H.StemBase} \times h_{footing} - R_{M.StemBase}$ = **98.56** kNm/m

Footing; $M_{Footing} = F_{V.Footing} \times l_{total} / 2$ = **8.44** kNm/m

Retained soil; $M_{Soil} = F_{V.Soil} \times (l_{toe} + t_{stem} + l_{heel} / 2) - F_{H.Soil} \times D_{FH.Soil}$ = **-0.95** kNm/m

Surcharge load; $M_{Surch} = F_{V.Surch} \times (l_{toe} + t_{stem} + l_{heel} / 2) - F_{H.Surch} \times h_{footing} / 2$ = **-0.27** kNm/m

Water; $M_{Water} = F_{V.Water} \times (l_{toe} + t_{stem} + l_{heel} / 2) - F_{H.Water} \times D_{FH.Water}$ = **-0.79** kNm/m

Horizontal base prop; $M_{H.Prop} = F_{H.Prop} \times h_{footing}$ = **14.45** kNm/m

Moment resisted by base prop; $M_{Rest.Prop} = l_{total} / 2 \times F_{V.Total} - (M_{Stem} + M_{Footing} + M_{Soil} + M_{Surch} + M_{Water} + M_{H.Prop})$ = **-49.58** kNm/m

Total; $M_{Total} = M_{Stem} + M_{Footing} + M_{Soil} + M_{Surch} + M_{Water} + M_{H.Prop} + M_{Rest.Prop}$ = **69.86** kNm/m

Bearing pressure check

Distance to reaction; $\bar{x} = M_{Total} / F_{V.Total}$ = **750** mm

Eccentricity of reaction; $e = \bar{x} - l_{total} / 2$ = **0** mm

Loaded length of base; $l_{load} = l_{total}$ = **1500** mm

Bearing pressure at toe; $q_{toe} = F_{V.Total} / l_{total} \times (1 - 6 \times e / l_{total})$ = **62.1** kN/m^2

Bearing pressure at heel; $q_{heel} = F_{V.Total} / l_{total} \times (1 + 6 \times e / l_{total})$ = **62.1** kN/m^2

Factor of safety; $FoS_{bearing} = P_{bearing} / \max(q_{toe}, q_{heel})$ = **1.610**

PASS - Allowable bearing capacity exceeds maximum applied bearing pressure

RETAINING BASEMENT WALL DESIGN

In accordance with EN1992-1-1:2004 incorporating Corrigenda January 2008 and the UK national annex

Tedds calculation version 1.0.00

Concrete details - Table 3.1. Strength and deformation characteristics for concrete

Concrete strength class; C28/35

Aggregate type; Quartzite

Aggregate adjustment factor - cl.3.1.3(2); AAF = **1.0**

Characteristic compressive cylinder strength; f_{ck} = **28** N/mm^2

Mean value of compressive cylinder strength; $f_{cm} = f_{ck} + 8$ N/mm^2 = **36** N/mm^2

Mean value of axial tensile strength; $f_{ctm} = 0.3$ N/mm$^2 \times (f_{ck}/ 1$ N/mm$^2)^{2/3}$ = **2.8** N/mm^2

Secant modulus of elasticity of concrete; $E_{cm} = 22$ kN/mm$^2 \times (f_{cm} / 10$ N/mm$^2)^{0.3} \times$ AAF = **32308** N/mm^2

Compressive shortening strain - Table 3.1; ε_{c3} = **0.0018**

Ultimate strain - Table 3.1; ε_{cu2} = **0.0035**

Shortening strain - Table 3.1; ε_{cu3} = **0.0035**

Effective compression zone height factor; λ = **0.80**

Effective strength factor; η = **1.00**

Coefficient k_1; k_1 = **0.40**

Coefficient k_2; $k_2 = 1.0 \times (0.6 + 0.0014 / \varepsilon_{cu2})$ = **1.00**

Coefficient k_3; k_3 = **0.40**

Coefficient k_4; $k_4 = 1.0 \times (0.6 + 0.0014 / \varepsilon_{cu2})$ = **1.00**

