

Master Thesis in Marine Technology - 2013

Coupled analyses of a moored Sevan Floating Storage Unit

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Problem

Give an overview of the theoretical background for the dynamic response of a moored floater. Perform coupled analyses of a moored Sevan Floating Storage Unit subjected to several environmental. Compare the results obtained from the analyses to model test results and preferably other software tools.

Introduction

The oil and gas industry is increasing their search for hydrocarbons on deep waters. These water depths can range from 1000-3000 meters. In deeper water, the effects on the floater motion from the mooring and riser systems increases significantly. Viscous damping, inertial mass, current loading and restoring effects from riser and mooring systems need to be adequately modeled in order to predict the system motion of response. Accurate prediction of the system motion of response is vital in the context of design verification of the complete system. The recommended method of numerical analysis of the dynamics of a moored structure, especially in deep waters, is by a coupled analysis approach [1]. This is recognized by the dynamics of the floater, mooring lines and risers are solved simultaneously.

A decoupled separated approach to the analysis of moored structures has previously been used. In deep water, especially for low frequency translatory modes, this procedure is referred to as both complex and as a possible inaccurate method for design verification [2]. In addition, the existing laboratories available for model testing of moored structures are challenged by the depth increase. Small scales used in model tests can introduces uncertainties related to measurements, and an accurate prediction of viscous effects is challenging due to the nature of scaling laws.

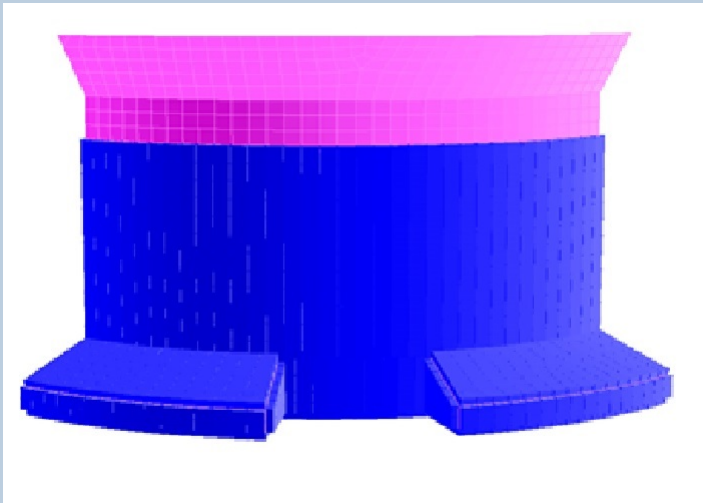
In a hybrid verification procedure, both model tests and numerical simulations are utilized together in order to predict the system motion. This is done by running the model test with truncated mooring and riser systems in order to apply a reasonable model scale. The results obtained from the model tests are used to tune the numerical model. Once this is accomplished, i.e. there is compliance between the numerical model and the model test results, the mooring and riser systems are extrapolated [2]. The possible inaccuracy of a decoupled numerical approach and the depth limitation of existing basin laboratories high lights the position of coupled analyses in design verification of moored offshore systems. In this thesis, coupled numerical simulations of a moored Sevan FSU (Floating Storage Unit) have been performed by the use of the software tool OrcaFlex. The results obtained from the OrcaFlex analyses are compared to results from a model test conducted on the moored FSU by Marintek.

References

- [1] DNV *Environmental Conditions and Environmental Loads*, 2007
- [2] Astrup, *DeepC Coupled Analysis Tool*, 2004

