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Hydrodynamic Forces Acting on a Floating Body in a Harbor of Arbitrary Geometry

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ABSTRACT

A new method for computation of the hydrodynamic forces acting on a floating body in a harbor of arbitrary geometry is developed. This method is composed of a finite element method for solving the harbor response and a three-dimensional integral equation method for solving the floating body response. These two methods are combined by making use of the eigen function expansion method. The finite element method for the harbor response problem is based on the mild-slope assumption. The integral equation method for the floating body response problem is based on the three-dimensional potential theory with the linearized free surface condition. The overall solution is obtained by solving the combined matrix obtained by combining the harbor response coefficient matrix with the floating body response coefficient matrix. In order to verify the accuracy of the present method, some numerical results are compared with numerical results of previous research. It shows that present results are in good agreement with previous ones. The influence of the heading angle of the floating body and the bottom topography is investigated. Results shows that the influence of the heading angle is significant. On the other hand, the influence of the bottom topography is not significant.

INTRODUCTION

Recent developments in computers permit the motion of a three-dimensional floating body in a open sea to be estimated very accurately and quickly and a lot of research on this problem has been done. However, the floating body motion in a harbor has been seldom investigated. So, the research on a floating body motion in a harbor of arbitrary geometry and bottom topography is necessary. As a step in this direction, we developed a new computational method.

The finite element method with mild-slope equation is convenient for solving the response of the harbor of arbitrary geometry and bottom topography (Mei, 1978). On the other hand, the three-dimensional boundary integral equation method is convenient for solving the response of the floating body of arbitrary geometry. These two methods are easily combined; however, the following problems will arise.

The first problem is that the harbor response problem with complicated geometry requires a lot of number panels and the three-dimensional body response problem also requires a lot of panels, and if these two problems are combined, the requirement of the total number of panels would be two times larger than that of each problem individually. This means a big computer memory would be necessary and computer time would be four times longer. The second problem is that there are many parameters, such as the position of the floating body, the heading angle, wave period, wave direction and so on. This requires many computations and long computer times.

Kagemoto and Yue (1986) developed a new method for the calculation of a number of separate nonoverlapping members using the diffraction properties of individual members only. Specifically, they represent the wave field around each body as a series of partial waves of undetermined amplitudes. By applying a transformation to express the influence of the wave system at one body in terms of those at all the other bodies, a set of linear algebraic equations can be derived to satisfy the diffraction characteristics of all the member bodies. This system is solved simultaneously for all the unknown amplitude coefficients.

Their idea can be applied to our problem by replacing the diffraction characteristics of all other member bodies with the harbor diffraction characteristics. In order to get an exact solution they take local wave terms into account in their theory. However, since it is well known that the effect of local waves is negligible when the body is not so close to the harbor wall, local wave terms are neglected in our theory.

Our method is composed of a finite element method for solving the harbor response and a three-dimensional integral equation method for solving the floating body response. These two methods are combined by making use of the eigen function expansion method. The finite element method for the harbor response problem is based on the mild-slope assumption, and it is applicable to the harbor of arbitrary geometry and also arbitrary bottom topography. The integral equation method for the floating body response problem is based on the three-dimensional potential theory with the linearized free surface condition, and it is applicable to the arbitrary body geometry and arbitrary water depth. The overall solution is obtained by solving the combined matrix obtained by combining the harbor response coefficient matrix with the floating body response coefficient matrix.

As these two problems are solved separately, their panel size can be selected separately and the number of panels can be chosen as much as is allowed by the memory size of the computer. If a harbor response matrix once calculated were memorized and combined with every floating body response matrix and vice versa, a considerable computer time saving would be achieved.

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