Partial factor for concrete -Table 2.1N; γ_C = **1.50**

Compressive strength coefficient - cl.3.1.6(1); α_{cc} = **0.85**

Design compressive concrete strength - exp.3.15; $f_{cd} = \alpha_{cc} \times f_{ck} / \gamma_C$ = **15.9** N/mm^2

Compressive strength coefficient - cl.3.1.6(1); α_{ccw} = **1.00**

Design compressive concrete strength - exp.3.15; $f_{cwd} = \alpha_{ccw} \times f_{ck} / \gamma_C$ = **18.7** N/mm^2

Maximum aggregate size; h_{agg} = **20** mm

Reinforcement details

Characteristic yield strength of reinforcement; f_{yk} = **500** N/mm^2

Partial factor for reinforcing steel - Table 2.1N; γ_S = **1.15**

Design yield strength of reinforcement; f_{yd} = **435** N/mm^2

Nominal cover to wall front reinforcement; $c_{nom.front}$ = **50** mm

Nominal cover to wall rear reinforcement; $c_{nom.rear}$ = **50** mm

Nominal cover to footing top reinforcement; $c_{nom.foot.top}$ = **75** mm

Nominal cover to footing bottom reinforcement; $c_{nom.foot.bot}$ = **75** mm

Wall vertical reinforcement details

Reinforcement provided; 2 Layers of 10 mm ϕ bars at 200 mm c/c

Bar diameter; $\phi_{Stem.V}$ = **10** mm

Area of reinforcement provided; $A_{s.prov.Stem.V} = 2 \times \pi \times \phi_{Stem.V}^2 / (4 \times s_{Stem.V})$ = **785** mm^2/m

Maximum allowable spacing - cl.9.6.2(3); $s_{max.Stem.V} = \min(3 \times t_{stem}, 400mm)$ = **400** mm

PASS - Maximum allowable spacing exceeds reinforcement spacing

Min.area required per metre length - cl.9.6.2; $A_{s.min.Stem.V} = 0.002 \times t_{stem}$ = **600** mm^2/m

PASS - Reinforcement provided exceeds minimum reinforcement required

Wall horizontal reinforcement details

Reinforcement provided; 2 Layers of 10 mm ϕ bars at 200 mm c/c

Bar diameter; $\phi_{Stem.H}$ = **10** mm

Area of reinforcement provided; $A_{s.prov.Stem.H} = 2 \times \pi \times \phi_{Stem.H}^2 / (4 \times s_{Stem.H})$ = **785** mm^2/m

Maximum allowable spacing - cl.9.6.3; $s_{max.Stem.H} = \min(3 \times t_{stem}, 400mm)$ = **400** mm

PASS - Maximum allowable spacing exceeds reinforcement spacing

Min.area required per metre length - cl.9.6.3; $A_{s.min.Stem.H} = \max(0.25 \times A_{s.prov.Stem.V}, 0.001 \times t_{stem})$ = **300** mm^2/m

PASS - Reinforcement provided exceeds minimum reinforcement required

Footing main reinforcement details

Reinforcement provided; 10 mm ϕ bars at 100 mm c/c

Bar diameter; $\phi_{Foot.long}$ = **10** mm

Area of reinforcement provided; $A_{s.prov.Foot.long} = \pi \times \phi_{Foot.long}^2 / (4 \times s_{Foot.long})$ = **785** mm^2/m

Maximum allowable spacing - 9.3.1.1(3); $s_{max.Foot.long} = \min(3 \times h_{footing}, 400mm)$ = **400** mm

PASS - Maximum allowable spacing exceeds reinforcement spacing

Min.area required per metre length - exp.9.1N; $A_{s.min.Foot.long} = \max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times \max(d_{foot.top}, d_{foot.bot})$ = **316** mm^2/m

PASS - Reinforcement provided exceeds minimum reinforcement required

Footing distribution reinforcement details

Reinforcement provided; 10 mm ϕ bars at 200 mm c/c

Bar diameter; $\phi_{Foot.tran}$ = **10** mm

Area of reinforcement provided; $A_{s.prov.Foot.tran} = \pi \times \phi_{Foot.tran}^2 / (4 \times s_{Foot.tran})$ = **393** mm^2/m

