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Numerical Simulation of Focused Wave Interaction with a Fixed Vertical Cylinder

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In high sea states, offshore structures may suffer from extreme wave impact loads, which can result in serious local structural damage. It is still a great challenge for offshore designers to accurately predict wave impact loads. In this study, a coupled potential-viscous flow method is applied to simulate focused wave interaction with a fixed vertical cylinder. In the present method, an in-house computational fluid dynamics (CFD) code is coupled with a potential wave generation library MrNWB (Mooring/riser Numerical Wave Basin) based on Euler Overlay Method (EOM). Free surface elevation and dynamic pressure on the cylinder are calculated and discussed. The results of the present method are compared with the data of a benchmark model test. Comparisons show that the coupled potential-viscous flow method has reasonably good accuracy in predicting free surface elevation and dynamic pressure on cylindrical structures.

INTRODUCTION

Prediction of wave impact loads in harsh sea conditions is still a great challenge, since wave impact is a very complex physical phenomenon, involving wave runup, wave breaking, air entrapment, etc. Great efforts have been made on investigating the wave impact phenomenon and on predicting the loads on offshore cylindrical structures (Wienke and Oumeraci, 2005). In addition to model tests (Deng et al., 2016; Wang et al., 2016; Harish et al., 2018), numerical simulations based on CFD are becoming a promising method for predicting the wave loads. Mohseni et al. (2018) employed OpenFOAM (Open Field Operation And Manipulation) to investigate wave runups on a fixed vertical surface-piercing cylinder subjected to regular, nonbreaking waves. Xie et al. (2017) applied a three-dimensional (3-D) two-phase flow model to study 3-D breaking wave interaction with a vertical cylinder. Kamath et al. (2016) simulated plunging breaking wave interaction with a vertical cylinder with the open-source CFD code REEF3D. The effect of breaking location was analyzed by changing the position of the cylinder in their work. A Reynolds-averaged Navier–Stokes (RANS) equations-based method was used to study focused waves impacting on a fixed cylinder by Yoo et al. (2018). In the above-mentioned publications, a traditional damping zone was commonly applied to absorb reflecting waves at the outlet boundary. The damping zone should be large enough, usually twice of the wavelength. Thus, a large computational domain size is required that would result in high computational costs.

To overcome the disadvantage of the traditional damping zone strategy, a coupled potential-viscous flow method, based on domain decomposition strategy, would be preferable. Generally, for wave-body interaction problems, the concept of coupled potential-viscous flow method is that the approach for solving fully Navier–Stokes equations is used in the inner domain in the vicinity of a structure, while an efficient method based on potential theory for wave generation is applied in the region outside the inner domain. There are two types of domain decomposition strategies, i.e., two-way coupling and one-way coupling. The two-

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