MASTER THESIS IN MARINE TECHNOLOGY – 2013

ANALYSIS OF MOTIONS AND ANCHOR LINE FORCES FOR FLOATING PRODUCTION UNITS

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PROBLEM

Ship shaped units for floating production, storage and offloading (FPSOs) will normally have a turret structure where anchor lines and production risers are linked to the floater. Dynamic interaction between line forces and floater motions will take place; floater motions will introduce line forces, but the line forces will also influence the floater motions. Simultaneous computation of motions and line forces is hence wanted, but requires time domain models for both vessel motions and line forces.

INTRODUCTION

Hydrocarbons are found in deeper and deeper waters, and the numbers of deepwater floating production units are growing rapidly. This results in new technological challenges. The dynamic behaviour of a multi-component offshore structure due to environmental sea loads (wind, waves and current) is a complex problem, and requires extensive computational effort to obtain realistic simulations. (ITTC, 1999)

The traditional uncoupled analysis is performed in two steps; first the motions of the floater due to waves are calculated, then the dynamic responses in the mooring lines and risers are found by using the vessel motions from the first step. The main shortcomings with the traditional uncoupled analysis are the simplification of the current forces and the low frequency damping contribution from mooring lines and risers. The effect of these so-called interaction effects will increases with increasing water depths, and an uncoupled analysis may be too inaccurate.

METHOD

Three different analysis techniques have been used to perform analyzes on a floating production system, two uncoupled analyses and one coupled analysis (Ormberg et al., 1998):

Uncoupled vessel motion analysis: In a vessel motion analysis the primary purpose is to give a good description of the vessel motion. The slender structure response is not so important in this kind of analysis, and the mooring lines and risers are therefore included in a simplified way. This analysis is performed is performed in the MARINTEK program SIMO.

Uncoupled slender structure analysis: In a slender structure analysis are the slender elements represented by a detailed FE model, while the floater motions are applied as external loading in terms of forced boundary displacements. This means that floater motions must be known prior to the analysis. This analysis is performed in the MARINTEK program RIFLEX.

Fully coupled analysis: In a coupled analysis is the vessel force model introduced in a detailed FE model of the complete slender structure system including all mooring lines and risers. This approach yields dynamic equilibrium between the forces acting on the floater and slender structure response at every time step. All the interaction effects are then taken into account. The coupled analysis will be performed in the new program SIMA, which is based on SIMO and RIFLEX.

SIMULATIONS

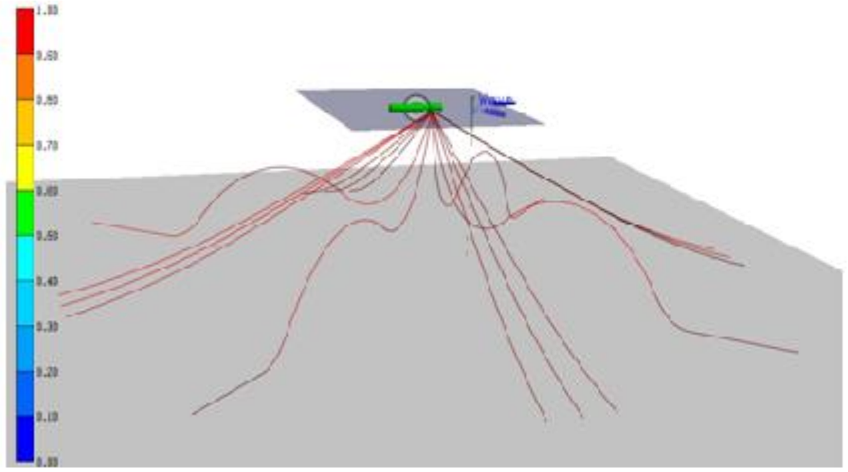
The FPSO to be analyzed is operating in a water depth of 913.5 m. It has 12 catenary mooring lines which are paired in groups of three, and 4 lazy wave risers. The floating system is shown in the figure.

The waves are described by a 3-parameter JONSWAP spectrum with:

- Significant wave height: 12.18 m
- Peak period: 14 s

The FPSO will also experience an ISO 19901-1 (NPD) wind spectrum and current.

The simulation time in these analyses is 512 s.



In a coupled analysis are the vessel motion and the mooring line and riser dynamics calculated simultaneously. The interaction effects are then taken into account, and accurate floater motions and slender structure dynamic loads are obtained. The main disadvantage with the use of a coupled approach is that the analyses are time consuming and require a large amount of CPU time. (Ormberg et al., 1997, Ormberg and Larsen, 1998, Heurtier et al., 2001, Gurumurthy et al., 2011)

In this paper the methodology for both a traditional uncoupled analysis and a coupled analysis is presented. The methodologies are applied to a turret-moored FPSO operating in a water depth of 913.5 m. The results are compared, and the need for coupled analysis is pointed out.