Modeling

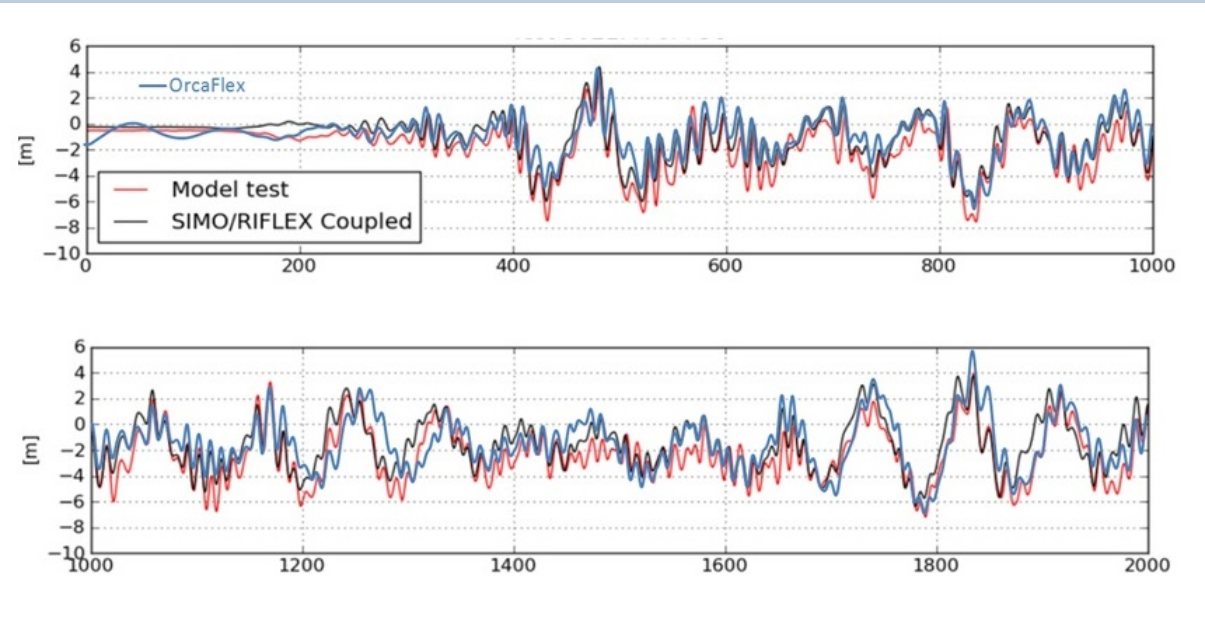
Two different mooring systems were built in OrcaFlex by Morison elements. Based on available information on the Sevan hull a FE-model was established in the software tool GeniE. Further, a diffraction analysis was performed utilizing the panel method software tool WADAM.



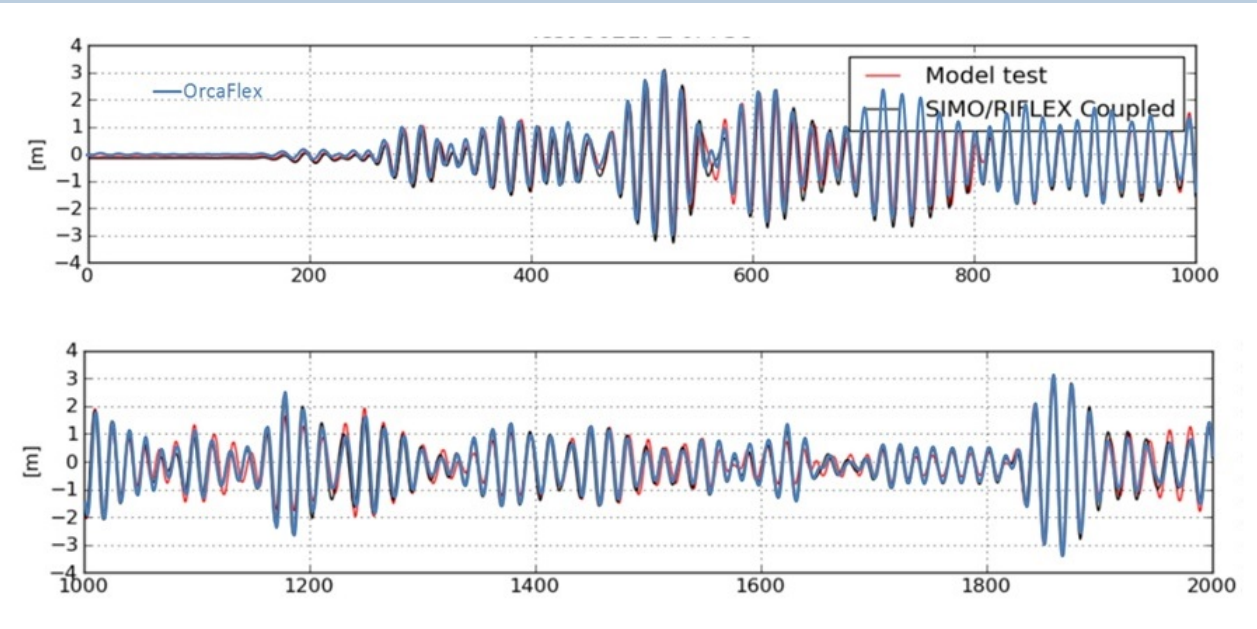
Output results imported to OrcaFlex were (i) Frequency and direction dependent first and second order excitation coefficients (ii) Frequency dependent added mass and potential damping. Viscous effects were estimated based on free decay tests of the floater, and later adjusted based on time series results.

