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Note on a paper by Ogilvie: the interaction between waves and a submerged horizontal cylinder

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Ogilvie (1963) obtained the solution for the interaction between gravity waves and a horizontal submerged circular cylinder on deep water. It is shown herein that in this solution the expressions for the velocity potential (both for the moving cylinder and for the fixed cylinder) lack one term: a time-periodic space-independent term, which does not modify the load, but has some important consequence on the pressure distribution.

1. Re-examination of Ogilvie's solution

We adopt the same symbols as in Ogilvie (1963).

Let the velocity potential of the wave field interacting with a horizontal submerged cylinder be the real part of the function $f(z,t)$ and the velocity potential of the incident wave be the real part of the function $f_0(z,t)$. If this function is written as

$$f_0(z,t) = A\exp(-\nu h)\exp(\nu r\mathrm{e}^{-\mathrm{i}\theta})\exp(-\mathrm{i}\sigma t)$$

(Ogilvie's equation 17) the third term of the product is expanded in the form

$$\exp(\nu r\mathrm{e}^{-\mathrm{i}\theta}) = \sum_{n=0}^{\infty}\frac{(\nu r)^n}{n!}\mathrm{e}^{-\mathrm{i}n\theta}.$$

Later in Ogilvie's paper, in rearranging the solution obtained for $f(z,t)$, Ogilvie omits the $n=0$ term of f_0, that is

$$A\mathrm{e}^{-\nu h}\,\mathrm{e}^{-\mathrm{i}\sigma t}.$$

This term must be added to the right-hand side of Ogilvie's equation (19') for the case of a moving cylinder and (22) for the case of a restrained cylinder.

Ogilvie only presents results for the total pressure load so the omission has no effect. However, the missing term has some important consequences on the wave pressure and hence on cylinder stresses and fatigue.

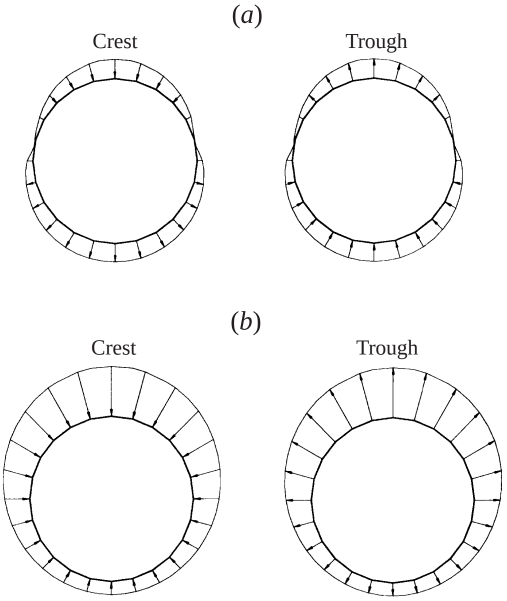

FIGURE 1. Wave pressure on a restrained cylinder, for $\nu a = 0.3$ and $\nu h = 1$ (ν = wavenumber, a = radius of the cylinder, h = submergence of cylinder centre). (*a*) Ogilvie's solution (1963). (*b*) Correct solution (including the additional periodic term). Inward oriented vector denotes positive pressure. Outward oriented vector denotes negative pressure.

As an example, figure 1(*a*) shows the wave pressure obtained by means of Ogilvie's equation (22), and figure 1(*b*) shows the corrected form of the pressure distribution.

REFERENCE

OGILVIE, T. F. 1963 First- and second-order forces on a cylinder submerged under a free surface. *J. Fluid Mech.* **16**, 451–472.