Wave Excitations on a Body in a Bifurcated Three-Dimensional Channel

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Abstract

A numerical method for a wave diffraction problem in three-dimensional channels is developed. The physical models are various shapes of channel connected to the open sea. When a ship or an offshore structure is moored in various configurations of channel connected to an open sea, the prediction of the hydrodynamic force exerting on the moored ship could be important for the prediction of its motion. It is assumed that the fluid is inviscid and incompressible and its motion is irrotational. From the continuity equation, the Laplace equation can be obtained as the governing equation. The surface tension at free surface is neglected, and wave amplitude is assumed to be small compared to the wave length. Then the free surface condition can be linearized. The numerical method used here is the localized finite element method based on a variational formulation..

Keyword: *Localized finite element method, wave diffraction, bifurcated channel, potential flow*

Introduction

The propagation of water waves in the bifurcated channel connected to the open sea is a topic of interest for costal engineers. When a ship is moored in the bifurcated channel, the prediction of the hydrodynamic force exerting on the ship could be important for the computation of the ship motion.

In this study, a numerical method for wave diffraction in three-dimensional channels is developed for a time-harmonic analysis. Bai[1], and Bai & Yeung[2] applied the localized finite element method to a potential flow with a free surface and interface with success. Recently, this method has been successfully applied to the sediment pocket problem in Kim & Bai[3].

The fluid domain is subdivided into the inner and the outer sub-domains. An appropriate juncture condition is imposed on the boundary surface between the inner and outer domains, requiring the continuity of the function and its first derivatives. From the functional equation equivalent to the original boundary value problem with appropriate juncture conditions, the matrix equation can be obtained.

Mathematical Formulation

We assume that the fluid is inviscid and incompressible, and fluid motion is irrotational. In addition, it is assumed that the surface tension can be ignored. Then one can define the velocity potential, ϕ, in the fluid domain where satisfies Laplace's equation from the conservation of mass and the homogeneous Neumann condition on the wall and the bottom as follows,

$$\nabla^2\phi = \frac{\partial^2\phi}{\partial x^2} + \frac{\partial^2\phi}{\partial y^2} + \frac{\partial^2\phi}{\partial z^2} = 0 \quad in \quad \Omega, \tag{1}$$

$$\frac{\partial\phi}{\partial n} = 0 \qquad on \quad S_W \ \& \ S_B, \tag{2}$$

Paper No. : 2-3D-1

where S_W and S_B denote the wall and the bottom boundary of the channel, respectively. And n denotes the outward unit normal to the boundary. The linearized boundary conditions are imposed on the free surface as

$$\phi_n - \nu\phi = 0 \qquad on \quad S_F . \tag{3}$$

where S_F denotes the free surface and $\nu = \sigma^2 / g$. σ is the frequency of the incident wave potential and g is the gravitational acceleration.

Results

Figure 1 shows the wave profile when the branch angle is 60 degrees. Fig 2 shows the conservation of the energy at the same branch angle. This figure shows that this numerical method conserves energy very well.

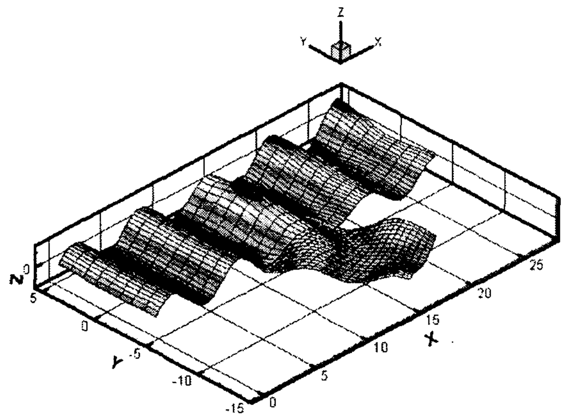

Figure.1. Wave profile of 60 degrees

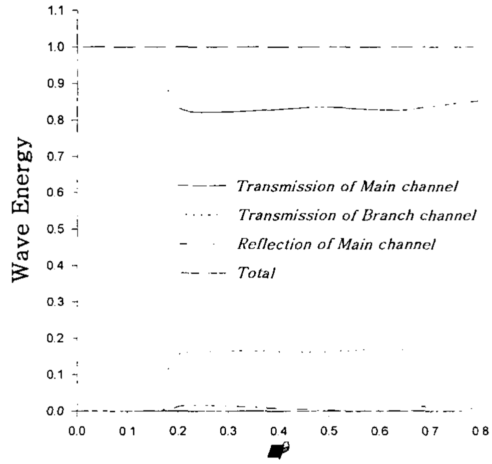

Figure. 2. Wave energy at 60 degrees

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