Prediction of Floating Platform Mooring Responses in South China Sea

Jianhui Liu, Wenjun Zhong, Yanfang Zhang
Offshore Oil Engineering Co., Ltd.
Tianjin, China

ABSTRACT

In designing offshore mooring systems, the dynamic behavior of mooring chains, wires and multi-component lines is of increasing importance. In order to investigate the global performance of deepwater floating systems in South China Sea, nonlinear hull/mooring/riser coupled dynamic analyses of a truss spar designed for 1500-m waterdepth are conducted in the time domain. In addition, deepwater offshore basin and wind tunnel model tests of the truss spar were carried out. The vital wind coefficients for topsides and current coefficients for hull and truss section of Spar were gained from model tests. Discussion and comparison of mooring line tensions and global motions of hull/mooring/riser coupled system between the model tests and numerical simulations are provided.

KEY WORDS: spar; mooring; global performance; offshore basin model test; wind tunnel model test; coupled dynamic response.

INTRODUCTION

So far, three competitive spar concepts have been proposed: classic spars using a deep-draft hollow vertical cylinder; truss spar using a combination of relatively shallow-draft hollow cylinder and truss structure extended to a soft tank; cell spar using combination of small diameter tubes. The floating spars have been increasingly popular as an economic and reliable oil production platform in deep or ultra-deep water, particularly in the remote areas of the Gulf of Mexico (Wichers, et al., 2004).

As the offshore industry move into deeper water, the capacity to analyze and model test deepwater floating systems are challenged. The portion of the mooring line and riser mass becomes larger against the hull mass, and the resulting inertia and damping effects from them are expected to be important (Gupta, et al., 2000). When the design of risers and mooring lines was based on uncoupled quasi-static analysis or semi-coupled dynamic analysis (Tahar, et al., 2002; Steen, et al., 2004), the contribution of the mooring lines and risers in damping for surge/sway and pitch/roll would be neglected. As a result, it may lead to significant overestimation of mean and maximum pitch/roll responses. In this case, to accurately account for the inertia and damping effects of mooring lines and risers on the hull motions, hull/mooring/riser coupled dynamic analyses in time domain need to be employed (Kim, et al., 2001; Hansen, et al., 2004).

In order to better develop the calibration scheme against model-testing data, offshore basin model tests and wind tunnel model tests were conducted and compared against fully coupled results in this paper. Several useful conclusions are drawn based on the present study.

MODEL TESTS

On the one hand, offshore basin tests were conducted January 2010 in the deepwater offshore basin of the State Key Laboratory of Ocean Engineering (SKLOE) in Shanghai Jiao Tong University. The objective of the tests was to assess global responses of spar, with emphasis on the effect of mooring line and riser dynamics in deeper water. On the other hand, wind tunnel tests were performed in the low speed wind tunnel in China Ship Scientific Research Center (CSSRC). The aim of tests was to obtain the wind/current coefficients of spar platform. In addition, since the results of the model tests program will be used for post-model test computations(model-the-model), the performance and the reporting of the model test set-up must be as accurate as possible.

Offshore Basin Tests

The deepwater offshore basin is 10 m deep and 50 m×40 m in cross section, a pit with 5m diameter and 40 m deep at the center of test basin. Multi-flap wave generators on two sides can produce irregular long-crested or short crested waves up to 0.3 m with periods 0.3~3.0 seconds, model scale. Current can be generated over the full basin depth with a vertical profile. Wind spectra are produced with electrical fans on a free moving and position-controlled frame.

Due to the dimensional limit of basin, the equivalent water depth truncated mooring system was used in model test. The so-called "equivalent water depth truncated mooring system” refers to the