Master Thesis in Marine Technology - 2019

Analysis of Accidental Ice Impacts of Polar Class Vessels

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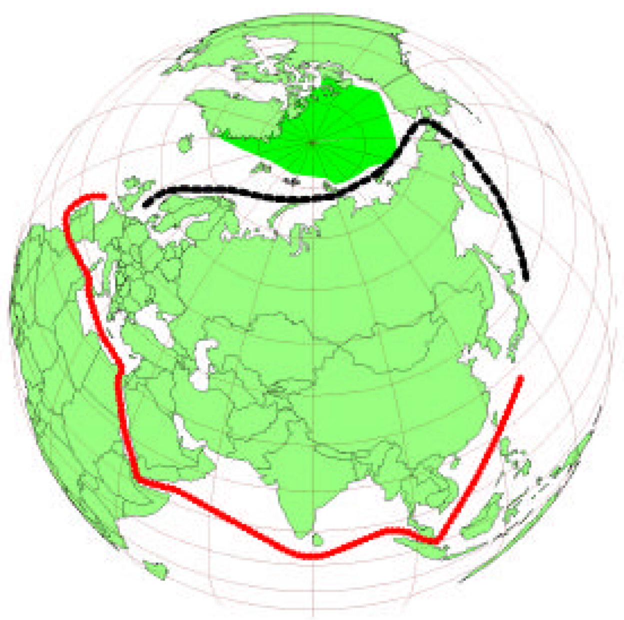
Introduction

The Arctic is becoming more accessible due to climate change. This opens for increased activity in the Arctic in the search for natural resources, shipping, tourism and research. The Northern Sea Route is now available for traffic for a limited period of about three months a year. This period is expected to increase in the future and consequently the commercial traffic through the route as well.

The Northern Sea Route can be significantly shorter than the route through the Suez canal, see figure below. [3] However, the Northern Sea Route poses other difficulties, such as ice coverage, the cost of ice class vessels, fees for icebreaker escorts, insurance and a lack of search and rescue teams.



Vessels operating in ice-infested waters require ice classifications. This include requirements to ice strengthening as they can be subjected to ice loads in the polar regions. The vessels are designed for various thicknesses of level ice. The level ice can include hidden pressure ridges which will result in increased loads on the vessel.

Glacial ice floating in the water are called icebergs, bergy bits or growlers depending on the size. Growlers protrude less than 1 m above the surface and can be difficult to detect and spot, especially in high sea states. This poses a risk to accidental impacts in the bow in the polar regions and the result can be catastrophic. While this may not pose a great risk to icebreakers, vessels of lower ice classes are not necessarily designed for such impacts.

Choosing the Northern Sea Route may not be beneficial if the risk of ice loads means that additional ice strengthening must be applied, or the speed be reduced. This master thesis will look closer on the loads growler impacts can produce and the structural response of the hull.

