



The University Centre in Svalbard

Exam

AT-327 & AT-827 Arctic Offshore Engineering
Friday 30th of November 2018, hours: 09.00-13.00

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Permitted aids: Dictionary between English and mother tongue. Approved particular simple calculator. This set of problems consists of 4 pages. Four problem sets are presented; you must answer all 4 problem sets. In case of obvious mistakes or omissions in the problem sets, make your own assumptions.

The exam questions should be answered in: *English (or) Norwegian, English, Danish or Swedish.*

Problem Set 1 (25 %)

Drift and deterioration of icebergs:

Consider a glacier with terminus in an open fjord.

- Explain and sketch the difference behind the processes of forming a tabular and an irregular iceberg from a glacier with a water front terminus?
- Consider an iceberg drifting in open water with presence of waves and sea current as indicated in the vertical cross-section shown in Fig. 1. Sketch qualitatively the corresponding heat flux due to waves and sea current?

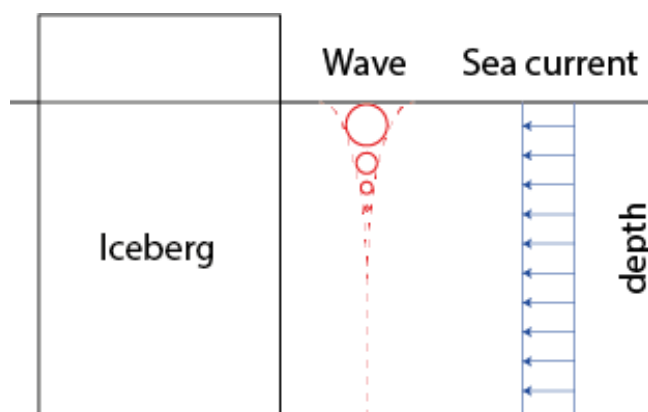


Fig. 1. A vertical cross-section of an iceberg with a sketch of the waves and current shown.

- An iceberg in the ocean can calf. Explain the most common process behind it?

- d) Consider an iceberg with a mass of 800 000 tons drifting at a speed of 30 cm/s colliding (central hit) with a wide and rigid GBS. Consider an added mass of 40 %. How much energy must be dissipated in the collision?
- e) For the case in d) estimate the average load from that iceberg when it stops (zero relative speed to the structure) after 1.5 m of indentation?

Problem Set 2 (25 %)

Marine icing:

- a) Can sea spray created by a vessel interaction with waves become supercooled before reaching the surface of the vessel? Support your answer with some arguments.
- b) Calculate the temperature of the supercooled fresh-water droplet which would be enough for complete and immediate solidification?
(Use a specific heat capacity of water of 4000 J/kg/K, and the latent heat of fusion of water of 3.4×10^5 J/kg)
- c) What is the main source of uncertainty in icing rate calculations?
- d) What are the main sources of cooling in the case of marine icing? List the main heat fluxes involved in the marine icing? State which of them create main contribution to the heat balance?
- e) Why is the specific heat capacity (or more exact effective heat capacity) of the ice created by sea spray higher than the specific heat capacity of the fresh water ice? Why does it depend on the temperature?

Problem Set 3 (25 %)

Bending failure and ice bearing capacity:

- a) Give examples of bending failure occurrence in ice-structure interactions?
- b) Explain the bending failure mechanism of an ice beam in terms of stresses? The normal stress in a cantilever beam is expressed as follows: $\sigma_{xx}(x, y) = -\frac{M_b(x)y}{I}$, where $M_b(x)$ is the bending moment across the beam, and I is its moment of inertia. For rectangular beam, $I = \frac{bh^3}{12}$, where h is the thickness and $b = h$ is the width of the beam. Explain where the cross section of a maximum bending moment is; find the locations and derive magnitude of maximum normal stresses?

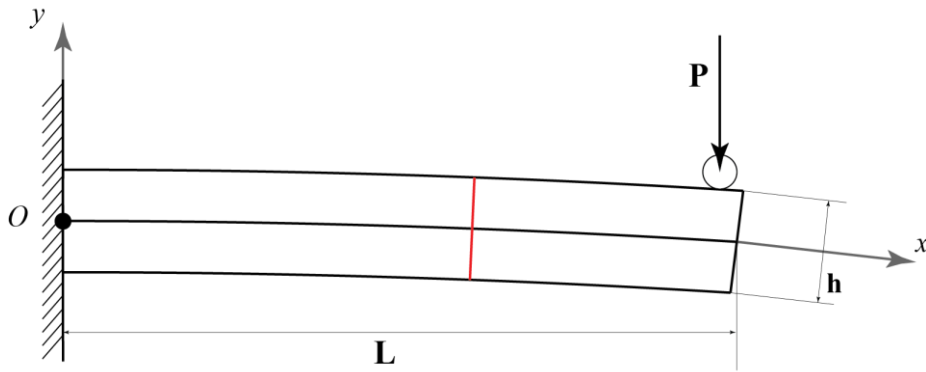


Fig. 2. Cantilever beam schematic.

