Tekla.Tedds Burroughs	Project	Godre'graig School Spoil Options		Job no. 50084
	Calcs for	Embeded Retaining Wall		Start page no./Revision 1
	Calcs by BG	Calcs date 08/07/2021	Checked by KJ	Checked date
			Approved by	Approved date

EMBEDED PILE WALL ANALYSIS & DESIGN

In accordance with BS EN1997-1:2004 - Code of Practice for Geotechnical design and the UK National Annex

Tedds calculation version 2.0.02

Design summary

Combination 1

Description	Unit	Provided	Required	Utilisation	Result
Total length required	mm	14000	11069	1.265	PASS
Maximum moment in pile 458.8 kNm/mx2.5m(King Post spacing)=1147KNm					
Maximum shear in pile 395.6 kN/mx2.5m(King Post spacing)=989KN					

Combination 2

Description	Unit	Provided	Required	Utilisation	Result
Total length required	mm	14000	12038	1.163	PASS
Maximum moment in pile 431.2 kNm/mx2.5m(King Post spacing)=1078KNm					
Maximum shear in pile 353.6 kN/mx2.5m(King Post spacing)=884KN					

Geometry

Length of pile provided	$H_{pile} = 14000$ mm	No. of different types of soil	$N_s = 2$
Retained height	$d_{ret} = 4000$ mm	Unplanned excavation depth	$d_{ex} = 0$ mm
Total retained height	$d_s = 4000$ mm	Angle of retained slope	$\beta = 30.0$ deg
Water depth retained side	$d_w = 8000$ mm	Water depth retaining side	$d_{wp} = 4000$ mm

Loading

Variable surcharge $\quad\quad\quad p_{o,Q} = 5.0$ kN/m²

Soil characteristic properties table

Soil	ϕ'_k (deg)	δ_k (deg)	γ_m (kN/m³)	γ_s (kN/m³)	h (mm)
1	28.0	18.7	10.0	19.0	10000
2	30.0	20.0	15.0	20.0	7000

Partial factors on actions - Section A.3.1 - Combination 1

Perm. unfavourable action	$\gamma_G = 1.35$	Perm. favourable action	$\gamma_{G,f} = 1.00$
Vari. unfavourable action	$\gamma_Q = 1.50$		
Angle of shearing resistance	$\gamma_{\phi'} = 1.00$	Weight density	$\gamma_\gamma = 1.00$

Design properties table - combination 1

Soil	ϕ'_d	δ_d	$\gamma_{m.d}$	$\gamma_{s.d}$	K_a	K_p
1	28.0	18.7	10.0	19.0	0.823	5.151
2	30.0	20.0	15.0	20.0	0.798	6.105

Tekla.**Tedds** Burroughs	Project Godre'graig School Spoil Options		Job no. 50084
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SECTION THROUGH EMBEDED PILE WALL   BALANCE PRESSURE DIAGRAM (kN/m^2)
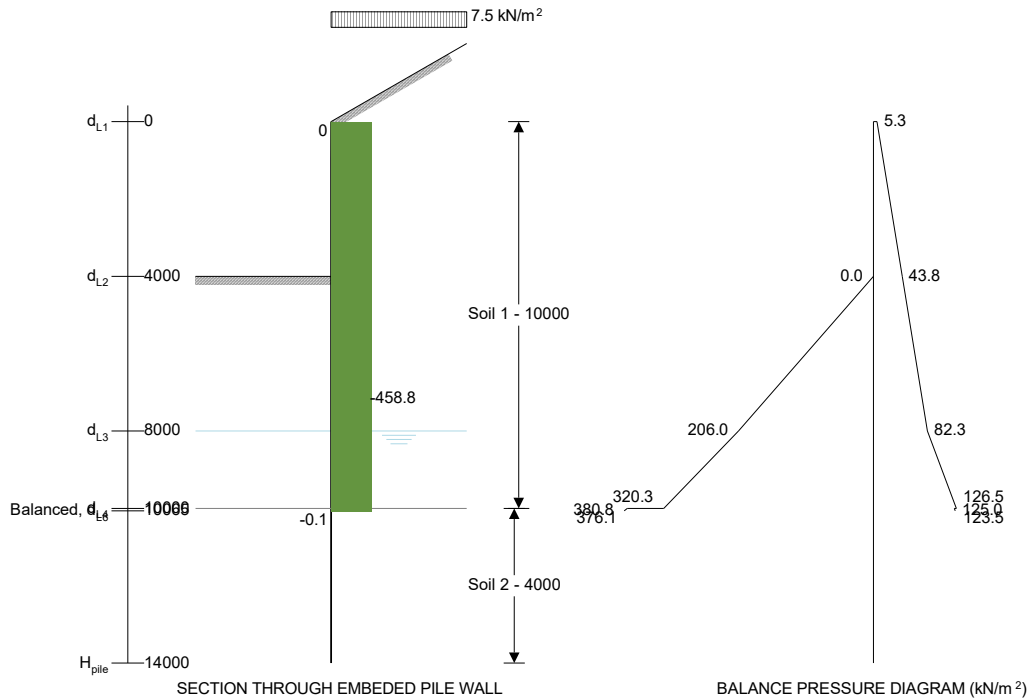
Overburden on active side