Simulations

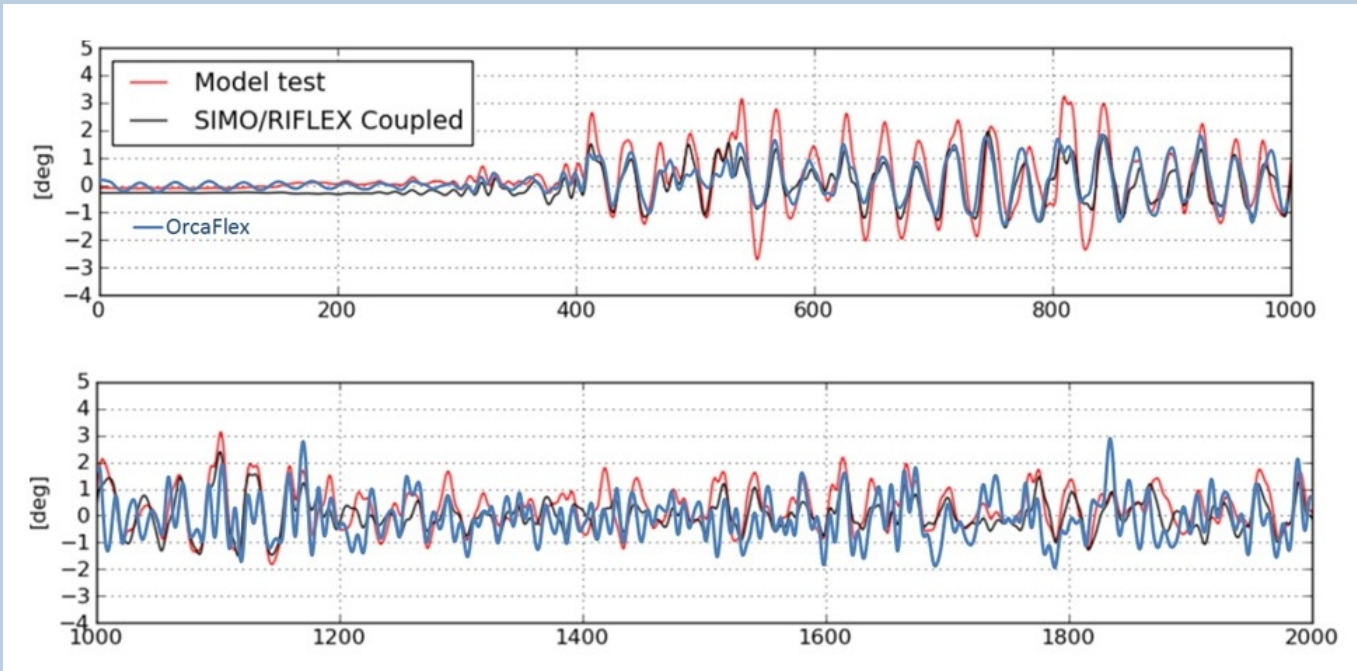
Time series of wave elevation and wind velocities recorded during the FSU model test were acquired through Marintek. These environmental conditions were integrated in the OrcaFlex analyses, enabling the FSU response during the model tests to be directly comparable to the OrcaFlex results. The regeneration of these environmental conditions turned out to be very CPU-costly. In OrcaFlex the user must define a dividing period which is used to filter the wave -and low frequency parts of the motion. This parameter, together with the viscous damping coefficients, needed adjusting based on time series results obtained from OrcaFlex.



FSU response in surge. $T_p=12s$ and $H_s=7.5m$. Current = 0.5m/s. Mean wind velocity 20m/s



FSU response in heave. $T_p=12s$ and $H_s=7.5m$. Current = 0.5m/s. Mean wind velocity 20m/s



FSU response in pitch. $T_p=12s$ and $H_s=7.5m$. Current = 0.5m/s. Mean wind velocity 20m/s

OrcaFlex uses Newman's approximation in order to estimate the slow-drift excitation of moored floaters. A method based on Aranha's approximation is utilized to predict the slow-drift damping.

Conclusion

The OrcaFlex results shows acceptable compliance to the model test and to a coupled numerical simulation performed by Marintek using the coupled software tool SIMO/RIFLEX. There are, on the other hand, deviation on the low frequency motion obtained from the OrcaFlex analyses and the model test. The differences are still investigated, but an interesting experience obtained from the implementation of these analyses is that the slow-drift damping coefficients estimated by OrcaFlex is not accessible through the user interface. This would be interesting as it can look like the OrcaFlex numerical analyses which has been carried out underpredicts the low-frequency amplitudes of the FSU. A 3000 seconds OrcaFlex simulation carried out on the available computer (2 cores, 2.93 GHz and 4 GB memory) had a duration of 11 days. Parameters like eddy-making damping need adjustments based on the time series results, i.e. coupled analyses is time consuming.

Acknowledgements

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