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Project:	TODDINGTON LANE, LITTLEHAMPTON, WEST SUSSEX				
Title:	RETAINING WALL - COVER PAGE				

STRUCTURAL CALCULATIONS

RETAINING WALL

TODDINGTON LANE

LITTLEHAMPTON

WEST SUSSEX

PERSIMMON HOMES THAMES VALLEY

DESIGN CODES
Basis of design to BS EN 1990
Actions (Loading) to BS EN 1991
Concrete design to BS EN 1992-1-1
Steelwork design to BS EN 1993-1-1
Timber design to BS EN 1995-1-1
Masonry design to BS EN 1996-1-1
Foundation design to BS EN 1997-1 (With checks for ABP adjusted for overburden)

KEY REFERENCES

1. Manual for the design of building structures to Eurocode 1 & basis of structural design - IStructE
2. Manual for the design of concrete building structures to Eurocode 2 - IStructE
3. Concise Eurocode 2 - The Concrete Centre
4. Manual for the design of steelwork building structures to Eurocode 3 - IStructE
5. Stability of steel beams and columns (P360) - Steel Construction Institute
6. Design of steel beams in torsion (P385) - Steel Construction Institute
7. Manual for the design of timber building structures to Eurocode 5 - IStructE/TRADA
8. Manual for the design of plain masonry in building structures to Eurocode 6 - IStructE
9. Eurocode for masonry EN 1996-1-1 and EN 1996-2 - IMS
10. Concise Eurocodes: Geotechnical design BS EN 1997-1 - BSI

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2. RETAINING WALL 1.5m - 2.0m 4

3. KING POST DESIGN 9

4. SHELF ANGLE DESIGN 12

5. RETAINING WALL 1.0m - 1.5m 16

6. RETAINING WALL 0.5m - 1.0m 21

7. APPENDIX A A1

8. APPENDIX B B1

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Title:	**WIND LOAD ASSESSMENT**				

Wind direction from North = 354 degrees

Wall height z = 1.800 m (Must be =< 50 m)

Fundamental basic wind velocity $v_{b,o}$ = 22.00 m/s

Altitude Factor, c_{alt} :

Height of site above sea-level A = 7.50 m

c_{alt} = 1+0.001A if z =< 10 m

c_{alt} = 1+0.001A(10/z)$^{1/5}$ if z > 10 m

Basic wind velocity, v_b

$v_b = c_{dir}\, c_{seaon} c_{prob} c_{alt}\, v_{b,o}$

c_{dir} = 0.788

c_{season} = 1

c_{prob} = 1

c_{alt} = 1 + 0.001 x 7.50 = 1.008

v_b = 1.000 x 0.788 x 1.000 x 1.008 x 22.00 = 17.47 m/s

Basic velocity wind pressure q_b

$q_b = 0.613 v_b^2$ = 0.613 x 17.47 x 17.47 = 187.09 N/m^2

Exposure factor $c_e(z)$:

Site is in town

Distance from sea = 100.000 km

From Fig 6.5 EC1 Manual:

$c_e(z)$ = 1.408

Exposure correction factor $c_{e,T}(z)$ for town terrain:

Distance into town = 0.50 km

From Fig 6.6 EC1 Manual:

$c_{e,T}(z)$ = 0.742

Orography factor $c_o(z)$:

Orography not significant

$c_o(z)$ = 1.000

Peak velocity pressure:

$q_p(z) = c_e(z) \times c_{e,T}(z) \times [(c_o(z)+0.6)/1.6]^2 \times q_b$ = 1.408 x 0.742 x [(1.000 + 0.6) / 1.6]^2 x 187.09 =

= 195.46 N/m^2

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Title:	MASONRY RW 'AT BOUNDARY' - (2 m RETAINED HEIGHT, 6.38 m OVERALL HEIGHT)				

RETAINING WALL 'AT BOUNDARY'

RETAINED HEIGHT = 2.000 m

PILE DIAMETER = 400 mm

NOMINAL PILE EMBEDMENT = 3.650 m

20% EXTRA EMBEDMENT BEYOND PIVOT = 0.730 m

TOTAL PILE EMBEDMENT = 4.380 m

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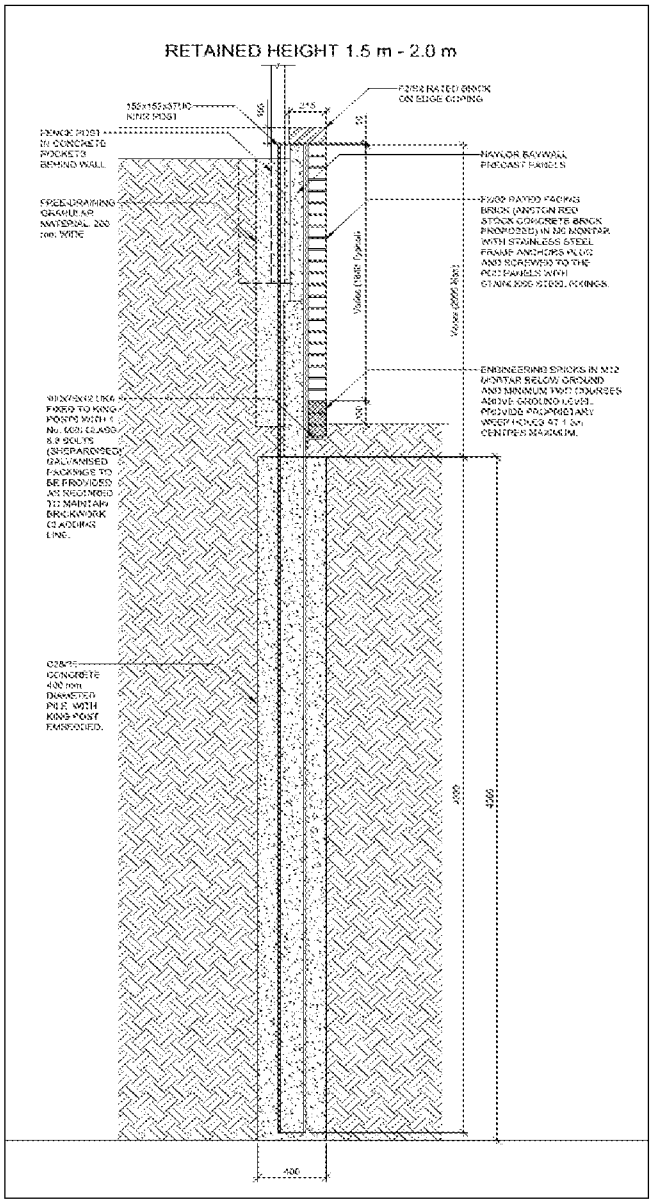
Title:	**MASONRY RW AT BOUNDARY - (2 m RETAINED HEIGHT, 6.38 m OVERALL HEIGHT)**		

RETAINING WALL: AT BOUNDARY - 2000 mm max. retained height [Toe at 6380 mm BGL]



Dimensions

Retained height:	h_r =	2,000	mm
Pile diameter:	D_p =	400.0	mm
Exposed pile:	h_{pex} =	287.5	mm
Buried pile:	h_{pbr} =	3,362.5	mm
Pile embedment:	z_p =	3,650.0	mm
Depth 1.5 x D_p:	z_0 =	600.0	mm
Resisting depth	h_{ppr} =	2,762.5	mm
WT bgl (ret side):	d_{w1} =	2,000	mm
WT bgl (red side):	d_{w2} =	0	mm
Unplanned excavation =		500	mm
O/A height of RW:	h =	6,380	mm
Overburden:	$h_{overburden}$ =	0.0	mm
Head on ret side:	$h_{h,ret}$ =	4,380.0	mm
Head on red side:	$h_{h,red}$ =	4,380.0	mm

Self weights

Soil bulk density = 20 kN/m^3
Soil saturated density = 21 kN/m^3

Wind loads on fence

Wind zone = C
c_{pnet} = 1.7
$q_p(z)$ = 0.195 kN/m^2
Wind load = $c_{pnet}q_p(z)$ = 0.332 kN/m^2
Boundary fence height = 1.8 m

Overburden and surcharge

Depth of overburden = 0.000 m
Applied surcharge = 2.50 kN/m^2
Total surcharge pressure q = 2.50 + 0.000 x 21.0 = 2.50 kN/m^2

Soil effective stress shear strength parameters

	Characteristic	DA1-C1	DA1-C2
Angle of shear resistance ϕ' =	27 °	27 °	22.18 °
Effective cohesion c' =	0 kN/m^2	0 kN/m^2	0 kN/m^2

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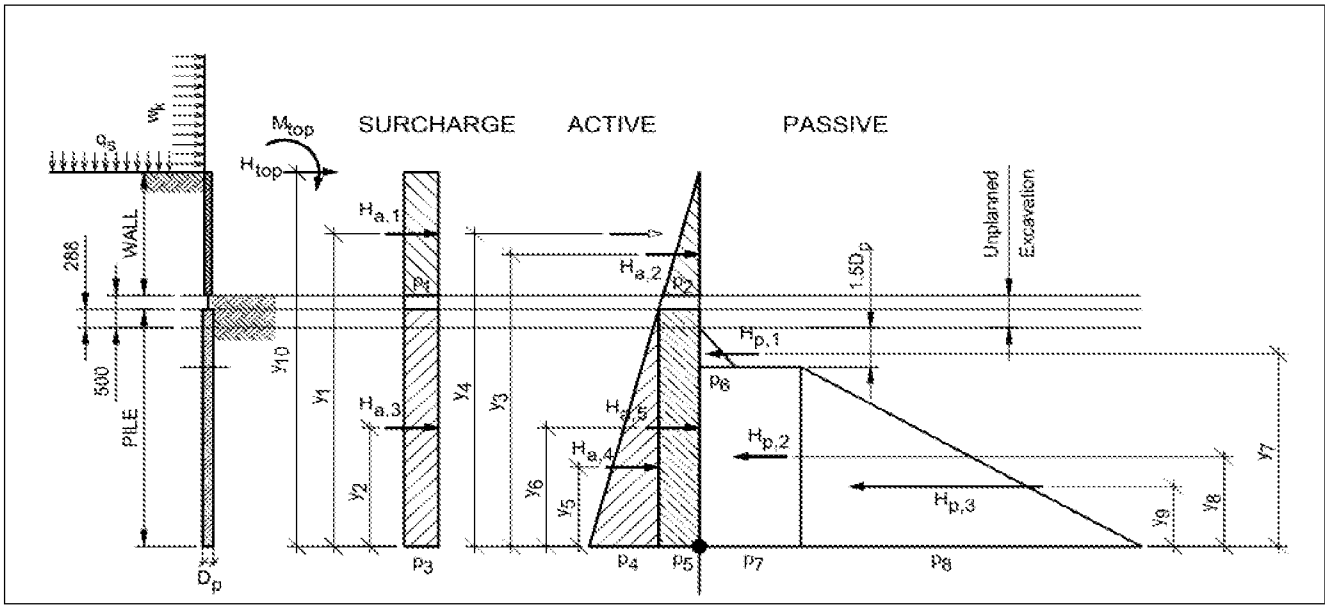
Title:	**MASONRY RW AT BOUNDARY - (2 m RETAINED HEIGHT, 6.38 m OVERALL HEIGHT)**				



$y_{wall,surchg}$ =	4650 mm (y_1)	$y_{pile,surchg}$ =	1825 mm (y_2)
$y_{a,wall,bulk,tri}$ =	4317 mm (y_3)	$y_{pile,bulk,tri}$ =	1217 mm (y_5)
$y_{a,wall,bulk,uni}$ =	4650 mm (y_4)	$y_{pile,bulk,uni}$ =	1825 mm (y_6)
$y_{p,pbr,1}$ =	2962.5 mm (y_7)		
$y_{p,pbr,2,uni}$ =	1381 mm (y_8)		
$y_{p,pbr,2,tri}$ =	920.8 mm (y_9)		
y_{top} =	5650 mm (y_{10})		
$y_{pb,hyd}$ =	1460 mm (y_{11})		

Rankine Theory	DA1-C1	DA1-C2
Coefficient of active pressure K_A =	0.324	0.384
Coefficient of passive pressure K_P =	3.847	3.060

