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MODELLING ICE RUBBLE WITH PSEUDO-DISCRETE CONTINUUM MODEL

The idea of pseudo-discrete continuum model for study the behaviour of ice rubble will be presented in this paper.

Ridges are quite common ice features in the northern seas. They are moving due to wind and sea currents causing remarkable loads to offshore structures during interaction. The ridge is often divided into three parts: sail (above the water level), consolidated layer and keel (below the water level). The sail and keel contain a pile of broken ice blocks, i.e. ice rubble. The cavities in the keel between ice blocks are filled by water and slush, while in the sail part they contain snow and air.

Ice rubble plays an important role in many engineering problems, ranging from the river engineering aspects to ice-cover interaction with offshore structures The knowledge about the mechanical properties of ice rubble is however rather limited. Usually ice rubble is assumed to behave as a linear Mohr-Coulomb material for which the shear strength (τ) is assumed to consist of cohesion (c) and /or friction (φ) components:

$$\tau = c + \sigma \tan \varphi \qquad (1)$$

Several programs on testing of ice rubble mechanical properties have been carried out since the beginning of the seventieths which results proved this suggestion. Two approaches were used so far to interpret the test results, namely analytical and numerical.

In the analytical approach the major problem was associated with use of the two-parametric Mohr-Coulomb failure criterion. Simplifications were done and ice rubble was considered either as frictionless or as cohesionless material. Besides the analytical approach does not take the complexity of deformation mode into account and thus may yield to unreliable results.

Therefore the numerical modelling of tests suggested to be useful tool for judgment of the ice rubble strength. Recently two finite-element modelling was conducted by Heinonen (1999, 2002) and Liferov et al. (2002, 2003), which are constitutive models based the plasticity theory. Ice rubble was assumed to behave like continuum elastic perfectly plastic material, that obeys the Mohr –Coulomb law.

In reality ridge keel is a porous feature with water and slush between ice blocks. In order to take it in to account a pseudo-discrete continuum model is create to study the behavior of ice rubble. Special program is developed to generate random assemblies of rectangular blocks in closed shape allowing to vary the block size and resulting porosity of the assembly. The obtained assemblies are further used as geometrical input for the finite element model. The PLAXIS finite element code is chosen for the simulation. The blocks are modelled as elasto-plastic bodies that refer to Mohr-Coulomb material. The water between blocks is modelled as elastic material, which characterized by minimum value of hardness. Contact elements are used to simulate the reduced strength at contacts between the blocks. Large deformation analysis is used in the calculations to account for substantial mesh distortion.

The first series of modelling test were done so far which gave quite suitable and realistic results. By applying different boundary conditions to assembly of the blocks it is possible to investigate the following aspects: effect of block size, porosity, mechanical properties of ice blocks and their contacts. These are in process of analyzing right now. The obtain results and further development will be present in nearest future.

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