

Corrosion analysis to buried portion of sheet piled wall

100 year analysis to 2122 with no remedial works

Location	Level of reading	Reading (mm)	start (mm)	Loss (mm)	% loss	Actual Rate of corrosion over 39 years (mm/year)	Loss of section over 100 years	residual pile thickness (mm)	residual % of thickness after 100 years	section modulus remaining after 100 years
A	-900	15.19	15.7	0.51	3.2	0.013	1.31	13.88	88.4	2134.52
B	-900	13.77	15.7	1.93	12.3	0.049	4.95	8.82	56.2	1356.34
C	-900	14.66	15.7	1.04	6.6	0.027	2.67	11.99	76.4	1844.07
D	-900	13.44	15.7	2.26	14.4	0.058	5.79	7.65	48.7	1175.50
E	-1600	14.57	15.7	1.13	7.2	0.029	2.90	11.67	74.3	1794.75
F	-1600	14.79	15.7	0.91	5.8	0.023	2.33	12.46	79.3	1915.31
G	-1600	14.14	15.7	1.56	9.9	0.040	4.00	10.14	64.6	1559.11
H	-1600	13.77	15.7	1.93	12.3	0.049	4.95	8.82	56.2	1356.34
K	-800	14.81	15.7	0.89	5.7	0.023	2.28	12.53	79.8	1926.27
L	-1100	13.4	15.7	2.3	14.6	0.059	5.90	7.50	47.8	1153.58
M	-1100	14.85	15.7	0.85	5.4	0.022	2.18	12.67	80.7	1948.19
N	-1500	13.33	15.7	2.37	15.1	0.061	6.08	7.25	46.2	1115.22
P	-1500	15.02	15.7	0.68	4.3	0.017	1.74	13.28	84.6	2041.35
Average		14.29	15.7	1.41	9.0	0.0362	3.62	10.67	67.94	1640.04

48 year analysis to 2070 with no remedial works

Location	Level of reading	Reading (mm)	start (mm)	Loss (mm)	% loss	Actual Rate of corrosion over 39 years (mm/year)	Loss of section over next 48 years	residual pile thickness (mm)	residual % of thickness after 48 years	section modulus remaining after 48 years
A	-900	15.19	15.7	0.51	3.2	0.013	0.63	14.56	92.8	2239.07
B	-900	13.77	15.7	1.93	12.3	0.049	2.38	11.39	72.6	1752.01
C	-900	14.66	15.7	1.04	6.6	0.027	1.28	13.38	85.2	2057.28
D	-900	13.44	15.7	2.26	14.4	0.058	2.78	10.66	67.9	1638.82
E	-1600	14.57	15.7	1.13	7.2	0.029	1.39	13.18	83.9	2026.41
F	-1600	14.79	15.7	0.91	5.8	0.023	1.12	13.67	87.1	2101.87
G	-1600	14.14	15.7	1.56	9.9	0.040	1.92	12.22	77.8	1878.92
H	-1600	13.77	15.7	1.93	12.3	0.049	2.38	11.39	72.6	1752.01
K	-800	14.81	15.7	0.89	5.7	0.023	1.10	13.71	87.4	2108.73
L	-1100	13.4	15.7	2.3	14.6	0.059	2.83	10.57	67.3	1625.10
M	-1100	14.85	15.7	0.85	5.4	0.022	1.05	13.80	87.9	2122.45
N	-1500	13.33	15.7	2.37	15.1	0.061	2.92	10.41	66.3	1601.09
P	-1500	15.02	15.7	0.68	4.3	0.017	0.84	14.18	90.3	2180.76
Average		14.29	15.7	1.41	9.0	0.0362	1.74	12.55	79.93	1929.58

Analysis after concrete encasement carried out within 1 year.

