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Wave Drifting Forces on Very Large Floating Structures

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ABSTRACT

The wave drifting forces acting on a very large floating structure consisting of multiple barge-type modules is studied theoretically in this paper. The three-dimensional panel method is used to determine the hydrodynamic forces, taking into account accurately the effect of hydrodynamic interactions among the modules, and the coupled equations of motions are solved directly. Furthermore, we estimate the wave drifting forces on the multiple floating structure with two module connectors of: a rotational-hinge connector and a rigid connector. The effects of connector conditions and the number of bodies on the wave drifting forces are discussed.

INTRODUCTION

Very large floating structures have been proposed for a number of applications, such as airport runways (Takarada, 1982), entire floating cities (Takarada, 1989), and oil storage (Uki, 1988). It is very important to estimate a wave drifting force on a very large floating structure from the viewpoint of the structure's safety, because it is impossible to catch the drifting huge structure.

So far the strip theory has been used for estimating the seakeeping performance from a practical point of view (Maeda et al., 1979). It seems, however, that the hydrodynamic forces on the huge structures are affected by effects of three-dimensional interactions, and many researchers have studied three-dimensional hydrodynamic forces on the multiple structures. However, most of them are studies of the first order force (Ertekin et al., 1991; Goo et al., 1989; Kagemoto, 1991; Riggs et al., 1991), and few researchers have studied the second order force such as a wave drifting force on it.

The wave drifting forces acting on a very large floating structure consisting of multiple barge-type modules is studied theoretically in this paper. We have considered two module connectors: a rotational-hinge connector and a rigid connector. The three-dimensional panel method is used to determine the hydrodynamic forces, which take into account accurately the effect of hydrodynamic interactions among the modules, and the coupled equations of motions are solved directly. The numerical results show the effect of the number of modules on the features of motions in head-sea conditions. Furthermore, we estimate the wave drifting forces on the multiple floating structure with the two above-mentioned module connectors. We discuss the effect of connector conditions on the wave drifting forces. It is made clear that the wave drifting force becomes zero in the range of the wave length ratio to the body length over 0.6, as the number of the modules increases.

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KEY WORDS: Wave drifting force, large floating structure, multiple connected structure, hinge connector, rigid connector, hydrodynamic interaction.

INTEGRAL EQUATION

Let us consider the linear interaction of monochromatic waves with three-dimensional bodies that consist of N floating bodies in infinitely deep water. A Cartesian coordinate system (x,y,z) with z positive upwards is used, and the origin is on the mean free surface as shown in Fig. 1. Assuming ideal fluid and small amplitude waves, a velocity potential around the body can be expressed as a sum of incident ϕ_0, diffraction ϕ_7 and radiation potentials ϕ_j:

$$\Phi=(x,y,z;t)=\Re\left(\phi(x,y,z)e^{i\omega t}\right) \tag{1}$$

$$\phi=\frac{g\zeta_a}{\omega}(\phi_0+\phi_7)+i\omega\sum_{j=1}^{6}\xi_j\phi_j \tag{2}$$

where

$$\phi_0=ie^{Kz-iK(x\cos\chi+y\sin\chi)} \tag{3}$$

ω : incident wave frequency
K : wave number ($=\omega^2/g$)
ζ_a : incident wave amplitude
ξ_j : motion amplitude of j-mode
g : gravitational acceleration

The velocity potential ϕ is governed by the three-dimensional Laplace equation, the linearized free surface condition and bottom condition.

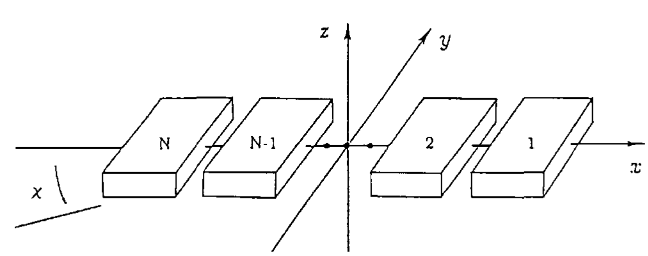

Fig. 1 Coordinate system (for N-blocks)