INTERFACE BETWEEN SHIP AND QUAY

Simplified introduction



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During the planning phase of a port or a quay, it's important to plan both the layout, fendering, and mooring to cover all design situations that might arise. There are several parameters that need to be reviewed, and in some situations, you must make compromises to come to a solution.

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This document is intended to provide a general introduction to issues related to ports, with a focus on the interface between ships and the quay. The document provides a simplified version of functions and requirements that must be met for each quay to operate satisfactorily. The content presented is a general introduction to the issues that need to be detailed by qualified personnel with experience in the field. Nyvoll Consult AS is not responsible for the use of the contents of this document.



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1. Design Vessel

Ships come in different shapes and appearances depending on the function the ship is supposed to have or the cargo it will carry. When planning the quay and the port, you need to consider what types of ships which will call in and how often. It's completely possible for a ship that differs significantly from the design ship, both in shape, function, and size, to berth at a quay. For example, a ship with a deeper draft than the sailing depth of the quay, can berth at high tide, if the ship continues to sail while there is enough water depth. Furthermore, a ship that is not fully loaded can also berth if the draft is within the allowed depth at the quay structure. There are many examples of possible combinations of ships that can be allowed to arrive even if the ship doesn't fit within the criterions of the quay.

However, it is not practical to design a port or a quay for smaller or different types of ships than those expected to call, as this can lead to a lot of downtime. Therefore, it is important to get information about which ships are expected to arrive and have an idea of which ships might come in the future.

Many different ship designs will, in turn, lead to many design criteria that must be met, which again results in more complex designs and usually higher construction costs.

PIANV WG235 *Ships Dimensions and Data for the Design of the Marine Infrastructure* has conducted a comprehensive survey of different types of ships. Based on the existing fleet, experts have prepared tables of ship sizes based on various ship categories.

Displacement based on DWT:

Vessel Type	Mean Maximum Displacement (tonnes) Linear Formulae [2, 3]	Typical Variability [1]
General cargo	Displacement = 1.35 DWT + 200	12 %
Container	Displacement = 1.29 DWT + 1700	5 %
Cruise	Displacement = 0.50 GT + 1900	7 %
Dry Bulk	Displacement = 1.12 DWT + 3500	5 %
Oil Tanker	Displacement = 1.13DWT + 3800	5 %
Product tanker	Displacement = 1.17 DWT + 1300	5 %
Chemical Tanker	Displacement = 1.25 DWT + 450	6 %
RoRo	Displacement = 1.50 DWT + 1950	17 %
Vehicle Carrier	Displacement = 1.64 DWT + 2900	20 %
Refrigerated Cargo	Displacement = 1.50 DWT + 500	17 %
LPG	Displacement = 1.33 DWT + 5400	10 %
LNG	Displacement = 1.33 DWT + 1400	10 %
Ferry, RoPax, Fishing	No reliable formulae	-

Notes:
[1] Represents likely max error, however, there are some outlying values for unusual vessels. Accuracy typically improves with larger vessels.
[2] For upper bound values the mean displacement should be adjusted for the variability.
[3] Values based on summer seawater displacement.

Summary of PIANC Report WG235 Appendix A: Vessel Data Spreadsheet Tables

Nominal DWT (GT where noted)	Key Dimensions (Typical Ships)						Capacity & Displacement				Wind Area					Typical MBL (t) for bollard design (by WG 186)
	LOA (m)	L_{bp} (m)	B (m)	T_{max} Fully Laden (m)	Moulded Depth (m)	Air Draft (m) Ballast	Cargo Capacity Approx. (units as noted)	C_b Approx. Range	Displacem't Fully Laden (t)	Displacem't In Ballast (t)	Lateral Windage: Fully Loaded (m^2)	Lateral Windage: In Ballast (m2)	Approx. Centroid of area from stern (% LOA)	Longitudinal Windage: Fully Loaded (m^2)	Longitudinal Windage: In Ballast (m^2)	
									Don't use to calculate Cb							
Container Ships (Post-Panamax)							TEU									
240 000	400	393	61,2	17,0	33,2	no data	24 000	0,73	307 000	Variable use only port specific data	19 000	21 500	47% laden 48% ballst	3 400	3 750	155
225 000	400	383	61,0	16,5	33,2	76	23 700	0.70 - 0.72	285 000		18 000	20 500		3 200	3 550	155
200 000	400	383	58,8	16,0	30,2	70	20 000	0.69 - 0.71	265 000		16 500	19 000		2 900	3 250	145
185 000	400	382	54,0	16,0	30,2	70	19 000	0.65 - 0.75	243 000		15 000	17 800		2 700	3 100	145
165 000	366	350	51,2	16,0	29,9	70	15 000	0.69 - 0.73	211 000		14 400	16 700		2 550	2 900	130
150 000	369	352	51,0	15,6	29,9	66	14 000	0.67 - 0.71	195 000		13 700	15 700		2 350	2 750	130
130 000	348	331	45,2	15,5	29,7	62	11 500	0.68 - 0.73	172 000		12 200	14 700		2 150	2 450	130
120 000	337	321	48,2	15,5	27,2	62	10 000	0.66 - 0.72	160 000		11 700	13 700		2 000	2 300	119
110 000	300	286	48,2	14,5	24,6	59	9 000	0.65 - 0.71	145 000		10 900	12 900		1 880	2 150	119
100 000	334	319	42,8	14,5	24,6	59	8 700	0.61 - 0.73	136 000		10 000	12 000		1 750	2 000	119
90 000	316	302	45,6	14,5	25,0	57	8 500	0.59 - 0.73	123 000		9 100	11 000		1 650	1 900	119
80 000	304	292	40,0	14,0	24,2	57	6 800	0.59 - 0.70	108 000		8 200	10 000		1 550	1 800	119
70 000	280	266	40,3	14,0	24,1	57	6 000	0.61 - 0.68	96 000		7 500	9 200		1 450	1 650	83
65 000	255	244	37,3	13,9	22,0	55	5 500	0.65 - 0.69	88 000		7 100	8 700	45% laden 46% ballst	1 400	1 570	83
60 000	249	235	37,4	13,5	22,1	54	5 200	0.61 - 0.67	82 000		6 700	8 200		1 250	1 500	83
52 000	228	218	37,3	12,5	19,3	54	4 300	0.61 - 0.66	72 000		6 100	7 400		1 000	1 150	83

Note:
1) Container ships are generally constructed around a beam that is a function of the number of container widths (2.44m) stored across the ship from 4 wide at the smallest end up to 25 wide. Minor beam variations occur to some extent around design detail.

Note:
2) The TEU v dwt capacity (i.e. TEU per dwt) will vary with ship design, container stack height and stacking layout so some variations from the above figures will occur.

Container Ships (Panamax & smaller)							TEU									
65 000	294	283	32,26	13,5	21,8	55	5 000	0.67 - 0.71	88 000	Variable use only port specific data	7 100	8 700	45% laden 46% ballst	1 400	1 570	83
60 000	275	262	32,26	13,5	21,5	54	5 000	0.66 - 0.73	83 000		6 700	8 200		1 250	1 500	83
55 000	261	249	32,26	13,0	19,3	54	4 500	0.66 - 0.70	72 000		6 300	7 600		1 250	1 400	83
50 000	261	249	32,26	12,6	19,3	54	4 200	0.65 - 0.70	68 000		6 000	7 100		1 150	1 300	83
45 000	247	232	32,26	12,3	19,3	54	3 500	0.60 - 0.72	62 000		5 600	6 700		1 050	1 200	83
40 000	233	220	32,26	11,8	17,1	54	3 200	0.63 - 0.70	56 000		5 100	6 300		950	1 100	83
35 000	210	199	30,2	11,5	16,7	54	2 800	0.59 - 0.68	46 000		4 600	5 700		950	1 050	64
30 000	199	187	30,2	11,2	17,5	54	2 500	0.59 - 0.76	43 000		4 000	5 100		900	1 000	64
25 000	185	176	30,0	9,5	16,5	53	2 200	0.62 - 0.71	36 000		3 500	4 600		850	950	50
20 000	170	161	25,0	9,5	14,2	49	1 500	0.62 - 0.70	28 000		3 000	4 000		750	850	50
15 000	147	135	25,0	9,0	13,7	47	1 200	0.58 - 0.72	22 000		2 800	3 650		650	750	50
10 000	140	133	20,5	7,5	10,5	43	800	0.64 - 0.76	15 000		2 500	3 300		550	650	50
General Cargo Vessels							GT	Often not fully laden								
55 000	190	187	32,2	12,9	18,5	60	34 900	0,85	68 000	Variable use only port specific data						
50 000	204	194	32,2	12,7	19,0	60	37 500	0,83	68 000							
45 000	185	176	32,2	12,1	17,0	60	28 200	0,81	57 000							
38 000	190	186	28,5	11,0	15,8	60	26 600	0.77 - 0.87	53 000							
35 000	188	177	27,7	11,3	15,5	60	25 000	0.8 - 0.88	47 000							
30 000	193	182	27,8	11,2	15,5	60	23 200	0.73 - 0.83	42 500							
25 000	175	166	26,5	10,3	14,3	60	19 000	0.77 - 0.84	35 000							
18 000	157	148	22,8	10,3	14,0	60	16 000	0.67 - 0.81	29 000							
10 000	111	102	19,2	8,5	13,5	50	7 500	0.66 - 0.87	17 000							
5 000	101	95	16,2	6,4	8,2	46	3 500	0.70 - 0.88	7 500							
2 500	80	73	13,0	5,2	8,5	27	1 750	0.71 - 0.9	4 000							

General Cargo vessel topside wind areas vary with the purpose of the vessel. Total wind areas can be as low as the equivalent LOA geared bulk carriers or as high as the equivalent LOA container vessel.