Location	Level of reading	Reading (mm)	start (mm)	Loss (mm)	% loss	Actual Rate of corrosion over 39 years (mm/year)	Loss of section over next 1 year	residual pile thickness (mm)	residual % of thickness after 100 years years	section modulus remaining after 100 years
A	-900	15.19	15.7	0.51	3.2	0.013	0.01	15.19	96.8	2335.58
B	-900	13.77	15.7	1.93	12.3	0.049	0.05	13.77	87.7	2117.25
C	-900	14.66	15.7	1.04	6.6	0.027	0.03	14.66	93.4	2254.09
D	-900	13.44	15.7	2.26	14.4	0.058	0.06	13.44	85.6	2066.51
E	-1600	14.57	15.7	1.13	7.2	0.029	0.03	14.57	92.8	2240.25
F	-1600	14.79	15.7	0.91	5.8	0.023	0.02	14.79	94.2	2274.08
G	-1600	14.14	15.7	1.56	9.9	0.040	0.04	14.14	90.1	2174.14
H	-1600	13.77	15.7	1.93	12.3	0.049	0.05	13.77	87.7	2117.25
K	-800	14.81	15.7	0.89	5.7	0.023	0.02	14.81	94.3	2277.16
L	-1100	13.4	15.7	2.3	14.6	0.059	0.06	13.4	85.4	2060.36
M	-1100	14.85	15.7	0.85	5.4	0.022	0.02	14.85	94.6	2283.31
N	-1500	13.33	15.7	2.37	15.1	0.061	0.06	13.33	84.9	2049.59
P	-1500	15.02	15.7	0.68	4.3	0.017	0.02	15.02	95.7	2309.44
Average		14.29	15.7	1.41	9.0	0.0362	0.04	14.29	91.00	2196.85

The above table conservatively assumes no increase to the section modulus of the pile, however the concrete encasement would be connected to the sheet piling with shear studs. This would create a composite steel & concrete section, the section modulus would therefore increase sufficiently to allow the additional load from the raisings to be accommodated.

Section	Dimensions				A	G _{sp}	G _w	I _y	W _{el,y}	W _{pl,y}
	w	h	t _f	t _w						
	mm	mm	mm	mm						
4A	400	381	15.7	9.4	236	74	185.1	45 160	2 371	-
4/20	508	381	15.7	9.4	218	86.8	170.9	45 924	2 414	-

Project : *Customs House*
Job Number : *A7752*
Designed By : *RB*
Location :
Date : *Sep-22*



Sheet Number : S - 1

The sheet pile analysis is based upon the as built record drawings.

The sheet pile section used is a 4/20.

The steel grade is mild steel

The geotechnical properties are given on a borehole log of the Customs House Jetty

The ground conditions behind the wall are engineered fill material, gravel with some silty clay and medium dense to occasionally dense brown sandy fine to coarse gravel. The angle of friction used is ϕ of 34 degrees. This represents the lower end of the range for this material

In order to get K_a and K_p , the active and passive pressure of the soil, the friction angle between the soil and the sheet piling is used as δ/ϕ dash. This is taken as 0.5 for steel sheet piling.

Using the graphs on the following pages, the horizontal earth pressures are obtained.

These K_a of 0.26 and K_p of 6 are used in the analysis

The results graphs are included at the end of the calculations

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(3) Values of the effective earth pressure coefficients may be taken from Figures C.1.1 to C.1.4 for K_a and C.2.1 to C.2.4 for K_p .

(4) Alternatively, the analytical procedure described in C.2 may be used.

(5) In layered soils, the coefficients K should normally be determined by the shear strength parameters at depth z only, independent of the values at other depths.

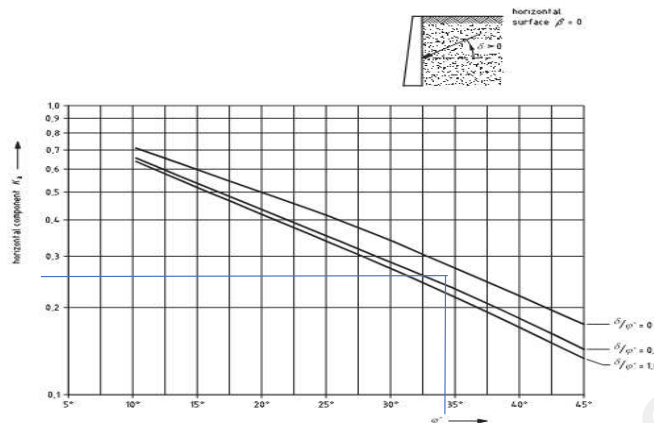


Figure C.1.1 — Coefficients K_a of effective active earth pressure (horizontal component): with horizontal retained surface ($\beta = 0$)

