INTRODUCTION

We are currently concerned with strongly nonlinear wave-body interactions such as a local, green-water impact on deck and its effects on the global motion of a floating body in large-amplitude waves. Numerical calculation methods applicable to such strongly nonlinear problems are being developed at the RIAM (Research Institute for Applied Mechanics) of Kyushu University (e.g. Hu and Kashiwagi, 2006). In particular, the method based on the CIP scheme (Yabe et al., 2001) in a Cartesian grid is named RIAM-CMEN (Computation Method for Extremely Nonlinear hydrodynamics). This computer code has been validated through comparisons with 2D experiments for wave-induced motions of a body including the water-on-deck phenomenon. Although RIAM-CMEN has now been extended to 3D problems and is being validated by comparison with 3D experiments measuring the pressure on deck and ship motions in waves (Hu and Kashiwagi, 2007), we realized that validation of the code should be made for fundamental components of the hydrodynamic force appearing in the motion equations of a floating body.

The model prepared for 2D experiments was box-shaped under the still-water surface, with a rather small freeboard and a box-shaped upstructure installed on the deck, because we planned to measure a phenomenon of water on deck and its effect on body motions. Using this model, we conducted the forced heave oscillation test to measure the added-mass and damping coefficients in heave. First the experiment was carried out with amplitude of forced heave oscillation set to 10 mm, and the obtained results were unnatural in variation particularly at the higher frequencies of \( Ka > 2.0 \) (where \( a \) is the half-length of a model and \( K = \omega^2/g \)). Although we did the same experiment with amplitude of forced oscillation lowered to 5 mm, the variation tendency was virtually the same and the results were much different from those computed by a 2D BEM (Boundary Element Method) based on the linear potential theory. Then, before proceeding to a comparison with computation by the 2D version of RIAM-CMEN, we were obliged to study the reasons for the unnatural results obtained in the experiment. Through observation of the wave field around the model, we noticed large-amplitude waves in the gap between the sidewalls of the model and the wave channel, which seemed to be not propagating away from the body. From this observation, we conjectured that the unnatural variation and values in the measured results, particularly at higher frequencies, must be associated with a flow in the gap.

After several trials, the model was modified, attaching a thin plate to both sides of the model, which lessened the gap between the model and wave channel from 5 mm to 1 mm. With this modification of the model, the obtained results were found to be reasonable and close to the computed results by a 2D BEM. In order to understand more clearly the hydrodynamic reasons in this drastic change, we performed numerical computations using a 3D BEM with the method of mirror images to see 3D effects, and the 2D RIAM-CMEN to see viscous effects. A comparison of these results with corresponding experiments seems to be convincing and provides us with a suggestion for carrying out 2D experiments in a wave channel.

This paper is organized as follows. First, the experiment and obtained results are shown in the next section, including a comparison with results computed by a 2D BEM. Next, a brief description is given for the numerical computation methods adopted; that is, a 3D BEM combined with the method of images and the 2D RIAM-CMEN solving the Navier-Stokes equations. Then, the comparison is shown between measured and computed results, and discussions are undertaken on 3D effects related to trapped waves in the gap and viscous effects associated with vortex shedding. Conclusions are summarized last.