Dem Simulation of First-Year Ice Ridge Interactions With Moored Structures

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Abstract: First-year ice ridges determine the design load of moored structures in many Arctic and sub-Arctic regions. Their interactions with moored structures were simulated with discrete element method (DEM), considering the complex internal structures of ice ridges. In the simulation, ice ridges were modeled as an assembly of consolidated ice blocks randomly packed through a dynamic process. The shapes of ice blocks were generated based on Voronoi tessellation and then filled with bonded sphere elements. The model was calibrated and validated by comparing the numerical results with the punch through experiments and direct shear box experiments data in the literature. Based on the numerical results, the effects of DEM parameters, loading rate and boundary conditions on ice ridge shear strength were analysed. This model was further employed to simulate a model test of ridge-structure interaction performed at Hamburg Ship Model Basin (HSVA). The mooring system was modeled by sphere particles packed in lines. The numerical results were similar to the experimental data, in terms of the ridge failure processes, ice loads, mooring forces and floater response. Finally the interactions between ice ridges and the well-known Kulluk platform were modeled. The numerical results indicate that ice ridge loads mainly depend on ridge cross-sectional areas and the stiffness of mooring systems, which can contribute to the design and ice management of moored structures.

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