Master Thesis in Marine Technology - 2013
Iceberg shape characterization for damage assessment of accidental impacts with ships and offshore structures

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Objective

The objective of the present work is to evaluate iceberg shapes primarily in terms of their damage potential with respect to the scantlings of the shipside. As the demand for strain energy dissipation for collisions with bergy bits, icebergs and growlers up to 1000 tons is moderate, a relatively small part of the iceberg will be crushed and contribute to the energy dissipation. Consequently, it is not essential to have exact information about the overall shape of the iceberg, but instead, the local shape is important and should be evaluated in view of the structural configuration of the ship.

Introduction

The possibility of an iceberg impact with a ship structure is growing. The cause of this is the increased activity in the northern areas of the world. There are two main reasons for this, the oil and gas exploration in the northern areas are intensified. The second reason is that the ice in the north pole is melting and thereby opening for new shipping routes.

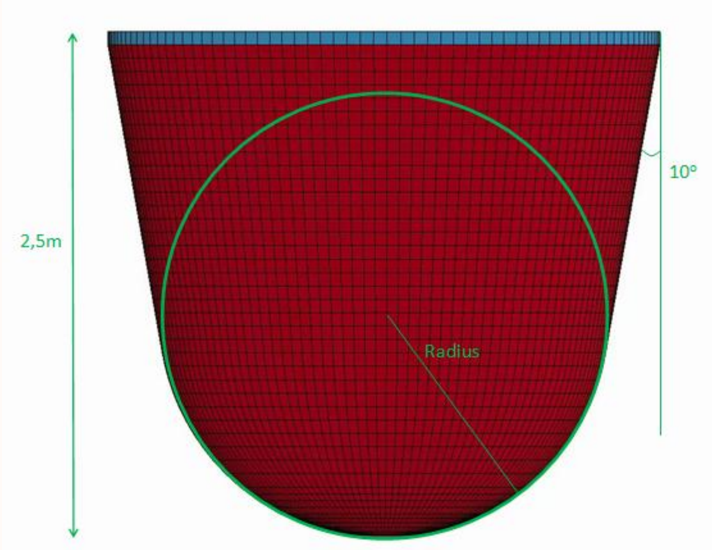
The increased possibility for collision gives the basis for further research on ice impact with structures. The regulations for an offshore impact are for two different events either for a 100 year return period, ULS (ultimate limit state), or for 10 000 year return period, ALS (accidental limit state), which both shall be checked.

This project is a master thesis trying to find appropriate shapes of the contact area of an iceberg in relation with the shipside scantlings that can be used for ALS design against iceberg impacts.

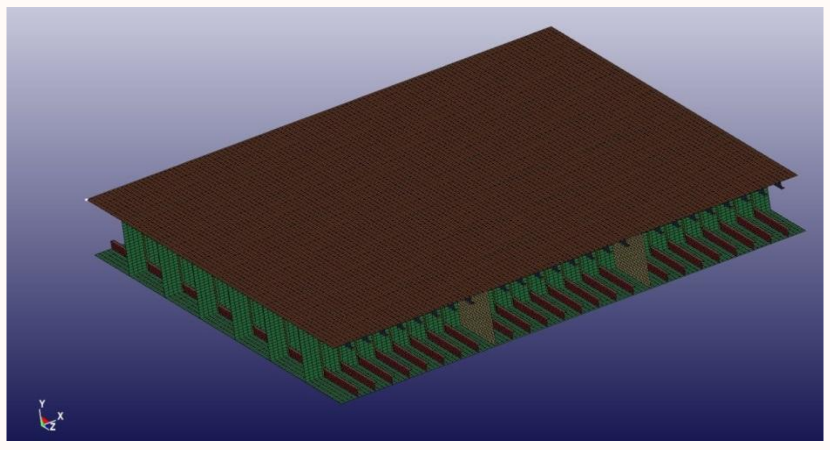
Method

The analysis is done by simulation the collision between the iceberg and a section of the shipside. The shipside and iceberg are modeled and meshed in Patran and analysed in LS-DYNA.

The shipside's weakest point will be midway between the frames with respect to getting the largest deflection and the least steel to penetrate to reach through the shipside. The sharper the iceberg is, the more likely is rupture of the plating on the shipside and the further in the iceberg will reach with a given energy. Therefore the midpoint position will be tested in this study with several dimensions of the iceberg to see the sharpest shape which the iceberg can have without being crushed by the shipside. Since the ice is likely to be crushed in a sphere shape in the contact area this analysis will be performed with an iceberg formed as a cone with a radius in the front. This way it is easy to change the radius to get a sharper or blunter iceberg.