FORCES	H_{top} =	0.33 x 1.800 =	0.60 kN/m length of retaining wall
	M_{top} =	0.5 x 1.8 x 0.6 =	0.54 kNm/m length of retaining wall

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ACTIVE SIDE PRESSURES (kN/m^2)	DA-1 C1	DA-1 C2
Lateral pressure due to surcharge $p_s = K_A q =$	0.81	0.96
Lateral earth pressure at water table $p_{bul} = K_A \gamma_{bulk}(h-h_{h,ret}) =$	12.96	15.37
Tri lateral earth pressure for wall base $p_{wall,bul,tri} = K_A \gamma_{bulk} \min(h_s, h-h_{h,ret}) =$	12.96	15.37
Uni lateral earth pressure for wall base $p_{wall,bul,uni} =$	0.00	0.00
Uniform lateral earth pressure for pile $p_{pile,eff,uni} =$	6.60	7.83
Tri lateral earth pressure for exposed pile $p_{pex,eff,tri} = K_A \gamma_{bulk} z_p =$	12.05	14.29

PASSIVE SIDE PRESSURES (kN/m^2)			
Tri lateral earth pressure for pile Zone 1 $p_{pp1,eff,tri} = K_P \gamma' z_0 =$		23.52	18.71
Uni lateral earth pressure for pile Zone 2 $p_{pp2,eff,uni} =$	$K_P^2 \gamma' z_0 =$	90.48	71.97
Tri lateral earth pressure for pile Zone 2 at base $p_{ppb,eff,tri} =$	$K_P^2 \gamma'(z_p - z_0) =$	326.12	259.38

ACTIVE FORCES			DA-1 C1	DA-1 C2
TOP:	$H_{top} =$		0.60 kN/m	0.60 kN/m
	$M_{top} =$		0.54 kN/m	0.54 kN/m
WALL:	$H_{a,wall,sur} =$	0.81 x 2.000 =	1.62 kN/m	1.92 kN/m
	$H_{a,wall,bulk,tri} =$	0.5 x 12.96 x 2.000 =	12.96 kN/m	15.37 kN/m
PILE:	$H_{pile,sur} =$	0.81 x 3.650 =	2.96 kN/m	3.51 kN/m
	$H_{a,pile,bulk,tri} =$	0.5 x 12.05 x 3.650 =	21.99 kN/m	26.08 kN/m
	$H_{a,pile,bulk,uni} =$	6.60 x 3.650 =	24.10 kN/m	28.58 kN/m
PASSIVE FORCES				
	$H_{p,wall,eff,tri,1} =$	0.5 x 23.52 x 0.600 =	7.06 kN/m	5.61 kN/m
	$H_{p,wall,eff,uni,2} =$	90.48 x 2.763 =	249.96 kN/m	198.80 kN/m
	$H_{p,wall,eff,tri,2} =$	0.5 x 326.12 x 2.763 =	450.45 kN/m	358.26 kN/m

CHECK FOR OVERTURNING

DESIGN APPROACH 1 COMBINATION 2 (DA-1 C2)

Overturning moments:

COMPONENT	FORCE	LEVER	MOMENT
$M_{top} =$	-	-	1.346
$H_{top} =$	1.50	5.650	8.448
$H_{a,wall,sur} =$	4.80	4.650	22.334
$H_{a,wall,bulk,tri} =$	38.42	4.317	165.87
$H_{pile,sur} =$	1.40	1.825	2.560
$H_{a,pile,bulk,tri} =$	10.43	1.217	12.693
$H_{a,pile,bulk,uni} =$	11.43	1.825	20.866
	67.99		234.11

Restoring moments:

COMPONENT	FORCE	LEVER	MOMENT
$H_{p,wall,eff,tri,1} =$	2.24	2.963	6.650
$H_{p,wall,eff,uni,2} =$	79.52	1.381	109.84
$H_{p,wall,eff,tri,2} =$	143.30	0.921	131.96
	225.07		248.45

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Title:	**MASONRY RW AT BOUNDARY - (2 m RETAINED HEIGHT, 6.38 m OVERALL HEIGHT)**		

Design overturning moment about bottom of toe M_d :

Due to G_k = 199.42 kNm

Due to $Q_{k,1}$ = 24.894 kNm (Surcharge) Due to $Q_{k,3}$ = 0.000 kNm (Inner leaf direct)

Due to $Q_{k,2}$ = 9.794 kNm (Wind load on fence)

M_{Ed} = 1.0x199.425+ 1.3x24.894+0.7x1.3x(0.000+9.794) = 240.7 kNm/m

Design restoring moment about bottom of toe M_d :

Due to G_k = 248.45 kNm Due to $Q_{k,1}$ = 0.000 kNm (Surcharge)

M_{Rd} = 1.0 x 248.450 + 0.7 x 1.3 x 0.000 = 248.45 kNm/m

DESIGN APPROACH 1 COMBINATION 1 (DA-1 C1)

Overturning moments:

COMPONENT	FORCE	LEVER	MOMENT
M_{top} =	-	-	0.538
H_{top} =	0.60	5.650	3.379
$H_{a,wall,sur}$ =	4.05	4.650	18.834
$H_{a,wall,bulk,tri}$ =	32.40	4.317	139.87
$H_{pile,sur}$ =	1.18	1.825	2.158
$H_{a,pile,bulk,tri}$ =	8.80	1.217	10.704
$H_{a,pile,bulk,uni}$ =	9.64	1.825	17.595
	56.67		193.08

Restoring moments:

COMPONENT	FORCE	LEVER	MOMENT
$H_{p,wall,eff,tri,1}$ =	2.82	2.963	8.362
$H_{p,wall,eff,uni,2}$ =	99.99	1.381	138.10
$H_{p,wall,eff,tri,2}$ =	180.18	0.921	165.92
	282.99		312.38

Design overturning moment about bottom of toe M_d :

Due to G_k = 168.17 kNm

Due to $Q_{k,1}$ = 20.992 kNm (Surcharge) Due to $Q_{k,3}$ = 0.000 kNm (Inner leaf direct)

Due to $Q_{k,2}$ = 3.918 kNm (Wind load on fence)

M_{Ed} = 1.35x168.169+ 1.5x20.992+0.7x1.5x(0.000+3.918) = 262.6 kNm/m

Design restoring moment about bottom of toe M_d :

Due to G_k = 312.38 kNm Due to $Q_{k,1}$ = 0.000 kNm (Surcharge)

M_{Rd} = 1.0 x 312.384 + 0.7 x 1.5 x 0.000 = 312.38 kNm/m

Pile embedment of 3.650 m is adequate for overturning for both DA-1 C1 and DA-1 C2.

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STEEL BEAM KP7

STEEL BEAM LOADINGS

Moments at stem base

COMPONENT	FORCE (kN/m^2)	LEVER (m)	MOMENT (kNm/m)	γ_f	FACTORED EFFECTS MOMENT (kNm/m)	FACTORED EFFECTS SHEAR (kN/m)
M_{top} =			0.538	0.75	0.404	
H_{top} =	0.60	2.213	1.323	0.75	0.992	0.449
$H_{a,wall,bulk,tri}$ =	12.96	0.879	11.395	1.35	15.383	17.497
$H_{a,wall,bulk,uni}$ =	0.00	1.213	0.000	1.35	0.000	0.000
$H_{s,sat}$ =	0.00	0.667	0.000	1.35	0.000	0.000
$H_{a,wall,sur}$ =	1.62	1.213	1.964	1.05	2.063	1.701
	15.18		15.221		18.842	19.647

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Title:	**STEEL COLUMN DESIGN**		

BEAM: KP7

Wall Tributary Span = 2.500 m

LHS Support: Free

Selfweight = 0.36 kN/m

RHS Support: Pile

LOADING

ULS: γ_G = 1.35 γ_Q = 1.5

SLS: γ_G = 1.0 γ_Q = 1.0

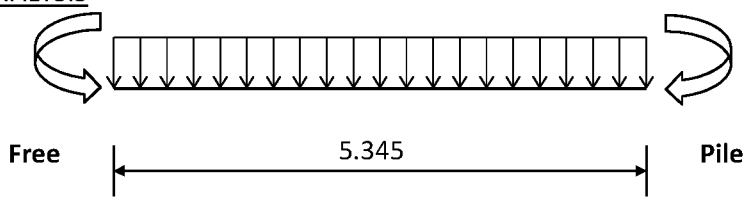
Uniformly distributed actions = 0.5 x tributary-span x patch-loading + directly applied load [+ self weight]

Beam Segment	Spans (m)		Patch loading (kN/m^2)		Uniformly distributed actions (kN/m)			
	Length	Tributary	$g_{k,patch}$	$q_{k,patch}$	g_k	q_k	SLS	ULS
w1	2.000	0.000	0.82	0.85	0.36	0.00		
	Actions	applied	directly	on beam ->	0.00	0.00	0.36	0.49

Concentrated actions

Action No.	Description	Offset (m) from LHS	Concentrated actions (kN)			
			G_k	Q_k	SLS	ULS

ANALYSIS



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Title:	**STEEL COLUMN DESIGN**		

M_1 = 47.105 kNm Type = Hogging Dorminant in-span loading = udl

M_1 = 1.009 kNm Type = Hogging

Maximum span free moment = 0.383 kNm

μ = Maximum span free moment / M = -0.008

ψ = 1 x 1.01 / 47.10 = 0.021

From charts C_1 = 1.687

DESIGN FOR BENDING Steel Grade = S275

Maximum bending moment at ULS M_{Ed} = **47.10** kNm

Section: **152 x 152 x 37 UC**

From LTBeam analysis: M_{cr} = 112.636 kNm $W_y f_y$ = 84.975 kNm

$\bar{\lambda}_{LT} = \sqrt{\frac{W_y f_y}{M_{cr}}} =$ 0.869 α_{LT} = 0.34 $\phi_{LT} = 0.5\left[1 + \alpha_{LT}(\bar{\lambda}_{LT} - 0.4) + 0.75\bar{\lambda}_{LT}^{\,2}\right] =$ 0.863

$\chi_{LT} = \frac{1}{\phi_{LT} + \sqrt{\phi_{LT}^{\,2} - 0.75\bar{\lambda}_{LT}^{\,2}}} =$ 0.778 γ_{M1} = 1.0

Moment of resistance $M_{b,Rd} = \chi_{LT}(W_y f_y)/\gamma_{M1} =$ 0.778 x 84.975 / 1.0 = **66.144** kNm OK.

DESIGN FOR SHEAR

Maximum shear force at ULS V_{Ed} = **19.65** kN

Shear resistance $V_{pl,y,Rd} = A_{v,y}(f_{yw}/\sqrt{3})/\gamma_{M0} =$ 14.256 x (275/ 1.732) / 1.0 = **226.344** kN

Normalised shear force = $V_{Ed}/V_{pl,y,Rd}$ = 19.647 / 226.344 = 0.087 < 0.5 OK.

CHECK FOR DEFLECTION

From computer analysis δ_{max} = **6.6** mm

Permissible deflection = 2000 / 180 = **11.1** mm OK.

