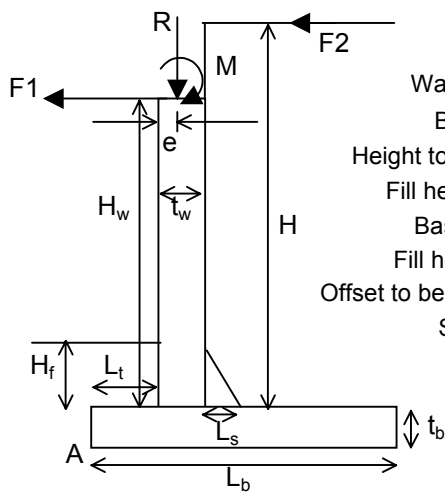


Free Abutment - CASE 1 B/Fill + Construction Surcharge



metres
 Toe Length $L_t = 1.100$
 Wall Thickness $t_w = 1.000$
 Base Length $L_b = 6.500$
 Height to deck soffit $H_w = 6.630$
 Fill height on heel $H = 6.630$
 Base thickness $t_b = 1.000$
 Fill height on toe $H_f = 0.000$
 Offset to bearing centre $e = 0.500$
 Splay length $L_s = 0.000$
 $L_h = 4.400$

$\phi_{\text{backfill}} = 35$ degrees
 $\phi_{\text{sliding}} = 30$ degrees
 Surcharge = 12 kN/m^2
 $R_{\text{dead}} = 0$ kN (+ve downwards)
 $R_{\text{live}} = 0$ kN (+ve downwards)
 $M = 0$ kNm (+ve clockwise)
 $F1 = 0$ kN (+ve to left)
 $F2 = 0$ kN (+ve to left)
 $\gamma_{\text{backfill}} = 19$ kN/m^3
 $\gamma_{\text{conc}} = 25$ kN/m^3

$K_a = 0.271$
 $K_o = 0.426$

STABILITY

	W	M_A
Base	162.50	528.13
Wall	165.75	265.20
B/fill	554.27	2383.35
S/charge	52.8	227.04
R	0.00	0.00
M		0.00
Σ	<u>935.32</u>	<u>3403.72</u>
H		M_A
F1	0	0
F2	0	0
B/fill	149.87	-381.1793
S/charge	24.81	-94.65721
Σ	<u>174.69</u>	<u>-475.8365</u>

$W \tan \phi = 540.01$

Factors of Safety

Overturning = **7.15**
 Sliding = **3.09**

BEARING PRESSURES (Using K_a)

$\Sigma P = 935.32$
 $\Sigma M_{CL} = -167.34$

Pressure at toe = **167.66**
 Pressure at heel = **120.13**
 Pressure at front of wall = 159.62
 Pressure at back of wall = 152.30

WALL MOMENTS AND SHEARS (Using K_o)

($\gamma_{f3} = 1.1$ included for ULS)

Section	Depth (m)	ULS Shear	SLS Moment	S/charg	F & M	SLS Moment	ULS Moment
H/8	0.829	11.59	0.77	1.76	0.00	2.53	4.17
H/4	1.658	32.36	6.15	7.03	0.00	13.18	21.74
3H/8	2.486	62.31	20.75	15.82	0.00	36.57	60.34
H/2	3.315	101.44	49.19	28.12	0.00	77.31	127.56
5H/8	4.144	149.76	96.08	43.93	0.00	140.01	231.02
3H/4	4.973	207.26	166.02	63.26	0.00	229.28	378.32
7H/8	5.801	273.93	263.64	86.11	0.00	349.74	577.08
Splay top	6.630	349.79	393.54	112.47	0.00	506.00	834.90
H	6.63	349.79	393.54	112.47	0.00	506.00	834.90

Estimated effective depth $d = 924$ mm

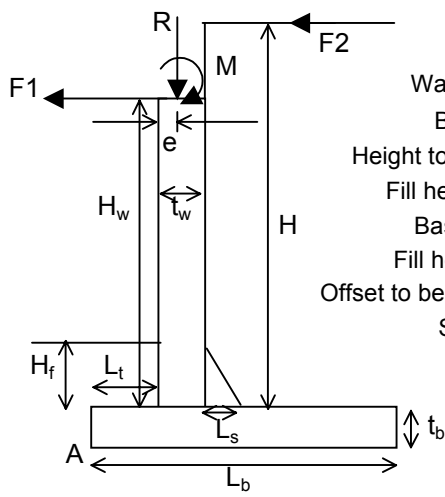
BASE MOMENTS AND SHEARS (Using K_o)

	ULS Shear	SLS Moment	ULS Moment
At d from front of wall	45.37	2.67	4.01
At front of wall	267.13	101.26	150.51
At back of wall	266.35	474.93	815.52
At bottom of splay	266.35	474.93	815.52

Bearing Pressures (Using K_o)

	At Toe	At Heel
SLS	198.55	89.24
ULS	265.69	74.61

Free Abutment - CASE 2 (Elastomeric Brng) B/Fill + HA Surcharge + Deck Dead Load + Contraction



Toe Length $L_t = 1.100$	$\phi_{backfill} = 35$	degrees
Wall Thickness $t_w = 1.000$	$\phi_{sliding} = 30$	degrees
Base Length $L_b = 6.500$	Surcharge = 10	kN/m^2
Height to deck soffit $H_w = 6.630$	$R_{dead} = 191$	$\text{kN (+ve downwards)}$
Fill height on heel $H = 8.630$	$R_{live} = 0$	$\text{kN (+ve downwards)}$
Base thickness $t_b = 1.000$	$M = 0$	$\text{kNm (+ve clockwise)}$
Fill height on toe $H_f = 0.000$	$F1 = 81$	kN (+ve to left)
Offset to bearing centre $e = 0.500$	$F2 = 0$	kN (+ve to left)
Splay length $L_s = 0.000$	$\gamma_{backfill} = 19$	kN/m^3
$L_h = 4.400$	$\gamma_{conc} = 25$	kN/m^3
	$K_a = 0.271$	
	$K_o = 0.426$	

STABILITY

	W	M_A	
Base	162.50	528.13	
Wall	165.75	265.20	
B/fill	721.47	3102.31	
S/charge	44	189.2	
R	191.00	305.60	
M		0.00	
$\Sigma =$	<u>1284.72</u>	<u>4390.44</u>	$W \tan\phi = 741.73$
	H	M_A	
F1	81	-618.03	
F2	0	0	
B/fill	238.74	-766.3631	
S/charge	26.10	-125.6539	
$\Sigma =$	<u>345.84</u>	<u>-1510.047</u>	

Factors of Safety

Overturning = **2.91**
Sliding = **2.14**

BEARING PRESSURES (Using K_a)

$\Sigma P = 1284.72$	Pressure at toe = 388.11
$\Sigma M_{CL} = -1341.14$	Pressure at heel = 7.19
	Pressure at front of wall = 323.64
	Pressure at back of wall = 265.04

WALL MOMENTS AND SHEARS (Using K_o)

($\gamma_{f3} = 1.1$ included for ULS)

Section	Depth (m)	ULS Shear	SLS Moment	S/charg	F & M	SLS Moment	ULS Moment
H/8	1.079	131.20	1.70	2.48	0.00	4.18	6.89
H/4	2.158	162.12	13.56	9.92	12.76	36.24	56.99
3H/8	3.236	208.61	45.77	22.33	100.14	168.24	255.56
H/2	4.315	270.64	108.49	39.70	187.52	335.70	512.66
5H/8	5.394	348.24	211.89	62.03	274.89	548.82	845.07
3H/4	6.473	441.39	366.15	89.32	362.27	817.74	1269.58
7H/8	7.551	550.10	581.43	121.58	449.65	1152.66	1802.97
Splay top	8.630	674.37	867.91	158.79	537.03	1563.74	2462.02
H	8.63	674.37	867.91	158.79	537.03	1563.74	2462.02

Estimated effective depth $d = 924$ mm

BASE MOMENTS AND SHEARS (Using K_o)

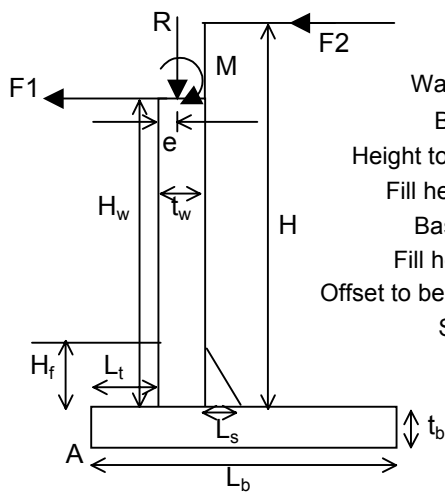
	ULS Shear	SLS Moment	ULS Moment
At d from front of wall	120.61	7.35	10.69
At front of wall	672.37	272.58	387.58
At back of wall	664.05	1414.85	2130.67
At bottom of splay	664.05	1414.85	2130.67

