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Experimental Study on Phase Difference between Total Horizontal and Vertical Forces Acting on Perforated Caissons Located on a Rubble Mound Foundation

Zhisheng Xia[1] *Dapeng Sun*[1] *Yong Liu*[2] *Yucheng Li*[1] *Qingyu Wan*[1]

1. State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology, Dalian, China
2. College of Engineering, Ocean University of China, Qingdao, China

ABSTRACT

By means of the regular wave experiments in the wave-current flume, the phase differences between the total horizontal and vertical forces of regular waves acting on partially perforated caissons located on a rubble mound foundation are investigated. The effects of several significant dimensionless parameters including the relative foundation height, the relative chamber width, the relative water depth, the wave steepness and the porosity of perforated wall are examined, using single-dimensional correlation analysis. Also, the empirical formulas for calculating the phase differences of perforated caisson on the rubble mound foundation are presented by means of the least square method, which are useful for practical engineering.

KEY WORDS: phase differences; partially perforated caissons; regular waves; rubble mound foundation.

INTRODUCTION

Perforated caissons have been often used in practical engineering due to their merits of smaller reflection coefficients and wave forces. Since the initial study of Jarlan (1961), the hydrodynamic performance of perforated caissons has been examined many times by different researchers. The related studies have been mainly focused on the calculation of the reflection coefficient (e.g., Fugazza and Natale, 1992; Takahashi et al., 2002; Suh et al., 2006; Yueh and Chuang, 2010) and of the horizontal wave force (Takahashi, 1996; Tabet-Aoul and Lambert, 2003). However, in practice, the perforated caissons are generally constructed on rubble foundation. So, the vertical force acting on the perforated caissons should be considered for the engineering design.

Recently, both the horizontal and vertical forces acting on perforated caissons located on a rubble fill foundation have been carefully examined by Li (2007) and Liu et al. (2008). It was found by experimental and numerical results that there was an obvious phase difference between the total horizontal and vertical forces acting on the perforated caissons. When the total horizontal wave force reached a peak, the in-phase total vertical wave forces were rather small or even downwards. This should be helpful to the stability of perforated caissons.

In the present paper the experimental work of Li (2007) and Liu et al. (2008) is extended to the case of rubble mound foundation, which is often constructed in practice. The existence of the expected phase difference between the total horizontal and vertical force peaks or troughs for perforated caissons located on the rubble mound foundation is clearly demonstrated. Moreover, empirical formulas are derived for the phase difference calculation. These formulas should be useful for practical engineering.

EXPERIMENTS

The experiments were carried out in a wave-current flume at the State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology, China. The flume was 56 m in length, 0.7 m in width, and 1.0 m in height, and was equipped with a piston-type irregular wave maker.

The model of caisson, made of plexiglass plates of 1.0 cm in thickness, was 45 cm long, 68 cm wide and 60 cm high (see Fig. 1). It was divided into four uniform boxes named No. 1~No. 4 from left to right by partition plates. The front wall was perforated by four rows uniform rectangular holes from a distance 20 cm above the bottom of caisson to the top, and the back wall was solid. Two front plates with different porosities of 0.2 and 0.4 were used in the tests. The length of the holes was 0.110 m and their width was 0.037 m when μ was 0.2, where μ is the porosity of perforated wall; and when μ was 0.4, the width of the holes was 0.074 m and the length of the holes was the same as for the porosity of 0.2. Three different wave chamber widths b_c = 15, 20 and 30 cm were used in the tests by changing the positions of the chamber rear walls.