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Coupled Mini-TLP Barge Response in Random Seas

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The response behavior of a coupled mini-TLP and tender barge in head and beam West African sea conditions is studied. Both vessels are independently moored, and coupling is introduced through a fender and breast line system. The dynamic response of the mini-TLP/barge system in uncoupled and coupled configurations is of particular interest. The experimental data obtained during the model test program are characterized using statistical parameters, correlation functions, spectra and coherence functions. It is confirmed that the connection system reduces the horizontal vessel motions of the barge, and that the forces exerted on the fender system are quite sensitive to sea heading conditions.

INTRODUCTION

The use of 2 or more closely positioned platforms for offshore operations is quite common. Examples of 2-body hydrodynamic systems include a tender barge floating adjacent to an offshore structure, and more recently the side-by-side loading or offloading of LNG vessels. It is important to develop a good understanding of the basic 2-body hydrodynamic response behavior before considering even more complex systems. For instance, in the case of an LNG tanker moored to a deepwater terminal, the ability to more accurately predict the tanker's heave and roll motions could better facilitate the necessary product transfer between the platforms. Similarly, improving the prediction of the sway and yaw motions could help designers to avoid collisions between the platform and the vessel.

The hydrodynamic behavior of a 2-body system is different from that of a single-body system, as the motions of each body will be influenced by the presence of its neighboring structure. Besides tie-offs and soft or hard connections for product transfer, the hydrodynamic interaction effects such as diffraction, radiation and amplitude of the wave field between the platforms present significant design challenges. The response behavior is greatly influenced by the configuration of the 2-body system, in particular the size and shape of the structures, the separation distance between them and the stiffness of the various mooring and docking connections.

Over the years, many researchers have investigated multi-body hydrodynamic problems, particularly 2-body systems. Both numerical and experimental studies have been conducted. The most widely used numerical simulation methods are based on the linear potential theory: Kim (1972), Ohkusu (1976) and Kodan (1984) applied the strip method to slender bodies; Van Oortmerssen (1979), Inoue et al. (1996) and Hong (2005) used the boundary integral method to study the 2-body system's hydrodynamic behaviors; the finite element method was adopted by Taylor and Zietsman (1982) and Chen et al. (1991) for the same purpose. At the same time, studies based on experimental results from model testing have played an important role in the process of validating and refining numerical simulation tools used for design. Teigen and Niedzwecki (1999) reported on a series of model tests involving a fully coupled mini-TLP and tender barge system. Both Hong et al. (2002) and Van der Valk and Watson (2005) studied experimentally the system behavior of LNG vessels in both side-by-side and tandem mooring configurations. A recent study reported by Fournier, Naciri and Chen (2006) provided a comparison of experimental results with several numerical simulation methods used by industry to study side-by-side vessel configurations. The focus of that study was to investigate the resonance between a model of a floating storage and regasification unit and a typical LNG carrier.

The present research investigation focuses on the interpretation of model test data for a selection of mini-TLP and tender barge system data subject to benign sea conditions (Teigen and Niedzwecki 1999). The 2 vessels are located in close proximity for both the uncoupled and coupled configurations. They are coupled side by side using a connection system consisting of 2 breast lines that bring the tender barge in contact with the mini-TLP fender system. The model tests selected had combined environmental loading of wind, random waves and ocean current conditions. The study presented does not involve nonlinear computational predictions, but rather focuses on the characterization and interpretation of the experiment and the resulting measurements. The primary objective is to investigate the relative motions of the mini-TLP / barge system as it responds to the combined wind-wave-current external forces, and to assess the influence of the connection system.

EXPERIMENT

Prototype Mini-TLP/Barge System

This unmanned platform concept was based upon proven technology and viewed as a cost-effective solution for offshore operations in benign environments such as those found off the coast of West Africa. It was designed for deepwater operations for a target location in West Africa's Gulf of Guinea, where the water depth is typically 1000 m and the wave spectrum has a peak period of 16 s and a significant wave height of about 4 m. This particular side-by-side moored 2-body system was first studied by Teigen and Niedzwecki (1999), and here a completely different data set

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