Bearing Pressures (Using K_o)

	At Toe	At Heel	**
SLS	503.97	0.00	5.098
ULS	664.55	0.00	4.562

** = adjusted base length for uplift

Free Abutment - CASE 2a (Sliding Bearing) B/Fill + HA Surcharge + Deck Dead Load + Contraction



Toe Length $L_t = 1.100$	$\phi_{\text{backfill}} = 35$ degrees
Wall Thickness $t_w = 1.000$	$\phi_{\text{sliding}} = 30$ degrees
Base Length $L_b = 6.500$	Surcharge = 10 kN/m^2
Height to deck soffit $H_w = 6.630$	$R_{\text{dead}} = 191$ kN (+ve downwards)
Fill height on heel $H = 8.630$	$R_{\text{live}} = 0$ kN (+ve downwards)
Base thickness $t_b = 1.000$	$M = 0$ kNm (+ve clockwise)
Fill height on toe $H_f = 0.000$	$F1 = 16$ kN (+ve to left)
Offset to bearing centre $e = 0.500$	$F2 = 0$ kN (+ve to left)
Splay length $L_s = 0.000$	$\gamma_{\text{backfill}} = 19$ kN/m^3
$L_h = 4.400$	$\gamma_{\text{conc}} = 25$ kN/m^3
$K_a = 0.271$	
$K_o = 0.426$	

STABILITY

	W	M_A	
Base	162.50	528.13	
Wall	165.75	265.20	
B/fill	721.47	3102.31	
S/charge	44	189.2	
R	191.00	305.60	
M		0.00	
$\Sigma =$	<u>1284.72</u>	<u>4390.44</u>	$W \tan\phi = 741.73$
	H	M_A	
F1	16	-122.08	
F2	0	0	
B/fill	238.74	-766.3631	
S/charge	26.10	-125.6539	
$\Sigma =$	<u>280.84</u>	<u>-1014.097</u>	

Factors of Safety

Overturning = **4.33**
Sliding = **2.64**

BEARING PRESSURES (Using K_a)

$\Sigma P = 1284.72$	Pressure at toe = 317.68
$\Sigma M_{CL} = -845.19$	Pressure at heel = 77.62
	Pressure at front of wall = 277.05
	Pressure at back of wall = 240.12

WALL MOMENTS AND SHEARS (Using K_o)

($\gamma_{f3} = 1.1$ included for ULS)

Section	Depth (m)	ULS Shear	SLS Moment	S/charg	F & M	SLS Moment	ULS Moment
H/8	1.079	38.25	1.70	2.48	0.00	4.18	6.89
H/4	2.158	69.17	13.56	9.92	2.52	26.01	42.36
3H/8	3.236	115.66	45.77	22.33	19.78	87.88	140.65
H/2	4.315	177.69	108.49	39.70	37.04	185.23	297.48
5H/8	5.394	255.29	211.89	62.03	54.30	328.22	529.62
3H/4	6.473	348.44	366.15	89.32	71.56	527.03	853.86
7H/8	7.551	457.15	581.43	121.58	88.82	791.83	1286.98
Splay top	8.630	581.42	867.91	158.79	106.08	1132.79	1845.76
H	8.63	581.42	867.91	158.79	106.08	1132.79	1845.76

Estimated effective depth $d = 924$ mm

BASE MOMENTS AND SHEARS (Using K_o)

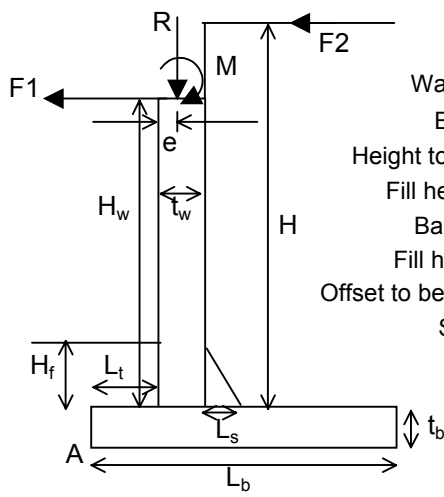
	ULS Shear	SLS Moment	ULS Moment
At d from front of wall	93.45	5.58	8.27
At front of wall	534.34	207.15	304.74
At back of wall	466.08	1029.04	1677.50
At bottom of splay	466.08	1029.04	1677.50

