Proceedings of the Eighteenth (2008) International Offshore and Polar Engineering Conference
Vancouver, BC, Canada, July 6-11, 2008

ISBN 978-1-880653-70-8 (Set); ISBN 1-880653-68-0 (Set)

Numerical Prediction of Interactions between Wave Flows and Flexible Structures with 3D MICS

Nozomu, Kuroda
Faculty of Engineering, Kyoto University
C-Cluster, Kyoto University, Kyoto-shi, 615-8540, Japan
Satoru Ushijima
Department of Civil and Earth Resources Engineering, Kyoto University
C-Cluster, Kyoto University, Kyoto-shi, 615-8540, Japan

ABSTRACT

In this paper, a computational method has been proposed to predict the interactions between wave flows and flexible structures which are deformed due to the fluid forces. The flexible structure, which is assumed to be an elastic body, is represented by tetrahedron elements and its deformation is calculated with a finite element method (FEM). This structure model is introduced into a computational method for a multiphase field, MICS. In the MICS, the free-surface flows including elastic objects, consisting of gas, liquid and solid phases, are modeled as a mixture of the immiscible and incompressible different fluids. The momentum equations of the mixture are solved in MICS and the results are used to estimate the fluid forces acting on the object. Since the momentum of the elastic object is taken into account in the computation of the multiphase field, the fluid-solid interactions are adequately treated.

The validity of the prediction method was examined through the comparisons with the experimental results, which were obtained in an accelerated water tank equipped with elastic plates.

KEY WORDS: free-surface flow; multiphase model; fluid-solid interaction; elastic body; FEM; MICS

INTRODUCTION

The interactions between free-surface flows and flexible objects which are deformed due to the fluid forces are important engineering subjects, such as the dynamic responses of floating elastic structures against wave motions and the fluid resistance forces of the flexible plants near coastal regions. While many investigations have been made for one and two-degree of freedom problems such as an oscillations of a cylinder in uniform flows, the numerical studies for multi-degree of freedom are relatively few.

In the present study, a flexible object is represented by a T-type FEM model, in which the object is represented by multiple tetrahedron elements and its deformation is calculated with a finite element method (FEM). This T-type model is introduced into a computational method for a multiphase field, MICS (Multiphase Incompressible-flow solver with Collocated grid System). In the MICS, the free-surface flows including solid objects, consisting of gas, liquid and solid phases, are considered as a multiphase field and it is modeled as a mixture of the immiscible and incompressible different fluids. The fluid-solid interactions are dealt with through the element of the T-type model and the fluid-cell in the MICS.

The prediction method was applied to the experimental results obtained in the sloshing motions in a water tank equipped with elastic plates. The oscillations of the water levels and the displacements of the elastic plates are compared between experiments and predictions. Through the comparisons, the validity of the prediction method is examined.

NUMERICAL PROCEDURES

Basic Equations

It is important to deal with the fluid-solid interactions accurately to predict the displacements of elastic bodies due to fluid forces in free-surface flows. In this study, a T-type FEM model, in which an object is represented by tetrahedron elements and its deformations are estimated with FEM, is introduced into the computational method for multiphase flows, MICS. In the MICS, the free-surface flows including flexible objects are treated as a multiphase field which is modeled as the mixture of the incom-