Numerical Simulation for Truncated Model Tests of Deepwater Semi-submersible Platform with Viscous Damper Compensated System in Mooring Lines

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ABSTRACT
Through a truncated model test of semi-submersible platform with the static equivalent mooring system, the availability of numerical simulation in the motions calculation of semi-submersible platform are validated and the results show the mooring damping may contribute significantly to the total damping of deepwater floating platform in the low frequency range. The viscous damper is designed to simulate the contribution of mooring damping. The dissipated energy by a mooring line from the floating platform as a result of its oscillation is applied to calculate the mooring-induced damping. The value difference of mooring induced damping between the truncated and full-depth mooring line is linearized to provide parameter for the design of viscous damper. The viscous damper is added to the numerical simulation of the motions calculation of semi-submersible platform with the truncated mooring line. Finally, the results are compared with motions calculation of semi-submersible platform with the full-depth mooring line.

KEY WORDS: viscous damper; truncated model test; mooring damping; dynamic analysis; numerical simulation; motion calculation.

INTRODUCTION
With the exploration of deepwater hydrocarbon resources, the application and research of floating platform are becoming more widespread. The semi-submersible platforms are widely applied due to the low initial investment and operation cost. During the design stage, a vital concern is how to accurately predict the motions of floating platforms under various complicated loads in the deep sea. Presently, there are two common approaches - numerical simulation and physical model testing.

It seems that the most realistic alternatives at hand will require the use of hybrid testing or hybrid verification in some form (Stansberg et al., 2002). It’s the sort of experimental technique which combines numerical simulation and truncated physical model test. Before the experiment, owing to the limitation of wave basin scale, the mooring system scope is truncated according to static equivalence firstly. The truncated mooring system is modeled by some numerical method, and then the mooring system is carried out by the standard reduced scale consistent with the upper platform. The motions and tensions are both considered during this procedure. At present, “passive truncation + numerical extrapolation” method is recognized as the most common in the hybrid model testing. Experimental results from the truncated model testing are used for numerical reconstruction and verification in the numerical calculation software, and then the dynamic characteristics of full-depth system are obtained through numerical extrapolation (Moxnes et al., 1998). In recent years, quite a few scholars have done the researches and achieved certain outcomes (Stansberg et al., 2000; Rolf et al., 2004; Hong et al. 2004).

In terms of the process of hybrid model testing, the motion responses of floating platform are finally accomplished via numerical simulation instead of directly using the results of model testing. This is mainly because the dynamic characteristics of truncated mooring line differ from the one of full-depth and are reflected in the contribution of mooring damping which has significant influence on motion responses of floating platform. Chen et al. (2000) studied the difference between the truncated and corresponding full-depth mooring line model using model tests. Chen et al. (2001) applied three numerical calculation software (two different versions of Cable3d and Orcaflex) to study the dynamic tension characteristic of truncated and corresponding full-depth mooring line model under different loads.

A brand-new model testing method is established in this paper that can directly get motion responses of floating platform via model testing. The main procedure is as follows: First, the contributions of mooring damping to the floating platform are calculated respectively in truncated and corresponding full-depth mooring line model. Second, the value differences of the two calculation results are provided for the design of viscous damper. Last, the viscous damper is added in the boundary of truncated mooring line to compensate the contribution of truncated mooring damping to the floating platform.

GOVERNING EQUATIONS AND FORMULATION
Governing equation of mooring line