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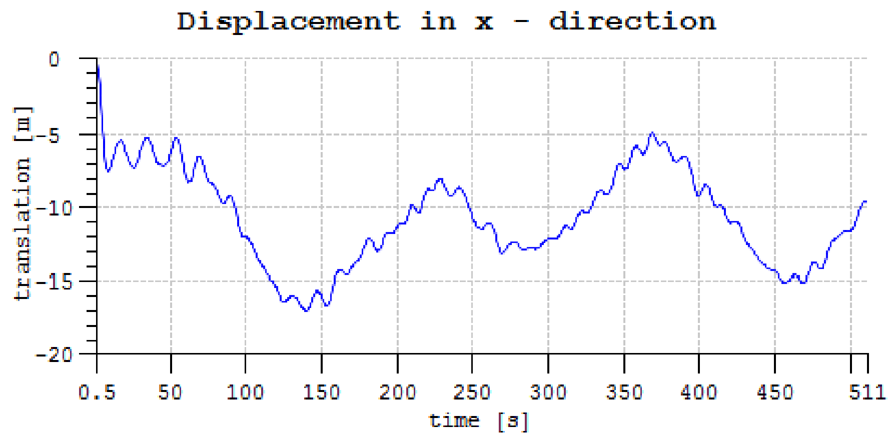
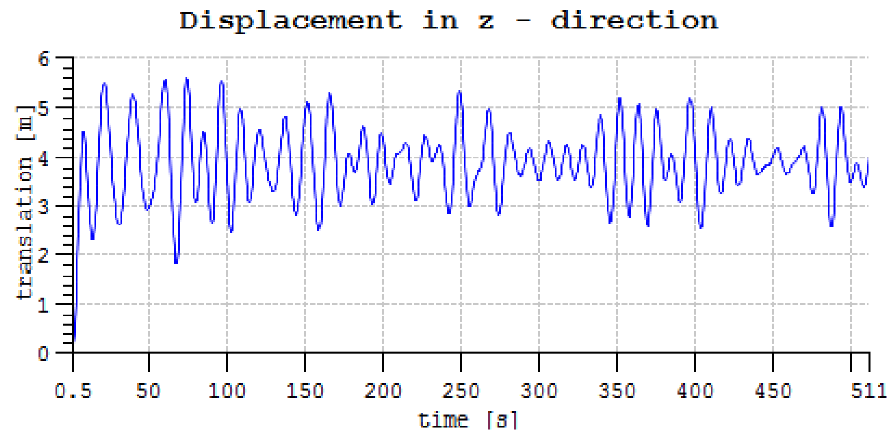
RESULTS

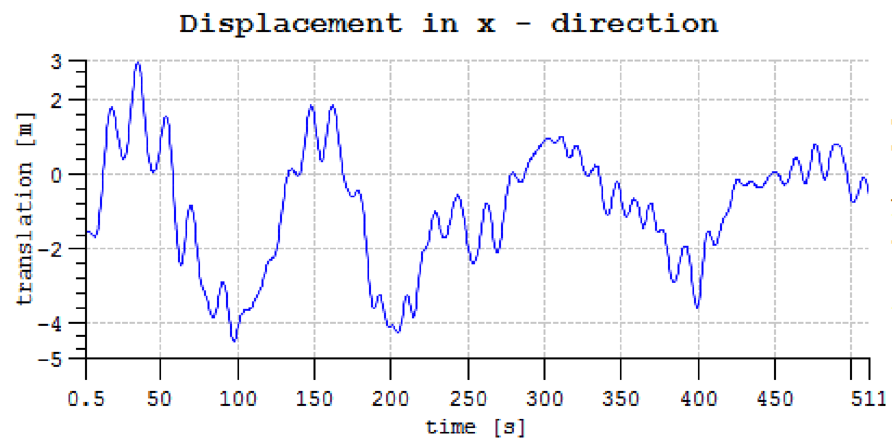
The results from the analyses are shown below. Since the slender structure analysis (RIFLEX) uses the floater motions obtained in the vessel motion analysis (SIMO), these two analyses gave very similar results. Due to space limitation, only the RIFLEX analysis is shown on the poster.

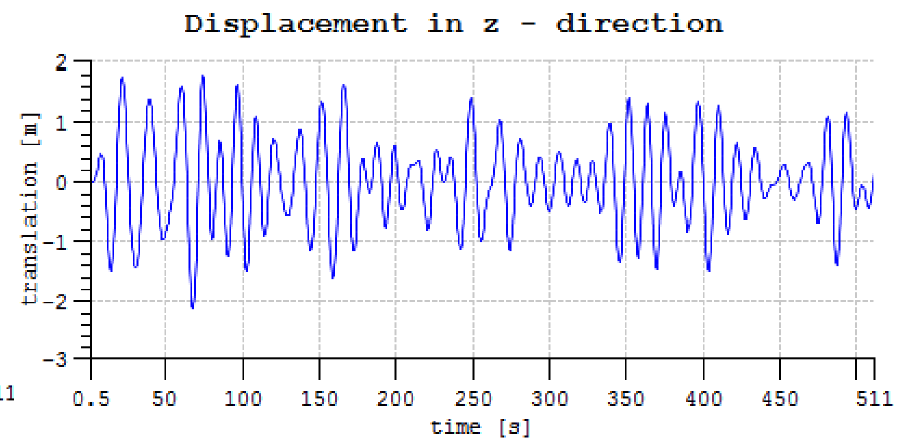
UNCOUPLED ANALYSIS – RIFLEX





COUPLED ANALYSIS – SIMA





CONCLUSION

The heave motion is not affected by the interaction effects, and is more or less the same in a coupled and an uncoupled analysis. However, from the figures above, it is clear that uncoupled analyses underestimate the low-frequency horizontal damping from the mooring lines and riser. The maximum surge amplitude obtain in a coupled analysis is much smaller than the amplitude obtain with an uncoupled analysis. In deep water, where the interaction effects are pronounced, it is necessary to use coupled analysis to achieve accurate floater motion estimates.