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Title:	**STEEL ANGLE SHELF DESIGN**		

STEEL ANGLE SHELF

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Title:	**PLOT 3 UNRESTRAINED STEEL BEAM DESIGN TO BS EN 1993-1-1**				

BEAM: SHELF

Span = 2.500 m
LHS Support: KP7

Selfweight = 0.15 kN/m
RHS Support: KP8

LOADING

ULS: γ_G = 1.35 γ_Q = 1.5
SLS: γ_G = 1.0 γ_Q = 1.0

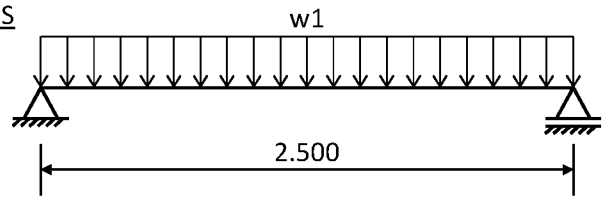
Uniformly distributed actions = 0.5 x tributary-span x patch-loading + directly applied load [+ self weight]

Beam Segment	Spans (m)		Patch loading (kN/m^2)		Uniformly distributed actions (kN/m)			
	Length	Tributary	$g_{k,patch}$	$q_{k,patch}$	g_k	q_k	SLS	ULS
w1	2.500	0.000	2.20	0.60	0.15	0.00		
	Actions	applied	directly	on beam ->	3.88	0.60	4.63	6.34

Concentrated actions

Action No.	Description	Offset (m) from LHS	Concentrated actions (kN) G_k	Q_k	SLS	ULS

ANALYSIS



SUPPORT REACTIONS

	KP7	KP8
G_k (kN)	5.04	5.04
Q_k (kN)	0.75	0.75
SLS (kN)	5.79	5.79
ULS (kN)	**7.93**	**7.93**

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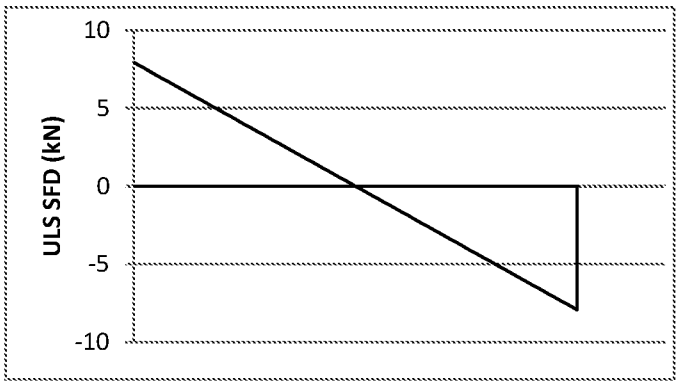
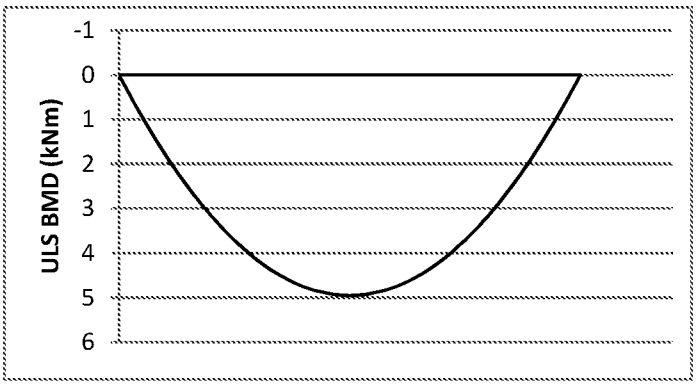
Title:	**PLOT 3 UNRESTRAINED STEEL BEAM DESIGN TO BS EN 1993-1-1**		





DESIGN FOR BENDING Steel Grade = S275

Maximum bending moment at ULS: $M_{y,Ed}$ = **0.00** kNm $M_{z,Ed}$ = **4.95** kNm

Section: **100 x 75 x 12 UKA**

Properties: f_y = 275 N/mm^2 Minor principal axis radius of gyration i_v = 1.59 cm

$W_{pl,v}$ = 26.33 cm^3 $W_{el,u,min}$ = 33.4 cm^3 α = 28.37 °

I_y = 189.0 cm^4 I_z = 90.2 cm^4 I_u = 230.0 cm^4 I_v = 49.5 cm^4

Length of beam: L = 2.500 m k = 1.2 $\lambda_v = kL/i_v$ = 1.2 x 2,500.00 / 15.90 = 188.68

ϕ_a = 2.1 ψ_a = 3.46 $v_a = \dfrac{1}{\sqrt{\left(\sqrt{\left(1+\left(\frac{4.5\psi_a}{\lambda_v}\right)^2\right)}+\frac{4.5\psi_a}{\lambda_v}\right)}}$ = 0.96

$\bar{\lambda}_{LT} = 0.72 v_a \sqrt{\frac{f_y}{E}\phi_a \lambda_v}$ = 0.498 α_{LT} = 0.76 $\phi_{LT} = 0.5\left[1+\alpha_{LT}(\bar{\lambda}_{LT}-0.4)+0.75\bar{\lambda}_{LT}^2\right]$ = 0.630

$\chi_{LT} = \dfrac{1}{\phi_{LT}+\sqrt{\phi_{LT}^2-0.75\bar{\lambda}_{LT}^2}}$ = 0.918 γ_{M0} = 1.0 γ_{M1} = 1.0

$W_{pl,v} f_y / \gamma_{M0}$ = 26.33 x 275 / (1 x 1000) = 7.240 kNm

$\chi_{LT} W_{el,u,min} f_y / \gamma_{M1}$ = 0.918 x 33.39 x 275 / (1 x 1000) = 8.428 kNm

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$M_{v,Ed} = -M_{y,Ed} sin \propto + M_{z,Ed} cos \propto =$ 0.000 x sin 28.4 + 4.954 x cos 28.4 = 4.359 kNm

$M_{u,Ed} = M_{y,Ed} cos \propto + M_{z,Ed} sin \propto =$ 0.000 x cos 28.4 + 4.954 x sin 28.4 = 2.354 kNm

$\frac{M_{v,Ed}}{W_{pl,,v} f_y / \gamma_{M0}} + \frac{M_{u,Ed}}{\chi_{LT} W_{El,,u,min} f_y / \gamma_{M1}} =$ 4.359 / 7.240 + 2.354 / 8.428 = 0.881 OK.

DESIGN FOR SHEAR

Maximum shear force at ULS V_{Ed} = **7.93** kN

Shear resistance $V_{pl,y,Rd} = A_{v,y} (f_{yw}/\sqrt{3})/\gamma_{M0} =$ 9 x (275/ 1.732) / 1.0 = **142.894** kN

Normalised shear force = $V_{Ed}/V_{pl,y,Rd}$ = 7.926 / 142.894 = 0.055 < 0.5 OK.

CHECK FOR DEFLECTION

By moment area method δ_{max} = **12.3** mm

Permissible deflection = 2500 / 180 = **13.9** mm OK.

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Title:	MASONRY RW 'AT BOUNDARY' - (1.5 m RETAINED HEIGHT, 4.98 m OVERALL HEIGHT)				

RETAINING WALL 'AT BOUNDARY'

RETAINED HEIGHT = 1.500 m

PILE DIAMETER = 400 mm

NOMINAL PILE EMBEDMENT = 2.900 m

20% EXTRA EMBEDMENT BEYOND PIVOT = 0.580 m

TOTAL PILE EMBEDMENT = 3.480 m

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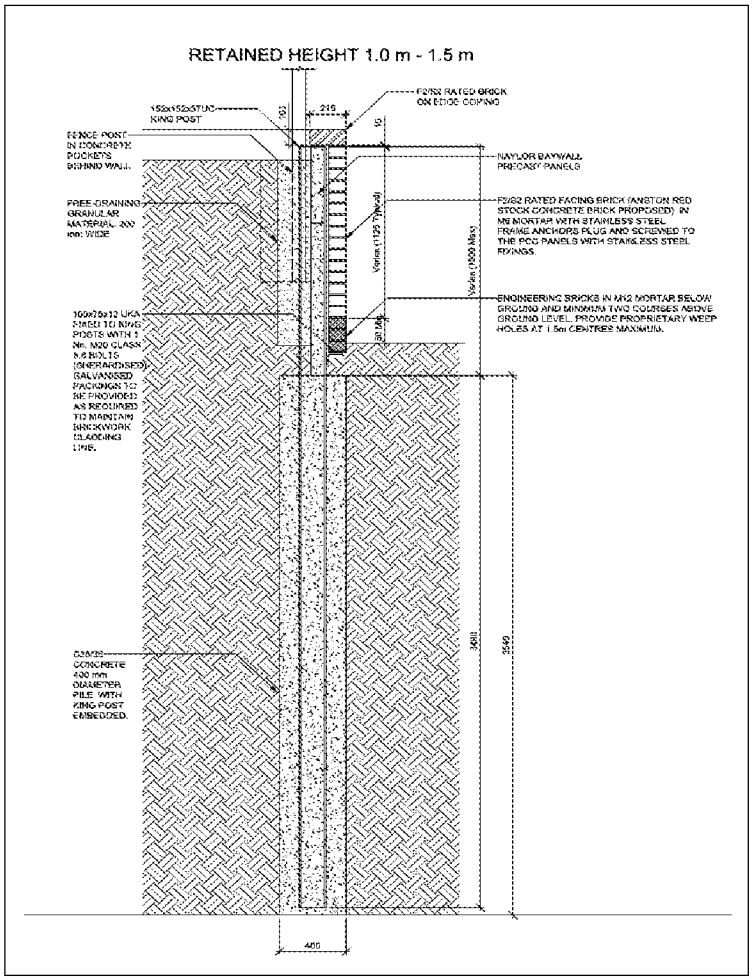
Title:	**MASONRY RW AT BOUNDARY - (1.5 m RETAINED HEIGHT, 4.98 m OVERALL HEIGHT)**		

RETAINING WALL: AT BOUNDARY - 1500 mm max. retained height [Toe at 4980 mm BGL]



Dimensions

Retained height:	h_r =	1,500	mm
Pile diameter:	D_p =	400.0	mm
Exposed pile:	h_{pex} =	287.5	mm
Buried pile:	h_{pbr} =	2,612.5	mm
Pile embedment:	z_p =	2,900.0	mm
Depth 1.5 x D_p:	z_0 =	600.0	mm
Resisting depth	h_{ppr} =	2,012.5	mm
WT bgl (ret side):	d_{w1} =	1,500	mm
WT bgl (red side):	d_{w2} =	0	mm
Unplanned excavation =		500	mm
O/A height of RW:	h =	4,980	mm
Overburden:	$h_{overburden}$ =	0.0	mm
Head on ret side:	$h_{h,ret}$ =	3,480.0	mm
Head on red side:	$h_{h,red}$ =	3,480.0	mm

Self weights

Soil bulk density = 20 kN/m^3

Soil saturated density = 21 kN/m^3

Wind loads on fence

Wind zone = C

c_{pnet} = 1.7

$q_p(z)$ = 0 kN/m^2

Wind load = $c_{pnet}q_p(z)$ = 0.332 kN/m^2

Boundary fence height = 1.8 m

Overburden and surcharge

Depth of overburden = 0.000 m

Applied surcharge = 2.50 kN/m^2

Total surcharge pressure q = 2.50 + 0.000 x 21.0 = 2.50 kN/m^2

Soil effective stress shear strength parameters

	Characteristic	DA1-C1	DA1-C2
Angle of shear resistance ϕ' =	27 °	27 °	22.18 °
Effective cohesion c' =	0 kN/m^2	0 kN/m^2	0 kN/m^2

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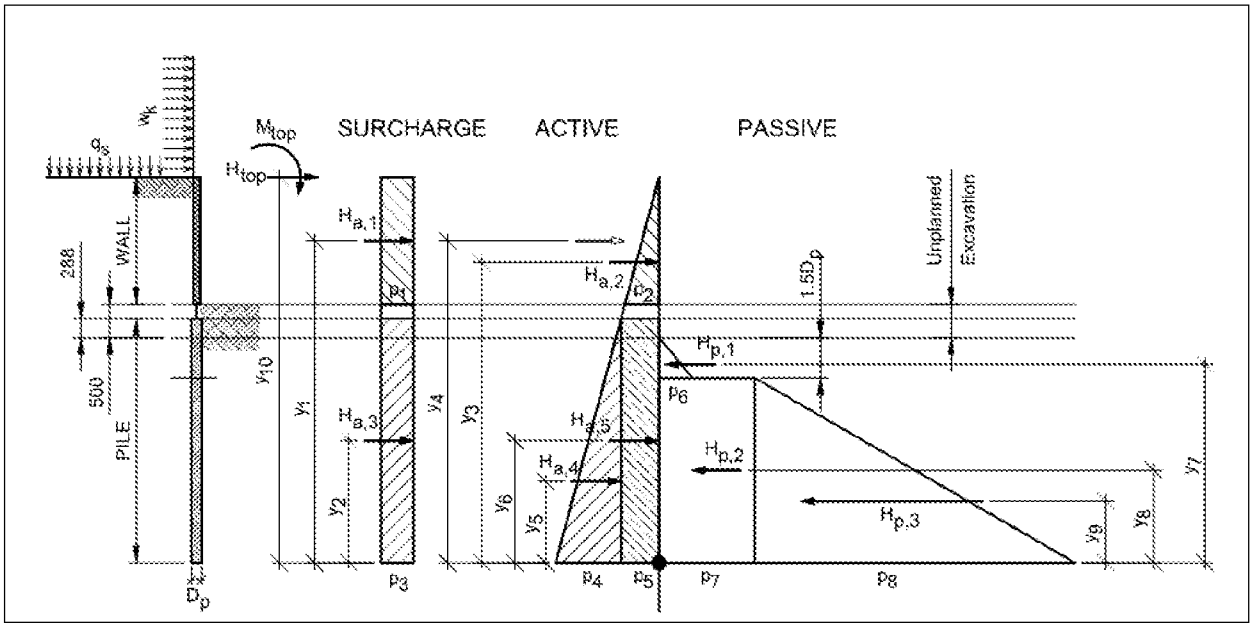

$y_{wall,surchg}$ =	3650	mm (y_1)	$y_{pile,surchg}$ =	1450	mm (y_2)
$y_{a,wall,bulk,tri}$ =	3400	mm (y_3)	$y_{pile,bulk,tri}$ =	966.7	mm (y_5)
$y_{a,wall,bulk,uni}$ =	3650	mm (y_4)	$y_{pile,bulk,uni}$ =	1450	mm (y_6)
$y_{p,pbr,1}$ =	2212.5	mm (y_7)			
$y_{p,pbr,2,uni}$ =	1006	mm (y_8)			
$y_{p,pbr,2,tri}$ =	670.8	mm (y_9)			
y_{top} =	4400	mm (y_{10})			
$y_{pb,hyd}$ =	1160	mm (y_{11})			

Rankine Theory	DA1-C1	DA1-C2
Coefficient of active pressure K_A =	0.324	0.384
Coefficient of passive pressure K_P =	3.847	3.060

FORCES	H_{top} =	0.33 x 1.800 =	0.60	kN/m length of retaining wall
	M_{top} =	0.5 x 1.8 x 0.6 =	0.54	kNm/m length of retaining wall

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Title:	**MASONRY RW AT BOUNDARY - (1.5 m RETAINED HEIGHT, 4.98 m OVERALL HEIGHT)**				

ACTIVE SIDE PRESSURES (kN/m^2)	DA-1 C1	DA-1 C2
Lateral pressure due to surcharge $p_s = K_A q =$	0.81	0.96
Lateral earth pressure at water table $p_{bul} = K_A \gamma_{bulk}(h-h_{h,ret}) =$	9.72	11.53
Tri lateral earth pressure for wall base $p_{wall,bul,tri} = K_A \gamma_{bulk} \min(h_s, h-h_{h,ret}) =$	9.72	11.53
Uni lateral earth pressure for wall base $p_{wall,bul,uni} =$	0.00	0.00
Uniform lateral earth pressure for pile $p_{pile,eff,uni} =$	4.95	5.87
Tri lateral earth pressure for exposed pile $p_{pex,eff,tri} = K_A \gamma_{bulk} z_p =$	9.58	11.35

PASSIVE SIDE PRESSURES (kN/m^2)			
Tri lateral earth pressure for pile Zone 1 $p_{pp1,eff,tri} = K_P \gamma' z_0 =$		23.52	18.71
Uni lateral earth pressure for pile Zone 2 $p_{pp2,eff,uni} =$	$K_P^2 \gamma' z_0 =$	90.48	71.97
Tri lateral earth pressure for pile Zone 2 at base $p_{ppb,eff,tri} =$	$K_P^2 \gamma'(z_p - z_0) =$	213.02	169.42

ACTIVE FORCES			DA-1 C1	DA-1 C2
TOP:	$H_{top} =$		0.60 kN/m	0.60 kN/m
	$M_{top} =$		0.54 kN/m	0.54 kN/m
WALL:	$H_{a,wall,sur} =$	0.81 x 1.500 =	1.22 kN/m	1.44 kN/m
	$H_{a,wall,bulk,tri} =$	0.5 x 9.72 x 1.500 =	7.29 kN/m	8.65 kN/m
PILE:	$H_{pile,sur} =$	0.81 x 2.900 =	2.35 kN/m	2.79 kN/m
	$H_{a,pile,bulk,tri} =$	0.5 x 9.58 x 2.900 =	13.88 kN/m	16.46 kN/m
	$H_{a,pile,bulk,uni} =$	4.95 x 2.900 =	14.36 kN/m	17.03 kN/m

PASSIVE FORCES			
$H_{p,wall,eff,tri,1} =$	0.5 x 23.52 x 0.600 =	7.06 kN/m	5.61 kN/m
$H_{p,wall,eff,uni,2} =$	90.48 x 2.013 =	182.10 kN/m	144.83 kN/m
$H_{p,wall,eff,tri,2} =$	0.5 x 213.02 x 2.013 =	214.35 kN/m	170.48 kN/m

CHECK FOR OVERTURNING

DESIGN APPROACH 1 COMBINATION 2 (DA-1 C2)

Overturning moments:

COMPONENT	FORCE	LEVER	MOMENT
$M_{top} =$	-	-	1.346
$H_{top} =$	1.50	4.400	6.579
$H_{a,wall,sur} =$	3.60	3.650	13.148
$H_{a,wall,bulk,tri} =$	21.61	3.400	73.49
$H_{pile,sur} =$	1.11	1.450	1.616
$H_{a,pile,bulk,tri} =$	6.59	0.967	6.366
$H_{a,pile,bulk,uni} =$	6.81	1.450	9.879
	41.22		112.42

Restoring moments:

COMPONENT	FORCE	LEVER	MOMENT
$H_{p,wall,eff,tri,1} =$	2.24	2.213	4.967
$H_{p,wall,eff,uni,2} =$	57.93	1.006	58.29
$H_{p,wall,eff,tri,2} =$	68.19	0.671	45.74
	128.37		109.01

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Title:	**MASONRY RW AT BOUNDARY - (1.5 m RETAINED HEIGHT, 4.98 m OVERALL HEIGHT)**				

Design overturning moment about bottom of toe M_d :

Due to G_k = 89.73 kNm

Due to $Q_{k,1}$ = 14.764 kNm (Surcharge) Due to $Q_{k,3}$ = 0.000 kNm (Inner leaf direct)

Due to $Q_{k,2}$ = 7.925 kNm (Wind load on fence)

M_{Ed} = 1.0x89.732+ 1.3x14.764+0.7x1.3x(0.000+7.925) = 116.1 kNm/m

Design restoring moment about bottom of toe M_d :

Due to G_k = 109.01 kNm Due to $Q_{k,1}$ = 0.000 kNm (Surcharge)

M_{Rd} = 1.0 x 109.006 + 0.7 x 1.3 x 0.000 = 109.01 kNm/m

DESIGN APPROACH 1 COMBINATION 1 (DA-1 C1)

Overturning moments:

COMPONENT	FORCE	LEVER	MOMENT
M_{top} =	-	-	0.538
H_{top} =	0.60	4.400	2.632
$H_{a,wall,sur}$ =	3.04	3.650	11.088
$H_{a,wall,bulk,tri}$ =	18.23	3.400	61.97
$H_{pile,sur}$ =	0.94	1.450	1.363
$H_{a,pile,bulk,tri}$ =	5.55	0.967	5.369
$H_{a,pile,bulk,uni}$ =	5.75	1.450	8.330
	34.10		91.29

Restoring moments:

COMPONENT	FORCE	LEVER	MOMENT
$H_{p,wall,eff,tri,1}$ =	2.82	2.213	6.245
$H_{p,wall,eff,uni,2}$ =	72.84	1.006	73.30
$H_{p,wall,eff,tri,2}$ =	85.74	0.671	57.52
	161.40		137.06

Design overturning moment about bottom of toe M_d :

Due to G_k = 75.67 kNm

Due to $Q_{k,1}$ = 12.450 kNm (Surcharge) Due to $Q_{k,3}$ = 0.000 kNm (Inner leaf direct)

Due to $Q_{k,2}$ = 3.170 kNm (Wind load on fence)

M_{Ed} = 1.35x75.668+ 1.5x12.450+0.7x1.5x(0.000+3.170) = 124.2 kNm/m

Design restoring moment about bottom of toe M_d :

Due to G_k = 137.06 kNm Due to $Q_{k,1}$ = 0.000 kNm (Surcharge)

M_{Rd} = 1.0 x 137.056 + 0.7 x 1.5 x 0.000 = 137.06 kNm/m

NOT OK. Base inadequate for bearing pressure under DA-1 C2.

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Title:	MASONRY RW 'AT BOUNDARY' - (1 m RETAINED HEIGHT, 3.76 m OVERALL HEIGHT)				

RETAINING WALL 'AT BOUNDARY'

RETAINED HEIGHT = 1.000 m

PILE DIAMETER = 400 mm

NOMINAL PILE EMBEDMENT = 2.300 m

20% EXTRA EMBEDMENT BEYOND PIVOT = 0.460 m

TOTAL PILE EMBEDMENT = 2.760 m

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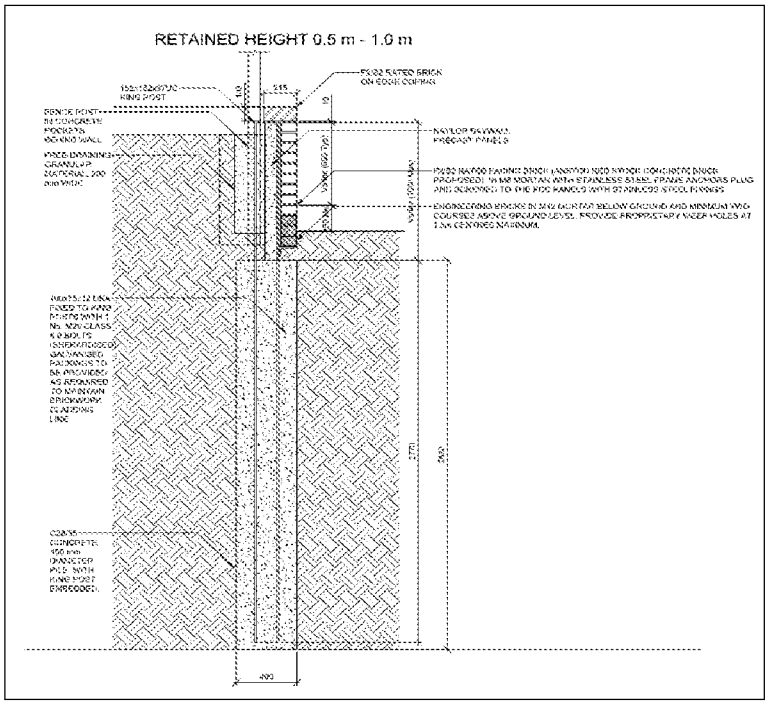
Title:	**MASONRY RW AT BOUNDARY - (1 m RETAINED HEIGHT, 3.76 m OVERALL HEIGHT)**				

RETAINING WALL: AT BOUNDARY - 1000 mm max. retained height [Toe at 3760 mm BGL]



Dimensions

Retained height:	h_r =	1,000	mm
Pile diameter:	D_p =	400.0	mm
Exposed pile:	h_{pex} =	287.5	mm
Buried pile:	h_{pbr} =	2,012.5	mm
Pile embedment:	z_p =	2,300.0	mm
Depth 1.5 x D_p:	z_0 =	600.0	mm
Resisting depth	h_{ppr} =	1,412.5	mm
WT bgl (ret side):	d_{w1} =	1,500	mm
WT bgl (red side):	d_{w2} =	0	mm
Unplanned excavation =		500	mm
O/A height of RW:	h =	3,760	mm
Overburden:	$h_{overburden}$ =	0.0	mm
Head on ret side:	$h_{h,ret}$ =	2,260.0	mm
Head on red side:	$h_{h,red}$ =	2,760.0	mm

Self weights

Soil bulk density = 20 kN/m^3
Soil saturated density = 21 kN/m^3

Wind loads on fence

Wind zone = C
c_{pnet} = 1.7
$q_p(z)$ = 0 kN/m^2
Wind load = $c_{pnet}q_p(z)$ = 0.332 kN/m^2
Boundary fence height = 1.8 m

Overburden and surcharge

Depth of overburden = 0.000 m
Applied surcharge = 2.50 kN/m^2
Total surcharge pressure q = 2.50 + 0.000 x 21.0 = 2.50 kN/m^2