Maximum allowable spacing - 9.3.1.1(3); $s_{max.Foot.tran} = \min(3.5 \times h_{footing}, 450mm)$ = **450** mm

PASS - Maximum allowable spacing exceeds reinforcement spacing

Min.area required per metre length - exp.9.1N; $A_{s.min.Foot.tran} = 0.2 \times A_{s.prov.Foot.long}$ = **157** mm^2/m

PASS - Reinforcement provided exceeds minimum reinforcement required

DA1 6.10 load combinations (ULSD)

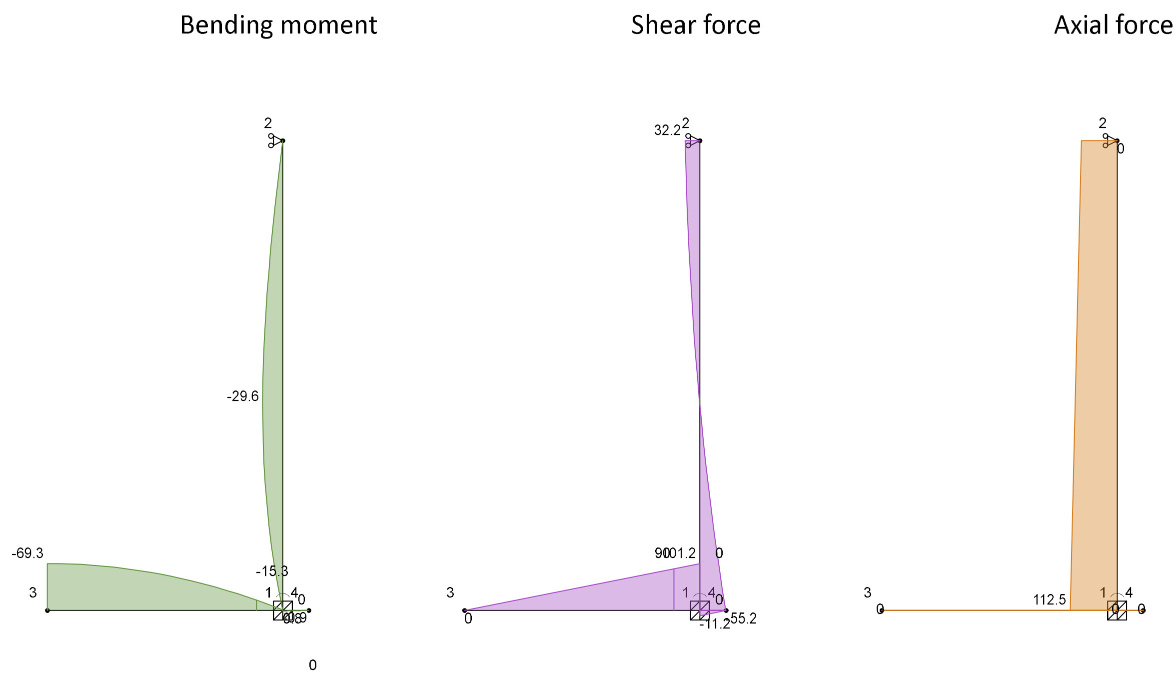
1.35G + 1.5Q + 1.5Qr (0.971)

1.00G + 1.5W (0.592)

1.35G + 1.5Q + 1.5Qr + $\psi_W \times$1.5W (0.971)

1.35G + 1.5Q + $\psi_W \times$1.5W + $\psi_S \times$1.5S (0.971)

Critical ULSD combination results: 1.35G + 1.5Q + 1.5Qr



Check pure axial capacity

Ultimate axial force; $N_{Ed.max}$ = **112.49** kN/m

Strain with uniform compression; $\varepsilon_0 = \varepsilon_{c3}$ = **0.00175**

Stress in reinforcement ; $\sigma_0 = \min(\varepsilon_0 \times E_s, f_{yd})$ = **350** N/mm^2

Pure axial design capacity; $N_{Rd0} = A_{s.prov.Stem.V} \times \sigma_0 + (t_{stem} - A_{s.prov.Stem.V}) \times f_{cd}$ = **5022.43** kN/m

