Enhanced wave effects on the weather side of reflective structures

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Strong wave effects are often observed on the weather side of marine or coastal structures. An example is wave runup, experienced by ships in beam waves and some offshore structures. These runup effects are sometimes far above design values, suggesting some "anomaly" of the incoming waves.

It is advocated that the incoming wave system can actually be modified through its nonlinear interaction with the reflected wave system from the structure. This statement is based on extensive model tests, performed at BGO-First in la Seyne sur mer, and on theoretical and numerical analyses.

The experimental model consisted in a vertical plate, projected from one of the side-walls of the basin. It was submitted to regular waves of varying wavelengths and steepnesses, in deep water conditions ($kh > 3$). At wavelengths comparable with the width of the plate, strong runups are observed at the plate-wall intersection, increasing with the wave steepness. These runups take many wave cycles to develop, with no steady-state being reached in some cases. Free surface elevations as high as 5 times the amplitude of the incoming waves have been measured in some cases, far above calculated values with numerical models based on linearized potential flow theory.

A simple theoretical model is proposed, based on tertiary (third-order) wave interaction, as first given by Longuet-Higgins & Phillips (1962). A parabolic equation is derived, that describes the space evolution of the amplitude of the incoming waves through their tertiary interaction with the reflected waves (locally idealized as plane waves). A steady-state solution is obtained through iterations, where the incoming and reflected wave systems are successively updated. Details can be found in Molin *et al.* (2005). The figure shows the incoming wave system on the weather side of the plate, obtained at the end of this process, for a steepness H/L of 4 % and a wavelength equal to the length of the plate (1.2 m): the incoming wave amplitude has nearly doubled as it reaches the plate (in $x = 0$).

The numerical model is based on the enhanced Boussinesq equations as first proposed by Agnon *et al.* (1999) and Madsen *et al.*, and further developed by Fuhrman & Bingham (2004).

It is noteworthy that these nonlinear (tertiary) interactions between the incoming and reflected waves have some similarity with shoaling: the incoming waves are "slowed down", the wavelength decreases, the crest-lines bend and the wave energy gets focused toward the plate-wall intersection. As a matter of fact our parabolic equation resembles the parabolic

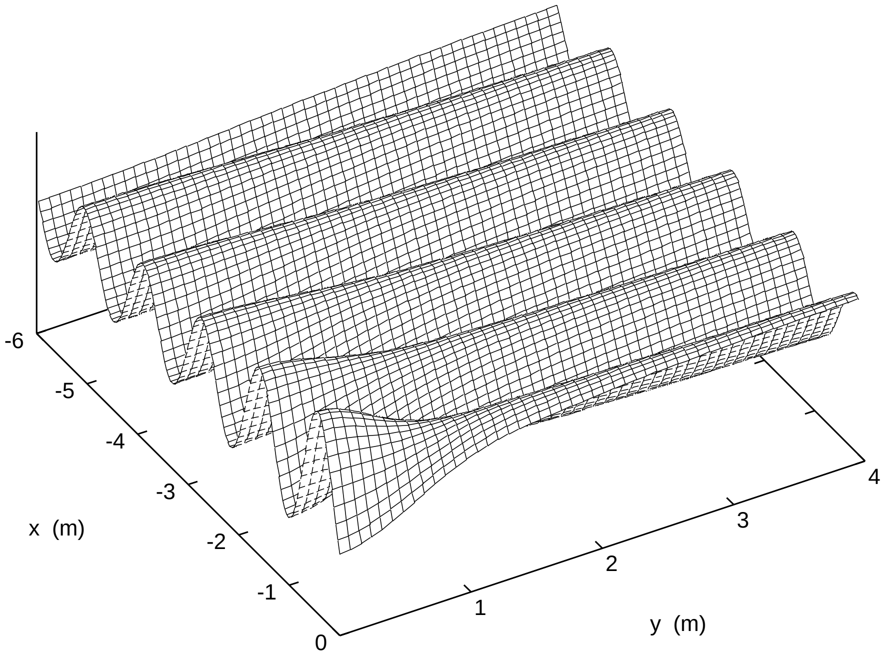

Figure 1: Three-dimensional view of the incoming waves by the plate.

approximation of the mild slope equation.

Numerical investigations have shown that the effective interaction area, between the incoming and reflected waves, can extend many wavelengths upwave. Contrary to intuition, the interaction area increases when the wavelength decreases, meaning that the incoming wave amplitude is being affected further and further from the plate.

Similar effects are expected to occur for other reflective bodies, such as multi-legged platforms or coastal structures.

References

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