NONLINEAR METHOD FOR REAL-TIME WAVE FORCE RECONSTRUCTION ON A CYLINDER BY USING MEASURED WAVE ELEVATION

Jiabin Liu , Harbin Institute of Technology, liujiabin1990@foxmail.com
Anxin Guo, Harbin Institute of Technology, guoanxin@hit.edu.cn

INTRODUCTION

For a constructed offshore structure, wave force evaluation on its foundation in an intricate wave field will benefit the load data collection and structural safety monitoring. Then, the collected data can provide valuable references for similar structures constructed in the same ocean region in the future. A real-time wave force prediction can further contribute to the active control of the structural dynamic responses. According to the incident waves known or unknown, the wave force reconstruction issue can be divided into two categories. When the incident waves are known, the wave forces on the cylinder can be achieved by the theoretical methods or numerical methods. When the incident waves are unknown, researchers try to reconstruct the wave force indirectly. For a small-scale cylinder, researchers predicted the wave forces by using the Morison equation in random wave fields with measured data of wave elevation. These studies indicated a shortcut for determining the wave force on the cylinder by using the data of water surface elevation. However, the wave fields are assumed to be undisturbed by the structure in the mentioned studies. For a vertical larger-scale cylinder, Liu et al. (2018) established a prediction method to reconstruct wave force by using the recorded data of wave elevation around the cylinder. A linear method for the circular cylinder is provided that shows an excellent reconstruction of wave force for its dominant frequent components. However, reconstruction results showed that high-frequency wave forces are underestimated and low-frequency wave forces are overestimated, which means the linear method is incapable to predict the nonlinear wave forces on the structure.

CONTENT

In this study, an improved method is presented for reconstructing wave forces on a circular cylinder in the real-time. Assisted by the historical data of measured wave elevation, a novel approach is built to ameliorate the accuracy of nonlinear wave force reconstruction. Similar to the linear method, wave forces in the improved method are reconstructed directly by integrating the transformed wave elevation along the side surface of the cylinder. Hydrodynamic tests were carried out in the wave flume on a circular cylinder to examine the reconstructed results of the improved method, as shown in Fig. 1. Comparative results demonstrate that the accuracy of real-time reconstructed wave forces is significantly enhanced. The over prediction errors at force crests and under prediction errors at force troughs have been reduced. Two different algorithms, Fast Fourier Translation (FFT) and Recursive Least Squares (RLS), for the real-time reconstruction are conducted (Fig. 2). Comparative results show that the improved method performed by the FFT algorithm provides the most accurate results, as shown in Fig. 3. Time cost analysis for the linear method and improved method is investigated with different input data. The efficiency of the RLS algorithm makes the real-time wave force reconstruction has great potential in practical applications.

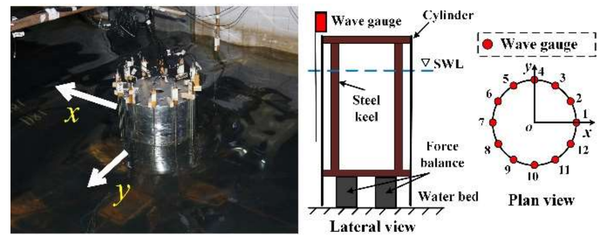

Figure 1. Close-up image of the test model and wave gauge contribution

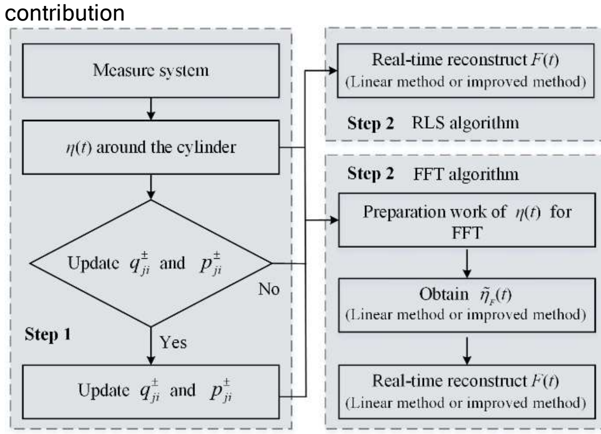

Figure 2. Flow chart for real-time wave force reconstruction.

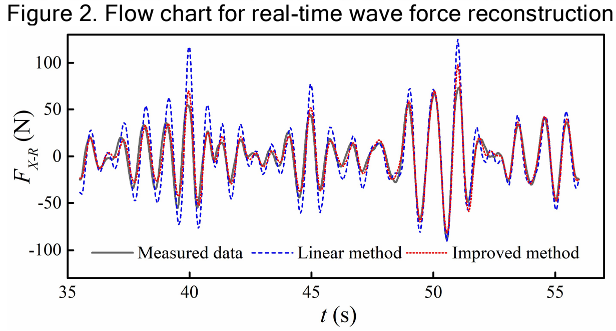

Figure 3. Comparative results of real-time wave force reconstruction between linear method and improved method

REFERENCES

Liu Jiabin, Guo Anxin, Li Hui and Hu Hui (2018). Methodology for wave force monitoring of bottom-mounted cylinder using the measurement of the wave surface elevation around the body surface. Journal of Fluids and Structures, 78: 197-214.