$N_{Ed.max} / N_{Rd0}$ = **0.022**

PASS - Design axial capacity exceeds ultimate axial force

Slenderness limit - (cl.5.8.3.1)

Effective length factor (Fig. 5.7); f = **1**

Unsupported length; l_u = **2700** mm

Effective length; $l_0 = f \times l_u$ = **2700** mm

Radius of gyration; $i = t_{stem} / \sqrt{(12)}$ = **8.7** cm

Slenderness ratio (5.8.3.2(1)); $\lambda_{slender} = l_0 / i$ = **31.2**

Analysis moments combined with moments due to imperfections (cl. 5.2 & 6.1(4))

Smaller factored end moment; $M_{1.end}$ = **0.0** kNm/m

Larger factored end moment; $M_{2.end}$ = **0.0** kNm/m

Ecc. due to geometric imperfections; $e_i = l_0 / 400$ = **6.8** mm

Minimum end moment; $M_{01} = \min(\text{abs}(M_{1.end}), \text{abs}(M_{2.end})) + e_i \times N_{Ed.max}$ = **0.8** kNm/m

Maximum end moment; $M_{02} = \max(\text{abs}(M_{1.end}), \text{abs}(M_{2.end})) + e_i \times N_{Ed.max}$ = **0.8** kNm/m

Slenderness limit for buckling (cl. 5.8.3.1)

Area of concrete;	$A_c = t_{stem} - A_{s.prov.Stem.V}$ = **299215** mm^2/m
Factor A;	A = **0.7**
Mechanical reinforcement ratio;	$\omega = A_{s.prov.Stem.V} \times f_{yd} / (A_c \times f_{cd})$ = **0.072**
Factor B;	$B = \sqrt{(1 + 2 \times \omega)}$ = **1.070**
Moment ratio;	$r_m = M_{01} / M_{02}$ = **1.000**
Factor C;	$C = 1.7 - r_m$ = **0.700**
Relative normal force;	$n = N_{Ed.max} / (A_c \times f_{cd})$ = **0.024**
Slenderness limit;	$\lambda_{lim} = 20 \times A \times B \times C / \sqrt{(n)}$ = **68.1**
	$\lambda_{slender} / \lambda_{lim}$ = **0.458**

Actual slenderness ratio is less than limit, slenderness effects may be neglected

Wall design moment (negative)

Stem moment;	M_{stem} = **-29.6** kNm/m
Wall design moment (conservative);	$M_{Ed} = \min(M_{stem} - e_i \times N_{Ed.max}, -N_{Ed} \times \max(t_{stem} / 30, 20mm))$ = **-30.3** kNm/m

Check bending capacity when F is N_{Ed} at bottom of storey

Design axial force;	N_{Ed} = **112.5** kN/m
Design bending moment;	M_{Ed} = **-30.3** kNm/m; (front face in tension)
Position of neutral axis (by iteration)	z = **34.8** mm

Moment of resistance of concrete

Concrete compression force (3.1.7(3))	$F_c = \eta \times f_{cd} \times \min(\max(\lambda_{sb} \times z, 0mm), t_{stem})$ = **442.1** kN/m
Moment of resistance	$M_{Rdc} = F_c \times (t_{stem} / 2 - \min(\lambda_{sb} \times z, t_{stem}) / 2)$ = **60.2** kNm/m

