Vortex-induced forces and vibration of subsea structures in proximity to larger objects

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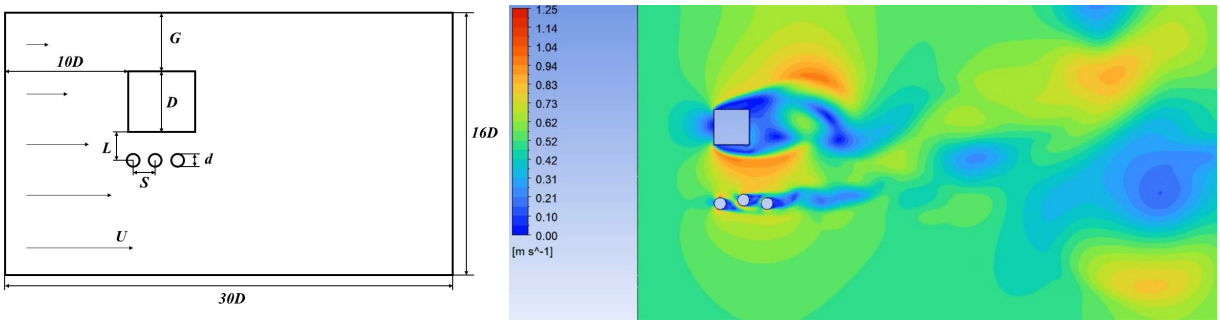
Abstract. Flow around three identical circular cylinders in statics and undergoing transversal vortex-induced vibration in close proximity to a subsea equipment is modelled using computational fluid dynamics. Simulation results include time histories of hydrodynamic coefficients, FFT data, pressure distribution, velocity fields, accompanied by the sensitivity analysis of the spacing among the structures and the flow profile.

Introduction

Analysis of the vortex-induced loads on structures in a group in a fixed position and experiencing vibration is essential to obtain correct fatigue estimates and ensure safe design of offshore systems. In the current work, a group of three subsea structures of a circular cross-section and arranged in tandem is modelled in statics and with one structure experiencing transversal oscillations. The circular structures are considered, first, standalone, and then placed in proximity to a larger piece of the subsea equipment, presented by a squared cylinder, as shown in Fig. 1. Three types of flow are investigated: uniform, linearly sheared current and the flow of a parabolic velocity profile. Proximity of structures, their hydrodynamic properties and flow features create complex wake interference effects, especially, when the lock-in and near-lock-in conditions are considered.



(a) (b)

Figure 1: Group of identical subsea circular structures in proximity to an equipment under the linearly sheared flow: (a) general view on the computational domain; (b) velocity contour for the case of the moving middle structure.

Results and discussion

The computational fluid dynamics (CFD) method and the $k-\omega$ SST turbulence model is used in this study to investigate the vortex shedding process and vibration characteristics of the fluid-structure interaction. Simulations are performed with the ANSYS Fluent software, including the initial benchmarking of the numerical model with the published results for a submerged cylindrical object under the uniform flow conditions [1–3]. Changes are observed in the pressure and velocity fields, vortex formation process, frequency and amplitude of the hydrodynamics force components with respect to each structure, and displacement time histories for oscillating bodies. Several considered scenarios indicate variations in the flow field and load fluctuations related to the wake superposition from a larger subsea object and the group of smaller structures.

References

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