Improvements of Rubble Ice Generation In Numerical Simulation of Ice Ridge and Structure Interaction

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1 – Arctic Engineering

- Application: Ships and offshore structures in Northern Sea Route
- Ice ridges are the main design criteria for those structures

1 – Arctic Engineering

- Model ice ridge at HSVA basin

2 – Discrete Elements Method (DEM) simulation

- Full DEM in house algorithm
- Seidel (2016) -> DEM introduction and punch test
- Alekseev (2016) -> Ship simulation

Investigate rubble ice geometry
2 – Discrete Elements Method (DEM) simulation

- DEM calculates the forces when two elements are interacting
- Inputs for force calculation:
  - Volume of the interaction
  - Position of the CG of the elements and the interaction volume
  - Young’s modulus
  - Mechanical properties

3 – Investigation of rubble ice geometry

At the ice basin  Pre-processed  Post-processed
4 – Rubble ice measurements processing

- Axis-aligned bounding box height
- Axis-aligned bounding box width
- Number of edges

**Axis-aligned Bounding Box Width**

Shape parameters
4 – Rubble ice measurements processing

Axis-Aligned Bounding Box Width

- Algorithm
- Experimental

Number of samples

Width [mm]

EMship
Advanced Design
5 – Generation of rubble ice in the simulation

1) Generate a unit square

![Diagram of a unit square and a transformed square]
5 – Generation of rubble ice in the simulation

2) Create the polygon accordingly to the number of edges
5 – Generation of rubble ice in the simulation

• Centre the polygon at the origin
• Add thickness -> User input
• Triangulated mesh
• Calculate the following properties:
  • Mass
  • Volume
  • Wetted surface area
  • Moment of inertia
6 – Punch Test
7 – Ship Simulation
Comparison Numerical and Experimental Ship Testing

- Experiment
- Rectangular rubble ice
- Polygon rubble ice

Velocity [m/s]

Time [s]

0 5 10 15 20 25

0 0.1 0.2 0.3 0.4 0.5
8 – Conclusion

- Experimental data analysis of model scale rubble ice geometry
- Influence of the rubble ice geometry in Discrete Elements Methods simulation
- Different friction model for punch and ship simulation