Moment of resistance of reinforcement

Area of tension face reinforcement;	$A_s = A_{s.prov.Stem.V} / 2$ = **392.7** mm^2/m
Depth to tension face reinforcement;	$d_t = t_{stem} - c_{nom.front} - \phi_{Stem.H} - \phi_{Stem.V} / 2$ = **235** mm
Strain in tension face reinforcement;	$\varepsilon_s = \varepsilon_{cu3} \times (1 - d_t / z)$ = **-0.02011**
Stress in tension face reinforcement;	$\sigma = \max(\varepsilon_s \times E_s, - f_{yd})$ = **-434.78** N/mm^2
Force in tension face reinforcement;	$F_{st} = A_s \times \sigma$ = **-170.74** kN/m
Tension face reinf. moment of resistance;	$M_{Rdst} = F_{st} \times (t_{stem} / 2 - d_t)$ = **14.51** kNm/m
Area of compression face bars;	$A'_s = A_{s.prov.Stem.V} / 2$ = **392.7** mm^2/m
Depth to compression face reinforcement;	$d' = c_{nom.rear} + \phi_{Stem.V} / 2$ = **55** mm
Strain in compression face reinforcement;	$\varepsilon'_s = \varepsilon_{cu3} \times (1 - d' / z)$ = **-0.00203**
Stress in compression face reinforcement;	$\sigma' = \max(\varepsilon'_s \times E_s, - f_{yd})$ = **-405.37** N/mm^2
Force in compression face reinforcement;	$F_{sc} = A'_s \times \sigma'$ = **-159.19** kN/m
Comp. face reinf. moment of resistance;	$M_{Rdsc} = F_{sc} \times (t_{stem} / 2 - d')$ = **-15.12** kNm/m

Total resistance of section

Resultant concrete/steel force;	$F = F_c + F_{st} + F_{sc}$ = **112.18** kN/m

PASS - F is within half of one percent of N_{Ed}

Moment of resistance;	$M_{Rd} = M_{Rdc} + M_{Rdst} + M_{Rdsc}$ = **59.55** kNm/m
	$abs(M_{Ed}) / M_{Rd}$ = **0.509**

PASS - Design moment capacity exceeds ultimate bending moment

Check bending capacity when F is N_{Ed} at top of storey

Design axial force;	N_{Ed} = **85.1** kN/m
Design bending moment;	M_{Ed} = **-30.3** kNm/m; (front face in tension)
Position of neutral axis (by iteration)	z = **33.6** mm

Moment of resistance of concrete

Concrete compression force (3.1.7(3)) $F_c = \eta \times f_{cd} \times \min(\max(\lambda_{sb} \times z, 0mm), t_{stem})$ = **426.5** kN/m

Moment of resistance $M_{Rdc} = F_c \times (t_{stem} / 2 - \min(\lambda_{sb} \times z, t_{stem}) / 2)$ = **58.2** kNm/m

Moment of resistance of reinforcement

Area of tension face reinforcement; $A_s = A_{s.prov.Stem.V} / 2$ = **392.7** mm^2/m

Depth to tension face reinforcement; $d_t = t_{stem} - c_{nom.front} - \phi_{Stem.H} - \phi_{Stem.V} / 2$ = **235** mm

Strain in tension face reinforcement; $\varepsilon_s = \varepsilon_{cu3} \times (1 - d_t / z)$ = **-0.02098**

Stress in tension face reinforcement; $\sigma = \max(\varepsilon_s \times E_s, - f_{yd})$ = **-434.78** N/mm^2

Force in tension face reinforcement; $F_{st} = A_s \times \sigma$ = **-170.74** kN/m

Tension face reinf. moment of resistance; $M_{Rdst} = F_{st} \times (t_{stem} / 2 - d_t)$ = **14.51** kNm/m

Area of compression face bars; $A'_s = A_{s.prov.Stem.V} / 2$ = **392.7** mm^2/m

Depth to compression face reinforcement; $d' = c_{nom.rear} + \phi_{Stem.V} / 2$ = **55** mm

Strain in compression face reinforcement; $\varepsilon'_s = \varepsilon_{cu3} \times (1 - d' / z)$ = **-0.00223**

Stress in compression face reinforcement; $\sigma' = \max(\varepsilon'_s \times E_s, - f_{yd})$ = **-434.78** N/mm^2

Force in compression face reinforcement; $F_{sc} = A'_s \times \sigma'$ = **-170.74** kN/m

Comp. face reinf. moment of resistance; $M_{Rdsc} = F_{sc} \times (t_{stem} / 2 - d')$ = **-16.22** kNm/m

Total resistance of section

Resultant concrete/steel force; $F = F_c + F_{st} + F_{sc}$ = **85.01** kN/m

PASS - F is within half of one percent of N_{Ed}

Moment of resistance; $M_{Rd} = M_{Rdc} + M_{Rdst} + M_{Rdsc}$ = **56.53** kNm/m

$abs(M_{Ed}) / M_{Rd}$ = **0.536**

PASS - Design moment capacity exceeds ultimate bending moment

Check shear capacity of wall (cl.6.2.2)

