Dynamic Responses of Moored Floating Dual Pontoon Structure in a Fully Nonlinear Numerical Wave Tank

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ABSTRACT

This paper is to investigate the wave-body interaction of floating dual pontoon structure in a 2D fully nonlinear numerical wave tank (NWT) based on the boundary integral equation method (BIEM). This model was validated by comparing the body motions and reflection coefficient with those from other sources. Except near the resonant frequencies of body motions, the results indicate good agreement between the simulations and experimental data. Near the resonant frequencies, the body motions were damped obviously due to the fluid viscous effect. The results show that the resonant frequencies of body motions shift to lower frequencies as wave height increases. Besides, if the uncoupled damping coefficients matrix is incorporated into the vibration system of this model, the simulated results will be much closer to the experimental data.

KEY WORDS: dynamic response; floating structure; dual pontoon structure; NWT; BIEM.

INTRODUCTION

In recent years, the development of dual pontoon floating structure has attracted wide attention due to its stability feature in waves, for example: catamaran (twin hull boat), floating breakwaters and cage aquacultural platform, etc. In this paper, a numerical model is developed to investigate the dynamic responses of a moored floating dual pontoon structure.

Recently, Williams and Abul-Azm (1997) investigated the wave reflection properties of a dual pontoon floating structure by developing a numerical model using the BIEM. Weng and Chou (2007) used both BIEM-based numerical model and physical model to investigate dynamic responses of body motion and wave reflection. However, the flow field in the above models was considered with the linear wave theory.

The nonlinear wave-body interaction problem of a floating single pontoon structure has been studied by Isaacson (1982) using BIEM. In recent years, the numerical simulation of nonlinear wave-body interaction was investigated by a fully nonlinear numerical wave tank (Tanizawa, 1995; Koo and Kim, 2004; Huang et al. 2008, etc). In this paper, the boundary integral equation (BIE) is formulated by using the linear element method. Subsequently, the nonlinear free surface is traced by the Mixed Eulerian and Lagrangian method (MEL), referred to Longuet-Higgins and Cokelet (1976), and the 4th order Runge-Kutta method (RK4), meanwhile a node-regridding technique is applied by using a cubic spline scheme to free surface nodes that are moving too close to each other. Two numerical damping zones (Cointe, 1990 and Tanizawa, 1996) are implemented on both ends of numerical wave tank to absorb or dissipate the reflected and transmitted waves due to wave-body interaction. The instantaneous hydrodynamic force is calculated by an acceleration potential method (Tanizawa, 1995) and a modal decomposition method (Vinje and Brevig, 1981).

The objective of this paper is to investigate the dynamic properties of a floating dual pontoon structure response to waves by comparing the response amplitude operator (RAO) of body motions and the reflection coefficient. The nonlinear wave effects on body motions are also discussed by varying the incident wave height. Finally, an uncoupled damping coefficient matrix is incorporated into the equation of body motion to reduce the discrepancy between simulated and experimental results caused by fluid viscous effects.

NUMERICAL MODEL

A dual pontoon floating structure consisting of a pair of floating cylinders of rectangular section is restrained by a linear symmetric mooring system, as shown in Fig. 1, where a is the width of each pontoon, b is the spacing between two pontoons, d is the draft, (x_G, z_G) is the position of gravity center, l_p is the roll moment arm, θ_0 is the mooring angle and l_0 is the original length of mooring line. This floating structure is deployed in a numerical wave tank where the water depth h is held constant. Two numerical damping zones are deployed at both sides of the wave tank to dissipate reflected and transmitted waves, where x_{d1} and x_{d2} are the entrance positions.

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