Soil effective stress shear strength parameters

	Characteristic	DA1-C1	DA1-C2
Angle of shear resistance ϕ' =	27 °	27 °	22.18 °
Effective cohesion c' =	0 kN/m^2	0 kN/m^2	0 kN/m^2

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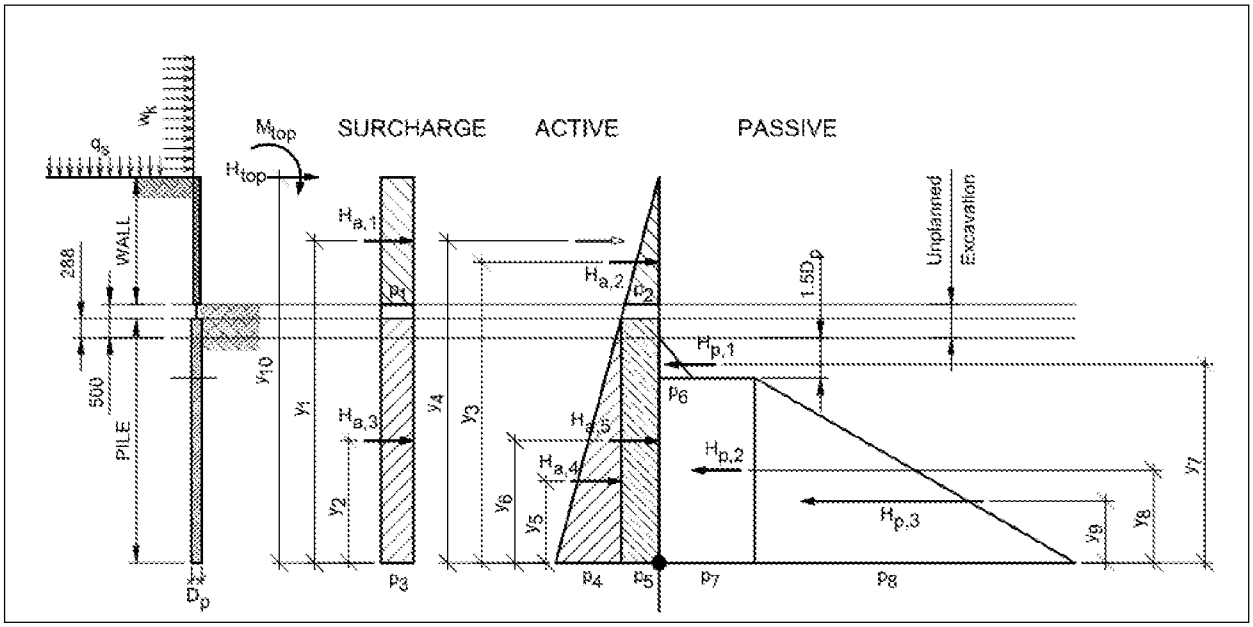

$y_{wall,surchg}$ =	2800	mm (y_1)	$y_{pile,surchg}$ =	1150	mm (y_2)
$y_{a,wall,bulk,tri}$ =	2633	mm (y_3)	$y_{pile,bulk,tri}$ =	766.7	mm (y_5)
$y_{a,wall,bulk,uni}$ =	2800	mm (y_4)	$y_{pile,bulk,uni}$ =	1150	mm (y_6)
$y_{p,pbr,1}$ =	1612.5	mm (y_7)			
$y_{p,pbr,2,uni}$ =	706.3	mm (y_8)			
$y_{p,pbr,2,tri}$ =	470.8	mm (y_9)			
y_{top} =	3300	mm (y_{10})			
$y_{pb,hyd}$ =	920	mm (y_{11})			

Rankine Theory	DA1-C1	DA1-C2
Coefficient of active pressure K_A =	0.324	0.384
Coefficient of passive pressure K_P =	3.847	3.060

FORCES	H_{top} =	0.33 x 1.800 =	0.60	kN/m length of retaining wall
	M_{top} =	0.5 x 1.8 x 0.6 =	0.54	kNm/m length of retaining wall

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Title:	**MASONRY RW AT BOUNDARY - (1 m RETAINED HEIGHT, 3.76 m OVERALL HEIGHT)**				

ACTIVE SIDE PRESSURES (kN/m^2)	DA-1 C1	DA-1 C2
Lateral pressure due to surcharge $p_s = K_A q =$	0.81	0.96
Lateral earth pressure at water table $p_{bul} = K_A \gamma_{bulk}(h-h_{h,ret}) =$	6.48	7.68
Tri lateral earth pressure for wall base $p_{wall,bul,tri} = K_A \gamma_{bulk} \min(h_s, h-h_{h,ret}) =$	6.48	7.68
Uni lateral earth pressure for wall base $p_{wall,bul,uni} =$	0.00	0.00
Uniform lateral earth pressure for pile $p_{pile,eff,uni} =$	3.30	3.92
Tri lateral earth pressure for exposed pile $p_{pex,eff,tri} = K_A \gamma_{bulk} z_p =$	7.59	9.01

PASSIVE SIDE PRESSURES (kN/m^2)			
Tri lateral earth pressure for pile Zone 1 $p_{pp1,eff,tri} = K_P \gamma' z_0 =$		23.52	18.71
Uni lateral earth pressure for pile Zone 2 $p_{pp2,eff,uni} =$	$K_P^2 \gamma' z_0 =$	90.48	71.97
Tri lateral earth pressure for pile Zone 2 at base $p_{ppb,eff,tri} =$	$K_P^2 \gamma'(z_p - z_0) =$	122.53	97.45

ACTIVE FORCES			DA-1 C1	DA-1 C2
TOP:	$H_{top} =$		0.60 kN/m	0.60 kN/m
	$M_{top} =$		0.54 kN/m	0.54 kN/m
WALL:	$H_{a,wall,sur} =$	0.81 x 1.000 =	0.81 kN/m	0.96 kN/m
	$H_{a,wall,bulk,tri} =$	0.5 x 6.48 x 1.000 =	3.24 kN/m	3.84 kN/m
PILE:	$H_{pile,sur} =$	0.81 x 2.300 =	1.86 kN/m	2.21 kN/m
	$H_{a,pile,bulk,tri} =$	0.5 x 7.59 x 2.300 =	8.73 kN/m	10.36 kN/m
	$H_{a,pile,bulk,uni} =$	3.30 x 2.300 =	7.59 kN/m	9.01 kN/m
PASSIVE FORCES				
	$H_{p,wall,eff,tri,1} =$	0.5 x 23.52 x 0.600 =	7.06 kN/m	5.61 kN/m
	$H_{p,wall,eff,uni,2} =$	90.48 x 1.413 =	127.81 kN/m	101.65 kN/m
	$H_{p,wall,eff,tri,2} =$	0.5 x 122.53 x 1.413 =	86.54 kN/m	68.83 kN/m

CHECK FOR OVERTURNING

DESIGN APPROACH 1 COMBINATION 2 (DA-1 C2)

Overturning moments:

COMPONENT	FORCE	LEVER	MOMENT
$M_{top} =$	-	-	1.346
$H_{top} =$	1.50	3.300	4.934
$H_{a,wall,sur} =$	2.40	2.800	6.724
$H_{a,wall,bulk,tri} =$	9.61	2.633	25.30
$H_{pile,sur} =$	0.88	1.150	1.016
$H_{a,pile,bulk,tri} =$	4.14	0.767	3.176
$H_{a,pile,bulk,uni} =$	3.60	1.150	4.143
	22.13		46.64

Restoring moments:

COMPONENT	FORCE	LEVER	MOMENT
$H_{p,wall,eff,tri,1} =$	2.24	1.613	3.620
$H_{p,wall,eff,uni,2} =$	40.66	0.706	28.72
$H_{p,wall,eff,tri,2} =$	27.53	0.471	12.96
	70.44		45.30

Optimal Structural Engineers Ltd

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Tel: [redacted]

Mob:

e-mail:

Project No.:	**OP1314**	Sheet: **23**	of **23**	Rev:	-
Designed:	**TZ**	Date: **April '18**		Checked:	
Project:	**TODDINGTON LANE, LITTLEHAMPTON, WEST SUSSEX**				
Title:	**MASONRY RW AT BOUNDARY - (1 m RETAINED HEIGHT, 3.76 m OVERALL HEIGHT)**				

Design overturning moment about bottom of toe M_d :

Due to G_k = 32.61 kNm

Due to $Q_{k,1}$ = 7.741 kNm (Surcharge) Due to $Q_{k,3}$ = 0.000 kNm (Inner leaf direct)

Due to $Q_{k,2}$ = 6.280 kNm (Wind load on fence)

M_{Ed} = 1.0x32.615+ 1.3x7.741+0.7x1.3x(0.000+6.280) = 48.39 kNm/m

Design restoring moment about bottom of toe M_d :

Due to G_k = 45.30 kNm Due to $Q_{k,1}$ = 0.000 kNm (Surcharge)

M_{Rd} = 1.0 x 45.299 + 0.7 x 1.3 x 0.000 = 45.30 kNm/m

DESIGN APPROACH 1 COMBINATION 1 (DA-1 C1)

Overturning moments:

COMPONENT	FORCE	LEVER	MOMENT
M_{top} =	-	-	0.538
H_{top} =	0.60	3.300	1.974
$H_{a,wall,sur}$ =	2.03	2.800	5.670
$H_{a,wall,bulk,tri}$ =	8.10	2.633	21.33
$H_{pile,sur}$ =	0.75	1.150	0.857
$H_{a,pile,bulk,tri}$ =	3.49	0.767	2.678
$H_{a,pile,bulk,uni}$ =	3.04	1.150	3.493
	18.00		36.54

Restoring moments:

COMPONENT	FORCE	LEVER	MOMENT
$H_{p,wall,eff,tri,1}$ =	2.82	1.613	4.551
$H_{p,wall,eff,uni,2}$ =	51.12	0.706	36.11
$H_{p,wall,eff,tri,2}$ =	34.61	0.471	16.30
	88.56		56.96

Design overturning moment about bottom of toe M_d :

Due to G_k = 27.50 kNm

Due to $Q_{k,1}$ = 6.527 kNm (Surcharge) Due to $Q_{k,3}$ = 0.000 kNm (Inner leaf direct)

Due to $Q_{k,2}$ = 2.512 kNm (Wind load on fence)

M_{Ed} = 1.35x27.503+ 1.5x6.527+0.7x1.5x(0.000+2.512) = 49.56 kNm/m

Design restoring moment about bottom of toe M_d :

Due to G_k = 56.96 kNm Due to $Q_{k,1}$ = 0.000 kNm (Surcharge)

M_{Rd} = 1.0 x 56.955 + 0.7 x 1.5 x 0.000 = 56.96 kNm/m

NOT OK. Base inadequate for bearing pressure under DA-1 C2.