It is recommended that specific data should be sort from the terminal operator.

Refrigerated Cargo							GT	highly variable at the smaller end								
22 000	190	180	30,7	10,5	15,5	43	21 500	0,64	38 000	Variable use only port specific data						
15 000	145	136	23,6	10,0	15,7	43	15 000	0.46 - 0.66	25 000							
10 000	152	139	23,0	8,7	13,0	43	10 500	0.55 - 0.65	17 000							
7 500	134	127	20,2	7,1	10,3	40	7 000	0.58 - 0.73	13 000							
5 000	121	113	16,6	6,9	10,0	31	4 500	0.56 - 0.74	11 000							
2 000	89	81	12,5	5,3	6,8	30	2 500	0.62 - 0.70	3 600							
1 000	85	76	13,0	4,3	6,5	no data	2 500	0.60 - 0.71	3 000							
500	67	61	11,5	4,0	6,0	no data	1 000	0.54 - 0.66	1 700							
Freight RoRo Ships							GT	Often not fully laden								
55 000	296	287	37,6	11,5	23,0	limited data	100 000	0,70	90 000	Variable use only port specific data						
45 000	240	220	37,5	11,5	20,0		Highly Variable	0.61 - 0.75	68 000							
30 000	236	222	36,2	9,8	13,9			0.64 - 0.71	53 000							
25 000	211	197	32,26	9,8	13,5			0.58 - 0.71	45 000							
18 000	205	190	25,5	8,5	15,7	53		0.60 - 0.73	37 000							
10 000	193	182	26,0	7,4	16,7	46		0.51 - 0.74	23 000							
5 000	142	133	23,0	5,7	16,3	38		0.54 - 0.71	11 000							
2 500	92	79	18,0	4,2	7,9	33		high variation	5 000							

Poor correlation with DWT, best estimated using GT

Refer Charts in Appendix B for details

Note: Many RORO ships also carry Containers or General Cargo to various degree's and others are

Nominal DWT (GT where noted)	Key Dimensions (Typical Ships)						Capacity & Displacement				Wind Area					Typical MBL (t) for bollard design (by WG 186)
	LOA (m)	L_{bp} (m)	B (m)	T_{max} Fully Laden (m)	Moulded Depth (m)	Air Draft (m) Ballast	Cargo Capacity Approx. (units as noted)	C_b Approx. Range	Displacem't Fully Laden (t)	Displacem't In Ballast (t)	Lateral Windage: Fully Loaded (m^2)	Lateral Windage: In Ballast (m2)	Approx. Centroid of area from stern (% LOA)	Longitudinal Windage: Fully Loaded (m^2)	Longitudinal Windage: In Ballast (m^2)	
									Don't use to calculate Cb							
Refer Note 5							Refer Notes 2,10 & 14				Refer Note 13					
Crude Oil & Larger Product Tankers (Shuttle Tankers similar)							t									
450 000	380	366	68,0	24,5	34,0	64	436 500	0,78	510 000	Typically about 50% of fully laden displacement	5 500	10 000		1 400	2 250	133
320 000	333	320	60,0	22,6	30,5	64	310 400	0.78 - 0.80	370 000		4 700	8 300		1 320	2 000	133
300 000	333	316	60,0	21,6	29,7	64	291 000	0.77 - 0.82	350 000		4 600	8 100		1 300	1 950	133
280 000	333	319	60,0	20,4	28,8	61	268 800	0.77 - 0.80	325 000		4 400	7 800	44% laden	1 270	1 900	133
193 000	288	274	50,0	19,6	28,0	61	185 280	0.79 - 0.81	230 000		3 700	6 300	47% ballast	1 100	1 650	133
165 000	274	264	50,0	17,1	23,1	50	158 400	0.79 - 0.81	190 000		3 400	5 800		1 050	1 500	133
150 000	274	264	50,0	16,0	23,2	50	142 500	0.75 - 0.80	177 000		3 300	5 500		1 030	1 450	103
115 000	250	239	44,0	14,8	21,0	50	109 250	0.78 - 0.81	135 000		2 900	5 000		970	1 300	100
100 000	248	238	43,0	13,5	19,8	50	95 000	0.78 - 0.79	120 000		2 750	4 600		930	1 250	100
70 000	228	219	32,2	13,6	19,8	50	65 800	0.81 - 0.84	83 000		2 350	3 900	43% laden	850	1 100	84
60 000	214	207	32,2	12,3	18,5	47	56 400	0.79 - 0.84	75 000		2 200	3 600	46% ballast	800	1 050	84
Product, Chemical and Dual Product Tankers (Similar characterist							t									
75 000	229	220	32,2	14,7	20,8	48	70 500	0.78 - 0.83	91 000	Typically about 50% of fully laden displacement	2 400	3 950		860	1 130	84
50 000	183	175	32,2	12,9	18,4	47	47 000	0.77 - 0.81	62 500		2 050	3 250	43% laden	770	950	82
40 000	182	174	32,2	11,0	17,3	45	37 500	0.76 - 0.79	52 000		1 950	3 000	46% ballast	680	870	82
30 000	177	168	29,0	9,5	14,0	45	28 000	0.67 - 0.78	38 000		1 800	2 700		570	750	77
20 000	164	154	23,0	8,5	12,7	45	18 500	0.72 - 0.79	26 000		1 400	2 000	41% laden	400	570	51
10 000	120	115	20,0	7,8	11,6	45	9 200	0.66 - 0.80	15 000		900	1 500	45% ballast	320	400	47
5 000	105	99	16,0	6,4	8,3	32	4 500	0.62 - 0.79	8 500		500	900	38% laden	250	300	43
3 000	89	82	13,0	5,5	6,5	28	2 700	0.64 - 0.84	4 500		400	600	42% ballast	230	260	43
Bulk Carriers							t									
400 000	360	353	65,0	23,0	30,4	63	384 000	0.83 - 0.84	450 000	211 000	4 400	9 700		1 450	2 400	130
325 000	333	327	60,0	22,7	29,8	63	312 000	0.82 - 0.87	380 000	188 000	4 300	8 700		1 400	2 200	130
300 000	327	318	55,0	21,6	29,3	63	288 000	0.79 - 0.87	340 000	168 000	4 000	8 500	44% laden	1 350	2 100	130
250 000	330	321	57,0	18,1	25,1	58	240 000	0.84 - 0.85	290 000	138 000	3 750	7 600	47% ballast	1 250	1 900	130
230 000	325	315	52,5	18,2	24,3	58	220 800	0.84 - 0.85	260 000	124 000	3 600	7 200		1 200	1 800	130
200 000	300	290	50,0	18,0	24,1	54	192 000	0.84 - 0.87	230 000	108 000	3 350	6 800		1 100	1 680	103
185 000	290	280	47,0	18,0	24,4	54	177 600	0.84 - 0.86	215 000	100 000	3 150	6 500		1 050	1 600	103
170 000	291	279	45,0	17,8	24,2	54	163 200	0.84 - 0.86	195 000	92 000	3 000	6 300		1 000	1 500	103
150 000	273	260	43,0	17,4	23,9	51	142 500	0.83 - 0.86	172 000	82 000	2 850	5 850		930	1 400	103
120 000	260	254	43,0	14,5	20,3	50	114 000	0.83 - 0.86	140 000	69 000	2 600	4 800		850	1 250	83
100 000	250	245	43,0	13,2	18,5	50	95 000	0.82 - 0.84	120 000	59 000	2 500	4 550	43% laden	800	1 100	83
100 000	240	236	38,0	14,5	20,0	50	95 000	0.82 - 0.86	110 000	59 000	2 400	4 550	46% ballast	700	1 000	83
85 000	229	225	38,0	13,5	19,1	49	80 750	0.81 - 0.89	95 000	48 000	2 300	4 100		750	1 050	83
80 000	229	222	32,2	14,5	20,1	49	76 000	0.87 - 0.89	95 000	46 000	2 150	4 000		730	1 000	75
70 000	225	215	32,2	13,3	18,5	48	65 800	0.83 - 0.85	80 000	41 000	2 100	3 800		700	950	75
60 000	200	195	32,2	13,0	18,6	48	56 400	0.84 - 0.86	72 000	36 000	2000**	3500**		650**	** These are ungeared areas. Add 15 to 20% of ballast wind area for wind area of	70
50 000	190	182	32,2	12,0	17,0	45	47 000	0.81 - 0.91	62 000	31 000	1900**	3300**		600**		70
40 000	180	177	30,0	10,7	15,0	45	37 200	0.81 - 0.86	50 000	26 000	1850**	3000**		550**		70
30 000	179	170	28,0	9,8	14,0	43	27 900	0.80 - 0.88	39 000	20 500	1700**	2700**		520**		60
20 000	155	144	23,7	9,2	13,0	39	18 200	0.79 - 0.88	26 000	15 000	1600**	2300**	41% laden	460**		60
10 000	114	107	19,4	8,0	10,4	35	8 900	0.76 - 0.84	14 000	9 000	1400**	1800**	45% ballast	400**		50
5 000	96	90	16,0	6,0	7,7	32	4 450	0.62 - 0.79	7 000	4 000	600**	900**		200**		50
LNG Carriers (All types)							m^3				LNG Wind Area is for "Membrane" type only. For "Moss" type refer Appendix B (data is limited)					
155 000	345	333	55,0	13,7	27,0	58	267 000	0,77	206 000	Typically about 80% of fully laden displacement	8 400	9 400		1 950	2 100	150
130 000	345	332	53,8	12,2	27,0	58	261 000	0,77	179 000		8 300	9 200		1 850	2 000	150
120 000	315	304	50,0	13,6	27,0	58	216 000	0,75	165 000		8 200	9 050		1 800	1 950	150
107 000	315	303	50,0	12,5	27,0	58	211 000	0,74	150 000		8 000	8 800		1 750	1 900	150
98 000	296	284	46,4	12,8	26,5	68	175 000	0.71 - 0.75	135 000		7 600	8 400		1 650	1 800	150
90 000	289	275	45,6	12,5	26,0	68	160 000	0.71 - 0.80	125 000		7 300	8 000		1 550	1 700	124
80 000	289	274	48,0	12,3	26,5	68	145 000	0.64 - 0.72	114 000		6 800	7 500		1 500	1 600	124
70 000	274	260	47,2	11,8	26,5	68	130 000	0.65 - 0.72	105 000		6 400	7 000		1 400	1 500	124
40 000	220	211	35,0	10,0	22,5	59	75 000	0,74	58 000		4 100	4 500		1 080	1 150	100
11 000	151	140	28,0	7,7	16,0	45	19 000	0.6 - 0.73	20 000		2 300	2 500		450	500	60
20 000	180	171	26,6	9,4	17,8	43	30 000	0,69	32 000							
10 000	137	127	19,8	8,3	11,5	38	16 500	0,70	16 500							
LPG Carriers							m^3									
64 000	228	217	36,0	13,6	22,6	55	90 000	0,74	85 000	Typically about 80% of fully laden displacement	3 550	4 100		960	1 050	
50 000	230	219	36,6	10,9	20,4	55	73 000	0.72 - 0.76	69 000		3 300	3 750		920	980	
43 000	205	195	32,2	11,9	20,8	55	59 000	0.72 - 0.75	60 000		3 100	3 550	45% to 50%	860	930	
30 000	182	172	29,4	10,4	18,0	55	37 000	0.71 - 0.76	42 000		2 650	3 000		770	820	
22 000	160	152	25,6	10,9	16,4	47	22 000	0.68 - 0.74	33 000		2 200	2 500		670	720	
10 000	120	112	19,8	8,8	11,2	41	12 000	0.68 - 0.75	16 000		1 350	1 550		450	480	
5 000	106	100	17,6	5,8	8,1	41	6 000	0.67 - 0.74	8 800		950	1 050	42% to 46%	340	360	
3 000	96	90	16,4	4,5	7,2	32	3 500	0.59 - 0.7	5 200		800	850		290	300	
1 000	65	60	11,0	4,2	5,1	24	1 500	0.57 - 0.68	2 000		600	650		230	240	