Design shear force; V = **55.18** kN/m

Depth to tension steel; $d_v = t_{stem} - c_{nom.front} - \phi_{Stem.H} - \phi_{Stem.V} / 2$ = **235** mm

$C_{Rd,c} = 0.18 / \gamma_C$ = **0.120**

$k_v = \min(1 + \sqrt{(200mm / d_v)}, 2)$ = **1.923**

Longitudinal reinforcement ratio; $\rho_l = \min(A_{s.prov.Stem.V} / (2 \times d_v), 0.02)$ = **0.002**

$v_{min} = 0.035\ N/mm^2 \times k_v^{3/2} \times (f_{ck} / 1N/mm^2)^{0.5}$ = **0.494** N/mm^2

$k_{1.v}$ = **0.15**

Comp stress in concrete from axial loading; $\sigma_{cp} = N_{Ed.max} / (t_{stem} - A_{s.prov.Stem.V})$ = **0.376** N/mm^2

Design shear resistance (exp.6.2a & 6.2b); $V_{Rd.c} = (\max(C_{Rd,c} \times k_v \times (100\ N^2/mm^4 \times \rho_l \times f_{ck})^{1/3}, v_{min}) + k_{1.v} \times \sigma_{cp}) \times d_v$ = **129.3** kN/m

$V / V_{Rd.c}$ = **0.427**

PASS - Design concrete shear capacity exceeds ultimate shear force

Check footing in flexure - Section 6.1

Design bending mnt, 1200 mm from wall face; $M_{Ed.foot}$ = **-69.3** kNm/m

Depth to tension reinforcement; $d_{foot.top} = h_{footing} - c_{nom.foot.top} - \phi_{Foot.long} / 2$ = **220** mm

$K_{foot} = abs(M_{Ed.foot}) / (d_{foot.top}^2 \times f_{ck})$ = **0.051**

$K'_{foot} = (2 \times \eta \times \alpha_{cc} / \gamma_C) \times (1 - \lambda \times (\delta - k_1)/(2 \times k_2)) \times (\lambda \times (\delta - k_1) / (2 \times k_2))$ = **0.207**

K' > K - No compression reinforcement is required

Lever arm; $z_{foot} = \min(0.5 + 0.5 \times (1 - 2 \times K_{foot} / (\eta \times \alpha_{cc} / \gamma_C))^{0.5}, 0.95) \times d_{foot.top}$ = **209** mm

Depth of neutral axis; $x_{foot} = 2.5 \times (d_{foot.top} - z_{foot})$ = **28** mm

Area of tension reinforcement required; $A_{s.des} = abs(M_{Ed.foot}) / (f_{yd} \times z_{foot})$ = **762** mm^2/m

Minimum area of reinforcement - exp.9.1N; $A_{s.min} = max(0.26 \times f_{ctm} / f_{yk}, 0.0013) \times d_{foot.top}$ = **316** mm^2/m

Maximum area of reinforcement - cl.9.2.1.1(3); $A_{s.max} = 0.04 \times h_{footing}$ = **12000** mm^2/m

Area of tension reinforcement provided; $A_{s.prov.Foot.long}$ = **785** mm^2/m

$abs(A_{s.req}) / A_{s.prov.Foot.long}$ = **0.971**

PASS - Area of reinforcement provided is greater than area of reinforcement required

Check shear capacity of footing (cl.6.2.2)