Bearing Pressures (Using K_o)

	At Toe	At Heel	**
SLS	388.98	6.32	
ULS	519.28	0.00	5.838

** = adjusted base length for uplift

Free Abutment - CASE 3 B/Fill + HA Surcharge & Braking behind Abutment + Deck Dead Load



- metres
- Toe Length $L_t = 1.100$
 - Wall Thickness $t_w = 1.000$
 - Base Length $L_b = 6.500$
 - Height to deck soffit $H_w = 6.630$
 - Fill height on heel $H = 8.630$
 - Base thickness $t_b = 1.000$
 - Fill height on toe $H_f = 0.000$
 - Offset to bearing centre $e = 0.500$
 - Splay length $L_s = 0.000$
 - $L_h = 4.400$
- $\phi_{\text{backfill}} = 35$ degrees
 - $\phi_{\text{sliding}} = 30$ degrees
 - Surcharge = 10 kN/m^2
 - $R_{\text{dead}} = 191$ kN (+ve downwards)
 - $R_{\text{live}} = 0$ kN (+ve downwards)
 - $M = 0$ kNm (+ve clockwise)
 - $F1 = 0$ kN (+ve to left)
 - $F2 = 39$ kN (+ve to left)
 - $\gamma_{\text{backfill}} = 19$ kN/m^3
 - $\gamma_{\text{conc}} = 25$ kN/m^3
- $K_a = 0.271$
 $K_o = 0.426$

STABILITY

	W	M_A	
Base	162.50	528.13	
Wall	165.75	265.20	
B/fill	721.47	3102.31	
S/charge	44	189.2	
R	191.00	305.60	
M		0.00	
Σ	<u>1284.72</u>	<u>4390.44</u>	$W \tan\phi = 741.73$
	H	M_A	
F1	0	0	
F2	39	-375.57	
B/fill	238.74	-766.3631	
S/charge	26.10	-125.6539	
Σ	<u>303.84</u>	<u>-1267.587</u>	

Factors of Safety

Overturning = **3.46**
Sliding = **2.44**

BEARING PRESSURES (Using K_a)

$\Sigma P = 1284.72$
 $\Sigma M_{CL} = -1098.68$

Pressure at toe = **353.67**
Pressure at heel = **41.62**
Pressure at front of wall = 300.87
Pressure at back of wall = 252.86

WALL MOMENTS AND SHEARS (Using K_o)

($\gamma_{f3} = 1.1$ included for ULS)

Section	Depth (m)	ULS Shear	SLS Moment	S/charg	F & M	SLS Moment	ULS Moment
H/8	1.079	68.99	1.70	2.48	42.07	46.25	67.05
H/4	2.158	99.92	13.56	9.92	84.14	107.63	159.08
3H/8	3.236	146.40	45.77	22.33	126.21	194.31	292.85
H/2	4.315	208.44	108.49	39.70	168.29	316.47	485.16
5H/8	5.394	286.04	211.89	62.03	210.36	484.28	752.78
3H/4	6.473	379.19	366.15	89.32	252.43	707.90	1112.50
7H/8	7.551	487.90	581.43	121.58	294.50	997.51	1581.10
Splay top	8.630	612.16	867.91	158.79	336.57	1363.28	2175.36
H	8.63	612.16	867.91	158.79	336.57	1363.28	2175.36

Estimated effective depth $d = 924$ mm

BASE MOMENTS AND SHEARS (Using K_o)