Nominal DWT (GT where noted)	Key Dimensions (Typical Ships)						Capacity & Displacement				Wind Area					Typical MBL (t) for bollard design (by WG 186)
	LOA (m)	L_{bp} (m)	B (m)	T_{max} Fully Laden (m)	Moulded Depth (m)	Air Draft (m) Ballast	Cargo Capacity Approx. (units as noted)	C_b Approx. Range	Displacem't Fully Laden (t)	Displacem't In Ballast (t)	Lateral Windage: Fully Loaded (m^2)	Lateral Windage: In Ballast (m2)	Approx. Centroid of area from stem (%LOA)	Longitudinal Windage: Fully Loaded (m^2)	Longitudinal Windage: In Ballast (m^2)	
									Don't use to calculate Cb							
Car Carriers	RORO only. This results significant variation in vessel parameters - GT and displacement. The values listed above are usual maximums ignore one-off special vessels.						CARS	Often not fully laden								
50 000	265	249	32,26	12,8	22,0	49	limited data	0,73	75 000	Variable use only port specific data	Poor correlation with DWT, best estimated using GT Refer Charts in Appendix B for details					75
40 000	245	226	32,26	11,8	32,5	49	limited data	0.68 - 0.73	70 000							75
30 000	231	219	32,26	11,3	34,7	49	8 000	0.61 - 0.68	55 000							70
25 000	230	224	32,26	10,3	35,1	48	8 000	0.57 - 0.72	48 000							73
20 000	200	189	35,40	10,0	33,0	48	7 500	limited data	42 000							70
	200	190	32,26	10,0	33,8	48	6 500	0.54 - 0.61								65
18 000	200	192	32,26	9,6	35,8	48	6 500	0.54 - 0.68	37 000							62
15 000	180	172	30,00	9,2	33,5	46	5 000	0.55 - 0.58	35 000							60
12 000	183	170	31,50	9,0	31,8	43	4 800	0.54 - 0.65	27 000							
7 000	140	131	22,70	7,4	23,3	limited data	2 200	0.51 - 0.61	16 000							
5 000	140	131	22,40	6,4	23,0	41	2 000	0.53 - 0.65	12 000							
2 500	116	108	17,20	5,1	12,0	40	800	high variation	6 500							
RoPax								Often not fully laden								
Ferries (Passenger vessels excluding cruise ships)																
GT							Passengers				Ferry designs are too variable to provide reliable area and shape parameters. Designers should seek specific information on vessel characteristics from terminal operators.					
14 000	147	130	23,4	5,9	13,4	No Reliable Data	1,500 - 3,000	0.56 - 0.60	11 000	Not Applicable						
6 000	100	91	18,0	4,2	9,4		1,000 - 1,900	0.53 - 0.67	5 000							
3 000	97	88	13,8	5,2	8,8		400 - 6,000	Values variable. Designers should seek specific data. If none available use Cb = 0.55 min								
1 000	66	58	10,0	3,0	4,1		400 - 2,000									
700	67	54	10,5	4,2	6,5		200 - 1,000									
400	49	42	11,5	2,5	4,0		150 - 600									
200	43	38	8,3	2,1	3,3		50 - 500									
Cruise Liners							Passengers									
GT																
225 000	362	331	47,0	9,3	22,6	70	5,000 / 6,500	0,71	105 000	Not Applicable	17 500	Not Applicable	Approx 50 % all cases	2 800	Not Applicable	
185 000	337	325	42,0	8,8	11,8	70	5,000 / 6,500	0,71	87 000		no data			no data		154
170 000	339	312	41,0	8,8	12,1	70	5,000 / 5,700	0,71	84 000							141
140 000	311	275	38,6	8,3	11,7	68	3,200 / 5,200	0.69 - 0.79	74 000		13 500			2 100		116
120 000	317	294	36,8	8,6	11,3	66	3,000 / 4,000	0.68 - 0.76	64 000		12 100			1 870		101
100 000	272	230	35,5	8,3	11,2	66	2,500 / 3,500	0.68 - 0.74	54 000		10 800			1 650		
80 000	281	258	32,26	8,0	20,1	66	2,300/3,200	0.66 - 0.70	45 000		9 200			1 450		
60 000	238	203	32,26	8,1	11,0	66	800/1,800	0.60 - 0.70	35 000		7 700			1 230		
40 000	210	177	28,0	6,8	8,8	66	600/1,800	0.60 - 0.71	26 000		6 000			1 030		86
30 000	181	158	25,5	6,0	18,1	66	400/1,000	0.59 - 0.68	20 000		5 200			900		75
20 000	167	147	24,0	6,6	13,5	66	200/1,000	0.53 - 0.67	15 000		4 200			800		
15 000	156	134	22,0	5,9	16,3	66	200/800	0.53 - 0.62	12 000		3 700			750		
10 000	133	112	19,0	5,0	12,4	65	200/800	0.52 - 0.68	9 000		3 300			700		
5 000	100	90	16,2	4,7	7,0	65	50/350	0.51 - 0.69	5 000		no data			no data		
2 500	97	78	14,9	4,9	8,5	58	50/200	0.40 - 0.81	3 200							
1 000	84	73	11,9	4,1	5,2	58	50/200	0.3 - 0.52	1 000							
Fishing Vessels > 200 GT (includes fish carriers but not specialist vessels such as factory ships, fishery patrol, research, seal catchers and the like)																
GT											Fishing Vessel designs are too variable to provide reliable area parameters. Designers should seek specific information on vessel characteristics from terminal operators.					
13 000	153	142	22,3	9,0	13,6	No Reliable Data	Not Applicable	0.57 - 0.68	21 000	Not Applicable						
9 000	108	100	21,0	7,3	8,4			limited data	16 000							
6 000	114	107	17,0	6,9	10,2			0.5 - 0.72	11 000							
3 000	92	80	15,2	6,5	9,4			0.48 - 0.7	6 000							
2 000	75	70	13,5	6,2	6,5			Values too variable. Designers should seek specific data								
1 500	65	60	13,0	6,4	8,3											
1 000	53	46	10,6	6,1	7,0											
600	54	46	10,4	5,1	7,1											
400	55	50	9,0	3,4	4,0											
300	47	43	7,8	3,3	3,6											
250	44	35	7,5	3,2	4,0											
200	38	32	8,3	3,7	3,9						Indicates data not available or in preparation					