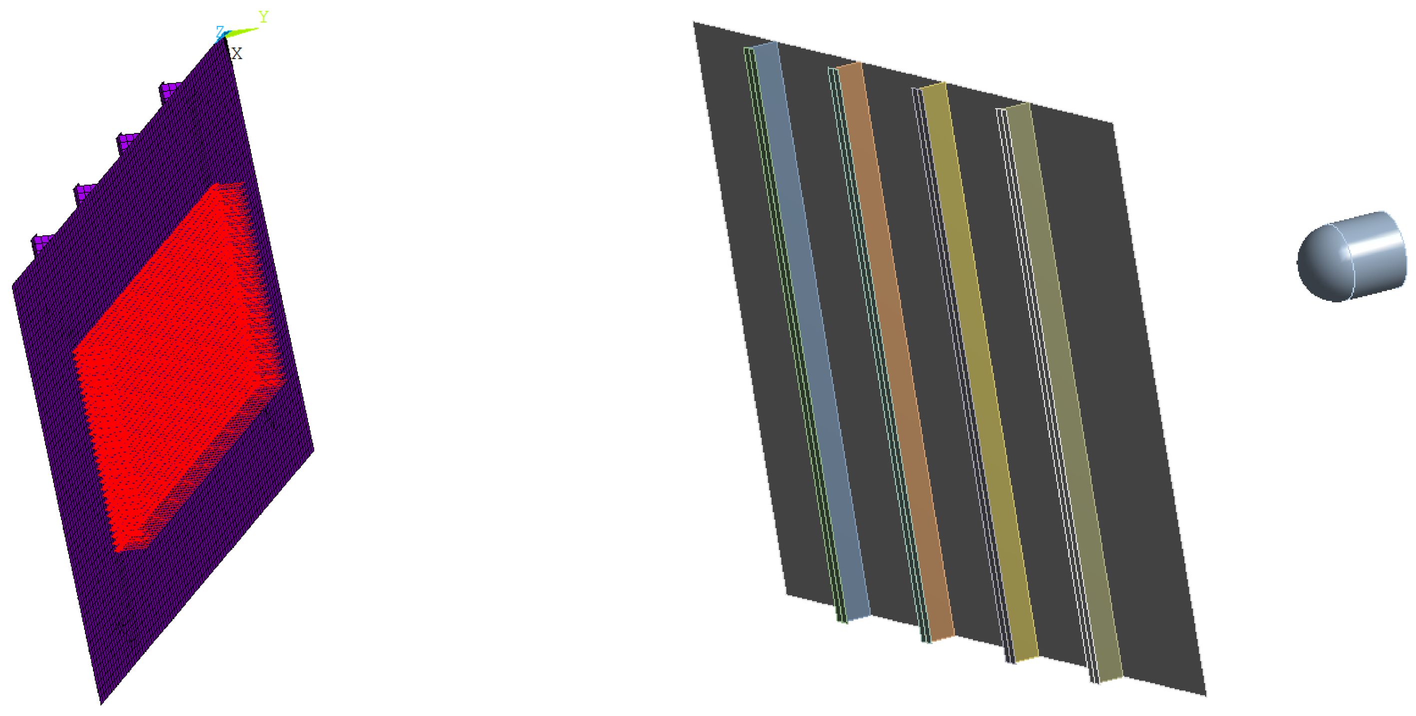
Problem

Complex material models are needed for modelling of nonlinear ship-growler impacts. These material models will be implemented in the integrated simulation using Ansys Explicit Dynamics. Using the minimum requirements for ice class vessel hulls will possibly highlight the severity of such unintentional impacts in remote locations such as in the Arctic.

Numerical Modelling

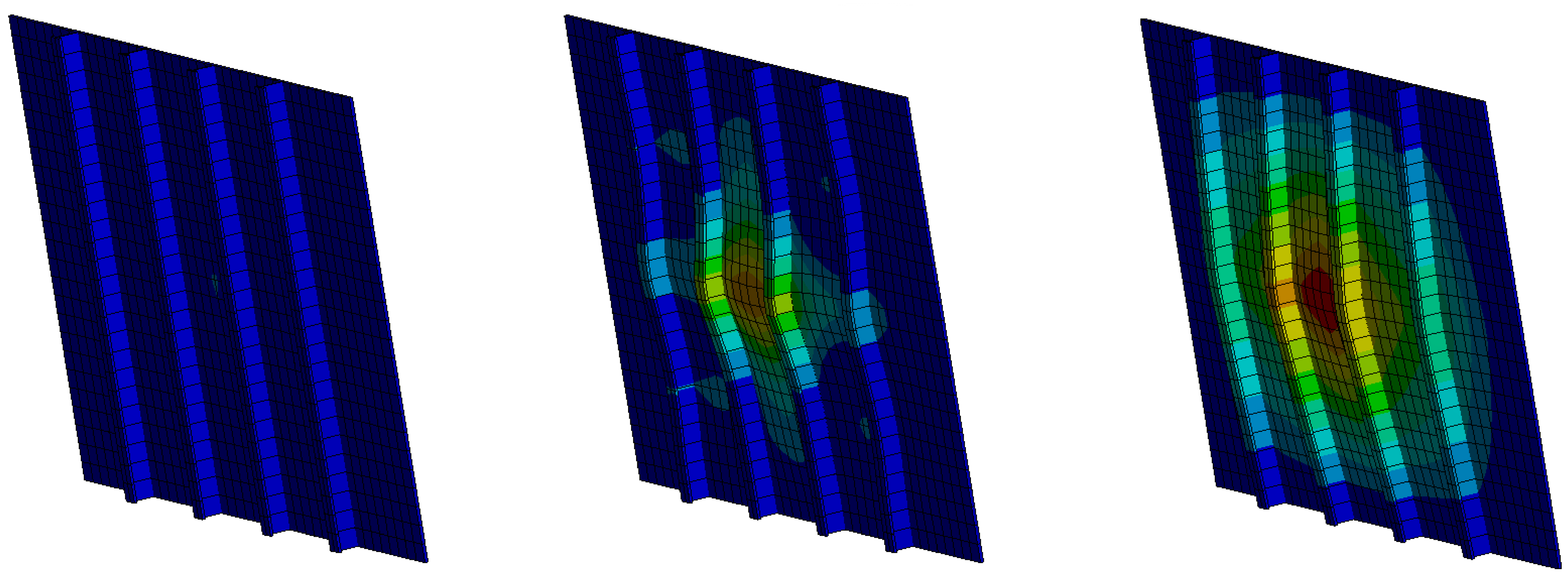
The geometry of the plate was based on requirements by the International Association of Classification Societies (IACS). [2] The Polar Code aims to provide rules for safe ship operations and environmental protection in the Arctic and Antarctic regions. IACS have regulations in accordance with the Polar Code. The requirements of the lowest polar class were used to determine the scantlings of the plate. The material of the plate was based on DNV-RP-C208. [1] The design load is a uniform pressure patch simulating level ice.