Ka2 0.26

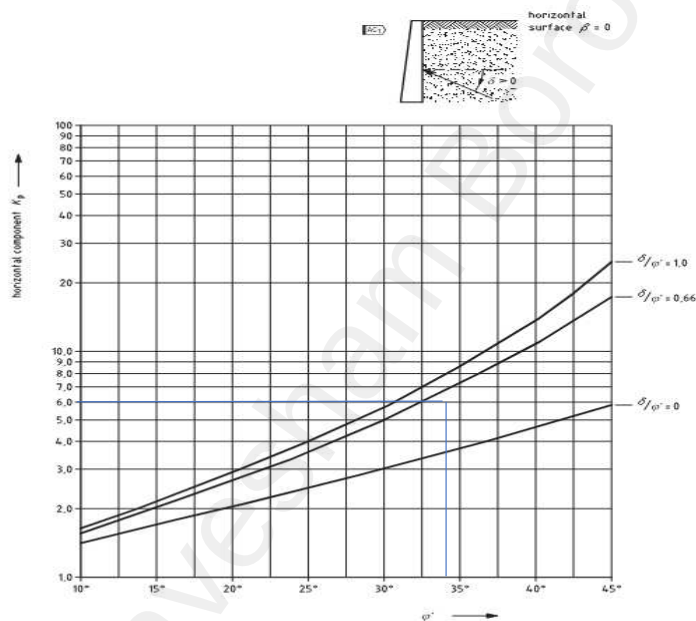


Figure C.2.1 — Coefficients K_p of effective passive earth pressure (horizontal component): with horizontal retained surface ($\beta = 0$)

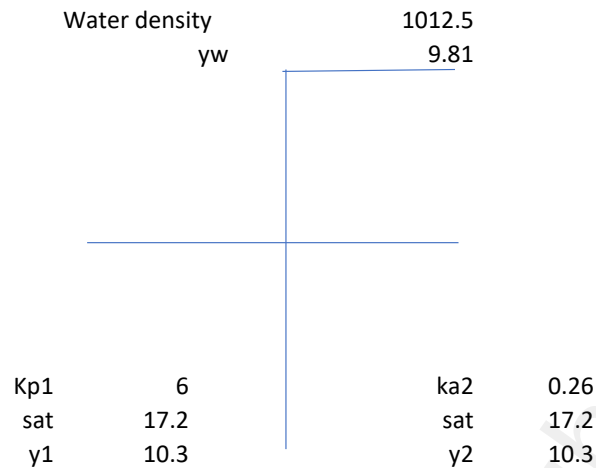
Kp1 6

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Sheet Number : S - 3

The river Thames and sea water mix to become brackish at Gravesend



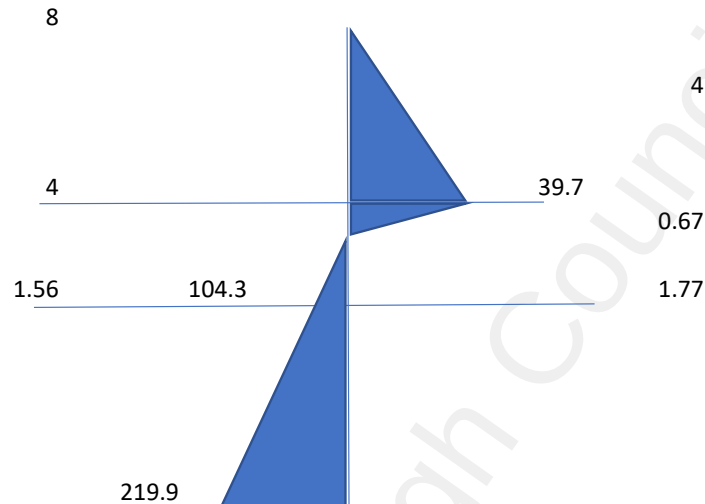
4	0	0	0	39.7305
1	10.3	9.932625	10.3	49.66313
1	20.6	19.86525	20.6	59.59575
1	30.9	29.79788	30.9	69.52838
1	41.2	39.7305	41.2	79.461

depth	Pp	Pa	Nett Pp
0	0.0	0.0	0
4	0.0	39.7	-39.7
4.5	35.8	46.0	-10.2
4.6	43.0	47.3	-4.3
4.672	48.1	48.2	-0.1
4.7	50.1	48.6	1.6
4.8	57.3	49.8	7.5
5	71.6	52.3	19.3
5.5	107.4	58.6	48.8
6	143.2	65.0	78.3
6.5	179.0	71.3	107.8
7	214.8	77.6	137.3
7.5	250.6	83.9	166.8
8	286.4	90.2	196.3
8.4	315.1	95.2	219.9

