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Table 4.6 *Asymptotic values of the dispersion relation and related quantities*

Variable	Approximations with criteria	
	Shallow-water or long wave approximation (*small kh*)	Deep-water or short wave approximation (*large kh*)
	h/L < 1/25 or $T\sqrt{g/h} > 25$	h/L > 1/2 or $T\sqrt{g/h} < 4$
Dispersion relation	$\omega^2 = gh\,k^2$	$\omega^2 = gk_o$
Wave number k (rad/m)	$k = \omega / \sqrt{gh}$	$k_o = \omega^2/g$
Wavelength L (m)	$L = T\sqrt{gh}$	$L_o = gT^2/(2\pi)$
Phase speed c (m/s)	$c = \sqrt{gh}$	$c_o = gT/(2\pi)$
Group velocity c_g (m/s)	$c_g = c = \sqrt{gh}$	$c_{go} = ½\, c_o = gT/(4\pi)$

Description and definitions for irregular waves or sea-states

For a sea-state, composed of waves having different characteristics but belonging to the same random process (ie constant environmental conditions), two approaches are used to describe the wave field.

1 ***Long-crested random waves*** are still unidirectional, but include a range of wave heights and periods. The irregular or **random** wave train is composed of successive waves having different heights and periods. Two approaches are used to describe random waves and are set out below: the statistical (or wave-by-wave) approach, which consists of determining the **statistical distributions** of wave heights, periods, directions etc (see Section 4.2.4.4), and the **spectral approach**, which is based on the determination and use of the spectrum of wave energy (see Section 4.2.4.5). In both cases, representative parameters can be calculated to characterise the sea-state (eg the significant wave height H_s and the mean wave period T_m).

2 ***Short-crested random waves*** additionally include a range of directions, defined in terms of the standard deviation of wave energy propagation direction or some other standard spreading function. A more complete description of the sea-state is given by the directional spectrum ($S(f,\theta)$), which gives the distribution of wave energy as a function of frequency and direction (see Section 4.2.4.5). Short-crested waves provide the best representation of true ocean waves, and this representation of wave conditions has now become the standard way of dealing with wave actions in the engineering practice. The direction of wave incidence and the angular spreading of wave energy have been shown to have some effects on wave-structure interaction processes, such as stability of rubble mound breakwaters, run-up and overtopping (Galland, 1995; Donnars and Benoit, 1997).

4.2.4.3 *Characterisation of wave conditions and wave kinematics*

Characterisation of wave conditions by non-dimensional numbers

In order to characterise wave conditions, to investigate which processes are dominant during wave propagation and transformation, and/or to estimate wave loading on structures, several non-dimensional numbers are used. They can be computed for regular waves or random waves by using representative wave parameters. The most useful parameters are set out below.

- ***The relative water depth: kh or h/L and the non-dimensional period*** $T\sqrt{g/h}$

They are used to determine the manner in which seabed bathymetry affects waves. For example, the parameters were used in the previous section (see Table 4.6) to derive approximations of phase speed and group velocity in low and large relative water depths respectively.