The established plate was then used in the simulated growler impact. Modelling the ice proved difficult as ice is a less understood material and one single numerical model that describes its mechanical properties has not been agreed upon. The growler impacts were simulated using the non-linear finite element method and the software ANSYS Explicit Dynamics.

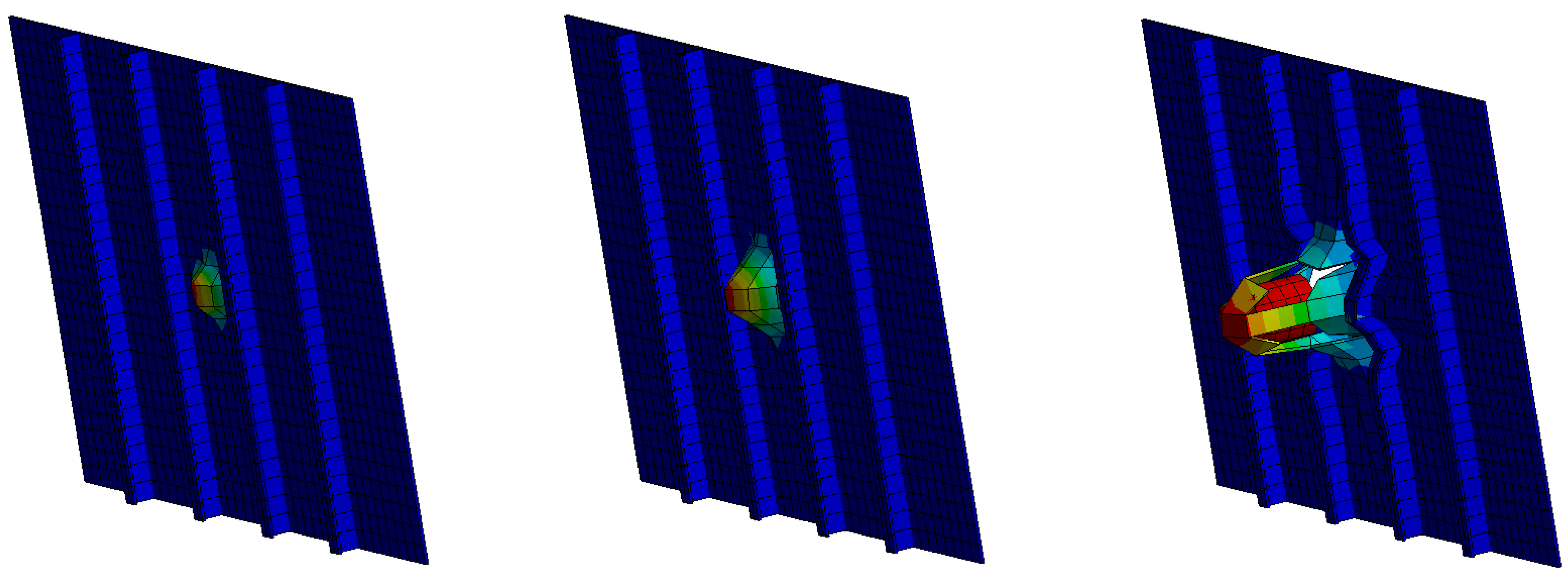


Results

The input parameters are not completely decided upon as of yet. Therefore the example results below are not to scale, but can give insight into future finished results. The deformation after impact depends on the energy absorption in the system. The plate structure is the same for both examples, but the impact speed and weight of the ice object have been increased for the second example. The figures show deformation over time.



This first example results in a permanent dent in the plate, but no fracture.



In this example the weight and speed of the ice object was increased and the plate fractures.

References

[1] *DNV-RP-C208: Determination of Structural Capacity by Non-linearFE analysis Methods* (2013)

[2] *Requirements concerning Polar Class.* International Association of Classification Societies (2016)

[3] Ragner, C.L. *Northern Sea Route Cargo Flows and Infrastructure - Present State and Future Potential.* FNI Report 13/2000 (2000)

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