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Sheet Number : S - 4



Moments at different levels

The yield stress of mild steel at the time of construction was with reference to the extract from the piling handbook of the time 255N/mm²

Using a global factor of safety of 1.5 on this gives allowable stress of

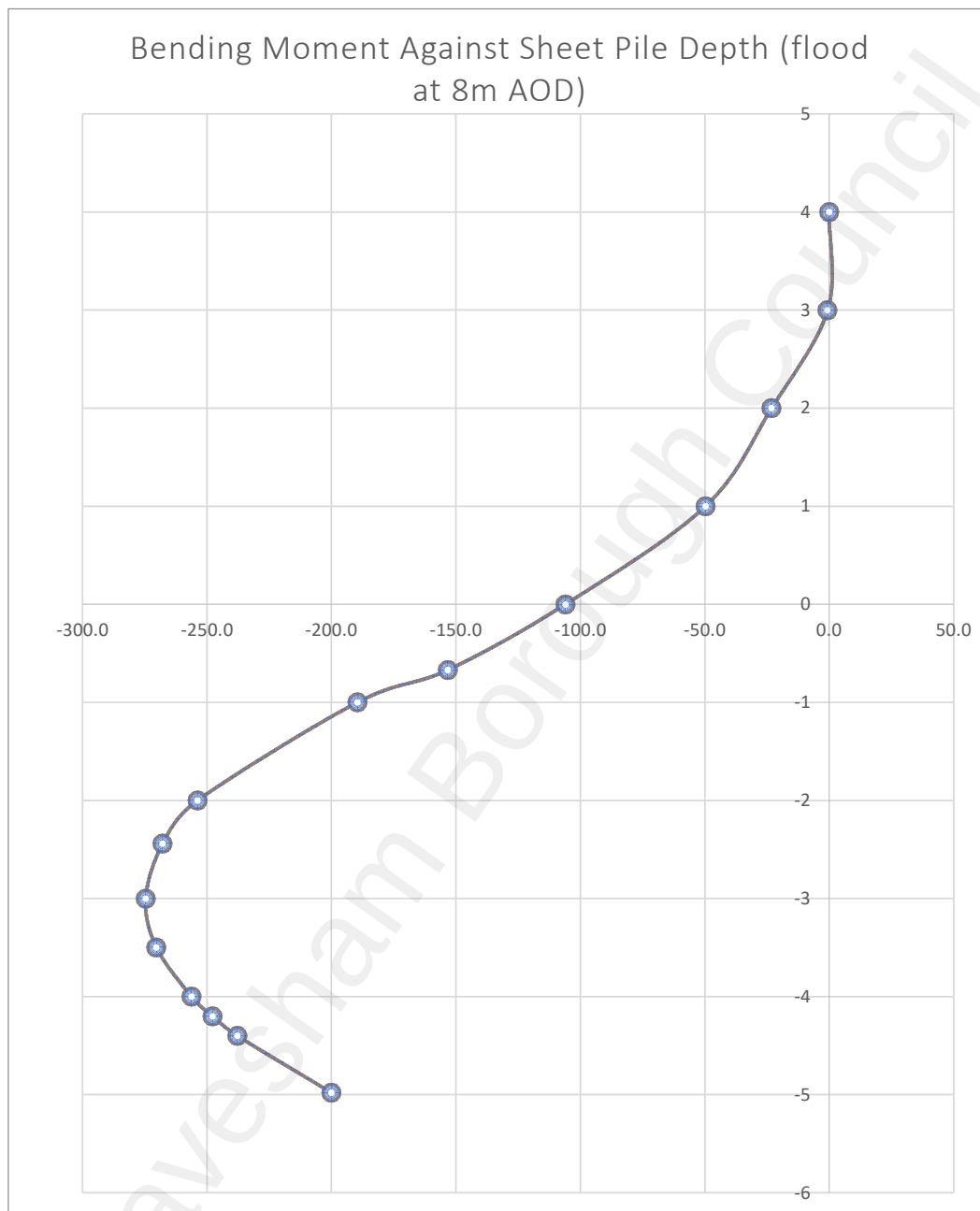
170 N/mm²

	AOD levels	from top of wall	from ground	kNm	modulus required	100 Y modulus	Encased modulus
top of wall	8	0	4	0.0	0.0	-1640.0	-2196.8
		1	3	-0.7	-3.9	-1640.0	-2196.8
		2	2	-23.2	-136.3	-1640.0	-2196.8
		3	1	-49.7	-292.1	-1640.0	-2196.8
	4	4	0	-105.9	-623.2	-1640.0	-2196.8
	3.33	4.67	-0.67	-153.2	-901.4	-1640.0	-2196.8
