Numerical Analysis on Coupling Dynamic Response of Twin Barge-Topside Floatover During Load Transfer Stage in Beam Waves

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The twin-barge floatover method can efficiently utilize two barges to install the mega topside installation. However, the twin-barge floatover system involves hydrodynamic and structural interactions of multiple bodies. In this study, a numerical model is developed for predicting motions and loads of the twin-barge floatover system in beam waves during load transfers. The effects of multibody hydrodynamic interaction and mating loads on various connections and constraint components are considered. The motion equations of the multiple bodies, together with the coupled stiffness matrix, are derived. The numerical results are compared with the experimental results in beam waves. Results indicate that the proposed numerical model can provide accurate and reasonable predictions of the twin-barge floatover installation.

INTRODUCTION

With the development of the offshore oil and gas industry, offshore platforms gradually become much larger and more intensive. Limited by the lifting capacity of a crane, the conventional crane lifting method has difficulty meeting the installation needs of a mega topside of offshore platforms, especially for a 10,000-ton mega topside. To install the mega topside safely and efficiently, a floatover installation method has been developed rapidly in recent years. In the floatover method, the topside of the offshore platform is carried by barges and lowered down onto the substructures by the tide level and barge ballast adjustment, finally transferring the topside loads onto the substructures. The floatover methods have various configurations and can be classified according to different criteria (Qin et al., 2021). As a floatover installation method that has emerged in recent years, the twin-barge floatover installation method is flexible in form and can use two barges to achieve the installation of the topside, which has a broad engineering application prospect. During the twin-barge floatover installation, the weight of the topside is transferred from the twin barge onto the jackets under the effects of wind, wave, and current loads. The complexity of the system involves a hydrodynamic interaction among multiple floating bodies, the elastic connection of multiple bodies, external restraint, and load transfer.

The floatover installation method was introduced in the late 1970s and extensively studied through field measurement and numerical and experimental simulations (O’Neill et al., 2002; Jung et al., 2009; Wang et al., 2010; Choi et al., 2014; Luo et al., 2015; Chen et al., 2017; Ma et al., 2018; Bai et al., 2020a; Liang et al., 2023), although most are related to the single-barge floatover installation. Ma (2018) used numerical simulations to investigate the hydrodynamic characteristics of a T-barge in the time domain by considering cable tension and fender collision forces, and they compared them with experimental results. Hu et al. (2017) and Chen et al. (2017) used a state-space model to research the interaction between multiple bodies during load transfer. The latter additionally considered the leg mating unit (LMU) and the deck support unit (DSU) as damped linear springs to simulate the heave-roll-pitch coupled impact in the time domain. Bai et al. (2020b) investigated the dynamic response characteristics during the floatover installation of a mega topside based on the fast load transfer technique using model tests. Zhao et al. (2021) and Du et al. (2022) considered the multibody coupling effect of a single-barge system and used numerical simulation to investigate the multibody hydrodynamic mutual interference problem.

There are few studies being carried out on the motion and loads of the twin-barge floatover process. Tahar et al. (2006) appropriately simplified the connection between the substructures of the twin-barge floatover system as spring connections or rigid connections, according to the different stages of load transfer. Cao et al. (2019) conducted a simulation study using AQWA-DRIFT software and found that rigid connections greatly increase the connection force compared with hinged connections. Dessi and Faiella (2019) conducted an experimental investigation of the twin barges’ seakeeping properties without taking topside weights into account. Tao et al. (2020) and Wang et al. (2022) simulated the load transfer process while considering the time-varying ballast mass. Koo et al. (2010) and Bai et al. (2021) conducted numerical simulations of a twin-barge floatover system with different load transfer phases. The former investigated the 0%, 20%, 30%, and