Numerical investigation on harmonic components of wave loads on a vertical cylinder

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Abstract

Offshore structures are generally exposed to extreme waves, which may involve strong nonlinear wave-structure interaction. Such interaction can cause unexpected damage to offshore structures. Numerous methods have been developed to study wave-structure interaction, such as linear diffraction theory and second-order theory. These methods may be insufficient in dealing with strong linear problems. The extreme wave loads on the structures generally comprise a linear harmonic component and higher-order harmonics. Although some methods based on potential flow have been developed to calculate higher-order wave loads on vertical circular cylinder, few researches using CFD method are published.

In this work, the interaction of steep waves with a vertical circular cylinder is investigated using the in-house CFD solver naoe-FOAM-SJTU, which is developed on the open source platform OpenFOAM. The incompressible unsteady Reynolds averaged Navier-Stokes (URANS) equations are adopted as the governing equations. The volume of fluid (VOF) method is applied to capture the free surface. The horizontal wave forces and moments for small wave steepness to large wave steepness are studied. The first five harmonics of the horizontal wave loads and surface elevation are separated by the Fourier transformation of the time histories. The predicted harmonic loads are compared with the experiments in order to validate the numerical approach. The wave run-up and the local flow field around the cylinder during the interaction are presented and discussed. Reasonable agreement indicates the present solver is capable to investigate the nonlinear interaction.

Keywords: Steep wave, higher-order wave loads, wave-structure interactions, naoe-FOAM-SJTU solver