Study on Interaction of Steep Focused Waves with Fixed Cylinder Based on CFD Method

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ABSTRACT

Extreme loads are the main cause of damage to marine structures. Therefore, it is of great significance to study the interaction of waves and structures under extreme sea conditions. In this paper, the focused wave is used to simulate the extreme sea conditions, and the interaction between the focused wave and the fixed cylinder is studied. Commercial CFD software STAR-CCM+ is used to simulate focused waves. This paper focuses on the implementation of Commercial CFD software STAR-CCM+ simulation focusing waves and the reliability of numerical results. Through numerical simulation and comparative analysis, we can get the following conclusion: (1) In STAR-CCM+, the simulation of focused waves can be realized by mesh deformation technology, and the results obtained are acceptable compared with the experimental data. (2) STAR-CCM+ can simulate the interaction of focused waves with objects. This provides a way to simulate the dynamic response of floating structures under extreme sea conditions.

KEY WORDS: Focusing wave; cylinder; interaction; CFD

INTRODUCTION

Most of offshore structures operate more than 20 years under the harsh environments on-site so that the integrity of structures should be secured. To do this, prediction of an extreme wave loads in harsh environmental conditions become currently a significant challenge for the offshore structure design. Recently, in order to predict the proper impact load by extreme wave, a focusing wave based on nonlinear wave-wave interaction is being widely employed.

Many researchers have studied focusing wave impact using experiment and numerical analysis based on CFD. Yang et al. (2011) carried out numerical studies regarding the highly nonlinear steady and unsteady free-surface flows using OpenFOAM which is open-source CFD software. Both flap-type and piston-type wavemakers were implemented for the wave generation. The generated wave elevations and greewater behaviors on a rectangular body were compared to the model test result. Chen et al. (2014) investigated numerically the interaction of focused waves with a vertical circular cylinder using OpenFOAM. Compared with physical experiments, the nonlinear interaction of focused wave groups with a vertical cylinder was well represented in the numerical simulation. In the work by Östman et al. (2015) the impact loads of extreme breaking waves on a vertical structure has been investigated. The breaking waves were generated by flat-type wave maker in the CFD simulation. At the location of the extreme wave event, the time history of wave impact force was reasonably agreement with the experiments. Pakozdi et al. (2016) carried out a CFD simulation to obtain the wave impact loads during green water events on a module on the deck of a TLP in 10000-year conditions. In their study, breaking waves generated by numerical wavemaker, which can be directly linked to the extreme events observed in model tests, were used for estimation of the wave impact load. Duz et al. (2017) performed experimental study using PIV(Particle Impulse Velocimetry) to measure kinematics of breaking waves and horizontal impact on a fixed deck box. These results were used for validation of CFD simulation (Schärcke, 2017). Seon Oh Yoo et al. (2018), based on the results of model tests performed by KRISO, used CFD technology to study the realization of focused waves and associated impact loads on a fixed cylinder. Their research shows that the cfd simulation results agree well with the experimental results. Shiqiang Yan et al. (2018) used the quasi-arbitrary Lagrangian Eulerian finite element method (QALE-FEM) method to study the interaction between a fixed FPSO-like structure and extreme focusing waves. Their research provides a practical reference for not only choosing an appropriate model in practices but also on developing/optimizing numerical tools for more reliable and robust predictions. Zhihua Xie et al. (2018) use a large eddy simulation to investigate focusing wave impact on a fixed FPSO-type offshore structure. In their paper, numerical results have been presented and compared with the experimental measurements and other numerical simulations using QALE-FEM+OpenFOAM in terms of the wave run-up and pressure on the structure. Most recently, as a experimental study, “Comparative Study on Interaction of Steep Focused Waves with Fixed and Moving Cylinder” has conducted a series of experimental study on impact loads acting on a fixed and moving cylinder.

In this paper, the interaction between focused waves and fixed cylinders is investigated. Commercial CFD software STAR-CCM+ is used to