	3	5	-1	-189.5	-1115.0	-1640.0	-2196.8
	2	6	-2	-253.8	-1492.7	-1640.0	-2196.8
	1.56	6.44	-2.44	-267.8	-1575.2	-1640.0	-2196.8
	0.56	7	-3	-274.6	-1615.4	-1640.0	-2196.8
	0.06	7.5	-3.5	-270.3	-1590.1	-1640.0	
	-0.44	8	-4	-256.2	-1506.9	-1640.0	
	-0.64	8.2	-4.2	-247.8	-1457.5	-1640.0	
toe level	-0.84	8.4	-4.4	-237.8	-1398.8	-1640.0	
	-1.42	8.98	-4.98	-200.0	-1176.4	-1640.0	

The results above do not take into consideration the concrete encasement

The concrete encasement will reduce the corrosion to the pile section & increase the section modulus

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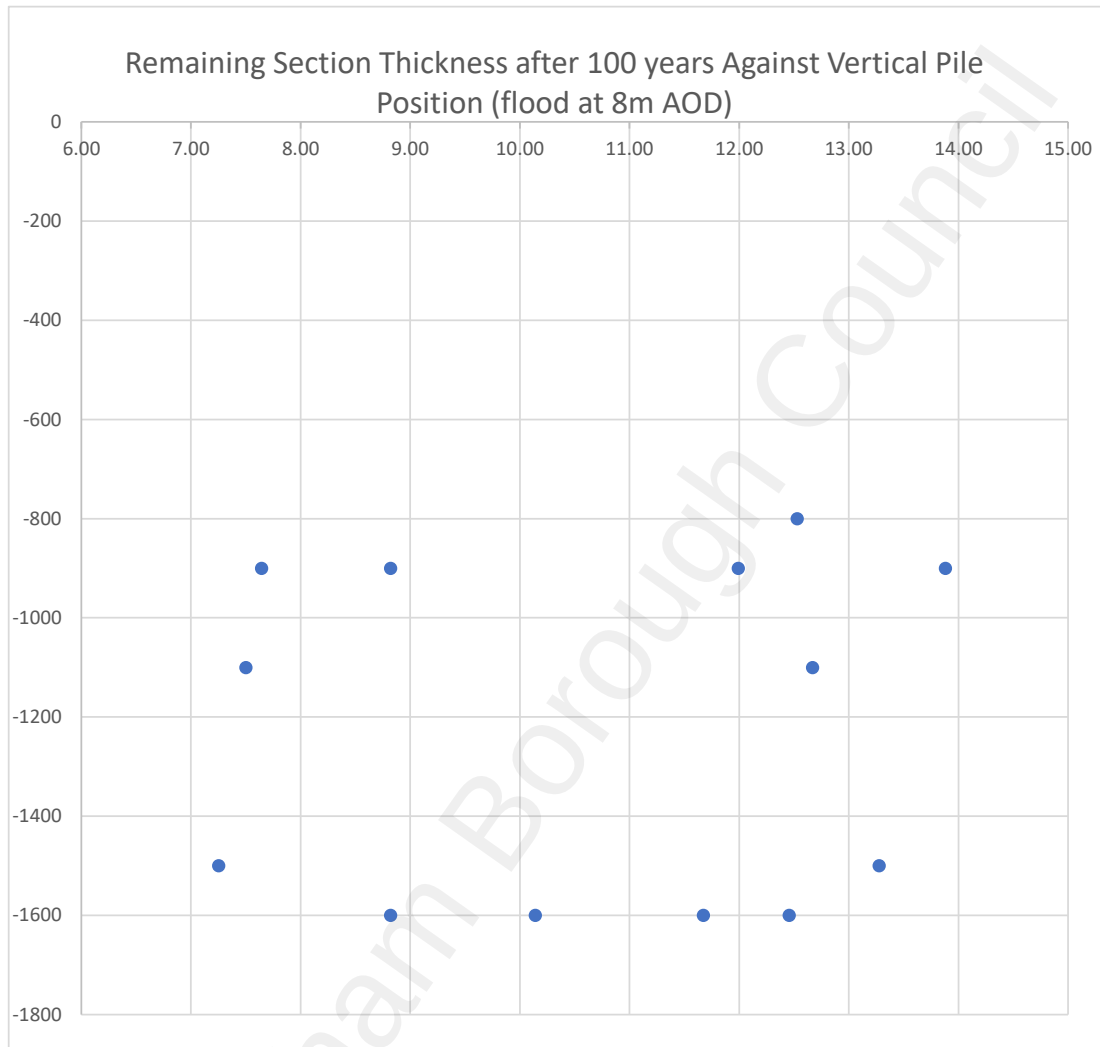