2. Wind

Wind affects the ship both during arrival and when the ship is moored. The shape and size of the superstructure, in turn, influence how much load is applied to the ship.

During arrival, wind applies loads to the ship's superstructure, which can affect the ship's approach speed and direction. Especially near the quay, where the ship's speed is lower than the rudder's response speed, wind can significantly impact the approach. Normally, a wind gust needs to last a certain duration before it affects the ship. The smallest ships can be affected by a 10-second gust, while the largest ships need at least 30 seconds to be noticeably impacted. Limit values for wind during arrival are clarified, and the impact on berthing speed is considered as part of the design criteria.

The moored ship will also be affected by wind. Here, wind loads are transferred to fenders and/or mooring lines. Onshore wind will push the ship against the fenders, while offshore wind will put tension on the transverse mooring lines. Longitudinal wind on the ship will cause a combination of tension in the longitudinal mooring lines and friction against the fenders, as well as reaction pressure on the fenders due to the directional difference and offset between the longitudinal mooring lines and the wind direction.

The starting point for determining wind load is EN1991-4 Loads on structures, Part 1-4: General actions. Wind actions. The basic wind for the relevant municipality can serve as a possible basis for design, with the possibility of reduction when considering downtime of the quay.

The current wind speed at the location is determined and used for design. Data for the relevant ships, along with the areas of the superstructure, can be found in tables based on Lloyd's ship register. The size and shape of the design ship then give a Gust factor, which accounts for wind gusts of a certain duration and, in turn, gives the design wind load (q_b).

Often, a shape factor C_w of 0.9 is used for wind load on the ship's front and 1.3 for wind load on the ship's side. For intermediate directions, interpolation is used. The wind load for the specific ship is calculated against the front and side for both loaded ships and ships in ballast.

The wind load on the ship can basically be calculated using the formula:
$P_w = C_w \cdot [A_w \cdot \sin^2(\alpha) + B_w \cdot \sin^2(\alpha)] \cdot q_b$
α is the angle between the wind direction and the ship's longitudinal axis, while A_w and B_w are the projected side and front areas of the ship above water.

Wind loads are combined with current and waves as specified in standards and regulations that form the basis for design.

3. Current

Current affects the ship both during berthing and while moored. The shape and size of the hull, as well as the flow speed, will in turn affect how much load is applied to the ship. During berthing, the current applies loads to the hull, which can affect the ship's docking speed and direction. Especially near the quay, where the ship's speed is lower than the rudder's response speed, the current can significantly influence the berthing.

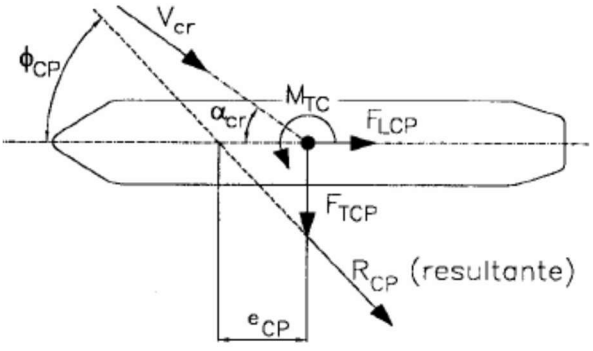
Current can decrease or increase speed along the ship's length or affect the ship's direction with sideways flow. Intermediate current directions also cause rotation. The maximum expected current speed during berthing is established, and the design current speed is set. Any differences between the design criteria and the expected intensity are clarified and included in the port regulations. If the expected upper current speed and the allowed upper current speed during docking differ, a flow meter should be installed to give a warning when the upper limit is approaching.

The moored ship will also be affected by the current. Here, loads are transferred from the current to fenders and/or mooring lines. A sideway current will push the ship against the fenders or put tension on the transverse lines. Current along the ship's length will cause a combination of tension in the longitudinal lines and friction against the fenders, as well as reaction pressure on the fenders due to the directional difference and offset between the longitudinal lines and the current.

Basically, there isn't general data on currents available, and these vary from place to place. During the planning phase, however, you can take some steps to reduce or map the effects of currents. Typically, the entrances to fjords are more exposed to tidal currents than the inner parts of the fjord. The intensity of currents also varies with tidal differences and local geography, like points or inlets, which affect the flow direction and can create turbulence. At river mouths, you need to be aware of the freshwater flow from the river, which usually runs along the surface with incoming flow direction in the deeper layers.

If possible, it’s recommended to be careful when building piers in river mouths and preferably to position the pier front parallel to the flow direction when constructing in the river current itself. Assistance from people with local flow knowledge under different conditions and seasons can be helpful. The pier’s layout and construction method can also be adjusted to provide optimal flow conditions for the finished project.

There are several types of formulas that can be used to calculate loads from current on ships.



The set of formulas may give very different results, and it's especially important to be aware of the limitations within the formulas before using them.

Limitations can be related to:

- ✓ Hull shape
- ✓ Water depth
- ✓ Valid range for flow speeds
- ✓ Directions

4. Waves

Waves put stress on ships and can reduce the port's operating time. It's common to place piers in sheltered areas where wave heights are minimized. Normally, waves cause less stress than wind and currents, but ship movement makes handling difficult and can lead to strong impacts directly on the fender.

A distinction is made between short-period waves, which are usually wind waves, and long-period waves, which can be described as swells. These can have very different effects on the ship.

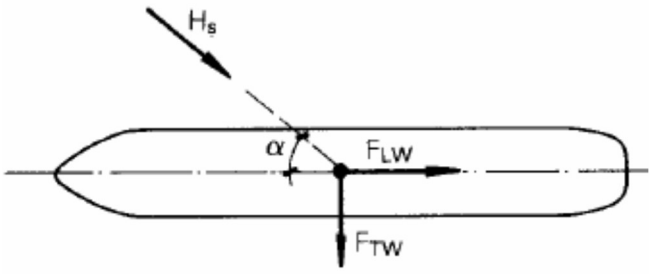
Short waves towards the bow or stern, usually put loads on the ship without causing significant movement, while short waves hitting the ship from the side can cause considerable rolling combined with vertical movement, without necessarily producing such large loads. Waves coming from intermediate directions will give a response that falls between the ones mentioned above.

Long waves coming toward the bow or stern can cause rolling along the ship's length or nearly vertical movements if the wavelength is much longer than the ship. Long waves hitting from the side usually cause vertical movement without much rolling. Long waves generally put less load on the ship than short waves, and waves from intermediate directions give a response that is between the responses mentioned above.