OB at 0 mm - soil 1	OB'$_{a11}$ = **7.5** kN/m^2	OB at 4000 mm - soil 1	OB'$_{a21}$ = **61.5** kN/m^2
OB at 8000 mm - soil 1	OB'$_{a31}$ = **115.5** kN/m^2	OB at 10000 mm - soil 1	OB'$_{a41}$ = **140.3** kN/m^2
OB at 10000 mm - soil 2	OB'$_{a42}$ = **140.3** kN/m^2	OB at 10065 mm - soil 2	OB'$_{a51}$ = **141.2** kN/m^2

Overburden on passive side

OB at 4000 mm - soil 1	OB'$_{p21}$ = **0.0** kN/m^2	OB at 8000 mm - soil 1	OB'$_{p31}$ = **40.0** kN/m^2
OB at 10000 mm - soil 1	OB'$_{p41}$ = **58.4** kN/m^2	OB at 10000 mm - soil 2	OB'$_{p42}$ = **58.4** kN/m^2
OB at 10065 mm - soil 2	OB'$_{p51}$ = **59.0** kN/m^2		

Pressure on active side

Active at 0 mm - soil 1	p'$_{a11}$ = **5.3** kN/m^2	Active at 4000 mm - soil 1	p'$_{a21}$ = **43.8** kN/m^2
Active at 8000 mm - soil 1	p'$_{a31}$ = **82.3** kN/m^2	Active at 10000 mm - soil 1	p'$_{a41}$ = **126.5** kN/m^2
Active at 10000 mm - soil 2	p'$_{a42}$ = **123.5** kN/m^2	Active at 10065 mm - soil 2	p'$_{a51}$ = **125.0** kN/m^2

Pressure on passive side

Passive at 4000 mm - soil 1	p'$_{p21}$ = **0.0** kN/m^2	Passive at 8000 mm - soil 1	p'$_{p31}$ = **206.0** kN/m^2
Passive at 10000 mm - soil 1	p'$_{p41}$ = **320.3** kN/m^2	Passive at 10000 mm - soil 2	p'$_{p42}$ = **376.1** kN/m^2
Passive at 10065 mm - soil 2	p'$_{p51}$ = **380.8** kN/m^2		

By iteration the depth at which the active moments equal the passive moments has been determined as 10065 mm as follows:-

Active moment about 10065 mm

Moment level 1	M$_{a11}$ = **93.3** kNm/m	Moment level 1	M$_{a12}$ = **648.5** kNm/m
Moment level 2	M$_{a21}$ = **414.8** kNm/m	Moment level 2	M$_{a22}$ = **559.5** kNm/m
Moment level 3	M$_{a31}$ = **115.1** kNm/m	Moment level 3	M$_{a32}$ = **92.6** kNm/m
Moment level 4	M$_{a41}$ = **0.2** kNm/m	Moment level 4	M$_{a42}$ = **0.1** kNm/m

Passive moment about 10065 mm

Moment level 2	M$_{p21}$ = **0.0** kNm/m	Moment level 2	M$_{p22}$ = **1400.5** kNm/m
Moment level 3	M$_{p31}$ = **288.2** kNm/m	Moment level 3	M$_{p32}$ = **234.5** kNm/m

	Project		Job no.	
Tekla Tedds	Godre'graig School Spoil Options		50084	
Burroughs	Calcs for		Start page no./Revision	
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	BG	08/07/2021	KJ			

Moment level 4	$M_{p41} = $ **0.5** kNm/m	Moment level 4	$M_{p42} = $ **0.3** kNm/m

Total moments about 10065 mm

Total active moment	$\Sigma M_a = $ **1924.0** kNm/m	Total passive moment	$\Sigma M_p = $ **1924.0** kNm/m

Required pile length

Length reqd to balance mnts	H = **10065** mm	Depth of equal pressure	$d_{contra} = $ **5046** mm
Add 20% below this point	$d_{e_add} = $ **6023** mm	Minimum required pile length	$H_{total} = $ **11069** mm