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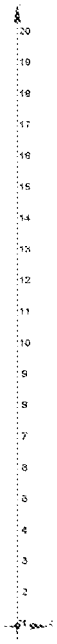
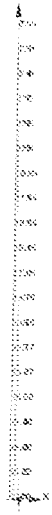
Email:
Web:

Job Number OP1314			Sheet A1
Job Title [redacted]DDINGTON LANE RETAINING WALL			
[redacted]RSIMMON HOMES THAMES VALLEY			
	Checked by JAB	Date JULY 2018	

A03



Load Case :GK



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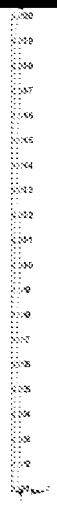
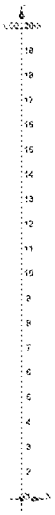
Job Number OP1314		Sheet A2	
Job Title TODDINGTON LANE RETAINING WALL			
[redacted]MMON HOMES THAMES VALLEY			
	Checked by JAB	Date JULY 2018	

Load Case :QK



Load Case :WK



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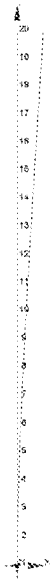
Job Number OP1314			Sheet A3
Job Title TODDINGTON LANE RETAINING WALL			
PERSIMMON HOMES THAMES VALLEY			
s by TZ	Checked by JAB	Date JULY 2018	

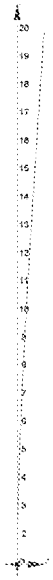
Deflections for Load Case C1

Maximum Deflections for Load Combination C1:
X: 6.34 mm at node 20
Y: 0.00 mm at node 20



Deflections for Load Case C2

Maximum Deflections for Load Combination C2:
X: 6.54 mm at node 20
Y: 0.00 mm at node 20



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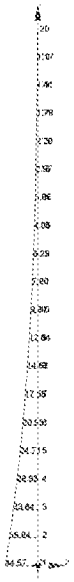
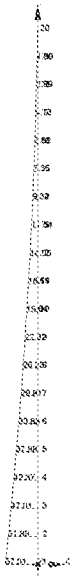
Web:

Job Number OP1314		Sheet A4	
Job Title TODDINGTON LANE RETAINING WALL			
RSIMMON HOMES THAMES VALLEY			
	Checked by JAB	Date JULY 2018	

X-Moments for Load Combination C1



Y-Shear for Load Combination C1



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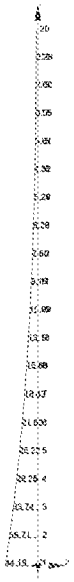
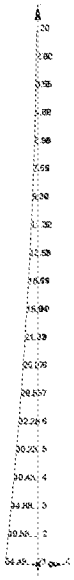
Email:
Web:

Job Number	OP1314		Sheet A5
Job Title	TODDINGTON LANE RETAINING WALL		
Client	PERSIMMON HOMES THAMES VALLEY		
Calcs by TZ	Checked by JAB	Date JULY 2018	

X-Moments for Load Combination C2



Y-Shear for Load Combination C2



Optimal Structural Engineers Ltd
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Web:

Job Number	OP1314	Sheet	A6
Job Title	TODDINGTON LANE RETAINING WALL		
	PERSIMMON HOMES THAMES VALLEY		
by	TZ	Checked by JAB	Date JULY 2018

========== S p a c e - F r a m e A n a l y s i s - P R O K O N ==========
Ver W2.6.05 - 27 Feb 2013

TITLE :Kingpost Analysis

Data file :
Created on: 01/08/2018

========== NODAL POINT COORDINATES ==========

Node No	X-coord m	Y-coord m	Z-coord m	Node No	X-coord m	Y-coord m	Z-coord m
1	0.000	0.000	0.000	2	0.000	0.105	0.000
3	0.000	0.211	0.000	4	0.000	0.316	0.000
5	0.000	0.421	0.000	6	0.000	0.526	0.000
7	0.000	0.632	0.000	8	0.000	0.737	0.000
9	0.000	0.842	0.000	10	0.000	0.947	0.000
11	0.000	1.053	0.000	12	0.000	1.158	0.000
13	0.000	1.263	0.000	14	0.000	1.368	0.000
15	0.000	1.474	0.000	16	0.000	1.579	0.000
17	0.000	1.684	0.000	18	0.000	1.789	0.000
19	0.000	1.895	0.000	20	0.000	2.000	0.000

========== ELEMENT DATA ==========

Beam	Secn. type	Fixity	Length m	ß (°)	Group no.
1-2	S1	00	0.105	0.00	0
2-3	S1	00	0.105	0.00	0
3-4	S1	00	0.105	0.00	0
4-5	S1	00	0.105	0.00	0
5-6	S1	00	0.105	0.00	0
6-7	S1	00	0.105	0.00	0
7-8	S1	00	0.105	0.00	0
8-9	S1	00	0.105	0.00	0
9-10	S1	00	0.105	0.00	0
10-11	S1	00	0.105	0.00	0
11-12	S1	00	0.105	0.00	0
12-13	S1	00	0.105	0.00	0
13-14	S1	00	0.105	0.00	0
14-15	S1	00	0.105	0.00	0
15-16	S1	00	0.105	0.00	0
16-17	S1	00	0.105	0.00	0
17-18	S1	00	0.105	0.00	0
18-19	S1	00	0.105	0.00	0
19-20	S1	00	0.105	0.00	0

========== SECTION PROPERTIES ==========

Section : S1 Section designation: 152x152x37 H1

A m^2	Ay m^2	Ax m^2	Ixx m^4	Iyy m^4	J m^4	Material
4.710E-3	0.000	0.000	22.1E-6	7.06E-6	195E-9	Steel:S275

========== MATERIALS ==========

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Web:

Job Number	OP1314		Sheet	A7
Job Title	TODDINGTON LANE RETAINING WALL			
Client	PERSIMMON HOMES THAMES VALLEY			
Calcs by	TZ	Checked by	JAB	Date JULY 2018

Designation	[redacted]	poisson	Density	Exp. coeff.
	kPa		kN/m^3	
Steel:S275	205.0E6	0.30	77.00	11.70E-6

========== SUPPORT DATA ==========

Prescribed displacements

Node	Fixity	X	Y	Z	X-Rot	Y-Rot	Z-Rot	Orien node
		m	m	m	rad.	rad.	rad.	
1	XY z	0.00	0.00	0.00	0.00	0.00	0.00	0

Spring constants

Node	Fixity	X	Y	Z	X-Rot	Y-Rot	Z-Rot
		kN/m	kN/m	kN/m	kNm/rad	kNm/rad	kNm/rad

========== LOADS ==========

Load Case Description

WK
QK
GK

Add own weight to load case : GK

========== LOAD CASE WK ==========

*** POINT LOADS ***

Node	Fx	Fy	Fz	Mx	My	Mz
	kN	kN	kN	kNm	kNm	kNm
20	1.50	0.00	0.00	0.00	0.00	-1.35

========== LOAD CASE QK ==========

*** BEAM ELEMENT LOADS ***

Element	Dir	P	a	Wl	Wr	a(left)	Length	dT
		kN	m	kN/m	kN/m	m	m	°C
1-2	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
2-3	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
3-4	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
4-5	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
5-6	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
6-7	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
7-8	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
8-9	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
9-10	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
10-11	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
11-12	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
12-13	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
13-14	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00

14-15				4.05	4.05	0.00	0.11	0.00
15-16	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
16-17	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
17-18	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
18-19	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00
19-20	X	0.00	0.000	4.05	4.05	0.00	0.11	0.00

========== LOAD CASE GK ==========

*** BEAM ELEMENT LOADS ***

Element	Dir	P kN	a m	Wl kN/m	Wr kN/m	a(left) m	Length m	dT °C
1-2	X	0.00	0.000	32.40	30.69	0.00	0.11	0.00
2-3	X	0.00	0.000	30.69	28.99	0.00	0.11	0.00
3-4	X	0.00	0.000	28.99	27.28	0.00	0.11	0.00
4-5	X	0.00	0.000	27.28	25.58	0.00	0.11	0.00
5-6	X	0.00	0.000	25.58	23.87	0.00	0.11	0.00
6-7	X	0.00	0.000	23.87	22.17	0.00	0.11	0.00
7-8	X	0.00	0.000	22.17	20.46	0.00	0.11	0.00
8-9	X	0.00	0.000	20.46	18.76	0.00	0.11	0.00
9-10	X	0.00	0.000	18.76	17.05	0.00	0.11	0.00
10-11	X	0.00	0.000	17.05	15.35	0.00	0.11	0.00
11-12	X	0.00	0.000	15.35	13.64	0.00	0.11	0.00
12-13	X	0.00	0.000	13.64	11.94	0.00	0.11	0.00
13-14	X	0.00	0.000	11.94	10.23	0.00	0.11	0.00
14-15	X	0.00	0.000	10.23	8.53	0.00	0.11	0.00
15-16	X	0.00	0.000	8.53	6.82	0.00	0.11	0.00
16-17	X	0.00	0.000	6.82	5.12	0.00	0.11	0.00
17-18	X	0.00	0.000	5.12	3.41	0.00	0.11	0.00
18-19	X	0.00	0.000	3.41	1.71	0.00	0.11	0.00
19-20	X	0.00	0.000	1.71	0.00	0.00	0.11	0.00

========== LOAD COMBINATIONS ==========

Load Comb Description

C1
C2

Comb. Load factor for each load case: Ultimate Limit State

	WK	QK	GK
C1	0.75	1.50	1.35
C2	1.50	1.05	1.35

Comb. Load factor for each load case: Serviceability Limit State

	WK	QK	GK
C1	0.50	1.00	1.00
C2	1.00	0.70	1.00

========== OWN WEIGHT ACCELERATIONS ==========

Direction	Acceleration (g)
X	0.00
Y	-1.00
Z	0.00

========== OUTPUT: LINEAR ANALYSIS ==========
========== NODAL POINT DISPLACEMENTS at SLS ==========

Node	Lcase	X-disp. mm	Y-disp mm	Z-rot. rad.
1	WK	0.00	0.00	0.0000
	QK	0.00	0.00	0.0000
	GK	0.00	0.00	0.0000
	C1	0.00	0.00	0.0000
	C2	0.00	0.00	0.0000
2	WK	0.01	0.00	-0.0001
	QK	0.01	0.00	-0.0002
	GK	0.03	0.00	-0.0005
	C1	0.04	0.00	-0.0007
	C2	0.04	0.00	-0.0007
3	WK	0.02	0.00	-0.0002
	QK	0.04	0.00	-0.0003
	GK	0.10	0.00	-0.0009
	C1	0.14	0.00	-0.0013
	C2	0.14	0.00	-0.0013
4	WK	0.05	0.00	-0.0003
	QK	0.08	0.00	-0.0005
	GK	0.20	0.00	-0.0012
	C1	0.31	0.00	-0.0018
	C2	0.31	0.00	-0.0018
5	WK	0.08	0.00	-0.0004
	QK	0.14	0.00	-0.0006
	GK	0.34	0.00	-0.0015
	C1	0.52	0.00	-0.0023
	C2	0.52	0.00	-0.0023
6	WK	0.12	0.00	-0.0005
	QK	0.21	0.00	-0.0007
	GK	0.51	0.00	-0.0017
	C1	0.78	0.00	-0.0026
	C2	0.78	0.00	-0.0026
7	WK	0.18	0.00	-0.0005
	QK	0.29	0.00	-0.0008
	GK	0.70	0.00	-0.0019
	C1	1.07	0.00	-0.0029
	C2	1.07	0.00	-0.0030
8	WK	0.24	0.00	-0.0006
	QK	0.38	0.00	-0.0009
	GK	0.90	0.00	-0.0020
	C1	1.40	0.00	-0.0032
	C2	1.40	0.00	-0.0032
9	WK	0.31	0.00	-0.0007
	QK	0.47	0.00	-0.0010
	GK	1.12	0.00	-0.0021
	C1	1.74	0.00	-0.0034
	C2	1.76	0.00	-0.0035
10	WK	0.38	0.00	-0.0008
	QK	0.58	0.00	-0.0010
	GK	1.34	0.00	-0.0022
	C1	2.11	0.00	-0.0036
	C2	2.13	0.00	-0.0037
11	WK	0.47	0.00	-0.0008
	QK	0.69	0.00	-0.0011
	GK	1.58	0.00	-0.0023
	C1	2.50	0.00	-0.0037
	C2	2.53	0.00	-0.0038

12	WK	0.56	0.00	-0.0009
	QK	0.80	0.00	-0.0011
	GK	1.82	0.00	-0.0023
	C1	2.90	0.00	-0.0039
	C2	2.94	0.00	-0.0040
13	WK	0.65	0.00	-0.0009
	QK	0.92	0.00	-0.0011
	GK	2.06	0.00	-0.0023
	C1	3.31	0.00	-0.0039
	C2	3.36	0.00	-0.0041
14	WK	0.76	0.00	-0.0010
	QK	1.04	0.00	-0.0012
	GK	2.31	0.00	-0.0024
	C1	3.73	0.00	-0.0040
	C2	3.80	0.00	-0.0042
15	WK	0.86	0.00	-0.0011
	QK	1.16	0.00	-0.0012
	GK	2.56	0.00	-0.0024
	C1	4.16	0.00	-0.0041
	C2	4.24	0.00	-0.0042
16	WK	0.98	0.00	-0.0011
	QK	1.29	0.00	-0.0012
	GK	2.81	0.00	-0.0024
	C1	4.59	0.00	-0.0041
	C2	4.69	0.00	-0.0043
17	WK	1.10	0.00	-0.0011
	QK	1.41	0.00	-0.0012
	GK	3.06	0.00	-0.0024
	C1	5.02	0.00	-0.0041
	C2	5.15	0.00	-0.0044
18	WK	1.22	0.00	-0.0012
	QK	1.54	0.00	-0.0012
	GK	3.31	0.00	-0.0024
	C1	5.46	0.00	-0.0042
	C2	5.61	0.00	-0.0044
19	WK	1.35	0.00	-0.0012
	QK	1.66	0.00	-0.0012
	GK	3.56	0.00	-0.0024
	C1	5.90	0.00	-0.0042
	C2	6.07	0.00	-0.0044
20	WK	1.48	0.00	-0.0013
	QK	1.79	0.00	-0.0012
	GK	3.81	0.00	-0.0024
	C1	6.34	0.00	-0.0042
	C2	6.54	0.00	-0.0045

