The Problem of Simulating the Simultaneous Distribution of Waves and Current in a Towing Basin in Shallow Water

Alevtina N. Kulikova, Viacheslav V. Magarovskii
Krylov Shipbuilding Research Institute
St-Petersburg, Russia

ABSTRACT

The paper discusses the issues related to modeling of hydrodynamic flow induced by simultaneous propagation of waves and current in test tank under shallow water conditions. For this purpose the paper considers the transformation of wave spectral density in presence of opposite and following currents under shallow-water conditions using well-known algorithms. The paper presents and analyses the results of experimental studies on hydrodynamic loads induced by waves and current on fixed structures of various architecture.

KEY WORDS: Shallow water; wave; current; experimental studies; wave loads; fixed offshore structures.

INTRODUCTION

The modeling of hydrodynamic flow induced by simultaneous propagation of waves and current in test tanks has always been considered as a challenging task. This problem is addressed by different methods. Some test tanks are capable to physically model a wave-induced flow which is superimposed with a constant-velocity fluid flow. The equipment and studies carried out in such test tanks are rather costly. Moreover, the current speed in this case is quite limited, and the current is generated only in one direction. The most common method for simultaneous modelling of wave and current effects on test object is a reversed motion when the object is moved against waves. However, this method often fails to realistically reproduce the true physical pattern of the interactions under consideration. The modelling technique discussed in this paper is based on the transformation of variations in wave ordinates generated in test tank. The studies performed by a number of authors have made it possible to suggest an algorithm for transformation of surface wave density due to constant current in deep water. This paper is using this algorithm as a basis for treating the transformation of wave density in shallow water. By way of example the authors present and analyse the results of experimental hydrodynamic load studies for a fixed platform subject to simultaneous effect of irregular waves and current. The tests were performed in the seakeeping tank of the Krylov Shipbuilding Research Institute.

1 MODELING OF CURRENT AND SIMULTANEOUS CURRENT AND WAVE EFFECTS

The currents in test tanks are most often simulated by means of reversed fluid motion. However the combination of reversed motion and wave-induced flow is not correct for modelling of simultaneous wave and current effects.

It is known [1], [2], [3], [4] that the current changes the characteristics of wave motion by transforming the spectral density of wave ordinates. The spectral density variations induced by current is dependent on the current speed and direction as well as on the wave characteristics. When the wave direction coincides with the current direction, the wavelengths increase and thus the wave energy level is reduced. Hence the following current results in lower wave dispersion. The opposite current increases the wave slopes and adds energy to the wave system, therefore the surface wave dispersion under the opposite current is increased.

It should be noted that the algorithms for calculating the transformed waves in ref. [1] and [2] coincide for the following current and differ for the opposite current. Both algorithms are based on a well-known solution of Longuet-Higgins [5] for regular waves. As a first step in solution of the problem under discussion the authors of this paper gave consideration to the algorithm of ref. [1] in ref. [1] it is shown that in case of a constant current the spectral densities of surface waves in deep water can be obtained from the equation

$$ S_{\omega \omega + \gamma} (\omega) = \frac{4 \omega^2}{1 + \left( \frac{4 \omega}{g} \right)^2 + \left( \frac{4 \omega}{g} \right)^7 + \left( \frac{4 \omega}{g} \right)^{10}} + \frac{4 \omega^2}{1 + \left( \frac{4 \omega}{g} \right)^2 + \left( \frac{4 \omega}{g} \right)^7 + \left( \frac{4 \omega}{g} \right)^{10}} \tag{1} $$

where $ S_{\omega \omega + \gamma} (\omega) $ – spectral density of surface waves without current effect;