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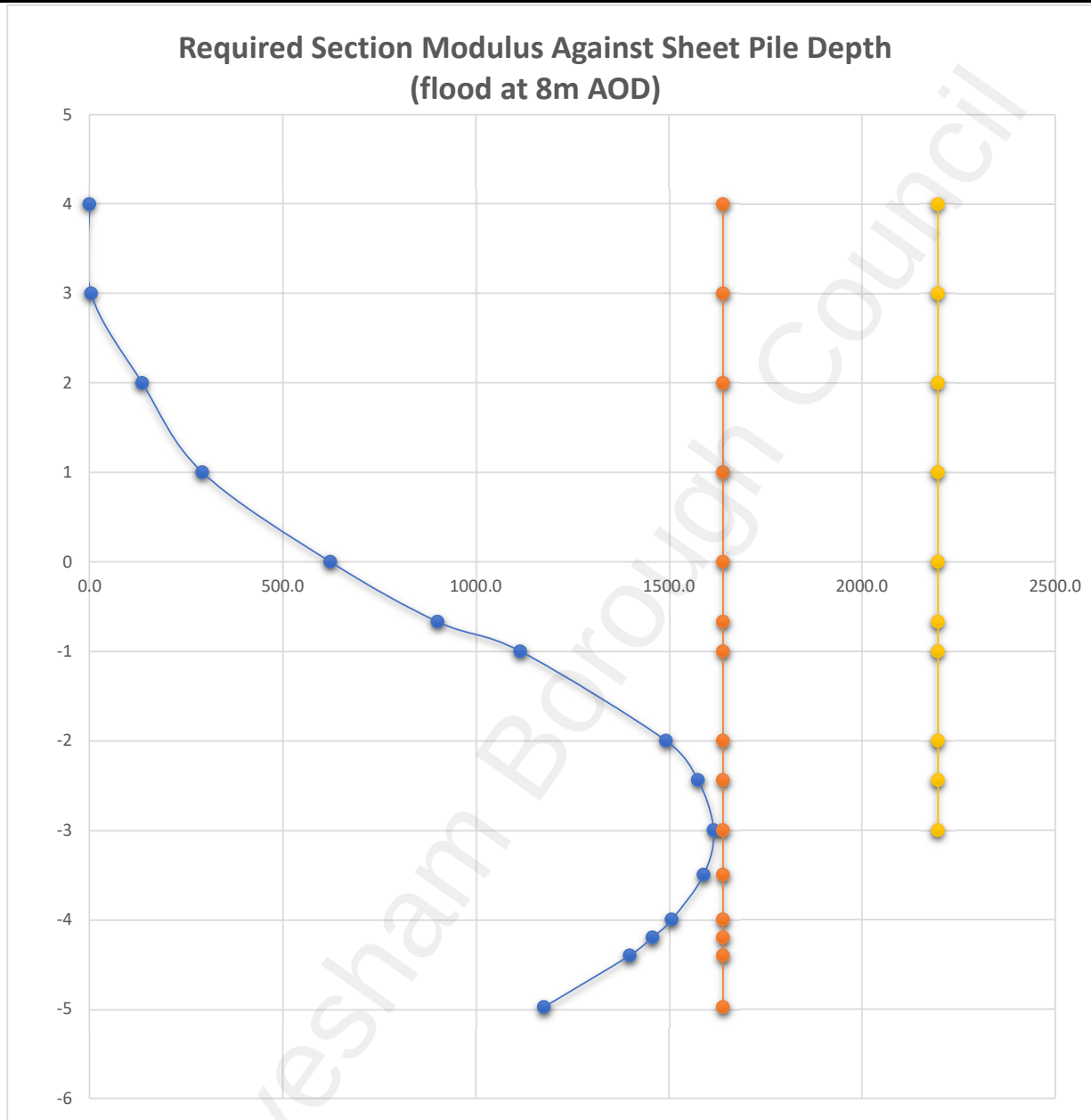