========== REACTIONS AT ULS ==========

(In rotated axes where applicable)

Note:Only load combinations have ULSses = 1

Node	Lcase	X-force kN	Y-forcet kN	Z-moment kNm
1	WK	-1.50	0.00	4.34
	QK	-8.10	0.00	8.10
	GK	-32.40	0.73	21.60
	C1	-57.01	0.98	44.57
	C2	-54.49	0.98	44.18

EQUILIBRIUM CHECK AT ULS:

LC APPLIED LOADS & MOMENTS about (0.0,0.0,0.0) in global axes

Sum of:	Px	Py	Mz
WK	1.50	0.00	-4.34
QK	8.10	0.00	-8.10
GK	32.40	-0.73	-21.60
C1	57.01	-0.98	-44.57
C2	54.49	-0.98	-44.18

LC REACTIONS & REACTION MOMENTS about (0.0,0.0,0.0) in global axes

Sum of:	Rx	Ry	MRz
WK	-1.50	0.00	4.34
QK	-8.10	0.00	8.10
GK	-32.40	0.73	21.60
C1	-57.01	0.98	44.57
C2	-54.49	0.98	44.18

========== REACTIONS AT SLS (Combinations only) ==========

(In rotated axes

Node	Lcase	X-force kN	Y-forcet kN	Z-moment kNm
1	C1	-41.25	0.73	31.87
	C2	-39.57	0.73	31.61

========== BEAM ELEMENT END FORCES IN LOCAL ELEMENT AXES at ULS ==========

Elem	Lcase	Axial kN	Y-Shea kN	M-xx kNm	Axial kN	Y-Shea kN	M-xx kNm
1-2	WK	0.00	1.50	4.34	0.00	-1.50	-4.19
	QK	0.00	8.10	8.10	0.00	-7.67	-7.27
	GK	0.73	32.40	21.60	-0.69	-29.08	-18.37
	C1	0.98	57.01	44.57	-0.93	-51.89	-38.84
	C2	0.98	54.49	44.18	-0.93	-49.56	-38.71
2-3	WK	0.00	1.50	4.19	0.00	-1.50	-4.03
	QK	0.00	7.67	7.27	0.00	-7.25	-6.48
	GK	0.69	29.08	18.37	-0.65	-25.94	-15.47
	C1	0.93	51.89	38.84	-0.88	-47.01	-33.64
	C2	0.93	49.56	38.71	-0.88	-44.88	-33.74
3-4	WK	0.00	1.50	4.03	0.00	-1.50	-3.87
	QK	0.00	7.25	6.48	0.00	-6.82	-5.74
	GK	0.65	25.94	15.47	-0.61	-22.98	-12.90
	C1	0.88	47.01	33.64	-0.82	-42.37	-28.93
	C2	0.88	44.88	33.74	-0.82	-40.43	-29.25
4-5	WK	0.00	1.50	3.87	0.00	-1.50	-3.71
	QK	0.00	6.82	5.74	0.00	-6.39	-5.05
	GK	0.61	22.98	12.90	-0.57	-20.19	-10.63
	C1	0.82	42.37	28.93	-0.77	-37.98	-24.71
	C2	0.82	40.43	29.25	-0.77	-36.23	-25.22
5-6	WK	0.00	1.50	3.71	0.00	-1.50	-3.56
	QK	0.00	6.39	5.05	0.00	-5.97	-4.40
	GK	0.57	20.19	10.63	-0.53	-17.59	-8.64
	C1	0.77	37.98	24.71	-0.72	-33.83	-20.93
	C2	0.77	36.23	25.22	-0.72	-32.26	-21.62
6-7	WK	0.00	1.50	3.56	0.00	-1.50	-3.40
	QK	0.00	5.97	4.40	0.00	-5.54	-3.79
	GK	0.53	17.59	8.64	-0.50	-15.17	-6.92
	C1	0.72	33.83	20.93	-0.67	-29.91	-17.58

				21.62	-0.67	-28.55	-18.42
7-8	WK	0.00	1.50	3.40	0.00	-1.50	-3.24
	QK	0.00	5.54	3.79	0.00	-5.12	-3.23
	GK	0.50	15.17	6.92	-0.46	-12.92	-5.44
	C1	0.67	29.91	17.58	-0.62	-26.25	-14.62
	C2	0.67	28.55	18.42	-0.62	-25.07	-15.60
8-9	WK	0.00	1.50	3.24	0.00	-1.50	-3.08
	QK	0.00	5.12	3.23	0.00	-4.69	-2.71
	GK	0.46	12.92	5.44	-0.42	-10.86	-4.19
	C1	0.62	26.25	14.62	-0.57	-22.82	-12.04
	C2	0.62	25.07	15.60	-0.57	-21.83	-13.13
9-10	WK	0.00	1.50	3.08	0.00	-1.50	-2.92
	QK	0.00	4.69	2.71	0.00	-4.26	-2.24
	GK	0.42	10.86	4.19	-0.38	-8.98	-3.15
	C1	0.57	22.82	12.04	-0.52	-19.64	-9.81
	C2	0.57	21.83	13.13	-0.52	-18.84	-10.99
10-11	WK	0.00	1.50	2.92	0.00	-1.50	-2.77
	QK	0.00	4.26	2.24	0.00	-3.84	-1.82
	GK	0.38	8.98	3.15	-0.34	-7.27	-2.30
	C1	0.52	19.64	9.81	-0.46	-16.69	-7.90
	C2	0.52	18.84	10.99	-0.46	-16.09	-9.16
11-12	WK	0.00	1.50	2.77	0.00	-1.50	-2.61
	QK	0.00	3.84	1.82	0.00	-3.41	-1.44
	GK	0.34	7.27	2.30	-0.31	-5.74	-1.61
	C1	0.46	16.69	7.90	-0.41	-14.00	-6.29
	C2	0.46	16.09	9.16	-0.41	-13.59	-7.60
12-13	WK	0.00	1.50	2.61	0.00	-1.50	-2.45
	QK	0.00	3.41	1.44	0.00	-2.98	-1.10
	GK	0.31	5.74	1.61	-0.27	-4.40	-1.08
	C1	0.41	14.00	6.29	-0.36	-11.54	-4.95
	C2	0.41	13.59	7.60	-0.36	-11.32	-6.29
13-14	WK	0.00	1.50	2.45	0.00	-1.50	-2.29
	QK	0.00	2.98	1.10	0.00	-2.56	-0.81
	GK	0.27	4.40	1.08	-0.23	-3.23	-0.68
	C1	0.36	11.54	4.95	-0.31	-9.32	-3.85
	C2	0.36	11.32	6.29	-0.31	-9.30	-5.20
14-15	WK	0.00	1.50	2.29	0.00	-1.50	-2.13
	QK	0.00	2.56	0.81	0.00	-2.13	-0.56
	GK	0.23	3.23	0.68	-0.19	-2.24	-0.39
	C1	0.31	9.32	3.85	-0.26	-7.35	-2.97
	C2	0.31	9.30	5.20	-0.26	-7.52	-4.32
15-16	WK	0.00	1.50	2.13	0.00	-1.50	-1.98
	QK	0.00	2.13	0.56	0.00	-1.71	-0.36
	GK	0.19	2.24	0.39	-0.15	-1.44	-0.20
	C1	0.26	7.35	2.97	-0.21	-5.62	-2.29
	C2	0.26	7.52	4.32	-0.21	-5.98	-3.61
16-17	WK	0.00	1.50	1.98	0.00	-1.50	-1.82
	QK	0.00	1.71	0.36	0.00	-1.28	-0.20
	GK	0.15	1.44	0.20	-0.11	-0.81	-0.09
	C1	0.21	5.62	2.29	-0.15	-4.13	-1.78
	C2	0.21	5.98	3.61	-0.15	-4.68	-3.05
17-18	WK	0.00	1.50	1.82	0.00	-1.50	-1.66
	QK	0.00	1.28	0.20	0.00	-0.85	-0.09
	GK	0.11	0.81	0.09	-0.08	-0.36	-0.03
	C1	0.15	4.13	1.78	-0.10	-2.89	-1.41
	C2	0.15	4.68	3.05	-0.10	-3.63	-2.62
18-19	WK	0.00	1.50	1.66	0.00	-1.50	-1.50
	QK	0.00	0.85	0.09	0.00	-0.43	-0.02
	GK	0.08	0.36	0.03	-0.04	-0.09	0.00
	C1	0.10	2.89	1.41	-0.05	-1.89	-1.17
	C2	0.10	3.63	2.62	-0.05	-2.82	-2.28
19-20	WK	0.00	1.50	1.50	0.00	-1.50	-1.35

[redacted]		0.43	0.02	0.00	0.00	0.00
GK	0.04	0.09	0.00	0.00	0.00	0.00
C1	0.05	1.89	1.17	0.00	-1.12	-1.01
C2	0.05	2.82	2.28	0.00	-2.25	-2.02

```
============================ STATISTICAL DATA ==============================


Weights of beam elements:       (Added to load case GK)

Section Designation                          Total   Mass
                                             (kN)        (kg)

 S1     152x152x37     H1                    0.725       73.9
                                          ---------------------
                                             0.725       73.9

 Total weight of structure = 0.73 kN

 No. of real numbers in Stiffness matrix = 0  (0 bytes)
 Time used to analyse = 0: 0:0.301 seconds
 Total number of : Nodes              = 20
                   Beam Elements      = 19
                   Cable Elements     = 0
                   Shell Elements     = 0
                   Supports           = 1
                   Section Properties = 1
                   Load Cases         = 3
                   Load Combinations  = 2

 ============================= END OF OUTPUT ================================
```

```
Frame Analysis  Ver W2.6.05 - 27 Feb 2013
Input file:D:\Optimal Structural Engineers\Projects\OP1314 - Littlehampton Phase 2\Toddington
Created  : 01/08/2018 08:01:48
```

A03

```
========== S p a c e - F r a m e   A n a l y s i s  -  P R O K O N ==========
                        Ver W2.6.05 - 27 Feb 2013

TITLE :

Data file : D:\Optimal Structural Engineers\Projects\OP1314 - Littlehampton Phase 2\Toddington
Created on: 01/08/2018
```

========== NODAL POINT COORDINATES ==========

Node No	X-coord m	Y-coord m	Z-coord m	Node No	X-coord m	Y-coord m	Z-coord m
1	0.000	0.000	0.000	2	0.250	0.000	0.000
3	0.500	0.000	0.000	4	0.750	0.000	0.000
5	1.000	0.000	0.000	6	1.250	0.000	0.000
7	1.500	0.000	0.000	8	1.750	0.000	0.000
9	2.000	0.000	0.000	10	2.250	0.000	0.000
11	2.500	0.000	0.000				

========== ELEMENT DATA ==========

Beam	Secn. type	Fixity	Length m	ß (°)	Group no.
1-2	SEC1	00	0.250	0.00	0
2-3	SEC1	00	0.250	0.00	0
3-4	SEC1	00	0.250	0.00	0
4-5	SEC1	00	0.250	0.00	0
5-6	SEC1	00	0.250	0.00	0
6-7	SEC1	00	0.250	0.00	0
7-8	SEC1	00	0.250	0.00	0
8-9	SEC1	00	0.250	0.00	0
9-10	SEC1	00	0.250	0.00	0
10-11	SEC1	00	0.250	0.00	0