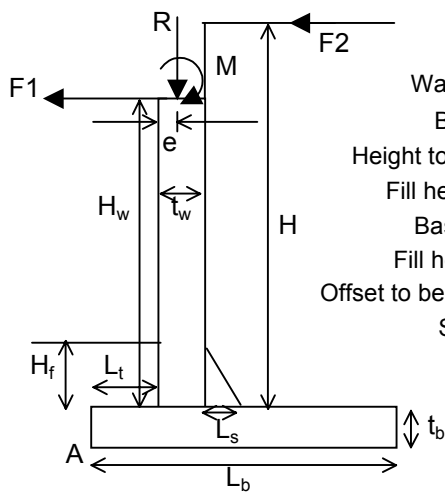
	ULS Shear	SLS Moment	ULS Moment
At d from front of wall	105.69	6.37	9.36
At front of wall	597.55	236.28	342.41
At back of wall	559.27	1233.12	1921.95
At bottom of splay	559.27	1233.12	1921.95

Bearing Pressures (Using K_o)

	At Toe	At Heel	**
SLS	440.39	0.00	5.834
ULS	584.60	0.00	5.185

** = adjusted base length for uplift

Free Abutment - CASE 4 B/Fill + HB Surcharge + Deck Dead Load



metres
 Toe Length $L_t = 1.100$
 Wall Thickness $t_w = 1.000$
 Base Length $L_b = 6.500$
 Height to deck soffit $H_w = 6.630$
 Fill height on heel $H = 8.630$
 Base thickness $t_b = 1.000$
 Fill height on toe $H_f = 0.000$
 Offset to bearing centre $e = 0.500$
 Splay length $L_s = 0.000$
 $L_h = 4.400$

$\phi_{\text{backfill}} = 35$ degrees
 $\phi_{\text{sliding}} = 30$ degrees
 Surcharge = 20 kN/m^2
 $R_{\text{dead}} = 191$ kN (+ve downwards)
 $R_{\text{live}} = 0$ kN (+ve downwards)
 $M = 0$ kNm (+ve clockwise)
 $F1 = 0$ kN (+ve to left)
 $F2 = 0$ kN (+ve to left)
 $\gamma_{\text{backfill}} = 19$ kN/m^3
 $\gamma_{\text{conc}} = 25$ kN/m^3

$K_a = 0.271$
 $K_o = 0.426$

STABILITY

	W	M_A	
Base	162.50	528.13	
Wall	165.75	265.20	
B/fill	721.47	3102.31	
S/charge	88	378.4	
R	191.00	305.60	
M		0.00	
$\Sigma =$	<u>1328.72</u>	<u>4579.64</u>	$W \tan\phi = 767.14$
H		M_A	
F1	0	0	
F2	0	0	
B/fill	238.74	-766.3631	
S/charge	52.19	-251.3078	
$\Sigma =$	<u>290.94</u>	<u>-1017.671</u>	

Factors of Safety

Overturning = **4.50**
 Sliding = **2.64**

BEARING PRESSURES (Using K_a)

$\Sigma P = 1328.72$
 $\Sigma M_{CL} = -848.77$
 Pressure at toe = **324.95**
 Pressure at heel = **83.88**
 Pressure at front of wall = 284.16
 Pressure at back of wall = 247.07

WALL MOMENTS AND SHEARS (Using K_o)

($\gamma_{f3} = 1.1$ included for ULS)

Section	Depth (m)	ULS Shear	SLS Moment	S/charg	F & M	SLS Moment	ULS Moment
H/8	1.079	22.96	1.70	4.96	0.00	6.66	10.98
H/4	2.158	61.47	13.56	19.85	0.00	33.41	55.13
3H/8	3.236	115.55	45.77	44.66	0.00	90.43	149.21
H/2	4.315	185.18	108.49	79.40	0.00	187.89	310.01
5H/8	5.394	270.36	211.89	124.06	0.00	335.95	554.32
3H/4	6.473	371.10	366.15	178.64	0.00	544.79	898.91
7H/8	7.551	487.40	581.43	243.15	0.00	824.59	1360.57
Splay top	8.630	619.26	867.91	317.59	0.00	1185.50	1956.07
H	8.63	619.26	867.91	317.59	0.00	1185.50	1956.07

Estimated effective depth $d = 924$ mm

BASE MOMENTS AND SHEARS (Using K_o)

