Experimental Study of Regular Wave Impact on the Three-dimensional Structure in the Splash Zone

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ABSTRACT
The experimental investigation of regular wave slamming on the three-dimensional structure in the splash zone is presented. The experiment is conducted in the marine environment channel in the State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology. The wave channel is 50m in length, 3.0m in width and 1.0m in height. The test wave is unidirectional regular wave. The experiments are carried out with perpendicular waves (θ=0°) and oblique waves (θ=15°, 30°, 45°), wave heights ranging from 7.5 cm to 20 cm with 2.5 cm increment, wave periods ranging from 0.75 s to 2.0 s with 0.25 s increment, and the relative clearance of the model with respect to wave height ranging from 0.1 to 0.5 with 0.1 increment. The statistical analysis results of different test cases are presented. The statistical distribution characteristics of the perpendicular wave impact pressures are compared with that of the oblique wave on the underside of the structure. The influence of the wave direction θ on the wave impact forces on the underside of the structure is investigated. Experimental results indicate that the impact forces depend on parameters such as wave height, wave period, the relative structure width and the relative clearance of the structure.

KEY WORDS:
Perpendicular wave; Oblique wave; wave impact; wave direction.

INTRODUCTION

Wave impacting forces on marine structures are considerably important for the security of open structures such as offshore platforms, piled wharfs and offshore trestle bridge. The previous studies and engineering practices prove that the great impacting loads may cause collapse and destroy of the superstructure of open structures (Kaplan, 1976).

Theoretical solutions to this problem were given by Wang (1970) and Kaplan (1992) under certain assumptions of wave conditions. Wang studied the wave induced pressures on the underside of a horizontal flat plate mounted on a pier deck under a dispersive wave system. Based on the assumption of irrotational flow and an incompressible fluid, Kaplan (1992, 1995) extended the solution of small horizontal cylinders to the larger plate. Laboratory experiments were carried out to estimate the wave impacting pressures by Goda (1967), Elghamry (1971), Guo (1980), Wang (1998), Ren (2002) and Zhou (2004). Wang (1997) and Ren (2004) developed numerical models based on improved VOF method to simulate the wave impacting pressures.

However the studies mentioned above are about wave slamming on the two-dimensional structure, the complex structures such as offshore platforms, artificial islands and sea terminals usually cannot be simplified as two-dimensional problems. And the incident wave direction is also complex. So the previous research achievements would not satisfy the demands of the engineering practices.

The objectives of this paper are to investigate the characteristics of wave impact on the three-dimensional structure and the corresponding spatial distribution and temporal distribution of impact pressures. The statistical distribution characteristics of the perpendicular wave impact pressures are compared with that of the oblique wave on the underside of the structure. The influence of the wave direction θ on the wave impact forces on the underside of the structure is investigated. Experimental results indicate that the impact forces depend on parameters such as wave height, wave period, the relative structure width and the relative clearance of the structure.

EXPERIMENTAL SET UP

The experiment is conducted in the marine environment channel in the State Key Laboratory of Coastal and Offshore Engineering, Dalian University of Technology. The wave channel is 50m in length, 3.0m in width and 1.0m in height. It is equipped with a wave generator driven by a servo-electro-hydraulic system, with a related computer control and a data acquisition system. At the far end of the tank, a wave energy dissipation device is set to attenuate the reflected waves. The structure model is centrally installed in the mid-back part of the tank, as shown in Fig. 1. The oblique waves are generated by rotating the model structure with respect to the wave paddle.

In the experiment a platform structure model is designed as the experimental model. The deck of the platform is made of organic glass and 60 cm long, 60 cm wide and 2 cm thick. The supporting legs of the platform are made of steel pipe with the diameter of 2 cm. The slope of the legs is 10:1. The clearance of the underside of the model deck above the water can be adjusted by adjusting the height of the supporting legs which are designed adjustable. The distance between the edge of the deck and the wall of the tank is from 1.0m to 1.2m. Sixteen pressure transducers are fixed on the underside of the deck, and are marked as 1 to 16 as Fig 2 shown. The wave impact pressures on the underside of the deck are measured using a SG-2000 multi-point pressure measuring system, which was made by the Institute Water Transportation of Tianjin. The natural resonant oscillating frequency of the pressure transducers is 500 Hz and the data-sampling interval is 0.004s.