========== SECTION PROPERTIES ==========

Section : SEC1 Section designation: 125x75x12 U3

A m^2	Ay m^2	Ax m^2	Ixx m^4	Iyy m^4	J m^4	Material
2.270E-3	0.000	0.000	955E-9	3.54E-6	116E-9	Steel:350W

========== MATERIALS ==========

Designation	E kPa	poisson	Density kN/m^3	Exp. coeff.
Steel:350W	200.0E6	0.30	77.00	11.70E-6

========== SUPPORT DATA ==========

Prescribed displacements

Node	[redacted]			Z	X-Rot	Y-Rot	Z-Rot	Orien node
		m	m	m	rad.	rad.	rad.	
1	XY	0.00	0.00	0.00	0.00	0.00	0.00	0
11	Y	0.00	0.00	0.00	0.00	0.00	0.00	0

Spring constants

Node	Fixity	X	Y	Z	X-Rot	Y-Rot	Z-Rot
		kN/m	kN/m	kN/m	kNm/rad	kNm/rad	kNm/rad

========== LOADS ==========

Load Case Description

GK
QK

Own weight not added to any load case/combination

========== LOAD CASE GK ==========

*** BEAM ELEMENT LOADS ***

Element	Dir	P	a	Wl	Wr	a(left)	Length	dT
		kN	m	kN/m	kN/m	m	m	°C
1-2	Y	0.00	0.000	-4.03	-4.03	0.00	0.25	0.00
2-3	Y	0.00	0.000	-4.03	-4.03	0.00	0.25	0.00
3-4	Y	0.00	0.000	-4.03	-4.03	0.00	0.25	0.00
4-5	Y	0.00	0.000	-4.03	-4.03	0.00	0.25	0.00
5-6	Y	0.00	0.000	-4.03	-4.03	0.00	0.25	0.00
6-7	Y	0.00	0.000	-4.03	-4.03	0.00	0.25	0.00
7-8	Y	0.00	0.000	-4.03	-4.03	0.00	0.25	0.00
8-9	Y	0.00	0.000	-4.03	-4.03	0.00	0.25	0.00
9-10	Y	0.00	0.000	-4.03	-4.03	0.00	0.25	0.00
10-11	Y	0.00	0.000	-4.03	-4.03	0.00	0.25	0.00

========== LOAD CASE QK ==========

*** BEAM ELEMENT LOADS ***

Element	Dir	P	a	Wl	Wr	a(left)	Length	dT
		kN	m	kN/m	kN/m	m	m	°C
1-2	Y	0.00	0.000	-0.60	-0.60	0.00	0.25	0.00
2-3	Y	0.00	0.000	-0.60	-0.60	0.00	0.25	0.00
3-4	Y	0.00	0.000	-0.60	-0.60	0.00	0.25	0.00
4-5	Y	0.00	0.000	-0.60	-0.60	0.00	0.25	0.00
5-6	Y	0.00	0.000	-0.60	-0.60	0.00	0.25	0.00
6-7	Y	0.00	0.000	-0.60	-0.60	0.00	0.25	0.00
7-8	Y	0.00	0.000	-0.60	-0.60	0.00	0.25	0.00
8-9	Y	0.00	0.000	-0.60	-0.60	0.00	0.25	0.00
9-10	Y	0.00	0.000	-0.60	-0.60	0.00	0.25	0.00
10-11	Y	0.00	0.000	-0.60	-0.60	0.00	0.25	0.00

========== LOAD COMBINATIONS ==========

Load Comb Description

C1

Comb. Load factor for each load case: Ultimate Limit State

	GK	QK
C1	1.35	1.50

Comb. Load factor for each load case: Serviceability Limit State

	GK	QK
C1	1.00	1.00

========== OWN WEIGHT ACCELERATIONS ==========

Direction	Acceleration (g)
X	0.00
Y	-1.00
Z	0.00

========== OUTPUT: LINEAR ANALYSIS ==========
========== NODAL POINT DISPLACEMENTS at SLS ==========

Node	Lcase	X-disp. mm	Y-disp mm	Z-rot. rad.
1	GK	0.00	0.00	-0.0137
	QK	0.00	0.00	-0.0020
	C1	0.00	0.00	-0.0158
2	GK	0.00	-3.37	-0.0130
	QK	0.00	-0.50	-0.0019
	C1	0.00	-3.87	-0.0149
3	GK	0.00	-6.37	-0.0109
	QK	0.00	-0.95	-0.0016
	C1	0.00	-7.32	-0.0125
4	GK	0.00	-8.73	-0.0078
	QK	0.00	-1.30	-0.0012
	C1	0.00	-10.03	-0.0090
5	GK	0.00	-10.22	-0.0041
	QK	0.00	-1.52	-0.0006
	C1	0.00	-11.74	-0.0047
6	GK	0.00	-10.73	0.0000
	QK	0.00	-1.60	0.0000
	C1	0.00	-12.33	0.0000
7	GK	0.00	-10.22	0.0041
	QK	0.00	-1.52	0.0006
	C1	0.00	-11.74	0.0047
8	GK	0.00	-8.73	0.0078
	QK	0.00	-1.30	0.0012
	C1	0.00	-10.03	0.0090
9	GK	0.00	-6.37	0.0109
	QK	0.00	-0.95	0.0016
	C1	0.00	-7.32	0.0125
10	GK	0.00	-3.37	0.0130
	QK	0.00	-0.50	0.0019
	C1	0.00	-3.87	0.0149
11	GK	0.00	0.00	0.0137
	QK	0.00	0.00	0.0020
	C1	0.00	0.00	0.0158

========== REACTIONS AT ULS ==========

(In rotated axes where applicable)

Note:Only load combinations have ULSses = 1

Node	Lcase	X-force kN	Y-forcet kN	Z-moment kNm
1	GK	0.00	5.04	0.00
	QK	0.00	0.75	0.00
	C1	0.00	7.93	0.00
11	GK	0.00	5.04	0.00
	QK	0.00	0.75	0.00
	C1	0.00	7.93	0.00

EQUILIBRIUM CHECK AT ULS:

LC APPLIED LOADS & MOMENTS about (0.0,0.0,0.0) in global axes

Sum of:	Px	Py	Mz
GK	0.00	-10.08	-12.59
QK	0.00	-1.50	-1.88
C1	0.00	-15.85	-19.81

LC REACTIONS & REACTION MOMENTS about (0.0,0.0,0.0) in global axes

Sum of:	Rx	Ry	MRz
GK	0.00	10.08	12.59
QK	0.00	1.50	1.88
C1	0.00	15.85	19.81

========== REACTIONS AT SLS (Combinations only) ==========

(In rotated axes

Node	Lcase	X-force kN	Y-forcet kN	Z-moment kNm
1	C1	0.00	5.79	0.00
11	C1	0.00	5.79	0.00

========== BEAM ELEMENT END FORCES IN LOCAL ELEMENT AXES at ULS ==========

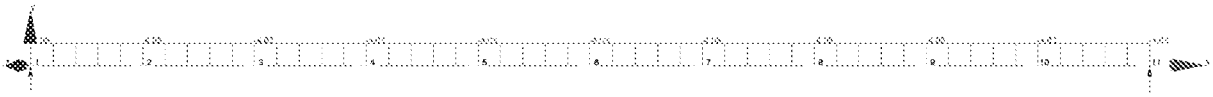
Elem	Lcase	Axial kN	Y-Shea kN	M-xx kNm	Axial kN	Y-Shea kN	M-xx kNm
1-2	GK	0.00	5.04	0.00	0.00	-4.03	1.13
	QK	0.00	0.75	0.00	0.00	-0.60	0.17
	C1	0.00	7.93	0.00	0.00	-6.34	1.78
2-3	GK	0.00	4.03	-1.13	0.00	-3.02	2.02
	QK	0.00	0.60	-0.17	0.00	-0.45	0.30
	C1	0.00	6.34	-1.78	0.00	-4.76	3.17
3-4	GK	0.00	3.02	-2.02	0.00	-2.02	2.64
	QK	0.00	0.45	-0.30	0.00	-0.30	0.39
	C1	0.00	4.76	-3.17	0.00	-3.17	4.16
4-5	GK	0.00	2.02	-2.64	0.00	-1.01	3.02
	QK	0.00	0.30	-0.39	0.00	-0.15	0.45
	C1	0.00	3.17	-4.16	0.00	-1.59	4.76
5-6	GK	0.00	1.01	-3.02	0.00	0.00	3.15
	QK	0.00	0.15	-0.45	0.00	0.00	0.47
	C1	0.00	1.59	-4.76	0.00	0.00	4.95
6-7	GK	0.00	0.00	-3.15	0.00	1.01	3.02

	QK	0.00	0.00	-0.47	0.00	0.15	0.45
	C1	0.00	0.00	-4.95	0.00	1.59	4.76
7-8	GK	0.00	-1.01	-3.02	0.00	2.02	2.64
	QK	0.00	-0.15	-0.45	0.00	0.30	0.39
	C1	0.00	-1.59	-4.76	0.00	3.17	4.16
8-9	GK	0.00	-2.02	-2.64	0.00	3.02	2.02
	QK	0.00	-0.30	-0.39	0.00	0.45	0.30
	C1	0.00	-3.17	-4.16	0.00	4.76	3.17
9-10	GK	0.00	-3.02	-2.02	0.00	4.03	1.13
	QK	0.00	-0.45	-0.30	0.00	0.60	0.17
	C1	0.00	-4.76	-3.17	0.00	6.34	1.78
10-11	GK	0.00	-4.03	-1.13	0.00	5.04	0.00
	QK	0.00	-0.60	-0.17	0.00	0.75	0.00
	C1	0.00	-6.34	-1.78	0.00	7.93	0.00

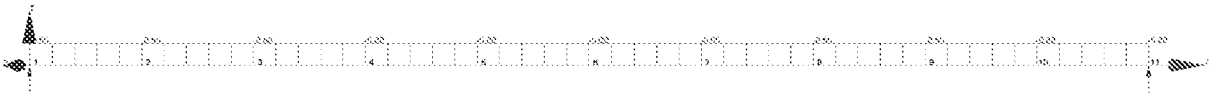
```
============================== STATISTICAL DATA ==============================


Weights of beam elements:       (Not included in analysis)

Section Designation                          Total  Mass
                                            (kN)       (kg)

 SEC1   125x75x12      U3                    0.437       44.5
                                         ---------------------
                                            0.437       44.5

 Total weight of structure = 0.00 kN

 No. of real numbers in Stiffness matrix = 0  (0 bytes)
 Time used to analyse = 0: 0:0.018 seconds
 Total number of : Nodes              = 11
                   Beam Elements      = 10
                   Cable Elements     = 0
                   Shell Elements     = 0
                   Supports           = 2
                   Section Properties = 1
                   Load Cases         = 2
                   Load Combinations  = 1

============================== END OF OUTPUT ==============================
```

Optimal Structural Engineers Ltd [redacted]	Job Number OP1314		Sheet B6
	Job Title TODDINGTON LANE RETAINING WALL		
	Client PERSIMMON HOMES THAMES VALLEY		
	Calcs by TZ	Checked by JAB	Date JULY 2018

Load Case :GK

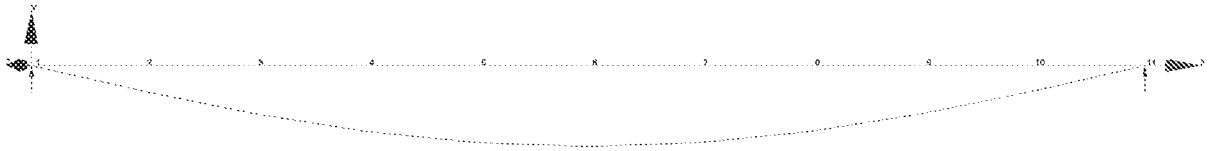


Load Case :GK



Optimal Structural Engineers Ltd	Job Number OP1314		Sheet B7
105 Godwin Road, Hove, East Sussex, BN3 7FS, United Kingdom [redacted]	Job Title TODDINGTON LANE RETAINING WALL		
	Client PERSIMMON HOMES THAMES VALLEY		
	Calcs by TZ	Checked by JAB	Date JULY 2018

Deflectio[redacted]

Maximum Deflections for Load Combination C1:

Y -12.33 mm at node 8