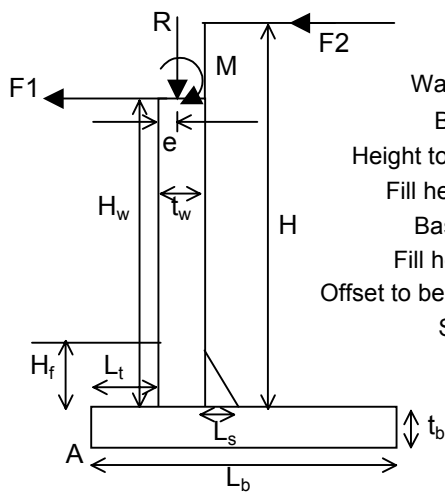
	ULS Shear	SLS Moment	ULS Moment
At d from front of wall	97.35	5.67	8.61
At front of wall	556.53	210.69	317.42
At back of wall	503.90	1054.89	1786.13
At bottom of splay	503.90	1054.89	1786.13

Bearing Pressures (Using K_o)

	At Toe	At Heel	**
SLS	394.73	14.11	
ULS	539.77	0.00	5.812

** = adjusted base length for uplift

Free Abutment - CASE 5 B/Fill + HA Surcharge + Dead & HB on Deck



Toe Length $L_t = 1.100$	$\phi_{\text{backfill}} = 35$ degrees
Wall Thickness $t_w = 1.000$	$\phi_{\text{sliding}} = 30$ degrees
Base Length $L_b = 6.500$	Surcharge = 10 kN/m^2
Height to deck soffit $H_w = 6.630$	$R_{\text{dead}} = 191$ kN (+ve downwards)
Fill height on heel $H = 8.630$	$R_{\text{live}} = 167$ kN (+ve downwards)
Base thickness $t_b = 1.000$	$M = 0$ kNm (+ve clockwise)
Fill height on toe $H_f = 0.000$	$F1 = 0$ kN (+ve to left)
Offset to bearing centre $e = 0.500$	$F2 = 0$ kN (+ve to left)
Splay length $L_s = 0.000$	$\gamma_{\text{backfill}} = 19$ kN/m^3
$L_h = 4.400$	$\gamma_{\text{conc}} = 25$ kN/m^3
$K_a = 0.271$	
$K_o = 0.426$	

STABILITY

	W	M_A	
Base	162.50	528.13	
Wall	165.75	265.20	
B/fill	721.47	3102.31	
S/charge	44.00	189.20	
R	358.00	572.80	
M		0.00	
$\Sigma =$	<u>1451.72</u>	<u>4657.64</u>	$W \tan\phi = 838.15$
	H	M_A	
F1	0	0	
F2	0	0	
B/fill	238.74	-766.3631	
S/charge	26.10	-125.6539	
$\Sigma =$	<u>264.84</u>	<u>-892.0169</u>	

Factors of Safety

Overturning = **5.22**
Sliding = **3.16**

BEARING PRESSURES (Using K_a)

$\Sigma P = 1451.72$	Pressure at toe = 365.16
$\Sigma M_{CL} = -998.66$	Pressure at heel = 81.52
	Pressure at front of wall = 317.16
	Pressure at back of wall = 273.52

WALL MOMENTS AND SHEARS (Using K_o)

($\gamma_{f3} = 1.1$ included for ULS)

Section	Depth (m)	ULS Shear	SLS Moment	S/charg	F & M	SLS Moment	ULS Moment
H/8	1.079	15.37	1.70	2.48	0.00	4.18	6.89
H/4	2.158	46.29	13.56	9.92	0.00	23.49	38.75
3H/8	3.236	92.78	45.77	22.33	0.00	68.10	112.36
H/2	4.315	154.81	108.49	39.70	0.00	148.19	244.51
5H/8	5.394	232.41	211.89	62.03	0.00	273.92	451.97
3H/4	6.473	325.56	366.15	89.32	0.00	455.47	751.53
7H/8	7.551	434.27	581.43	121.58	0.00	703.01	1159.97
Splay top	8.630	558.54	867.91	158.79	0.00	1026.71	1694.06
H	8.630	558.54	867.91	158.79	0.00	1026.71	1694.06

Estimated effective depth $d = 924$ mm

BASE MOMENTS AND SHEARS (Using K_o)

	ULS Shear	SLS Moment	ULS Moment
At d from front of wall	107.48	6.55	9.51
At front of wall	616.17	242.98	351.03
At back of wall	334.64	900.61	1480.49
At bottom of splay	334.64	900.61	1480.49

Bearing Pressures (Using K_o)

	At Toe	At Heel	**
SLS	451.82	5.14	
ULS	592.68	0.00	5.960

** = adjusted base length for uplift