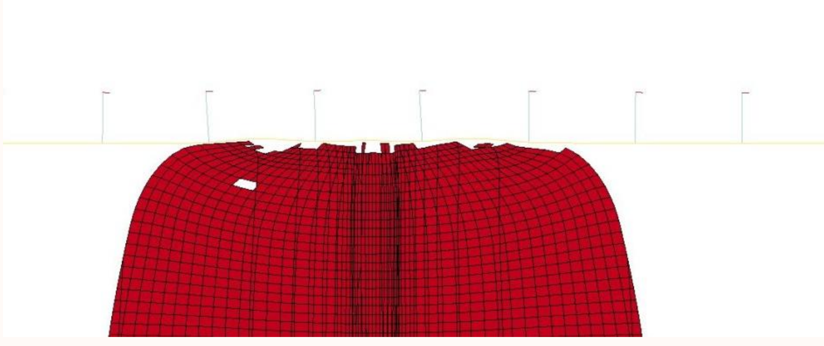
The values chosen for the iceberg is as shown the figure above, and the radius is varied. The effect of confinement is also considered with change of the cones angle.



When sailing in the northern areas there is the possibility of sailing in to an ice cover. The ships are therefore often built according to some ice class rules. A usual and often used ice class rule are the Finnish-Swedish ice class rules that were made for the Baltic sea. The most used of the Finnish-Swedish ice class rules in the arctic areas such as the Northwest Passage are the IA. In this study there will therefore be studied the IA class and the effect of having a lower ice class the IC and have a ship without ice strengthening. The dimension used are gathered from actual tanker ships with a size at about 150 000 tons.

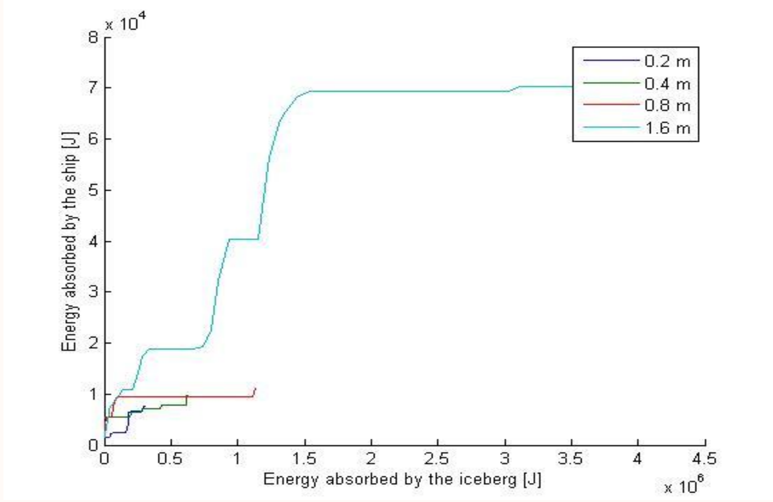
Simulation

From the simulations the deformations for the ship and for the iceberg is gathered and compared.

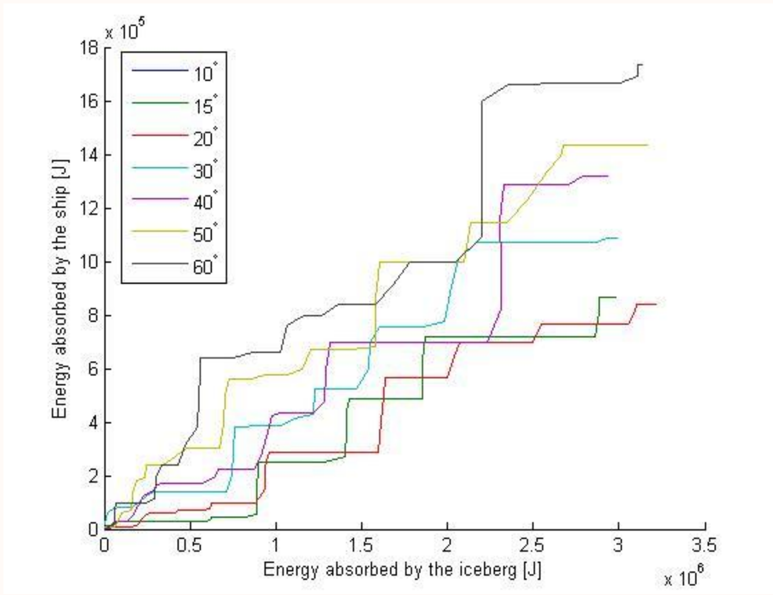


The figure above present the largest deformation of the ship without ice strengthening , which are about 5cm and barely visible on the figure . The iceberg has deformed to the side due to the Poissons effect . This may be unrealistically high deformation of ice since ice is known to be quite brittle.

From the simulations also the absorbed impact energy for the ship and for the iceberg is gathered and compared.



In the results shown above the energy absorbed by the ship without ice strengthening are in the vertical axis, and the energy absorbed by the iceberg in the horizontal axis. The different radius in front of the iceberg are shown with the different color lines. As seen in the figure above the largest iceberg give the steppes curve meaning that more percentage of the total energy goes to deform the shipside. The same tendency is seen for the two other ships.



The figure above present the second largest iceberg on the ship without ice strengthening, with different angels of the cone. The damage to the ship is increasing with the angle of the cone . As the forces are about the same .

Conclusion

The result can not give a definite answer since the largest iceberg with the largest angle gives the largest proportion of the total deformation energy to the shipside. Therefore it can be a even larger iceberg that are the most dangerous for this three ships. There are also some uncertainty connected to the Poisson's effect of the ice material. Further work should be done with icebergs with larger radius and larger cone angle, to check if the tendency continues.