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Numerical Analysis of Waves Profiles coming with Oblique Angle to Permeable Submerged Breakwater on the Porous Seabed

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ABSTRACT : *This analysis method is based on the wave pressure function with the continuity in the analytical region including fluid and porous structures. Wave profiles coming with oblique angle to permeable submerged breakwater on the porous seabed are computed numerically by using boundary element method. When compared with the existing results for the oblique incident wave, the results of this study show good agreement. The results indicate that wave profiles own high dependability regarding the change of oblique incident waves and permeable submerged breakwater on the porous seabed. Therefore, the analysis method of this study are estimated to be applied as an accurate numerical analysis referring to oblique incident waves and permeable submerged breakwater on the porous seabed in real sea environment.*

KEY WORDS : *boundary element method, permeable submerged breakwater, wave pressure function, oblique incident waves.*

1. Introduction

Submerged breakwaters have several advantages on the coastal environment and the ecosystem as well as wave protection. Generally, the numerical treatment of waves profiles are not considering the oblique incident waves.

In this study, when wave is coming with oblique angle, the wave profiles passing over the permeable submerged breakwater on a porous seabed are computed numerically.

2. Governing equations and boundary conditions

2.1 Governing equations

The submerged breakwater is placed in the water of uniform depth h. The z axis is directed vertically upwards, x and y axis are directed horizontally as shown in Fig. 1. The incident wave is coming with an angle θ to the positive x axis. It is assumed that the fluid is inviscid and incompressible and that its motion is irrotational. Therefore, the velocity potential $\Phi(x,y,z;t)$ can be defined as follows:

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

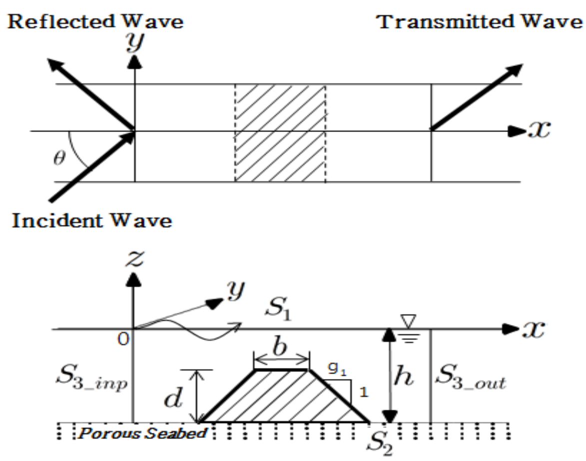

Fig. 1 Analytical region and coordinate

where η_o is the amplitude of wave, g is the acceleration of gravity, σ is the angular frequency($\sigma = 2\pi/T$).

2.2 Porous seabed boundary S_2

$$\frac{\partial \phi_l}{\partial n} = \frac{K}{\mu}\frac{\partial p_s}{\partial n} \quad (\text{ on seabed }) \tag{2-1}$$

$$\frac{\partial \phi_l}{\partial n} = \frac{\partial}{\partial n}\left(\beta\frac{\partial H}{\partial x}\right) + \frac{\partial}{\partial n}\left(\beta\frac{\partial H}{\partial z}\right) \quad (\text{ in structure }) \tag{2-2}$$

where n is the normal drawn outwardly on the boundaries,

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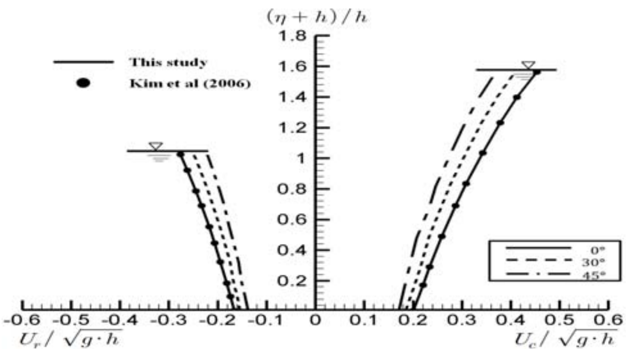
K is the coefficient of permeability, p_s is the soil domain pressure. The dispersion relationship for the porous seabed boundary conditions is given as follows(Dean and Dalrymple, 1984; Cruz et al., 1997):

