Consideration on 3-D Effects on Results of Forced Oscillation Test in a 2-D Wave Channel

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ABSTRACT

In order to validate an inhouse computer code, RIAM-CMEN (Computation Method for Extremely Nonlinear hydrodynamics), based on CFD techniques, the forced oscillation test in heave was conducted in a wave channel for obtaining the data of the added-mass and damping coefficients of a box-shaped floating body. Obtained results were expected to agree with computed ones by a 2-D BEM based on the potential-flow theory. However the result was not the case, and a large discrepancy was observed. Viscous effects associated with vortex shedding from a sharp corner of the model are one reason, but the magnitude in the difference was too large to attribute only to the effect of vortex shedding. To see the reasons, we carried out observation of the flow around the model and modified the settings in the experiment. One important factor was found to be the gap between the sidewalls of the model and wave channel. In fact the gap on each side was 5 mm in the original experiment, but after attaching a thin plate on both sides of the model to lessen the gap down to 1 mm, measured results became reasonable. To understand hydrodynamic reasons in this rather drastic change, numerical computations were performed using a 3-D BEM and the 2-D version of RIAM-CMEN. We confirmed through comparisons that unnatural variation observed at higher frequencies for the gap equal to 5 mm was associated with trapped waves generated in the gap and that the difference in the damping coefficient between the experiment and the computation by BEM was associated with the effect of vortex shedding.

KEY WORDS: Added mass and damping coefficient; 3-D effects; viscous effects; forced oscillation test.

INTRODUCTION

We are currently concerned with strongly nonlinear wave-body interactions such as ‘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 RIAM (Research Institute for Applied Mechanics) of Kyushu University (e.g. Hu & 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 2-D experiments for wave-induced motions of a body including the water-on-deck phenomenon. Although RIAM-CMEN is now extended to 3-D problems and being validated by comparison with 3-D experiments measuring the pressure on deck and ship motions in waves (Hu & 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 2-D experiments was of box-shape under the still-water surface, with rather small freeboard and a box-shaped upstructure installed on the deck, because we had a plan 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. Firstly the experiment was carried out with amplitude of forced oscillation set to 10 mm, and obtained results were unnatural in variation particularly at higher frequencies of $Ka > 2.0$ (where $a$ is half length of a model and $K = \omega^2/g$). Although we did the same experiment with amplitude of forced heave oscillation lowered to 5 mm, the variation tendency was virtually the same and the results were much different from computed ones by a 2-D BEM (Boundary Element Method) based on the linear potential theory. Then before proceeding to a comparison with computation by the 2-D version of RIAM-CMEN, we were obliged to study the reasons of 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 side walls of the model and the wave channel, which seemed to be not propagating away from the body. From this observation, we conjectured that 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...