Wave-Current Forces on Vertical Piles in Side-by-Side Arrangement

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ABSTRACT

The in-line and lift forces on vertical piles in a side-by-side arrangement induced by both irregular waves and currents were investigated experimentally. The characteristics of both time and frequency domain of in-line, lift and resultant forces as well were analyzed. The grouping effect coefficients of in-line and resultant forces on the piles related to a KC number and relative spacing parameters are given. Also, a comparison is made of the magnitude and direction of resultant forces on vertical piles in a side-by-side arrangement with the corresponding values for a single cylinder. The range of KC number tested is 6-60; the range of Reynolds number, (0.55~3.43)*10^4.

INTRODUCTION

The wave loading on a slender cylinder and a group of slender cylinders is one of the basic problems of hydrodynamics in offshore engineering. Since the development of Morison's Equation in 1950, the prediction of in-line force on a single cylinder has become realistic. In spite of its shortcomings (unstrictness in viewpoint of theoretical analysis and sometimes a large error may occur during the calculation), so far Morison's Equation is the only practical method to be used for engineering purposes. Expect for some point of theoretical analysis and sometimes a large error may occur by using Morison's Equation and experimental data, then to find no report about the wave-current force on cylinders caused by research on irregular wave-current forces on pile groups. Because reliable method for this study is the physical model test. The second method is more convenient for data analysis and more information for a single pile can be used for an engineering application, so in this paper we used only the second method.

METHOD OF ANALYSIS

The flow behaviour around multipiles is different from that around single piles, so the wave force acting on multipiles should be different from that on a single pile. This is the so-called multipile interference phenomenon. There are two kinds of methods for analyzing wave loading on multipiles. One is the method often used for single pile: To calculate the hydrodynamic coefficients by using Morison's Equation and experimental data, then to find the relationship between hydrodynamic coefficients and other parameters. Such a relationship may be used for an engineering application. Another way is to calculate the grouping effect coefficients. This paper is part of the results of the authors' research on irregular wave-current forces on pile groups. Because of the complexity of the flow behaviour around cylinders, a more reliable method for this study is the physical model test.

The wave force is proportional to the square root of zero order moment of wave force spectrum. Then, in frequency domain analysis, KC is defined as:

\[ KC = \frac{\pi S_1}{D} \]  

where \( S_1 \) is the maximum displacement in one direction of water particle in one wave period, and the value \( S_1/D \) may express the repeated effect of shed vortex on a pile, i.e., \( S_1/D \) is a characteristic parameter of flow behaviour around a pile. Eq. 3 may be expressed by: