Numerical Study on Wave Drift Loading on Slender Marine Structures

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Problem

The master thesis is exploring the Navier Stokes solver OpenFOAM for calculation of the wave drift forces on a slender quadratic cylinder fixed in space. The cylinder is subjected to regular and bi-chromatic waves.

Wave Drift Forces

Wave drift forces are second order effects and can be divided into mean and difference-wave frequency forces, slowly varying loads. Slowly varying loads have large periods and are caused by sea states with more than one wave frequency present [2]. The second order forces cane be important for structures with low natural periods and steep waves [3]. They typically increase with increasing wave steepness [1].

References

[1] Odd Faltinsen: *Sea Loads on Ships and Offshore Structures*, Cambridge (1990)

[2] Marilena Greco: *TMR 4215: Sea Loads Lecture Notes*, Department of Marine Technology, NTNU (2012)

[3] Petter A. Berthelsen: *Viscous Drift Forces and Responses on a Semisubmersible Platform in High Waves*, Hawaii, USA (2009)

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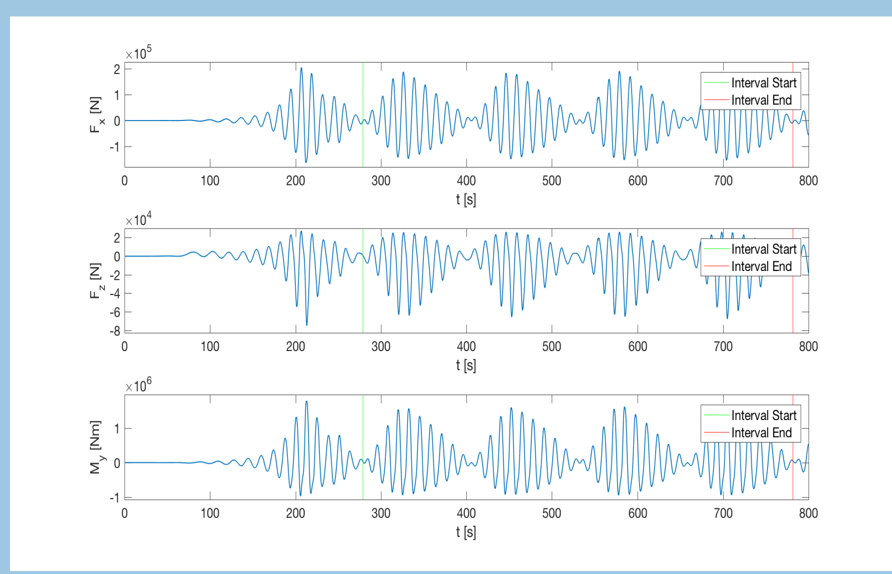
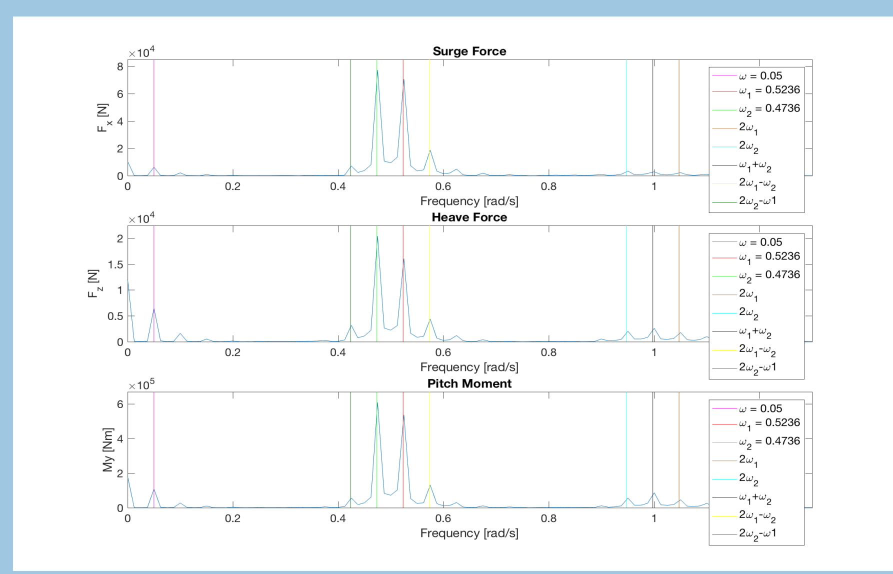
Modelling and Simulation

The analysis using OpenFOAM is performed for a 2D column of quadratic cross section mimicking one of the columns of a semi-submersible platform. The column is fixed in space, meaning that the diffraction problem is investigated. The column is subjected to both regular and bi-chromatic waves with wave height 4.5, 6 and 7 [m]. The ratio wave length to body size is such that the wave classifies as a long wave. The waves are generated two ways; by a numerical wavemaker and by using the built- in feature of the toolbox waves2Foam both based on first order wave theory. A brief convergence study is performed in order to investigate the correct time step to be used.

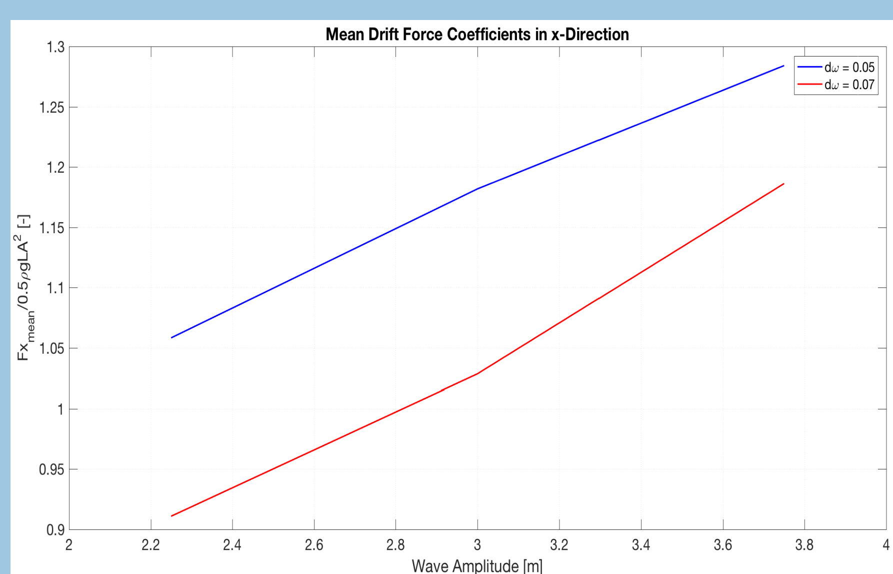


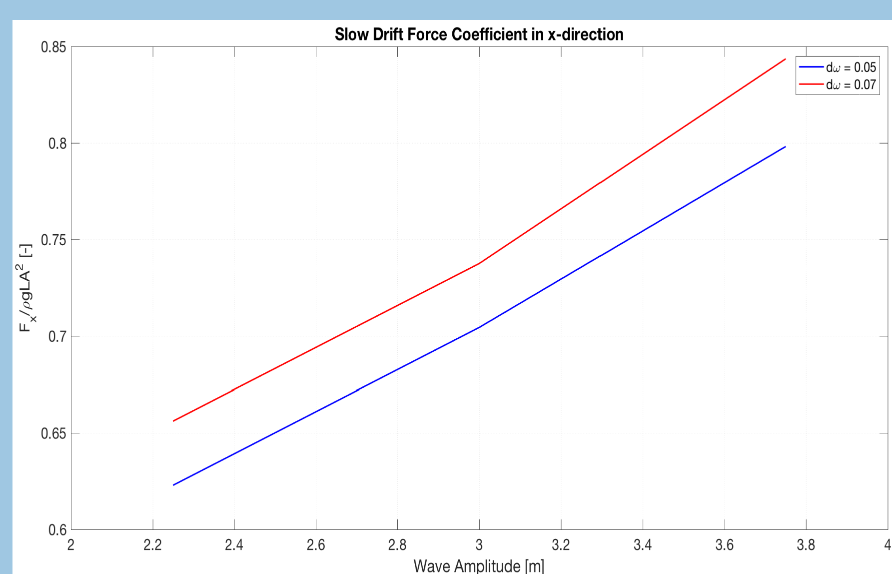


The figures above show the force time series and force spectra for one of the simulated bi-chromatic wave cases, where the wave height is 6 [m] and the difference frequency is 0.05 [rad/s].

Force Coefficient Results

The leftmost figure below shows the mean drift force coefficient in surge and the figure to the right show the slow drift force coefficients in surge.





Discussion and Concluding Remarks

The presented results show that the expected dominating frequencies are present in the spectra of the forces and wave elevation. For the bi-chromatic wave cases, the mean drift force in surge is proportional to more than the wave amplitude squared. The slow drift forces are also clearly increasing for higher wave amplitudes. Furthermore, the viscous contribution to the wave drift loads has shown to be small and non-viscous flow separation at the sharp corners is as important. The grid resolution might have been too low in order to capture the viscous effects properly.