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Maximum wave force and run up on the curtain wall-pile breakwaters

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Introduction

This paper outlines the numerical calculation of wave run up on the upwave side of the curtain-wall breakwater (CBP) using circular piles. Numerical results compare well with available experimental measurements of the wave transmission, reflection coefficients and indicate that the numerical model is able to account adequately for the maximum wave force and overturning moment and also wave run up. The effects of the porosity, relative draft of curtain-wall are discussed.

Mathematical model

A wave train of height *H* and angular frequency ω propagate in water of constant depth *h* past a thin CBP as shown in Fig. 1, in which *d* is draft of the CPB, *b* thickness of the wall, and *D* is the diameter of the pile. A Cartesian coordinate system *(x,z)* is defined with *x* measured in the direction of the wave propagation and *z* is measured

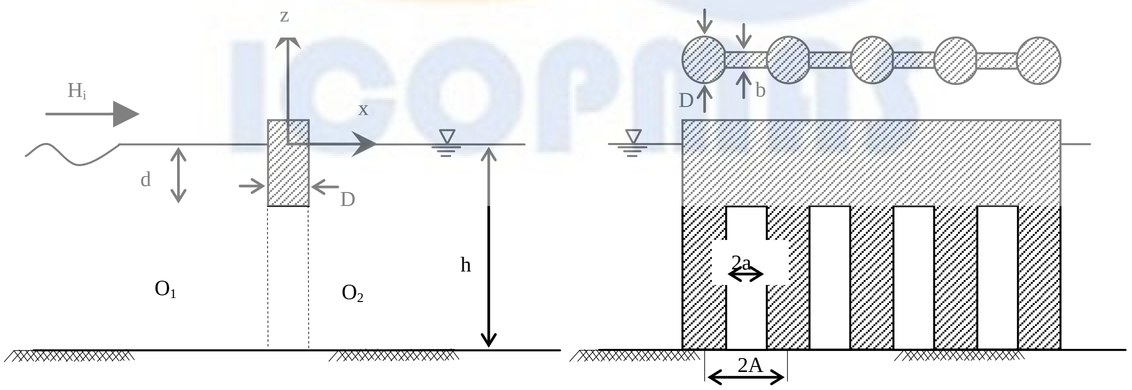

Fig. 1) Definition Sketch

upward from the steel water line. The distance between the centers of two neighboring piles is denoted as *2A* and the width of an opening is *2a* so that the porosity of the lower part of the breakwater at *x=0* is defined as $r_0 = a/A$. The fluid motion can be described by a velocity potential Φ , which satisfies the Laplace equation within the fluid region. Consequently, Φ is subject to the usual boundary conditions, linearized where appropriate, at the seabed, free surface, and far field (see for example, [1] and [2]), and may thus be expressed, using complex notation, in the form

$$\Phi(x,z,t) = \text{Re}\left[C\phi(x,z)\exp(-i\omega t)\right] \quad (1)$$

where

$$C = -\left(\frac{igH}{2\omega}\right)\frac{1}{\cosh(kd)} \quad (2)$$

Also, Re[ ] denotes that real part of the argument, $i=\sqrt{-1}$, t = time, k = wave number, and g = gravitational constant.

The ϕ_1 and ϕ_2 must satisfy the following matching conditions at $x=0$:

$$\frac{\partial\phi_1}{\partial x} = \frac{\partial\phi_2}{\partial x} = 0 \qquad \text{for} \qquad -d \le z \le 0, \qquad x=0, \quad (3)$$

$$\frac{\partial\phi_1}{\partial x} = \frac{\partial\phi_2}{\partial x} = iG(\phi_1 - \phi_2) \qquad \text{for} \qquad -h \le z \le -d, \qquad x=0, \quad (4)$$

The proportional constant G, often called permeability parameter, is in general complex. In present study, we adopt the method of Mei et al. (1974) as indicated in [3] and G is expressed by

$$G = \frac{1}{(\beta/\omega) - il} \quad (5)$$

where β is the energy dissipation coefficient derived by linearizing the nonlinear convective acceleration term in the equation of motion, and l is the length of the jet flowing through the gap between piles.

Comparison with experimental results

In this section, the mathematical model results are compared with results of experiments were carried out by Suh et el. [3]. Fig. 2 shows a comparison of the measured and calculated reflection coefficients. Overall agreement is acceptable, so we can calculate maximum wave force and momentum and run up.

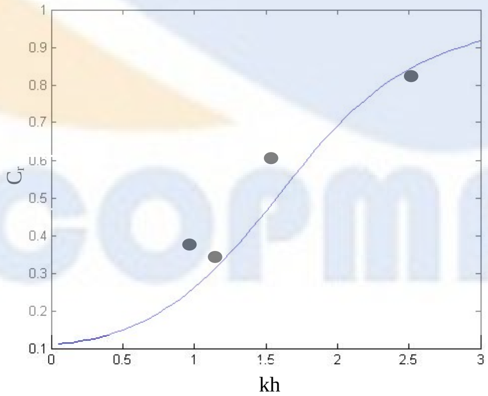

Fig. 2)Comparison of the predicted reflection and transmission coefficients with experimental results as a function of *kh* for r_0=0.4

Fig. 3 shows maximum horizontal force per unit width on CPB. The wave force is given as a ratio with respect to the wave force due to fully standing waves, F_s.

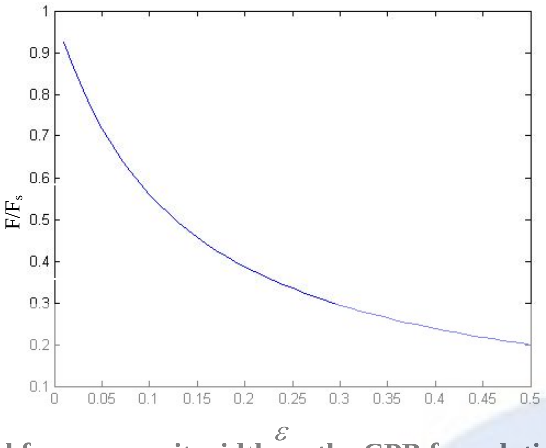

Fig. 3)Maximum horizontal force per unit width on the CPB for relative draft *d/h=1.0* and relative depth *kh=1.9*

Conclusion

Comparison between measurement and prediction showed that the mathematical model wave able to adequately reproduce most of important features. In the case of wave force, measurements shows maximum wave force increases with porosity.

Reference

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