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Ice loads on a ship in three-dimensional discrete element simulations

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ABSTRACT

On ice-covered waters, ships often encounter ice floe fields, which are sea areas with partial ice cover consisting of numerous individual ice floes. Here we study ice loads on a ship travelling through an ice floe field by using three-dimensional discrete element method (DEM) simulations.

Figure 1 shows simulation snapshots and illustrates complex interactions between the floes and the ship and between the floes themselves; contact interaction leads to contact forces, which result into floe translation, rotation, and rafting. In the simulations here, ship moved with a constant velocity of 1 m/s on a straight line through an ice floe field of length 2 km. Number of ice floes varied between about 3000 and 23000. The ice floe field properties, that is, floe shape and size and ice thickness and concentration, were varied and the effect of these properties on ice loads was studied.

The simulations were performed using inhouse 3D DEM code of Aalto University Ice Mechanics Group. The code was introduced in detail and validated against laboratory scale ice-structure interaction experiments by Polojärvi [2]. Similar code was used to model ship passage through ice rubble piles by Gong et al. [1]. The ice floes are modelled as rigid bodies not allowed to fracture. The contact force model accounts for local crushing of ice and friction between the contacting bodies. Hydrodynamics are accounted for by using simple model for water drag and added mass.

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Keywords: discrete element method, computational mechanics, ice mechanics, Arctic technology

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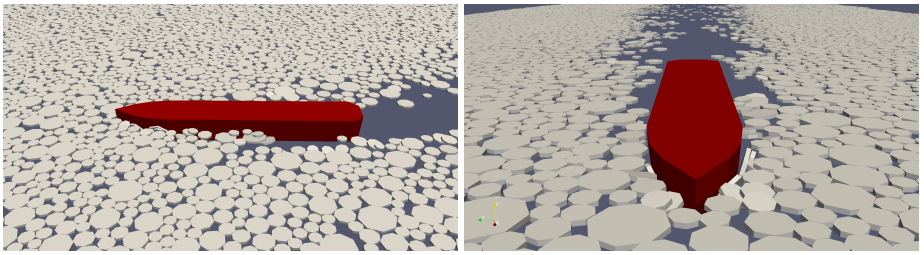

Figure 1. Simulation of a ship passing through a field of octagonal ice floes.