It’s worth mentioning that waves can be made up of both short and long waves coming from different directions, which can create a messy wave pattern and, in turn, cause unexpected movements of the ship.

Especially in areas with long-period waves, potential damage to fenders should be considered during the planning phase. Vertical movement of the ship combined with pressure against the fender can create loads greater than the fender’s resistance, causing the fender to come loose from the quay and/or damaging the fendering.

Generally, it’s recommended to place ports and quays in a sheltered area and to install breakwaters if needed.



Formula for calculating wave loads:

$$F_T = C_f \cdot C_d \cdot \gamma_w \cdot H_s^2 \cdot D' \cdot \sin\alpha$$

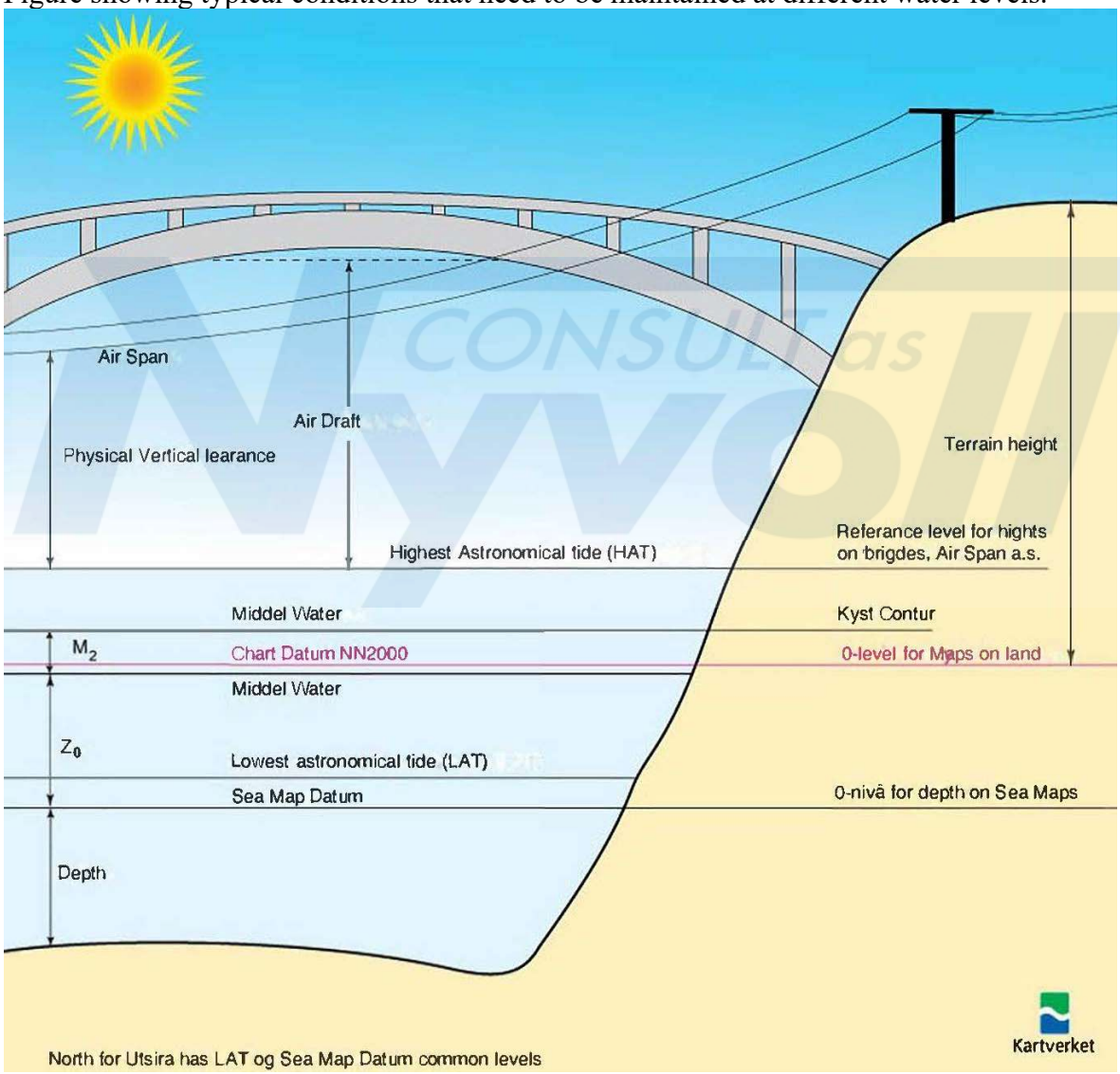
$$F_L = C_f \cdot C_d \cdot \gamma_w \cdot H_s^2 \cdot D' \cdot \cos\alpha$$

5. Water tide

Nautical charts and maps on land have different height references. While maps on land use elevation points that refer to NN2000, which is Norway's official height system with 0 elevation close to median sea level, nautical charts have a 0 point that refers to low water.

It's also worth noting that there are local reference systems for height levels around Norway. The relationship between nautical chart datum and NN2000 can be found at https://www.kartverket.no/en/at-sea/se-havniva for several water level gauges around Norway where the system chooses the nearest gauge, which is corrected according to local tide in each individual case.

Figure showing typical conditions that need to be maintained at different water levels.



Another important point is the clearance between the seabed and the ship. The requirements for free clearance can vary depending on the regulations being used, and there are also quite a few recommendations in the literature. For example, 5% of the ship's draft plus an addition for the hardness of the seabed can serve as a basis for the minimum depth at low water (LAT). For instance, 0.4m for sand/clay and 0.6m for harder materials like rock/bedrock can be used.

A ship with a draft of 10.0m would then require a depth at the quay of $10.0 \cdot 1.05 + 0.4 = 10.9$m at LAT in an area with a sandy bottom. It's worth noting that these values should be determined during the design phase and included as part of the port regulations so that arriving ships get exact and correct information before berthing.

The extension of any dredged area in front of the quay must also be larger than the ship. An extension of 1.25 times the ship's length and 1.5 times the ship's width nay be sufficient. The ship, of course, can only call and navigate when there is enough depth in the approach channel, and the dredged area only covers the necessary quay zone for the ship. When using tugboats and similar, the depth for these must be checked separately.

6. Accidental impact from Vessels

NS-EN1991-1-7:2006+NA:2008 may be used to set accidental impacts from ships (Norwegian text).

4.6 Ulykkeslaster forårsaket av skipstrafikk

4.6.1 Generelt

(1) Ulykkeslaster forårsaket av skipskollisjon bestemmes bl.a. ut fra følgende:

- type farvann;
- vannstandforholdene;
- fartøyenes type og dypgang og deres egenskaper ved støt;
- typen konstruksjoner og deres energiabsorpsjonsegenskaper.

(2) Typen skip på innlands vannveger som det skal tas hensyn til i tilfelle skipsstøt på konstruksjoner, bør klassifiseres etter CEMT-klassifiseringssystemet.

MERKNAD CEMT-klassifiseringssystemet er gitt i tabell C.3 i tillegg C.

(3) Egenskaper ved havgående fartøyer som det skal tas hensyn til ved støt fra skip på konstruksjoner, bør fastsettes.

MERKNAD 1 Det nasjonale tillegget kan angi et klassifiseringssystem for havgående fartøyer. Tabell C.4 i tillegg C gir en veiledende klassifisering av slike skip.

MERKNAD 2 Informasjon om sannsynlighetsteoretisk modell for behandling av skipskollisjon finnes i tillegg B.

(4) Der dimensjonerende verdier for laster forårsaket av støt fra skip bestemmes med hjelp av nøyaktigere metoder, bør det tas hensyn til virkningene av hydrodynamisk tilleggsmasse.

(5) Påvirkningen forårsaket av støt bør gis ved hjelp av to krefter som gjensidig utelukker hverandre:

- en frontalstøtkraft F_{dx} ;
- en tverrstøtkraft med en komponent F_{dy} som virker vinkelrett på den frontale støtkraften og med en friksjonskomponent F_R som er parallell med F_{dx}.

(6) Konstruksjoner som dimensjoneres for å tåle støt fra skip under normale driftsforhold (f.eks. kaivegger og fenderverk) omfattes ikke av denne delen av NS-EN 1991.

If fender systems are designed to absorb impacts from ships under normal operational conditions, this part of NS-EN 1991 don't have to be into account. In practice, this means that a quay structure with documented absorption of the berthing energy from the design ship in the fender system and the underlying structure doesn't have to, but can be, designed to absorb accidental impact loads from ships.

Impact loads beyond normal berthing should be determined in cooperation between the consulting engineer and the client and are handled in the accidental limit state as the dominant accidental load.

