TABLES

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Table 1 General Characteristics of Waves Generated by Various Types of Vessels

Vessel Types	Wave Characteristics
Monohull passenger ferries	◆ They generate various intensities of water waves. Fast vessels with powerful engines generate strong waves which propagate over a relatively large area. Double or triple deck passenger ferries sailing at relatively low speed generate insignificant waves which attenuate to the background water level quickly after their formation.
Hover ferries	◆ These vessels, which float over water on a cushion of air, have a shallow draft and travel at high speed. The waves generated are strong and have dominant diverging wave groups which can propagate over long distance.
Catamaran ferries	◆ These vessels, with two parallel hulls coupled by a single deck, are designed for high speed navigation and are equipped with powerful turbo engines which can drive the vessels to over 40 knots. High speed results in predominant diverging wave groups in catamarans' wave system propagating away from long breaking wakes and covering a very large area.
Hydrofoils	◆ The hulls of the hydrofoils are separated from the water surface under normal cruising. As such, hydrofoils do not generate strong waves because of the small resistance on the supporting wings. However, during departure from and arrival at a pier, the hulls are not separated from water and waves generated by hydrofoils in such conditions are very strong. Hence, in the neighbourhood of piers used by hydrofoils, waves generated by hydrofoils make a substantial contribution to the local wave field.
Tug boats	◆ Tug boats are of wide beam, deep draft, and are usually equipped with powerful engines ranging from a few hundreds to over a thousand horse power. Unloaded, full speed tug boats generate strong waves which affect moving vessels in the surrounding area. Waves associated with tug boats consist of significant transverse waves and diverging waves with large waves occurring around the boundary of the wave propagation wedge.
Derrick lighters/barges	◆ Cargo or containers are transported by lighters or barges with derricks towed by a tug boat with low navigation speed. Waves generated by these vessels are normally not significant to the wave field in the harbour.
Ocean-going containers	◆ Ocean-going container ships approach the port of Hong Kong mostly at the eastern and western ends of the harbour. The speeds of these vessels are low and the vessel-generated waves are relatively small in comparison to the waves due to normal cruising in the ocean. Waves due to ocean-going container ships do not affect the harbour wave field significantly.
Self-powered river trade vessels	◆ A wide variety of vessels characterized by types, speeds, sizes and displacement for cargo transportation are operated in the harbour. They generate waves with different propagation patterns. For cargo vessels navigating at low speed, waves generated usually make only a temporary contribution to the wave field in the harbour.
Service and engineering launches	◆ These vessels include police boats, fire-fighting boats, pilot boats and various other utility crafts. Most of them can generate significant waves because of their speeds.

Table 2 Comparison of Solid Piers and Piled Deck Piers

	Solid Piers	Piled Deck Piers
Construction Period	◆ Shorter usually	◆ Longer
Construction Cost	◆ Lower usually	◆ higher
Environmental Impact	◆ sediment plume generated if foundation is dredged and flow circulation affected	◆ noise generated during piling
Operation	◆ vessel berthing affected by wave reflected from vertical face; wave absorbing device may be provided to reduce reflection	◆ no operation problem from wave reflection
Maintenance	◆ low maintenance	◆ significant maintenance for reinforced concrete and piled foundation

Table 3 Comparison of Fendering Systems

	Timber fenders	Plastic fenders	Rubber fenders
Strength	◆ low strength ◆ moderate abrasive resistance	◆ strength similar to timber ◆ high abrasive resistance	◆ strength designed to specific requirements ◆ high abrasive resistance
Durability	◆ subject to rotting, marine borer attack ◆ cracks will develop in insufficiently seasoned timber	◆ resistant to most biological and chemical attack, ultraviolet exposure and corrosion ◆ longer service life than timber fenders	◆ resistant to most biological and chemical attack, ultraviolet exposure and corrosion ◆ longer service life than timber fenders
Energy absorption capacity	◆ low energy absorption capacity ◆ high contact pressure	◆ moderate energy absorption capacity ◆ high contact pressure	◆ moderate to high energy absorption capacity
Environment	◆ consumption of tropical hardwood	◆ use of recycled material, more environmentally friendly	◆ use of natural/synthetic rubber, more environmentally friendly
Cost	◆ lower initial cost but higher maintenance cost	◆ higher initial cost but lower maintenance cost relative to timber fenders	◆ higher initial cost but lower maintenance cost relative to timber fenders
Supply	◆ specific hardwood to meet the strength requirements.	◆ plastic fenders with or without fibre glass reinforcement available	◆ a wide range of products available

Table 4 Specification of Rubber Fenders

Property	Value	Test method and condition Part No. of BS 903
Density	1100 to 1300 kg/m³	Part A1
Hardness (International rubber hardness degrees)	≤ 72	Part A26 Method N
Tensile strength	≥ 16 N/mm²	Part A2
Elongation change	≥ 350%	Part A2
After accelerated air ageing test: Hardness (increase in IRHD) Reduction in tensile strength Reduction in elongation	 ≤ 8° ≤ 20% ≤ 20%	 Part A19 Method A at 70°C x 96 hours
Oil resistance (measured by volume change percentage) : Industrial gasoline Heavy oil	 ±60% ±20%	 Part A16 at 23°C x 22 hours
Compression set	≤ 30%	Part A6 Method A At 70°C x 22 hours Using Type 2 test pieces
Ozone resistance	no crack visible	Part A43 at 40°C x 100 hours
Tear resistance	≥ 60 kN/m	Part A3 Method C at 23°C
Abrasion resistance (volume Loss at 3000 revolutions)	≤ 1500 mm³	Part A9 Method C

Notes :

1. This table is based on Clause 21.19 and Table 21.5 of General Specification for Civil Engineering Works Chapter 21 (Hong Kong Government, 1992).