- c) Explain the concept of Flexural Strength. Using data from the field experiment in Svalbard, calculate the flexural strength of sea ice ($h=40$ cm, $b=h$, $L=6h$). Explain qualitatively why recommended beam length is of this order?

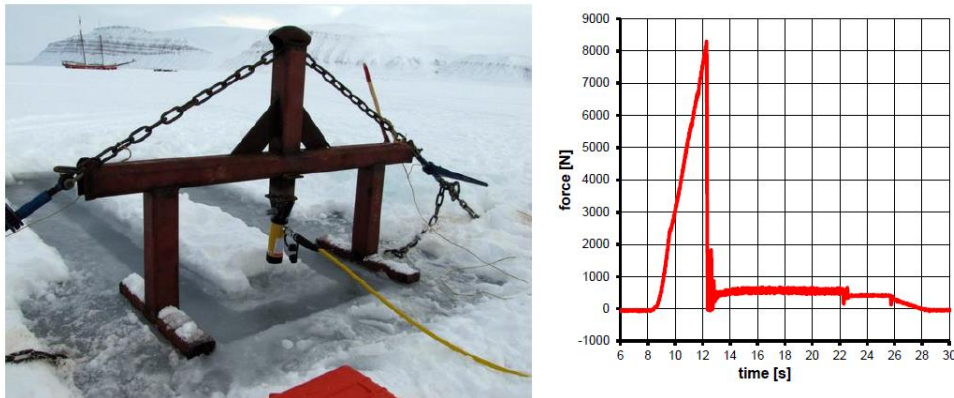


Fig. 3. In-situ cantilever beam setup (left), and load vs. time plot (right).

- d) Give some examples when the bearing capacity of ice is utilized for engineering projects? Explain the physics behind the bearing capacity of an infinite ice beam/plate. Formulate two design criteria to be considered when floating ice is loaded from the top.
- e) Estimate an average value of flexural strength based on data compiled from 5 different datasets in Fig. 4? What operational safety factor against first crack failure would you consider and what corresponding maximum design flexural strength level would you use in operation?

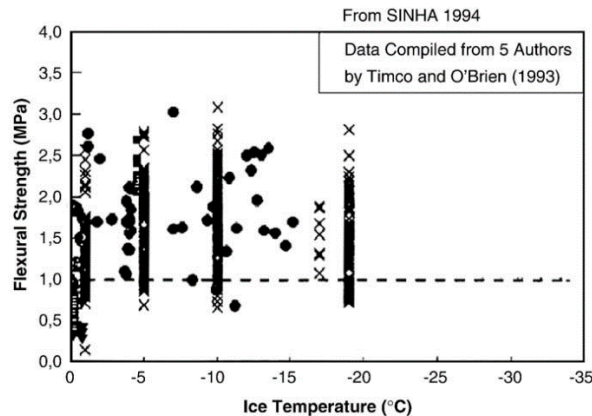


Fig. 4. Flexural strength of ice at different temperatures.

- f) Driving snowmobile on thinner ice late in the spring season, what else factors (in addition to two floating design criteria mentioned in d.) would you consider for safe travel?

Problem Set 4 (25 %)**Resources and reserves:**

a) There are three levels of certainty, namely P90, P50, and P10 that are often associated with probabilistic (stochastic) method of reserves evaluation.

1) Give a short definition to these categories of hydrocarbon reserves?

2) What method is most commonly used for stochastic evaluation of resources and reserves?

b) There are 5 necessary conditions that should be met in order to find petroleum (based on organic origin of petroleum).

Define these necessary conditions?

c) Assume that in a given area the following probabilities are given for each of the 5 necessary conditions to find petroleum:

Probability / chance	Min	Most likely	Max
P1	0.65	0.69	0.75
P2	0.60	0.65	0.70
P3	0.75	0.78	0.85
P4	0.70	0.76	0.80
P5	0.30	0.35	0.40

(These evaluations are expressed in fuzzy numbers, where numbers in parentheses denote minimum, most likely and maximum values, respectively).

Estimate a total probability of finding petroleum in this region based on the following evaluation methods:

- 1) Deterministic approach (use the MLV given in the table)
- 2) Fuzzy approach
- 3) Interval calculus

Compare the obtained results and the most likely values?