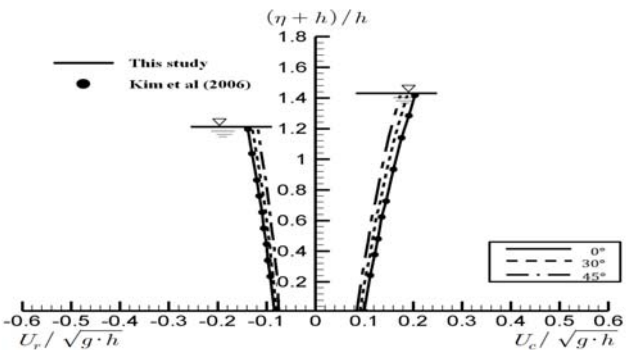
$$\sigma^2 - gk\tanh kh = -i\frac{\sigma K}{\nu}(gk - \sigma^2 \tanh kh) \qquad (3)$$

where ν is the kinematical viscosity. The dispersion relationship yields a complex valued k, which may be written as $k = k_r + ik_i$.

3. Application of numerical analysis



(a) Horizontal velocities on impermeable seabed ($R = 0.0$)



(b) Horizontal velocities on porous seabed ($R = 0.1$)

Fig. 2 Comparison of horizontal velocities due to different incident angle θ on seabed boundary condition.

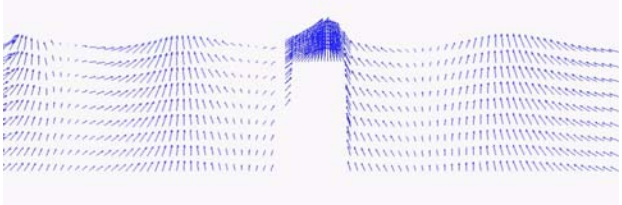


Fig. 3 Wave profile and velocity field in the vicinity of impermeable submerged breakwater on seabed.
($R = 0.0, B/h = 1.0, h/L = 0.1, q = 0.1$)

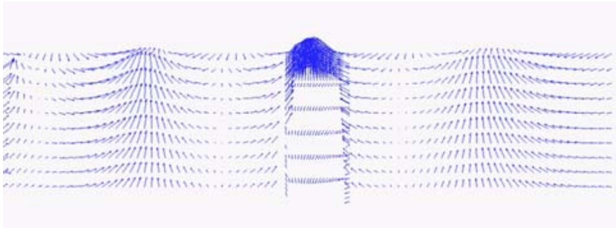


Fig. 4 Wave profile and velocity field in the vicinity of permeable submerged breakwater on porous seabed.
($R = 0.1, B/h = 1.0, h/L = 0.1, q = 0.1, \varepsilon = 0.5, \mu/\sigma = 2.0$)

The horizontal velocities with the oblique incident wave are computed in wave crest and trough as shown in Fig. 2. $\eta + h$ is the wave height, U_C is a horizontal velocity in wave crest, and U_T is a horizontal velocity in wave trough.

Fig. 3 and 4 display the results for the wave profile and velocity field due to the change of submerged breakwater and seabed conditions, respectively.

4. Conclusions

In this study, wave profiles coming with oblique angle to permeable submerged breakwater on the porous seabed are computed by using boundary element method based on the wave pressure function.

The horizontal velocities due to increasing incident angle θ are to be increased. The wave profile for the case of permeable submerged breakwater on porous seabed is smaller than the case of the impermeable submerged breakwater on seabed by the wave energy dissipation and effect of submerged breakwater.

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