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Discussion of Morison Formula Applied to Floating Structure

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ABSTRACT

The flotation ring, a vital component of the gravity-type fish cage in open ocean engineering, oscillates under the action of water waves. The wave forces on the element of the flotation ring can be represented by Morison formula. However, the computing results according to the common Morison formula can not be in good agreement with the experimental data. Therefore, the attempt to substitute the relative acceleration of water particle in the inertial forces is made. The fresh results improve the surge displacements in the negative direction to some extent. It is said that that the modification for Morison formula may provide another angle of view to describe the wave forces acting on the floating structures.

KEY WORDS: Morison formula; ring; inertial forces.

INTRODUCTION

Due to the decreasing fishery products and the lack of the offshore marine resources, fishery aquaculture in the open ocean is playing an increasingly important role, believed to be a very efficient farming technique. The deep-water anti-storm fish cages are frequently employed, which is a typical open ocean aquaculture technique. As a new form of offshore structures, fish cages have received the extensive investigations. Fredriksson (2003) studied the heave response of a central spar fish cage using the physical and finite-element model and the field observations. Huang (2006) proposed a numerical model of analyzing the dynamic characteristics of a net cage, and numerical results obtained was in good agreements with the experimental data. Herein the gravity-type fish cage is considered. It is composed of a flotation ring as the main load-bearing structure component, cage net to ensure that fishes are encircled inside, and mooring cables fastening the fish cage from floating away in waves and flows. And the focus is on its flotation ring. In this paper, numerical model of flotation collar was set up to simulate its hydrodynamic behaviors in waves. When the wave force in the numerical model was calculated according to the general Morison formula(Morison, et al. 1950) , our predicted results of the surge motion displacements in the negative direction, however, are not satisfactory compared with the experimental data, which are less than the corresponding experiment measurements. Therefore, the attempt to modify Morison formula is carried out, expected to obtain the good agreement between the numerical results and the experimental data.

Morison and his colleagues (1950) presented a semi-empirical formula to calculate the flow force on a slender vertical rod immersed in water, with the diffraction effect neglected based on the fact that the cross section of the body is much smaller than the incident wavelength. And the expression is extensively applied to marine structures owing to its simple form. For the flexible (compliant) structure, the modified form referenced to Brebbia and Walker (1979) is given, in which the relative velocity of water particle to the members is considered in drag force, and the relative accelerations in added mass force, while another inertial force is independent of the structures. The flotation ring considered, however, oscillates with the wave surface, which is not fit for the case described in Morison formula. Therefore, some changes of Morison formula may be made to better represent the wave forces acting on the floating structures. The following is to introduce the numerical model of a simple flotation ring neglecting the cage net, and to describe the modification of Morison formula in detail. And the conclusion is derived, expected to provide a new angle of view to Morison formula applicable to the floating structures.

NUMERICAL MODEL

The configuration of the fish cage model is shown in Fig. 1, which is the same as that of the model experiment conducted by Gui (2006). The flotation ring is simplified as a circular ring, and moored by four mooring cables. As is shown in Fig. 1, the radius of a circular ring is R, the angle coordinate is , and the size of the configuration can also be seen. A plane progressive wave propagates along the positive direction of X axis.

In the model tests the elasticity modulus of the ring is so large that the deformation of ring is quite small to be neglected. Therefore, the flotation ring is considered as a rigid body. In addition, due to the symmetrical configuration of the system and the wave's mono-propagation along X axis, the translation along the Y axis and the rotations around the X and Z axes vanish. So three degrees of freedom motions, surge, heave, and pitch, are under consideration.