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A Robust Procedure for Ultra Deepwater Model Testing

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ABSTRACT

Principles, uncertainties and limitations in model testing of ultra deepwater floating systems by use of truncated lines & risers in combination with coupled numerical analysis have been investigated. A numerical case study with a semi-submersible moored in ultra deep water GOM with a polyester system has been carried out. Three levels of truncation corresponding to model test depth to prototype depth ratios of 1:3, 1:6, and 1:12 have been made. Comparisons are also made to model test data for the 1:6 case. The results confirm that the current procedure works reasonably well even with truncation levels down to the 1:6 – 1:8 ranges. However, due to practical and numerical complications, truncation ratios less than 1:8 - 1:10 are not recommended.

KEY WORDS: Deep water model tests, hybrid verification, truncation, coupled analysis, global response

INTRODUCTION

Model testing for design verification of floating systems should preferably be done with the full-depth modeling, if possible. However, model test basins currently can only simulate prototype water depths of up to about 1,000 m with reasonable test scales. That presents significant challenges as ultra-deepwater floating systems extend to water depths of 3,000 m. Hence, model tests with truncated mooring line and riser models can in general not be avoided, and usually in combination with computer simulations as part of the verification process. This may in principle introduce uncertainties in the process since 1) the truncated mooring system may introduce differences from the real system, and 2) some of the actual model test data must be "transformed" to full-depth model data by help of a computer program. Therefore, procedures must be established that assure that these uncertainties are reduced to a level that makes the verification useful, and limitations of the procedure must be identified. The method should also be "robust and transparent" enough to avoid uncertainties due to practical and numerical complexity and unknown factors. This paper attempts to address these problems and demonstrate how analysis and model test can fit into the design process of ultra-deepwater floating systems - a "hybrid verification" method that aims to meet the above requirements. In the present work it is assumed that a validated numerical model of coupled floater/mooring line/riser dynamics is available for use in the design and calibration of the truncated system and in the extrapolation to the full-depth system.

A "hybrid verification" methodology that combines model tests with off-line numerical simulations has been established throughout extensive previous development (see e.g. Ormberg et al (1999), Stansberg et al (2000a), Stansberg et al (2000b) and Stansberg et al (2002)). A similar approach has been presented in by Waals and von Dijk (2004). It has also been addressed in a DeepStar Global Analysis Guideline work Stansberg et al (2004), and is proposed as an ITTC Procedure (ITTC (2005)). It can be described as follows:

- Design of truncated mooring and riser system according to specific guidelines.
- Pre-analysis of full-depth & truncated systems with coupled analysis is recommended
- Select and run a proper test programme with representative tests for the actual problem.
- Numerical reconstruction of truncated model tests ("model-the-model"), to verify/calibrate numerical tool
- Numerical extrapolation to the full-depth system by use of the calibrated numerical vessel model
- Transforming from un-scaled to prototype full-depth values

In this approach, the overall strategy behind the truncation design is to reproduce the floater motion dynamics of the real deepwater system, including low-frequency as well as wave-frequency components. Thus the aim is to reproduce the environmental loads on the vessel, and the most important part of the forces from moorings and risers, on the floater. In the practical procedure, we seek to obtain this by reproducing the quasi-static force vectors from individual lines and risers. In some cases two or more nearly parallel lines may be merged