Design shear force; V_{foot} = **89.99** kN/m

Depth to tension steel; $d_{v.foot} = d_{foot.top}$ = **220** mm

$C_{Rd,c} = 0.18 / \gamma_C$ = **0.120**

$k_{v.foot} = min(1 + \sqrt{(200mm / d_{v.foot})}, 2)$ = **1.953**

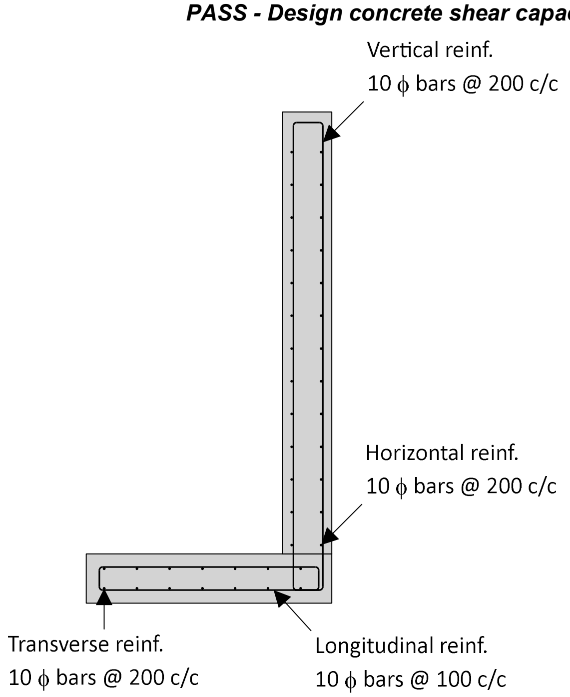
Main reinforcement ratio; $\rho_{l.foot} = min(A_{s.prov.Foot.long} / d_{v.foot}, 0.02)$ = **0.004**

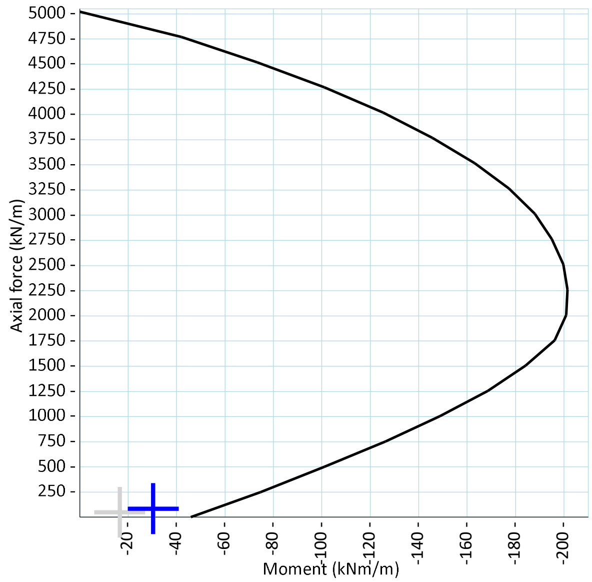
$v_{min.foot} = 0.035\ N/mm^2 \times k_{v.foot}^{3/2} \times (f_{ck} / 1N/mm^2)^{0.5}$ = **0.506** N/mm^2

Design shear resistance (exp.6.2a & 6.2b); $V_{Rd.c.foot} = max(C_{Rd,c} \times k_{v.foot} \times (100\ N^2/mm^4 \times \rho_{l.foot} \times f_{ck})^{1/3}, v_{min.foot}) \times d_{v.foot}$ = **111.2** kN/m

$V_{foot} / V_{Rd.c.foot}$ = **0.809**

PASS - Design concrete shear capacity exceeds ultimate shear force





Note: Crit. combination hightlighted: 1.35G + 1.5Q + 1.5Qr

N_{Ed} at top of storey

Interaction diagram - Negative moments

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WHITE & LLOYD

CONSULTING ENGINEERS

Job No.	Section	Sheet No.	Rev
Engineer		Checked	
Date		Rev. Date	

Project: 24 BURGESS HILL

Element: BASEMENT PROPS (TEMPORARY)