Sheet Number :

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Blue is the section modulus required

Orange is the remaining steel modulus without any measures after 100 years

Yellow line is the steel modulus protected by the concrete to reduce corrosion to 3m depth (additional capacity by concrete is not included)

In summary the sheet piled wall has enough capacity without further intervention, however to allow for assumptions and any irregularities additional capacity is conservatively provided

Steel Qualities

	Ultimate Stress	Minimum Yield Stress			Minimum Elongation on 200 mm	
		Up to and including 16 mm thick	Over 16 mm up to and including 25 mm thick	Over 25 mm up to and including 9 mm thick	Up to and including 9 mm thick	Over 9 mm thick
	kg/mm ² N/mm ²	kg/mm ² N/mm ²	kg/mm ² N/mm ²	kg/mm ² N/mm ²	%	%
BS.4360 (Mild Steel) Grade 43A	43.8/52.0 / 430 / 510	26.0 255	25.0* 245*	16	16	20
Medium Tensile Steel	52.0/60.2 / 510 / 590	31.5 309	29.9 293	16	16	20
BS.4360 (High Yield Steel) Grade 50B & 50C	51.0/63.2 / 490 / 620	36.2 355	35.2 345	15	15	18
Similar to ASTM—A328 or CSA G 40-7	49.2 min. 482.6 min.	27.0 265	27.0 265	—	—	17

Notes: COPPER BEARING STEEL—all the grades of steel are available with 0.20%–0.35% or over 0.35%–0.50% Copper.

* Section Larssen No. 6 (28.6 mm Web) Yield Stress = 24.5 kg/mm² = 240 N/mm²

Recommended Working Stresses for Steel Sheet Piling

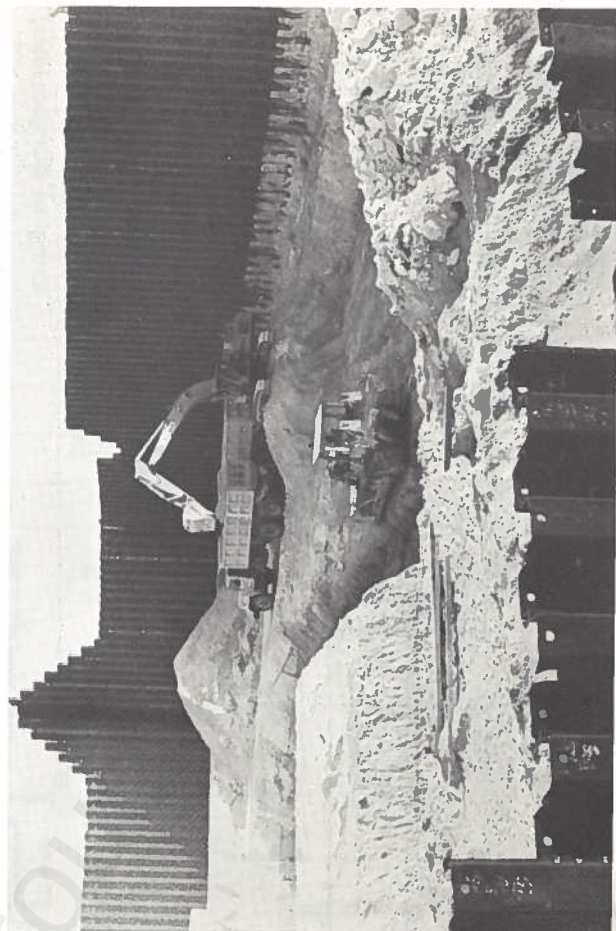
Class of Work	BS.4360 Grade 43A and 43A1 ASTM A328 and CSA G40.7 (Mild Steel)	Medium Tensile Steel	BS.4360 Grade 50B and 50C (High Yield Steel)
	kg/mm ² N/mm ²	kg/mm ² N/mm ²	kg/mm ² N/mm ²
Permanent	12.7 125	16.3 160	17.3 170
Temporary	15.8 155	19.9 195	21.9 215

