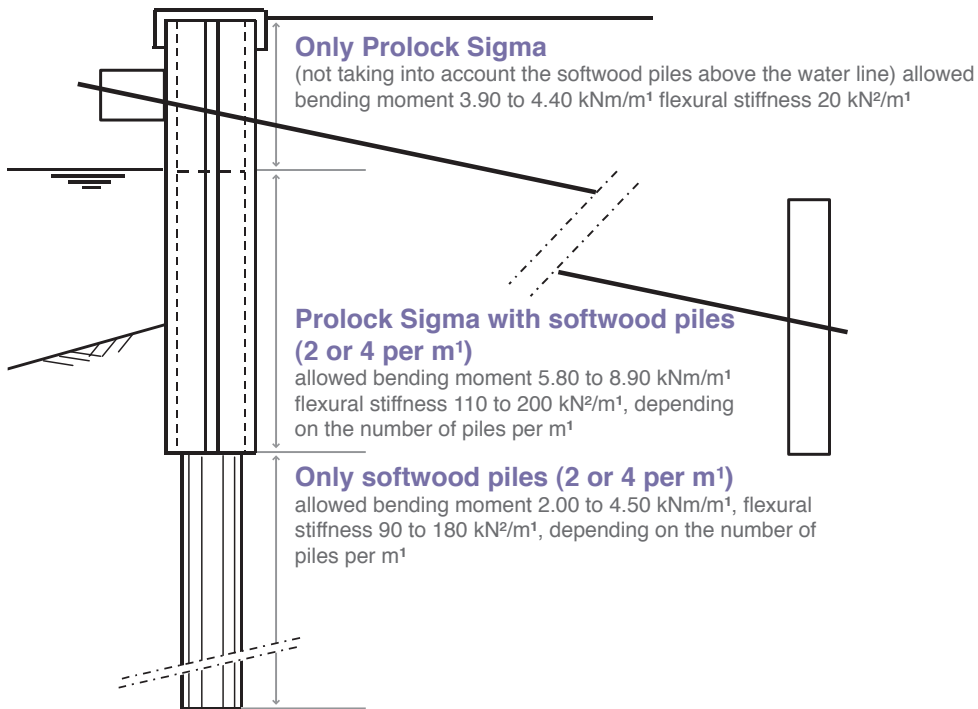


# Sigma

## Sustainable and environmentally friendly bank protection for ponds and ditches



### Constructional advantages

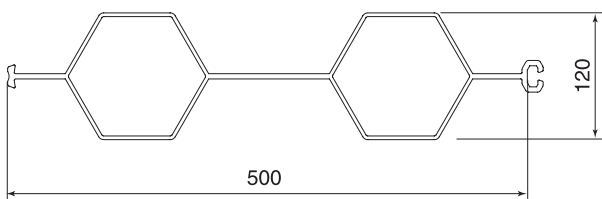
- sustainable above and below the waterline.
- where the most strength is needed, the piles and boards work together.
- it is easy to vary between 2 and 4 piles per m<sup>1</sup>, depending on the required strength; hardwood piles can also be used.



Prolock Sigma bulkhead			
flexural strength $f_{m, kar}$	60.0	N/mm <sup>2</sup>	
partial material factor $\gamma_m$	1.20		
modification factor $k_{mod}$	0.45 long term	0.50 short term	
flexural strength $f_{u, d}$	22.50 N/mm <sup>2</sup> long term	25.00 N/mm <sup>2</sup> short term	
section modulus	175	cm <sup>3</sup> /m'	
allowed bending moment	3.94 kNm/m' long term	4.38 kNm/m' short term	
elasticiteitsmodulus $E_{rep}$	2,300	N/mm <sup>2</sup>	serviceability limit state
modulus of elasticity $E_d$	697	N/mm <sup>2</sup>	ultimate limit state
moment of inertia	1,050	cm <sup>4</sup> /m'	
flexural stiffness EI	24	kNm <sup>2</sup> /m'	serviceability limit state
flexural stiffness EI	7	kNm <sup>2</sup> /m'	ultimate limit state

