

Numerical Study of Interaction of Focused Wave with JIP Spar Platform in Current

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ABSTRACT

In this paper, the focused wave and current interaction with a moored JIP Spar platform are investigated using a time-domain higher order boundary element method (THOBEM). Embodied by a linear superposition of finite cosine waves, the focused wave can be efficiently simulated through adjusting the initial phase of cosine wave and adding corrected wave. The finite element method is used to simulate the distortion and tension of the mooring system. The great effects of current and mean drift forces on the position and amplitude of the focus peak value of hydrodynamic characteristics are investigated.

KEY WORDS: Focused wave; Time-domain simulation; Wave-current interaction; Higher order boundary element method; JIP spar platform.

INTRODUCTION

With the development of offshore oil-gas exploitation, the study of hadal marine zone is an inevitable trend of ocean development. The waves with large wave steepness (e.g., focused wave) always appear in deep sea, resulting in tremendous damages to platforms. Under the combined effects of wave and current, the offsets of floating platform are sometimes measuring dozens of meters. For the sake of safety, extensive experimental and numerical studies were carried out for the solution of the interaction of extreme wave with floating platform in current. In the early period, most researchs about extreme wave were studied by experimental method. Baldock et al (1996) developed a series of researches of extreme waves in finite water depth, nonlinear dynamic characteristics are investigated. A wave basin experiment has been performed to investigate the interactions between multi-directional focused wave and vertical bottom-mounted cylinder by Li et al (2012). A laboratory study of the focusing of transient and directionally spread surface water waves was studied by Johannessen and Swan (2001). However, the extreme wave impact on offshore structures has not been fully understood as the impulsive wave pressure and wave loading on the structures are difficult to predict due to the complexity of the problem. As experimental studies often costliness, several numerical simulations have been used to explain extreme wave generation such as wave focusing, wavelet transform and higher-order spectrum method. Among these mechanisms, wave focusing was the most important mechanism and has been studied by Fochesato et al (2007). The mechanism kinematics characteristics of extreme wave in shallow water were investigated by Borthwick et al (2006). A new

booussinesq model for wave run-up on curved structure using Cartesian cut cell grids was studied by Zang et al (2007). Some attempts to study extreme waves have been made by Kim and Kim (2003), Zang et al (2009), and Liu et al (2010), but most of these studies are for two-dimensional cases only. As far as 3D concerned, Walker and Eatock Taylor (2005) investigated the extreme waves interaction with pile group by linear theory. Many researchers studied focused wave interaction with structures without current (Johannessen, 1997, Liu et al, 2007). However, numerical study of interaction of focused wave with floating structures in Current was less common.

In deep sea, floating platforms are anchored by moored system. Moored platform can arise large amplitudes motion under the action of focused wave and current. The nonlinear deformation may destroy the safety production. In the early stage, Luis et al (1996) developed the catenary analytical method to calculate the deformation and tension of cables. Using a series of assumption, the effect of current force was neglected in catenary theory. Along with the deepgoing and detailgoing of the research, the use of analytical method has been greatly limited. Meanwhile, experimental study encountered many difficulties. In recent years, the numerical simulation got rapid development. Most of the studies about moored systems were applied by the finite element method. Aamo and Fossen (2000) assumed the added mass can be neglected, equations for cable force calculating were simplified. Pascoal et al (2005) investigated the deformation and tension of the cable by set the upper displacement of cable. The simulation of deformation and tension of cables were applied by given the upper displacement, external force and pre-tension. It did not take into account the cooperation of the moored system and structures. In this paper, the simulation of hydrodynamic characteristics of moored systems by nonlinear finite element method is applied. In each load increment step, N-R Newton's method is used to solve the rope deformation and tension, and hydrodynamic loads and motion response of moored floating body are solved by coupling the cable function and body motion.

In this article, a THOBEM is developed for investigating the interaction of focused wave with JIP Spar platform in current. Using a perturbation with two small parameters ε and δ associated with wave slope and the current velocity, the boundary value problem is decomposed into a steady double-body flow problem at the zero-order of wave steepness and an unsteady wave problem at the first-order of wave steepness. An artificial damping layer is adopted to dissipate the scattering waves (Ferrant, 1993). The boundary surface is discretized into a set of higher-order boundary elements, which are composed of eight-node quadrangular elements and six-node triangular elements. Embodied by a linear superposition of finite cosine waves, the focused