7. Berthing Energy, Berthing Speed and Fender Reaction

When berthing, the ship has a certain speed [v] when it gets in contact with the fender, and this speed must be reduced towards 0 before the fender has reached its maximum energy absorption. As the fender deforms inward, kinetic energy is transformed into potential energy and partly into heat. The potential energy generates an inward reaction force that needs to be absorbed by the quay structure behind it, while the heat energy is vented out of the fender before the next docking.

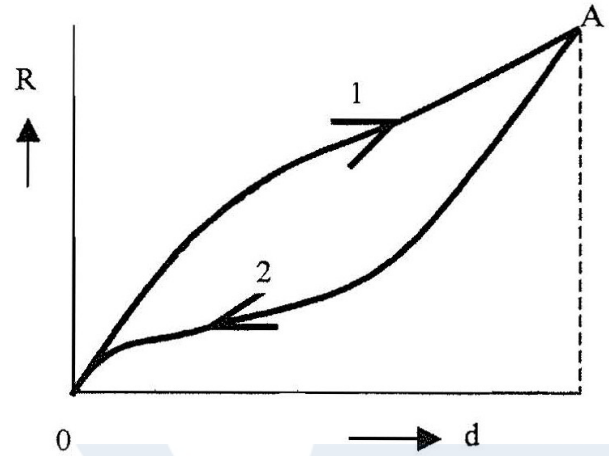


Figure showing the principle of force and deformation progression for a fender during impact. Curve 1 shows the reaction during impact and curve 2 shows the reaction from the fender as it straightens out again. The area in between represents the absorption of thermal energy.

Formula for characteristic energy intake during a berthing operation (Modifies Newton):

$\mathbf{E_c = ½ \cdot c \cdot m \cdot \delta v^2}$

c is the approach coefficient, and v is the ship's relative speed towards the quay front when touching the fender.

m = ship's displacement (total weight) which can be found in chapter 1 of this document.

Berthing coefficient **C** is a combined constant that consists of contributing hydrodynamic mass and eccentricity (rotation) between the ship's centre of mass and the point on the hull in contact with the fender.

$\mathbf{C = C_H \cdot C_E}$

Surcharge for hydrodynamic mass $\mathbf{C_H}$ consists of water that the ship has set in motion. Like the ship, this mass of water must also be brought to a complete stop. The formula for calculating virtual participating mass, can be found in PIANC WG211 *PIANC Fender Guidelines 2024*.

Anbefalte verdier i PIANC WG211 *PIANC Fender Guidelines 2024*:

- ✓ C_H = 1,5 with a greater average clearance under the keel than 50% of the ship's draft.
- ✓ C_H = 1,8 with less average clearance under the keel than 10% of the ship's draft.
- ✓ Upper values apply for sideways docking, and intermediate values are interpolated.
- ✓ C_H = 1,1 for longitudinal berthing.

Eccentricity factor. $\mathbf{C_E} = (K^2+R^2 \cdot \cos(\phi)^2)/(K^2+R^2)$ where R = distance from the ship's center of mass to the contact point with the fender and $K = (0.19 \cdot C_b + 0.11) \cdot L$ is the ship's radius of gyration. ϕ is the angle as shown in the sketch below. The eccentricity factor accounts for the transfer of the ship's approach speed to rotation after the first contact with the fender. It should be noted that the ship's rotation will also result in a second contact, which in field measurements has sometimes produced a higher impact energy than the first contact.

$C_b = M_{disp}/ (\rho \cdot L \cdot B \cdot D)$. (block coefficient that indicates the shape of the hull, which can vary from somewhat rectangular like a modern cargo ship to streamlined like on older cruise liners).

Choosing the right design approach speed is the most uncertain part of a ship approach. A ship arriving without assistance from a tug and/or thrusters usually has a forward speed in addition to the approach speed towards the quay, while the forward speed for ships docking with tug assistance is stopped completely before the first contact with the fender. Since it is the square of the approach speed that affects the energy, you can see that a small increase in approach speed results in a significant increase in approach energy.

Table showing the increase in energy with increasing or decreased design berthing speed.

V_0	0,10 m/s	0,12 m/s	0,15 m/s	0,20 m/s	0,25 m/s
0,10 m/s	100 %	144 %	225 %	400 %	625 %
0,12 m/s	69 %	100 %	156 %	278 %	434 %
0,15 m/s	44 %	64 %	100 %	178 %	278 %
0,20 m/s	25 %	36 %	56 %	100 %	156 %
0,25 m/s	16 %	23 %	36 %	64 %	100 %

There are several tables and recommendations for choosing design approach speed, and these can vary quite a bit depending on the type of ship and who issued the recommendation.

PIANC WG211: *PIANC Fender Guidelines 2024* gives the following recommendation:

Navigation Condition:	Favourable	Moderate	Unfavourable
Type of Vessel[a]	$V_{B.c}$ (m/s)		
Coaster	0.180[f]	0.300[e]	0.400[e]
Feeder, Handysize	0.150[b]	0.225[c]	0.300[d]
Handymax, Panamax	0.120[b]	0.200[e,g]	0.275[d]
Vehicle Carriers	0.120[e]	0.200[e]	0.275[e]
Post Panamax, Capesize (small), Aframax	0.100[b,e]	0.175[c]	0.275[d]
New Panamax, Capesize (large), Suezmax, ULCV, VLBC, VLCC, ULCC	0.100[b,e]	0.150[c,f]	0.250[d]
Cruise & Passenger Vessels	0.100[e]	0.150[e,f]	0.250[e]

a. Typical vessel dimensions: Coaster (5,000-15,000 DWT), Feeder, Handysize (15,000-42,000 DWT); Panamax, Handymax (42,000-85,000 DWT); Post Panamax, Capesize, Aframax (85,000-115,000 DWT); New Panamax, Capesize, Suezmax (115,000-170,000 DWT); ULCV, VLBC, VLCC, ULCC (>170,000 DWT). For vessels not listed in the table (e.g. LNG) use equivalent size. Although most gas tanker owners have their own global data set.
b. These recommended berthing velocities are largely based on field measurements in Rotterdam and Wilhelmshaven, (PIANC WG145, 2022), (Roubos, Gaal, Hein, Iversen, & Williams, 2022).
c. These recommended berthing velocities are largely based on the normal navigation conditions distinguished by PIANC WG 145 (PIANC WG145, 2022) and verified by WG 211 against new data sets from Poland, Korea, US and India.
d. These recommended berthing velocities are largely based on the measurements conducted in Bremerhaven, (PIANC WG145, 2022), (Roubos, Gaal, Hein, Iversen, & Williams, 2022).
e. These recommended berthing velocities are based on interviews with masters, pilots, harbour masters and experienced port engineers. The values are based on comparison with similar vessel sizes.
f. These recommended berthing velocities are based on EAU 2012 and ROM 2.0-11 (2012).
g. Some unpublished berthing records, of berths claiming to be moderate, include slightly higher velocities. BS6349 and WG 211 consider this value to be sufficient for the majority of berths.

The final choice of design approach speed is based on an assessment of factors affecting the approach and is made in collaboration between the consulting engineer and the port authority.

Design Energy is found by multiplying the characteristic energy with a safety factor.

$\gamma_E = \gamma_{E,ref} \cdot \gamma_n \cdot \gamma_p \cdot \gamma_c$

$\gamma_{E,ref}$ is a reference factor based on local port conditions, variation in the berthing vessels, and consequence classes.

γ_n takes into account the number of annual calls. A higher number increases the likelihood of exceeding reference values.

γ_p takes into account the use of a pilot or whether the captain is familiar with local conditions.

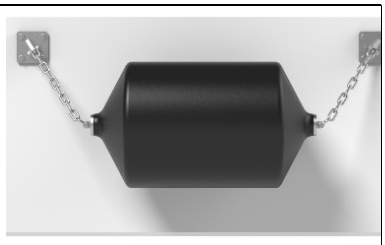
γ_c takes into account whether there correlations that suggest the safety factor can be reduced.