Pass - Provided length of pile greater than minimum required length of pile

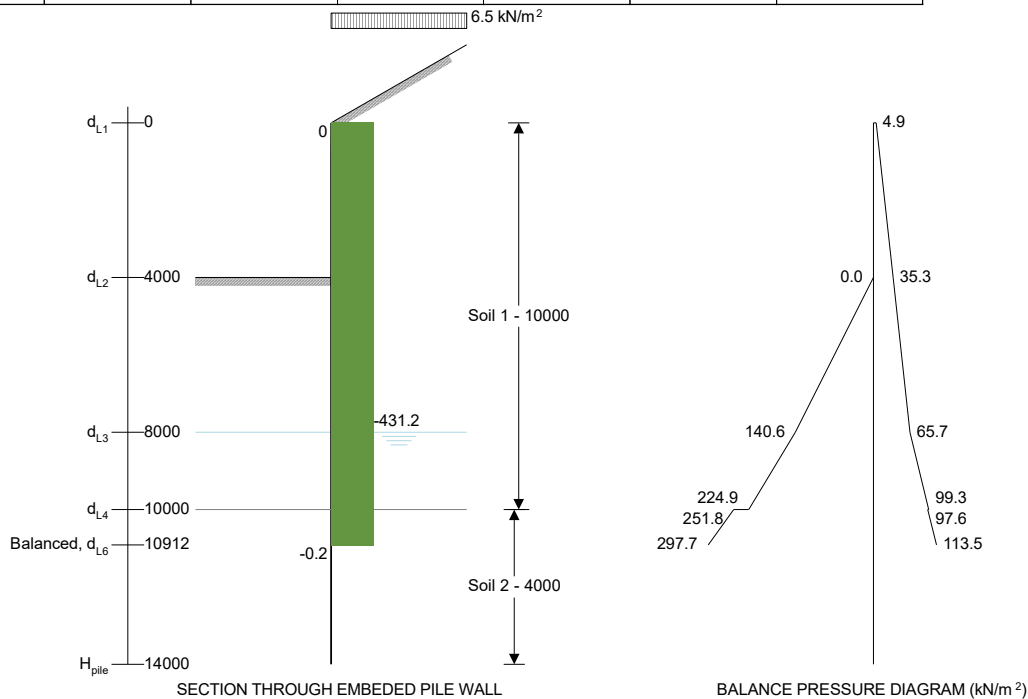### Partial factors on actions - Section A.3.1 - Combination 2

Perm. unfavourable action	$\gamma_G = $ **1.00**	Perm. favourable action	$\gamma_{G,f} = $ **1.00**
Vari. unfavourable action	$\gamma_Q = $ **1.30**		
Angle of shearing resistance	$\gamma_{\phi'} = $ **1.25**	Weight density	$\gamma_\gamma = $ **1.00**

Design properties table - combination 2

Soil	ϕ'_d	δ_d	$\gamma_{m.d}$	$\gamma_{s.d}$	K_a	K_p
1	23.0	15.1	10.0	19.0	0.877	3.516
2	24.8	16.2	15.0	20.0	0.858	3.977

SECTION THROUGH EMBEDED PILE WALL   BALANCE PRESSURE DIAGRAM (kN/m²)

Overburden on active side

OB at 0 mm - soil 1	$OB'_{a11} = $ **6.5** kN/m²	OB at 4000 mm - soil 1	$OB'_{a21} = $ **46.5** kN/m²
OB at 8000 mm - soil 1	$OB'_{a31} = $ **86.5** kN/m²	OB at 10000 mm - soil 1	$OB'_{a41} = $ **104.9** kN/m²
OB at 10000 mm - soil 2	$OB'_{a42} = $ **104.9** kN/m²	OB at 10913 mm - soil 2	$OB'_{a51} = $ **114.2** kN/m²

Overburden on passive side

OB at 4000 mm - soil 1	$OB'_{p21} = $ **0.0** kN/m²	OB at 8000 mm - soil 1	$OB'_{p31} = $ **40.0** kN/m²
OB at 10000 mm - soil 1	$OB'_{p41} = $ **58.4** kN/m²	OB at 10000 mm - soil 2	$OB'_{p42} = $ **58.4** kN/m²
OB at 10913 mm - soil 2	$OB'_{p51} = $ **67.7** kN/m²		

Pressure on active side

Active at 0 mm - soil 1	$p'_{a11} = $ **4.9** kN/m²	Active at 4000 mm - soil 1	$p'_{a21} = $ **35.3** kN/m²

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Active at 8000 mm - soil 1	p'_{a31} = **65.7** kN/m²	Active at 10000 mm - soil 1	p'_{a41} = **99.3** kN/m²
Active at 10000 mm - soil 2	p'_{a42} = **97.6** kN/m²	Active at 10913 mm - soil 2	p'_{a51} = **113.5** kN/m²

Pressure on passive side

Passive at 4000 mm - soil 1	p'_{p21} = **0.0** kN/m²	Passive at 8000 mm - soil 1	p'_{p31} = **140.6** kN/m²
Passive at 10000 mm - soil 1	p'_{p41} = **224.9** kN/m²	Passive at 10000 mm - soil 2	p'_{p42} = **251.8** kN/m²
Passive at 10913 mm - soil 2	p'_{p51} = **297.7** kN/m²		