Wooden piling	Softwood	Softwood	Angelim	Angelim		
diameter	100	100	76	76	mm	
distance between piles	0.50	0.25	0.50	0.25	m	
round/square	round	round	square	square		
strength class	C18	C18	D50	D50		
flexural strength $f_{m,0,rep}$	18.0	18.0	50.0	50.0	N/mm <sup>2</sup>	
partial material factor $\gamma_m$	1.20	1.20	1.20	1.20		
modification factor $k_{mod}$	0.60	0.60	0.60	0.60		long term
modification factor $k_{mod}$	0.70	0.70	0.70	0.70		short term
modification factor $k_h$	1.08	1.08	1.00	1.00		
flexural strength $f_{u,d}$	9.76	9.76	25.00	25.00	N/mm <sup>2</sup>	long term
flexural strength $f_{u,d}$	11.39	11.39	29.17	29.17	N/mm <sup>2</sup>	short term
modulus of elasticity $E_{rep}$	9,000	9,000	14,000	14,000	N/mm <sup>2</sup>	serviceability limit state
modulus of elasticity $E_{rep}$	6,000	6,000	11,800	11,800	N/mm <sup>2</sup>	ultimate limit state
modulus of elasticity $E_d$	4,000	4,000	7,867	7,867	N/mm <sup>2</sup>	ultimate limit state
section modulus	196	393	146	293	cm <sup>3</sup> /m'	
allowed bending moment	1.92	3.83	3.66	7.32	kNm/m'	long term
allowed bending moment	2.24	4.47	4.27	8.54	kNm/m'	short term
moment of inertia	982	1,963	556	1,112	cm <sup>4</sup> /m'	
flexural stiffness EI	88	177	78	156	kNm <sup>2</sup> /m'	serviceability limit state
flexural stiffness EI	39	79	44	87	kNm <sup>2</sup> /m'	ultimate limit state
<b>Prolock Sigma bulkhead with wooden piles</b>						
section modulus	371	568	321	468	cm <sup>3</sup> /m'	
allowed bending moment	5.85	7.77	7.60	11.25	kNm/m'	long term
allowed bending moment	6.61	8.85	8.64	12.91	kNm/m'	short term
moment of inertia	1,006	1,988	580	1,136	cm <sup>4</sup> /m'	
flexural stiffness EI	113	201	102	180	kNm <sup>2</sup> /m'	serviceability limit state
flexural stiffness EI	47	86	51	95	kNm <sup>2</sup> /m'	ultimate limit state

<b>Steel tubular piles</b>						
pile diameter	88.9	88.9	88.9	88.9	mm	
wall thickness	3.00	3.00	4.85	4.85	mm	
round/square	round	round	round	round		
distance between piles	0.50	0.25	0.50	0.25	m	
steel quality	FeE235	FeE235	FeE235	FeE235		
calculated tension	235	235	235	235	N/mm <sup>2</sup>	
modulus of elasticity	2.1E+8	2.1E+8	2.1E+8	2.1E+8	kN/m <sup>2</sup>	
section modulus	33.6	67.3	51.1	102.1	cm <sup>3</sup> /m'	
allowed bending moment	7.91	15.81	12.00	23.99	kNm/m'	
moment of inertia	150	299	227	454	cm <sup>4</sup> /m'	
flexural stiffness EI	314	628	477	953	kNm <sup>2</sup> /m'	serviceability limit state
<b>Prolock Sigma bulkhead with steel tubular piles</b>						
section modulus	209	242	226	277	cm <sup>3</sup> /m'	
allowed bending moment	11.84	19.75	15.93	27.93	kNm/m'	long term
allowed bending moment	12.28	20.19	16.37	28.37	kNm/m'	short term
flexural stiffness EI	338	652	501	977	kNm <sup>2</sup> /m'	serviceability limit state
flexural stiffness EI	321	635	484	960	kNm <sup>2</sup> /m'	ultimate limit state



## Notes

- Maximum moments were calculated with the high flexural stiffness because this gives the highest moments.
- Short-term moments were used because the surface load can be considered short term.