8. Fender Systems (PIANC WG211)

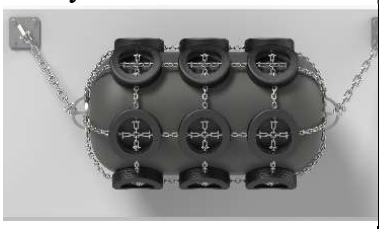




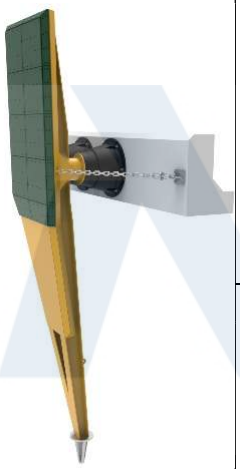




Luftfylt Fender



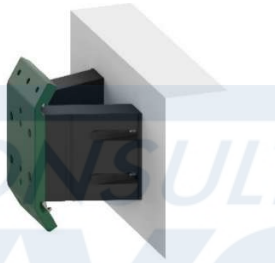
Pile/Pivot Fender



Element/Leg fender



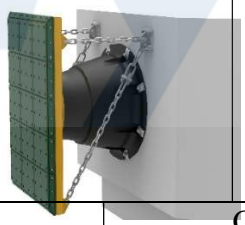
Spesial Element fender



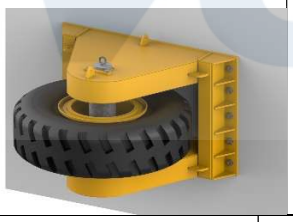
Sylinder Fender



Konisk Fender



Rulle Fender



Konisk Fender



Size: H 300 – 2500mm
E: ~ 10 – 9500 kNm
R: ~ 55 – 7200 kN

Cell Fender



Size: H 400 – 3000mm
E: ~ 10 – 9800 kNm
R: ~ 50 – 8850 kN

El[illegible]ler



Size: H[illegible]00mm
E: ~ 10 – 1300 kNm
R: ~ 80 – 1750 kN

Arch Fender



Size: H 150 – 1000 mm
E/A: ~ 5 – 450 kNm/m
R/F: ~ 90 – 1050 kN/m

Skumfender



Size: Ø 700 – 3300 mm
L 1500 – 6500 mm
E/A: ~ 30 – 2450 kNm
R/F: ~ 130 – 2750 kN

Luftfylt Fender



Size: Ø 500 – 4500 mm
L 1000 – 12000 mm
E/A: ~ 10 – 9050 kNm
R/F: ~ 90 – 10500 kN

Application of fender systems for various vessel types (WG211):

Vessel Types \ Fender System Types	Arch	Cell	Cone	Cylindrical	Donut	Element	Extruded	Foam	Hydropneumatic	Parallel Motion	Pile	Pneumatic	Roller	Wheel
Bulk Carriers	O	●	●	●		O				O	●			
Car Carriers		●	●	O		●				O	O			
Container Vessels	●	●	●	●		O					●			
Cruise Vessels		●	●	O		●		●	●		O	●		
Fast Ferries		●	●			●				O	O			
Fishing Vessels	●			O							●			
Gas Carriers		●	●	O		O		O	O	●	●	O		
General Cargo	●	●	●	●		●		O	O		O	O		
Navy Surface Ships	O	●	●	O		●	O	●	●		O	●		
RoRo Ferries		●	●	O	O	●	O			●	●			
Submarines	O				O				●		O			
Tankers	O	●	●	●		O		O	O	●	●	O		

● Generally considered suitable for this vessel type.

O Suitable for some vessels. Potential limits to be considered.

Generally not considered suitable for this vessel type except in special applications.

The choice of fenders varies depending on the size of the ship, approach speed, water level, belting, etc. Choosing the right fenders for the quay is an important task. Basically, there are two different types of fendering: berthing fendering and protective fendering. Berthing fendering is meant to absorb the berthing energy from the ship and transfer reactive loads to the quay structure, while protective fendering is intended to prevent direct contact between the hull and the quay.

Since ships can berth in a variety of ways, it's common to use berthing fenders along the entire length of the quay, while corners, mooring dolphins, and similar areas that ships generally shouldn't touch are protected with protective fenders. A properly designed berthing fender will generally also serve as protective fendering. Usually, protective fenders aren't designed to absorb the berthing energy of the design ship.

A berth fender must be chosen to accommodate different types of ships with varying load levels that call at different water levels. The fender panel or fender face must have enough surface area so that the ship side's compression capacity is not exceeded. Some ships have a fender strip, so it's important to ensure a vertical fender face, especially with frequent calls. Here, a torsion fender could be the solution, but this type of fender is among the most expensive.

Another issue to consider is that the fender strip can ride over or hook under the fender panel and damage the fender. Sufficient height on the fender face and/or beams at the top and bottom can solve this.

Frequent berthing requires more robust fenders.

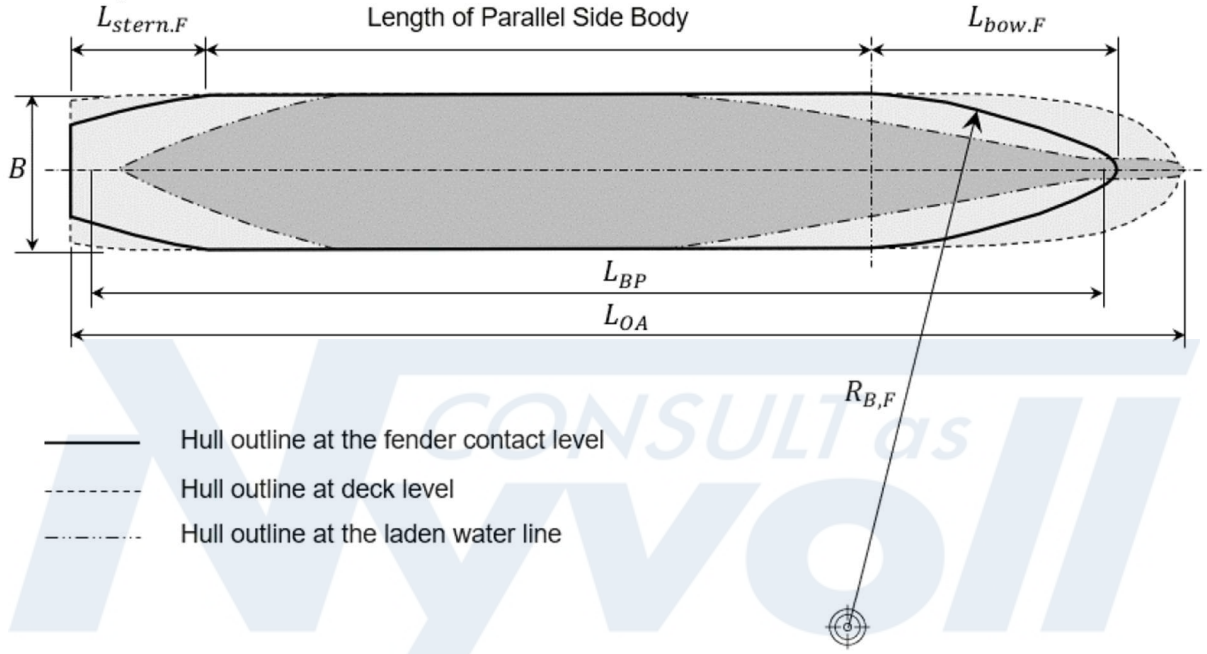
The maximum distance between fenders also needs to be calculated. This varies with the fender's construction height above the quay front and the shape of the ship's hull.

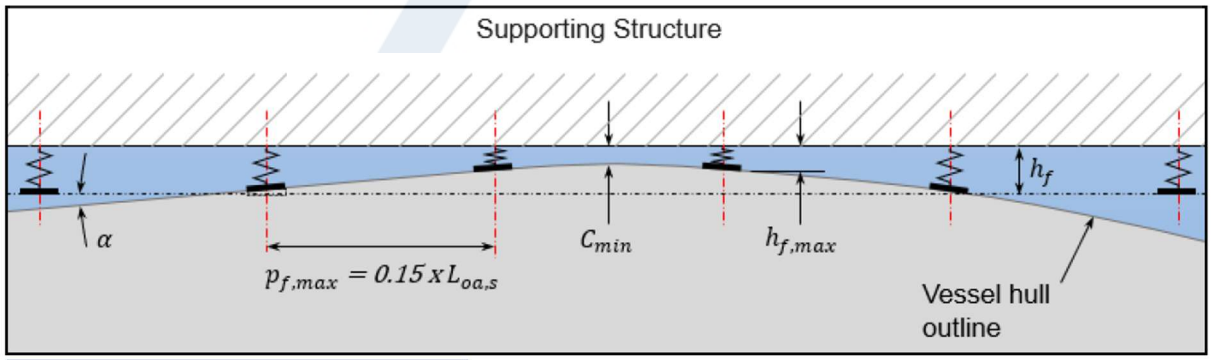
PIANC WG211 *PIANC Fender Guidelines 2024* gives the following:

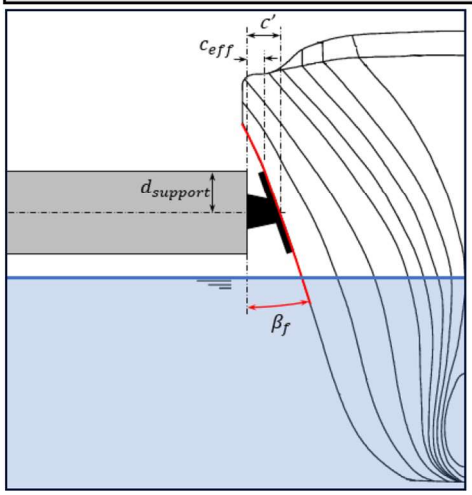
$$p_{f,max} \leq 2\sqrt{R_B^2 - (R_B - h_{f,act} + c_{min} + (d_{support} \tan \beta_f))^2}$$

$$R_{B,F} \approx \left(\frac{B}{4} + \frac{L_{bow,F}^2}{B}\right)$$

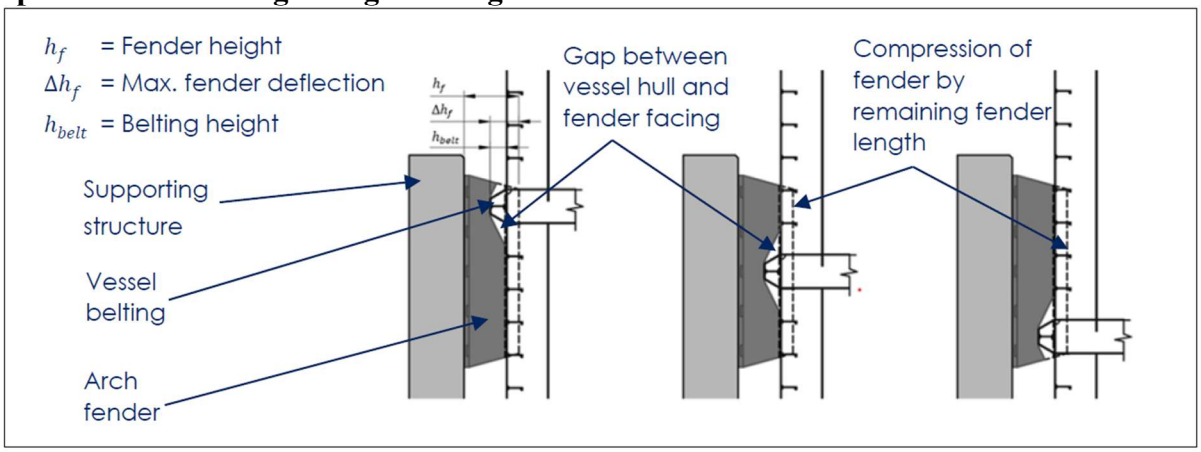
Radius og the vessel's hull are often not known can be difficult to determine.







Special situations regarding Belthing.



NOTE!

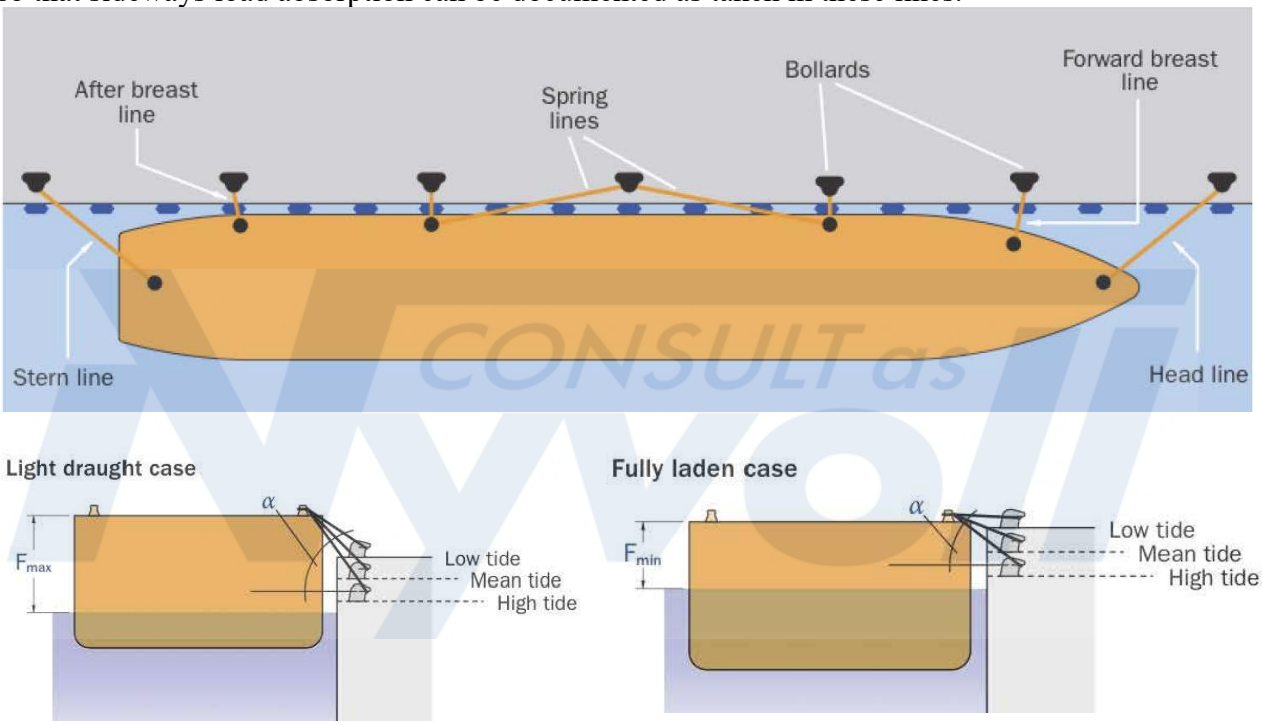
This document describes a very simplified approach to the design of fender systems and factors that need to be considered. This basis is not sufficient to design a fender system and does not provide a complete overview of the factors that must be taken into account.

Generally, it is recommended to leave the design of fender systems to experts with in-depth knowledge of all the factors affecting the fenders.

9. Mooring

Mooring of ships should be performed according on the loads as specified earlier in this note. You need to pay special attention to the angles of the mooring lines both horizontally and vertically in relation to the direction of the applied load. The vertical inclination of the lines can vary depending on the ship's load situation, water level, and the height difference between bollards at the quay and the mooring points on the ship. For transverse lines, the horizontal distance from the ship to the bollard is very important for the effect of the force direction. A large distance from the ship to the bollard reduces angular capacity loss in the line.

The picture shows a typical mooring of a vessel. The use of a headline and stern line may vary and is not considered necessary to the extent that the vertical angle for breast lines is limited so that sideways load absorption can be documented as taken in these lines.



Det finnes også flere varianter av pollere



The picture shows 3 types of bollards provided by Trelleborg. The size ranges from 15T to 200T, with a possible size up to 300T for the bollard on the left. Other suppliers offer similar sizes of bollards.

The size of bollards in relation to the design ship and applied loads can also vary. For cargo ships and tankers, the table below can serve as a starting point, while ships with a large wind profile usually require bigger bollards relative to the ship's displacement. If multiple lines are allowed to be used on the bollards, larger bollards than what the table shows may also be needed.

Displacement	Bruddlast
20,000	60
50,000	80
100,000	100
200,000	150

Mooring lines can consist of ropes or wires in different sizes. The normal capacity is up to 80 tons, and you can often place up to two lines on each bollard. Recently, Dyneema lines have also become available, offering high strength and low weight. It's up to the ship's captain to moor the ship, so mooring lines won't be covered in more detail here.

10. Ro-Ro ramps and passengers

If there is a need to move goods or vehicles directly between land facilities and ships, a RoRo-ramp can be built. It's important that this ramp is adapted to the vehicles or types of transport according to design specifications.

Transition zones shouldn't be too tight, so there's enough clearance between the vehicle and the surface. Trucks can usually handle a slope of 1:10, while many cars struggle with anything steeper than 1:12. If steeper ramps are used, levelling zones can be added. The length of the ramp needs to account for both local tidal variations and the ship's load conditions. Especially for ships in shuttle traffic, like ferries with frequent departures, they must be able to operate under all water levels and load situations.

RoRo-Ramps for heavy cargo with low cargo frequency aren't subject to special requirements beyond making sure the transport equipment can use the ramp. A starting point of a 1:12 slope works in most cases, but this needs to be specified in the design phase. For individual cases and existing ramps, it's also possible to ballast the ship so that the cargo deck height matches the ramp as well as possible.

Passenger tubes need to be designed according to universal design requirements. Especially in cases with large tidal differences and/or big variations in the ship's draft, long ramps might be needed. Current requirements in the Planning and Building Act must be identified and followed during the design phase.