SURCHARGE = 10kN/m^2 SOIL DENSITY, ρ = 19kN/m^3

SOIL DEPTH = 2.7m k_a = 0.43 k_p = 2.33

FORCE OF SOIL = $0.43 \times 18 \times 2.7 \times \frac{2.7}{2}$ = 28.2 kN/m

SURCHARGE FORCE = $0.43 \times 10 \times 2.7$ = 11.6 kN/m

FROM TEDDS ANALYSIS : MAX. MOMENT ON WALING BEAM = 44.5 kNm
MAX. SHEAR ON WALING BEAM = 90.8 kN

ALLOWABLE BM FOR MABEY 160 PROP = 60kNm ∴ OK
ALLOWABLE SF FOR MABEY 160 PROP = 120kN ∴ OK

REACTION FROM WALING BEAM THROUGH HORIZONTAL PROP = 182 kN

ASSUME THE SAME FOR BOTH SIDES ∴ TOTAL LOAD THROUGH PROP = 364 kN

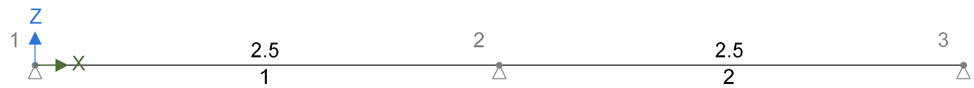
PROP LENGTH = 8.0m ∴ USE 2No. MABEY MASS 50

ANALYSIS

Tedds calculation version 1.0.37

Geometry

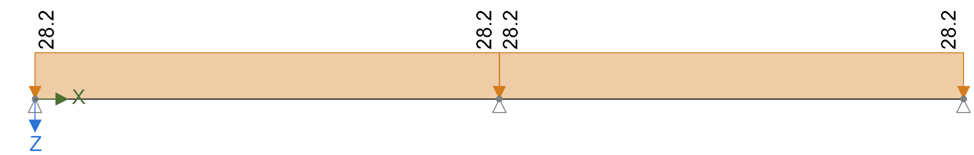
Geometry (m) - Steel (BS5950) - UB 203x133x30



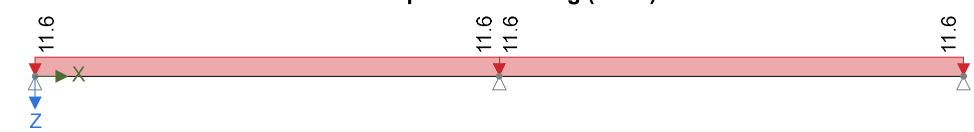
Loading

Self weight included

Permanent - Loading (kN/m)



Imposed - Loading (kN/m)



Results

Reactions

Load case: Self Weight

Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
1	0	0.3	0
2	0	0.9	0
3	0	0.3	0

Load case: Permanent

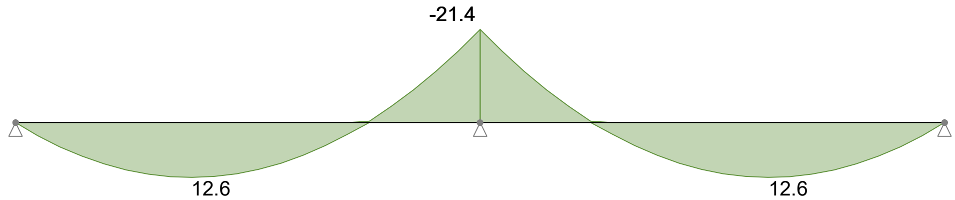
Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
1	0	26.7	0
2	0	87.7	0
3	0	26.7	0

Load case: Imposed

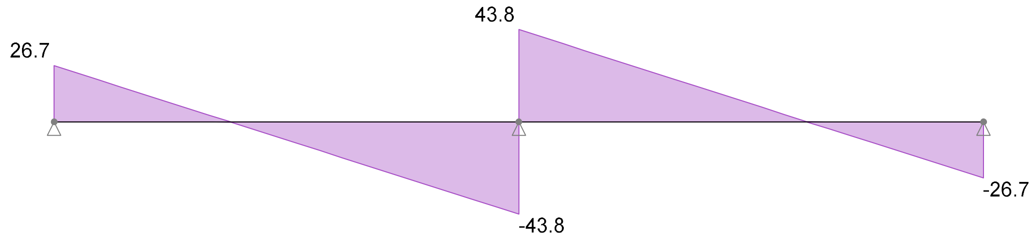
Node	Force		Moment
	Fx (kN)	Fz (kN)	My (kNm)
1	0	11	0
2	0	36.1	0
3	0	11	0

Forces

All load cases - Moment envelope (kNm)



All load cases - Shear envelope (kN)



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