By iteration the depth at which the active moments equal the passive moments has been determined as 10912 mm as follows:-

Active moment about 10912 mm

Moment level 1	M_{a11} = **94.6** kNm/m	Moment level 1	M_{a12} = **582.5** kNm/m
Moment level 2	M_{a21} = **394.1** kNm/m	Moment level 2	M_{a22} = **558.0** kNm/m
Moment level 3	M_{a31} = **147.6** kNm/m	Moment level 3	M_{a32} = **156.8** kNm/m
Moment level 4	M_{a41} = **27.1** kNm/m	Moment level 4	M_{a42} = **15.7** kNm/m

Passive moment about 10912 mm

Moment level 2	M_{p21} = **0.0** kNm/m	Moment level 2	M_{p22} = **1194.3** kNm/m
Moment level 3	M_{p31} = **315.9** kNm/m	Moment level 3	M_{p32} = **355.1** kNm/m
Moment level 4	M_{p41} = **69.9** kNm/m	Moment level 4	M_{p42} = **41.3** kNm/m

Total moments about 10912 mm

Total active moment	ΣM_a = **1976.5** kNm/m	Total passive moment	ΣM_p = **1976.5** kNm/m

Required pile length

Length reqd to balance mnts	H = **10912** mm	Depth of equal pressure	d_{contra} = **5282** mm
Add 20% below this point	d_{e_add} = **6757** mm	Minimum required pile length	H_{total} = **12038** mm

Pass - Provided length of pile greater than minimum required length of pile

	Project		Job no.	
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	King Psot Steel Section Property		5	
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CALCULATION OF SECTION PROPERTIES-305x305x240UC (Grade S355)

Tedds calculation version 2.0.07
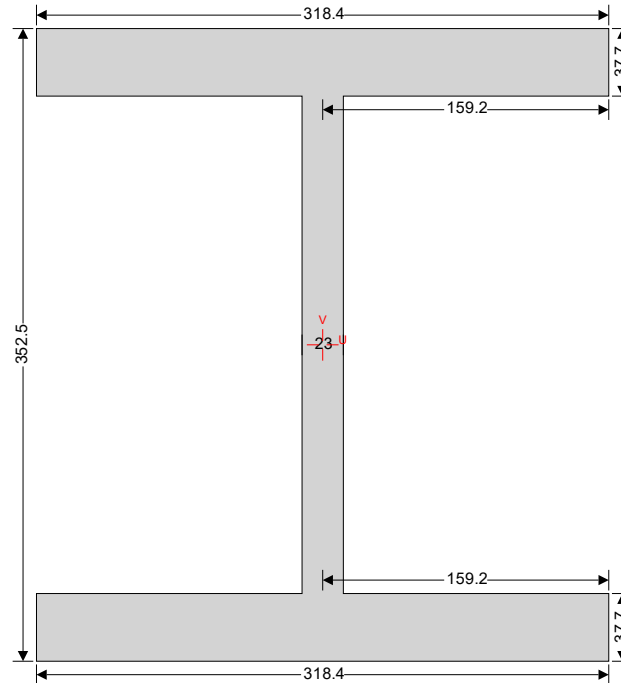
Area

A = **303.81** cm^2

2nd moment of area

I_{uu} = **63.8×10^3** cm^4 I_{vv} = **20.3×10^3** cm^4 I_{xx} = **63.8×10^3** cm^4 I_{yy} = **20.3×10^3** cm^4

Radius of gyration

r_{uu} = **145.0** mm r_{vv} = **81.8** mm r_{xx} = **14.5** cm r_{yy} = **8.2** cm

Plastic section modulus (only shapes with all rectangles at 90 degs)

S_{xx} = **4.22×10^3** cm^3 S_{yy} = **1.95×10^3** cm^3

Distance to combined centroid

X_e = **0.0** mm Y_e = **0.0** mm

Design bending resistance moment - eq 6.13; $M_{c,Rd}$ = $M_{pl,Rd}$ = $W_{pl.y}$ ´ f_y / g_{M0} = 1465.2 kNm
Design shear resistance - cl 6.2.6(2); $V_{c,Rd}$ = $V_{pl,Rd}$ = A_v ´ (f_y / Ö[3]) / g_{M0} = 1710 kN

Based on the embedded retaining wall design calculation presented in the previous pages, the maximum bending and shear force as a result of the ULS design value of actions are as follows:

Med:1147KNm<Mpl,Rd =1465.2 kNm Bending Check OK
Ved:989 KN< Vpl,Rd =1710 kN Shear Check OK

Deflection check for the pile section to be undertaken by the pile designer.