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Effects of Fluid Resistance Coefficient on Wave Characteristics around Permeable Submerged Breakwater

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Abstract : *Recently, the studies on submerged breakwater are increased due to needs considering the quality of water and the scenic view. In this paper, waves coming to permeable submerged breakwater coming with oblique angle are computed numerically by using wave pressure function. The wave pressure function throughout the analytical region including the fluid and submerged breakwaters is used. An unknown quantity expressed by the wave pressure function is simulated by boundary element method. The maximum reflection coefficient shows the tendency of decrease with the increase of oblique angle and The reflection coefficient shows the tendency of increase with the increase of the values of the linear dissipation coefficient and the added mass coefficient. It is means that the reflection coefficients are strongly dependent on the oblique angle and resistance coefficients.*

Key words : *Permeable submerged breakwater, Resistance coefficient, Porosity, Oblique incident waves*

1. Introduction

Although wave dissipating structures such as the existing breakwater are considered as the most effective methodology for calmness of harbor, it is not good in terms of landscape and marine environment. On the other hand, submerged breakwaters have several advantages on the coastal environment and the ecosystem as well as wave protection due to the construction below the sea level. In addition, It is provided that submerged breakwater prevents the erosion.

In this study, when waves are coming with oblique angle, the wave reflections of the permeable submerged breakwater are numerically computed .

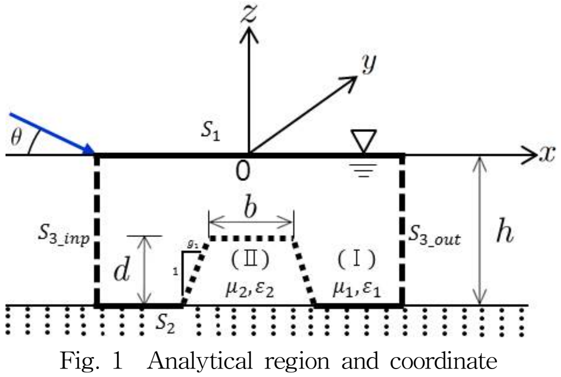

Fig. 1 Analytical region and coordinate

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2. Governing equations

2.1 Governing equations

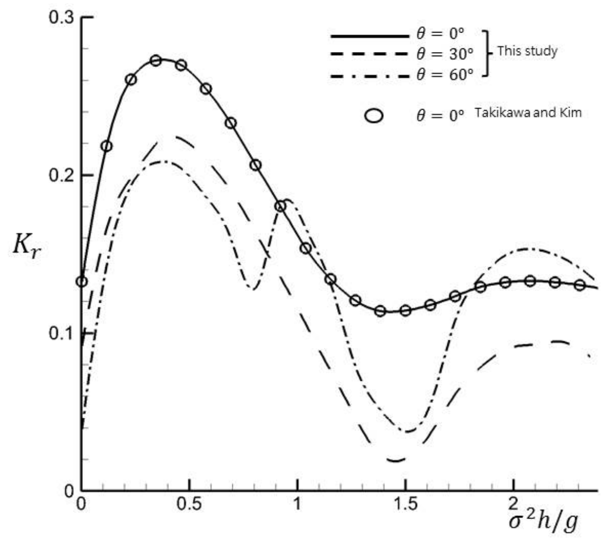
The submerged breakwater is placed in uniform depth h. The z axis is directed vertically upwards, x and y axis are directed horizontally as shown in Fig. 1. The velocity potential $\Phi(x,y,z;t)$ can be defined as follows:

$$\Phi(x,y,z;t) = \frac{g\,\eta_o}{\sigma}\,\phi(x,y,z)\,e^{i\sigma t} \tag{1}$$

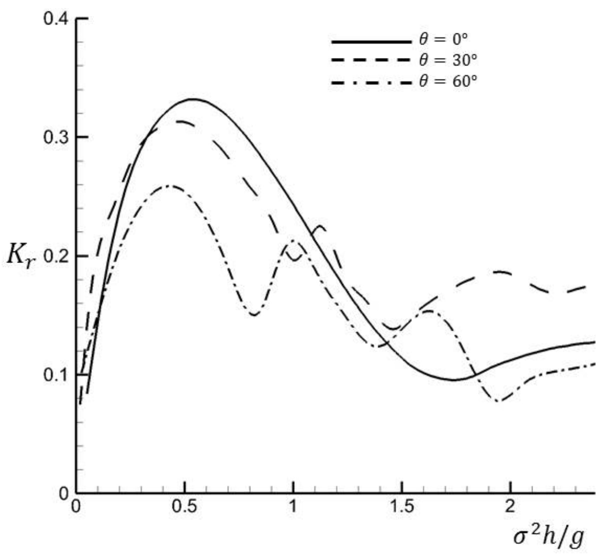
where η_o is the amplitude of wave, g is the acceleration of gravity. It is assumed that the fluid is inviscid and incompressible and that its motion is irrotational. Therefore, the energy dissipation is modeled by introducing a linear dissipation coefficient μ and an added mass coefficient C_m into the nonlinear energy dissipation terms. The equation of linearized motion is as follows:

$$\frac{1}{V}\frac{\partial\phi_l}{\partial t} + \mu\cdot\phi_l + \frac{P}{\rho} + g\cdot z = 0 \tag{1}$$

where $V = \varepsilon/(1 + C_m\cdot(1-\varepsilon))$, C_m is an added mass coefficient, u is the fluid motion in the x-direction, ε is the porosity, v is the fluid motion in the y-direction.



(a)



(b)

Fig. 2 Reflection coefficient for resistance coefficients due to the change of oblique angle.

3. Applications of numerical analysis

Fig. 2 (a) shows the reflection coefficient for the influence due to the oblique angle when θ is changed to $0°$, $30°$, $60°$, in which $b/h = 1.0$, $d/h = 0.7$, $g_1 = 1.0$, $\varepsilon = 0.5$, $\mu/\sigma = 2.0$, and $Cm = 0$ are fixed.

In Fig. 2 (a) circle symbol is the results obtained by Takikawa and Kim(1992) and solid lines are the results obtained in this study.

Fig. 2 (b) shows the reflection coefficient for the influence due to the oblique angle when θ is changed to $0°$, $30°$, $60°$, in which $b/h = 1.0$, $d/h = 0.7$, $g_1 = 1.0$, $\varepsilon = 0.5$, $\mu/\sigma = 2.0$, and $Cm = 0.5$ are fixed.

5. Conclusions

In this study, when waves are coming with oblique angle, the wave reflections of the permeable submerged breakwater are numerically computed by using boundary element method based on the wave pressure function.

The maximum reflection coefficient shows the tendency of decrease with the increase of oblique angle. Also, the reflection coefficient considering added mass coefficient ($C_m = 0.5$) is bigger than excluding added mass coefficient ($C_m = 0.0$). It is means that the reflection coefficients are strongly dependent on the resistance coefficients.

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