2. The testing requirements of rubber fenders are given in Clauses 21.95 to 21.99 of the General Specification for Civil Engineering Works.

Table 5 Comparison of Various Forms of Long Strip Rubber Fenders

Fenders	Circular fenders	D fenders	Arch fenders	Turtle fenders
Common sizes (Height of Section)	◆ 150, 200, 250, 300 mm & above	◆ 150, 200, 250, 300 mm & above	◆ 200, 250, 300 mm & above	◆ 150 & 200 mm
Typical characteristics	◆ relatively low energy absorption ◆ soft contact and low reaction force	◆ relatively low energy absorption ◆ soft contact and low reaction force	◆ relatively high energy absorption by compression of fender ◆ robust installation	◆ relatively high energy absorption by provision of stiffeners ◆ larger breadth to height ratio: lower contact pressure & less damage under severe mooring, upper end closed & inclined to avoid snagging, robust installation
Mounting	◆ loosely mounted and supported on chains	◆ fixed directly on seawall by bolts; fixing methods dependent on required robustness	◆ fixed directly on seawall by two rows of bolts	◆ fixed directly on seawall by two rows of bolts

Note : The above information is subject to change due to development of new products in the market.

Table 6 Testing Standards of Plastic Fenders

Material	Physical Properties	ASTM Standards
Plastic	Density	ASTM D792
	Water absorption	ASTM D570
	Impact resistance	ASTM D746
	Hardness	ASTM D2240
	Ultraviolet resistance	ASTM D4329
	Abrasion resistance	ASTM D4060
	Coefficient of friction	ASTM F489
Fibreglass reinforcement	Tensile property	ASTM D638
	Flexural property	ASTM D790
	Compressive property	ASTM D695

Table 7 Assessment of Berthing Energy

Energy to be absorbed by fender system under normal loading conditions :

$$\mathbf{E = 0.5\, C_M\, M_D\, V_B^2\, C_E\, C_S\, C_C} \qquad \text{(kNm)}$$

	Parameter	Unit
C_M	Hydrodynamic mass coefficient	-
M_D	Displacement of vessel	t
V_B	Berthing velocity of vessel normal to the berth	m/s
C_E	Eccentricity coefficient	-
C_S	Softness coefficient	-
C_C	Berth configuration coefficient	-
D	Draft of vessel	m
B	Beam of vessel	m

Notes:

1. For the determination of berthing velocity and various coefficients, refer to Section 5.12 Part 1 of the Manual.
2. For accidental loading conditions, E should be increased by :

   50% (structures of general use)

   100% (structures which are critical, heavily used or located in exposed waters)
3. Berthing loads are not normally considered under extreme loading conditions except for effects arising from temperature variations.

Table 8 Typical Water Levels for Design of Solid Wharfs

Loading Conditions	**Wave Condition**	**Still Water Level in front of Wharf**	**Ground Water Level behind Wharf**
Normal/ Accidental	Wave condition at tropical cyclone signal no. 3 or within the first few hours of hoisting of tropical cyclone signal no. 8	Sea water level at return period of 2 years	Sea water level at return period of 2 years
		Sea water level at return period of 2 years minus 0.7 m	
		Mean lower low water level	Mean lower low water level plus 0.7 m
Extreme	Wave condition at return period of 100 years	Sea water level at return period of 10 years	Sea water level at return period of 10 years
		Sea water level at return period of 10 years minus 1.0 m	
	Wave condition at return period of 10 years	Sea water level at return period of 100 years	Sea water level at return period of 100 years
		Sea water level at return period of 100 years minus 1.0 m	
	Wave condition at return period of 50 years	Sea water level at return period of 50 years	Sea water level at return period of 50 years
		Sea water level at return period of 50 years minus 1.0 m	
	Wave condition at return period of 100 years	Mean lower low water level	Mean lower low water level plus 1.0 m

Notes :
1. The water levels for temporary loading conditions should be determined by the designer.
2. The critical still water level may be some intermediate level between the quoted water levels in this table and should be assessed by the designer for each case.
3. The designer should take into account the worst credible ground water condition when determining the ground water levels behind the wharf. Hence, the design ground water level may be higher than the levels given in this table.

Table 9 Assessment of Possibility of Impulsive Breaking Wave Pressure

A-1	Is the angle between the wave direction and the line normal to the breakwater less than 20°?	No → Little Danger
	↓ Yes	
A-2	Is the rubble mound sufficiently small to be considered negligible?	No → Go to B-1
	↓ Yes	
A-3	Is the sea bottom slope steeper than 1/50?	No → Little Danger
	↓ Yes	
A-4	Is the steepness of the equivalent deepwater wave less than about 0.03?	No → Little Danger
	↓ Yes	
A-5	Is the breaking point of a progressive wave (in the absence of a structure) located only slightly in front of the breakwater?	No → Little Danger
	↓ Yes	
A-6	Is the crest elevation so high as not to allow much overtopping	No → Little Danger
	↓ Yes	
	Danger of Impulsive Pressure Exists	
	(Continued from A-2)	
B-1	Is the combined sloping section and top berm of the rubble mound broad enough?	No → Little Danger
	↓ Yes	
B-2	Is the mound so high that the wave height becomes nearly equal to or greater than the water depth above the mound?	No → Little Danger
	↓ Yes	
B-3	Is the crest elevation so high as not to cause much overtopping?	No → Little Danger
	↓ Yes	
	Danger of Impulsive Pressure Exists	

Source : Reproduced from “Random Seas and Design of Maritime Structures” by permission of Prof. Y. Goda.