Assessment and Calibration of Numerical Coupled Models of a Deep-Draft Semisubmersible Platform Based On Model Tests

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ABSTRACT

This work presents the calibration, based on results of ocean basin tests, of numerical models of a deep-draft semi-submersible platform including mooring lines and risers. The models are generated with in-house Petrobras and commercial coupled programs. The programs consider different approaches in the hydrodynamic representation of the hull, including a classic Diffraction-Radiation model based in the Potential Theory, and a hybrid model that combines the Morison formulation with diffraction-radiation effects of potential damping and drift forces. The comparisons are evaluated in terms of statistical parameters and motion response spectra for wave-frequency and low-frequency components, and of force response spectra on selected lines.

KEY WORDS: Semisubmersible Platforms; Numerical Models; Coupled Analysis; Calibration; Model Tests.

INTRODUCTION

It has recently been established that the use of coupled analysis tools is very important to evaluate the global behavior of floating platforms for deep and ultra-deep waters (Senra et al., 2002; Correa et al., 2002; Correa, 2003; Senra, 2004). Such tools are able to consider the nonlinear coupling effects that arise from the interaction between the hydrodynamic behavior of the hull and the structural-hydrodynamic behavior of the mooring lines and risers.

The generation of representative numerical coupled models involves the determination of some coefficients that describe the motion response of the hull. Such coefficients calibration should be calibrated from experimental model tests or, alternatively, determined from numerical CFD models. In this work, the former alternative is considered, since the practice of performing model tests for platform hulls has been considered by Petrobras in all projects.

This is due to the fact that the basic design of a hull and its mooring system requires a step of verification where several parameters must be confirmed and calibrated, to deal with known limitations of the available numerical simulation tools, and also to preview new or unexpected physical behaviors that the numerical tools still cannot represent. Therefore, the objective of such experimental tests is not only to obtain the global response of the platform due to wave, wind and current (including results such as extreme motions, air-gap in critical positions and mooring forces), but to calibrate the numerical models generated for the coupled simulation tools developed by Petrobras and its partners in Brazilian universities. More important, such results should also be obtained using models where the lines are connected.

Therefore, the purpose of this work is to use results of model tests to assess and calibrate numerical coupled models, generated with different in-house Petrobras and commercial programs, for a deep-draft semisubmersible platform. Quasi-static results are expressed in terms of nonlinear restoring curves for the lines; dynamic results are expressed in terms of statistical parameters and motion response spectra, separately for 1st and 2nd order motion components, and of force response spectra on selected lines. Some important aspects related to the comparisons and calibrations are highlighted.

PHYSICAL AND NUMERICAL MODELS

It is expected that the motions of deepwater platforms, with large number of lines connected to the hull, will be modified by the influence of the lines. Physical models combining hull and lines have been proposed, in order to obtain a more realistic evaluation of the global behavior of such systems.

However, for deep water scenarios some adjustments must be made in the model in order to fit it into the ocean basin dimensions while using a reasonable scale, such as the grouping and the truncation of lines. The consequence of the truncation is that some losses can be observed in the dynamic response of the lines. In addition, certain requirements must be met with respect to the moored system: the correct natural period of heave, roll and pitch of the hull in critical conditions on the air-gap; the correct total horizontal stiffness; "representative" level of damping; "representative" tension of the isolated line, at least quasi-static.

Therefore, in (Ormberg et al., 1999) a strategy that combines the results