Note: Stresses in temporary conditions occurring during construction may be varied at the discretion of the client's engineer.



Thames Tidal Defences
Consulting Engineer Sir Bruce White, Wolfe, Barry & Partners
Main Contractor French Kier Ltd (Contract No. 5) Swanscombe

Client Southern Water Authority



Sea Water Pumphouse Cofferdam, Jubail

Kong Yung Construction Co. Ltd

Location				Record of BOREHOLE 2 (sheet 2 of 2)			
Orientation				River Bed Level (m.O.D.) -1.65			
				Date commenced			
Depth (m)	Type	Casing Depth (m)	Water Depth (m)	Date and Depth (m)	DESCRIPTION OF STRATA	O.D. Level (m.O.D.)	Legend
1.0	C18	10.50					
1.1	3D						
2.0	C21	12.00			Fragmented and putty CHALK with flints. (Grade IV to V)		
2.00	BD						
3.0	C32	13.50		13.50		-15.15	
3.50	BD				Fragmented and putty CHALK with flints. (Grade II to III)		
4.0	D	15.00					
5.0	D						
			Tidal	16.00		-17.65	
6.0	D		Tidal	25/4			
6.50	S49	16.50					
6.50	BD						
8.00	D						
8.00	S80	18.00			Fragmented and putty CHALK with flints. (Grade II)		
8.00	BD						
9.50	D						
10.50	S71	19.50					
10.50	3D						
			Tidal	20.00		-21.85	
REMARKS				END OF BOREHOLE			
For explanation of symbols and abbreviations see Notes, pages (i) and (ii)							
B.S. Ref. No. 16720		GRAVESEND - CUSTOMS AND EXCISE JETTY				Fig. 2 (CONT'D)	
WIMPEY LABORATORIES LIMITED							

Shell and Auger				Location TQ 652 744		Record of BOREHOLE 2 (sheet 1 of 2)	
200 to 14.00m						River Bed Level (m.O.D.) -1.65	
150 to 20.00m						Date commenced 24.4.80	
200 to 14.00m							
150 to 20.00m							
Pilcon Hayfarer 20							
Casing and Tests		Casing Depth (m)	Water Depth (m)	Date and Depth (m)	DESCRIPTION OF STRATA		O.D. Level (m.O.D.)
2m (m)	Type				TQ 67 SE/278 652 744		
0.3	U	0.45	Tidal	24/4			
1.0	D						
1.15	D	1.50			Very soft black silty CLAY with occasional bands of grey fine sand		
1.50	BD						
3.00	U	3.00					
3.50	D			3.80			-5.45
4.50	C14	4.50		4.50	Fine to coarse GRAVEL with some brown silty clay		-6.15
5.00	BD						
6.00	C15	6.00			Medium dense, occasionally dense, brown sandy fine to coarse GRAVEL		
7.50	BD						
8.00	C23	7.50		8.00			-9.85
8.50	BD			8.50	Fine to coarse flint GRAVEL with fragments of chalk		-10.25
9.00	C19	9.00					
9.50	BD				(See sheet 2)		
REMARKS							
Height of Jetty above River Bed level = 6.00m.							
Date	Surface Water Level Below Top of Jetty		Date	Surface Water Level Below Top of Jetty			
14/4/80 am	2.30m		25/4/80 am	2.40m			
noon	5.30m		noon	4.50m			
pm	6.00m		pm	-			
Explanation of symbols and abbreviations see Notes, pages (i) and (ii)							
LAB Ref. No. 16720		GRAVESEND - CUSTOMS AND EXCISE JETTY				Fig. 2	
WIMPEY LABORATORIES LIMITED							

SCALE 1:50