PERFORMANCE ASSESSMENT OF A FLOATING PLATFORM SURROUNDED BY ELASTIC ICE PLATES

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Oil and gas resources are abundant in the Arctic. In recent decades, with global warming and the melting of polar ice coverages, the Arctic marginal ice zone (MIZ) has gradually expanded, particularly in summer [1]. It is therefore more accessible to carry out oil and gas exploitation in the region. However, different from open water, the design of floating platforms in a polar sea state must consider the influence of floating ices. Previous studies have shown that the existence of elastic ice floes has complex effects on the water wave characteristics [2], [3]. Thus, for ensuring the structural safety of polar floating platforms, it is essential to assess the hydrodynamic loads combining with sea ice effects.

Until now, there is little research on wave-ice-structure interactions. The majority of previous work relied on analytical methods [4], [5], including two-dimensional linear potential flow theory and linear elastic theory. Meanwhile, studies on the interaction between waves and ice floes have made considerable progress [6], [7]. For the last several years, numerical approaches have been significantly developed and show the potential to improve the accuracy by accounting for nonlinear features that are excluded in analytical solutions.

In such a context, this study establishes a two-dimensional numerical structure-ice-wave interactive model based on OpenFOAM. The layout of the model is shown in Figure 1. Water waves are generated from the left-hand side and propagate towards the right-hand-side. A two-way fully fluid-structural coupling algorithm is applied to simulate the interaction between elastic floating ice floes and waves [8], [9]. The associated hydrodynamic effects on the floating platform are investigated systematically, considering different distribution modes and stiffness of elastic ice floes and incident wave frequencies. More detailed results will be presented in the full-length paper.

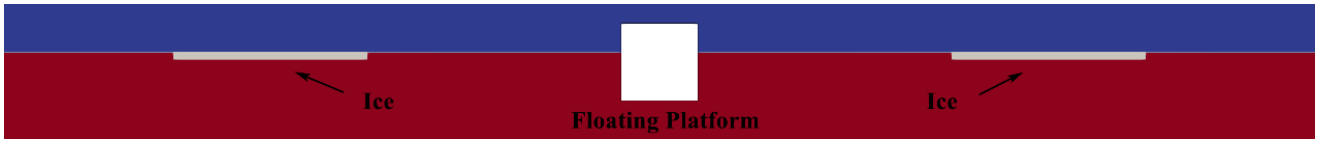

Figure 1: Layout of the structure-ice-wave tank

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References

[1] C. Strong and I. G. Rigor, “Arctic marginal ice zone trending wider in summer and narrower in winter,” *Geophys. Res. Lett.*, vol. 40, pp. 4864–4868, Sep. 2013.

[2] L. G. Bennetts, N. R. T. Biggs and D. Porter, “A multi-mode approximation to wave scattering by ice sheets of varying thickness,” *J. Fluid Mech.*, vol. 579, pp. 413–443, May 2007.

[3] C. Wang, M. Song, C. Guo, S. Wang, T. Tian and W. Luo, “Experimental Study of Sea Ice Motion in Waves.” *J. Cold Reg Eng.*, vol. 34, pp. 04020010, Jun. 2020.

[4] Z. Li, Y. Shi and G. Wu, “Interaction of wave with a body floating on a wide polynya,” *Phys. Fluids.*, vol. 29, pp. 097104, Sep. 2017.

[5] Z. Li, Y. Shi and G. Wu, “A hybrid method for linearized wave radiation and diffraction problem by a three dimensional floating structure in a polynya,” *J. Comput. Phys.*, vol. 412, pp. 109445, Apr. 2020.

[6] L. G. Bennetts, M. A. Peter, V. A. Squire and M. H. Meylan, “A three-dimensional model of wave attenuation in the marginal ice zone,” *J. Geophys. Res.*, vol. 115, pp. C12043, Dec. 2010.

[7] L. Huang, K. Ren, M. Li, Ž. Tuković, P. Cardiff, and G. Thomas, "Fluid-structure interaction of a large ice sheet in waves", *Ocean Eng.*, vol. 182, pp. 102–111, 2019.

[8] Ž. Tuković, A. Karač, P. Cardiff, H. Jasak, and A. Ivanković, 'OpenFOAM Finite Volume Solver for Fluid-Solid Interaction', Transactions of FAMENA, vol. 42, no. 3, pp. 1–31, Oct. 2018, doi: 10.21278/TOF.42301.

[9] P. Cardiff et al., 'An open-source finite volume toolbox for solid mechanics and fluid-solid interaction simulations', arXiv preprint arXiv:1808.10736, 2018.