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INVESTIGATION OF ICE ACTION ON ARCTIC HARBOURS (AN EXAMPLE OF LONGYAERBYEN HARBOUR, SVALBARD, NORWAY)

A sea ice study observations were held on in a Longyearbyen (LYB) harbor. These observations gave a data about that type of ice-structure interaction could occur, that type of ice action is the most critical for different kinds of harbour structures.

In a spring 2004 ice study observations were conducted. Measuring of ice and snow thickness, ice movement (vertical and horizontal), ice accumulations on a structure surface, estimating of ice break up forces were done.

The ice and snow thickness measurement were made to get data about average ice thickness in the LYB harbour, and to predict the ice growth by Stefan's law. The average difference between calculated and measured thickness was at the range of ±5%.

The total station Laica and optical prism were used to determine the position of 49 points, which were marked with bamboo sticks. Analyzing the difference in coordinated it is possible to define horizontal and vertical ice movement. The results show that ice is practically not moving (horizontally). The bamboo sticks that were close to the quay and in front of it are gone because there were an icebreaker coming in on the 6th of March and crushed the ice so the Bamboo sticks turn over or was drifting away.

To get an idea of which forces the ice can apply on a structure there were placed five ice anchors in the ice. These anchors were connected with chains to the bollard on shore via a weak link. The weak link will be a shackle with certain strength. When the ice breaks up during spring the shackles were observed.

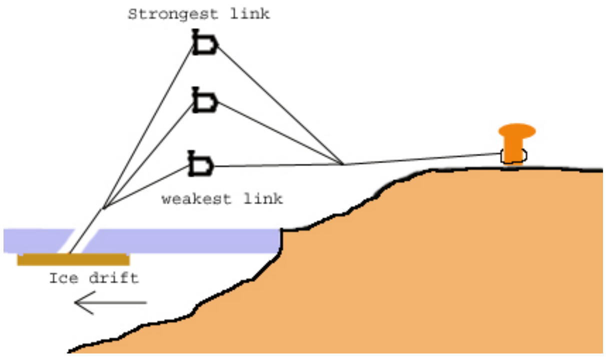

Fig. 2. Principal sketch of the ice anchors.

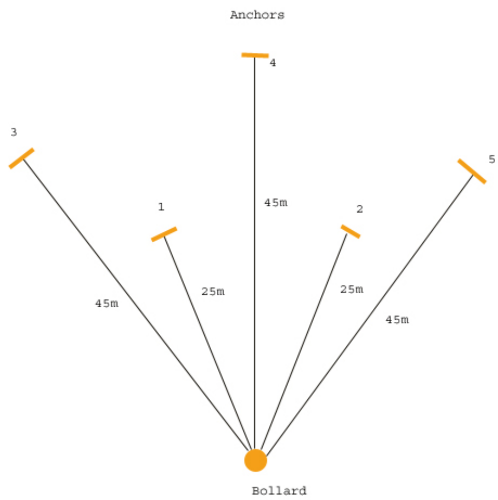

Fig. 3. Placement of the anchors.

The results of this investigation are shown in a Table 1 [1].

Table 1. Chains and shackles.

	Chain		Shackle		Force	
	Diameter	Date of installation	Failure	Non-failure	Minimum	Maximum
1 and 2	13mm	18 May	-	5,5mm	-	800 kg
3	13mm	18 May	5,5mm	7,1mm	900kg	1500 kg

4	13mm	4 May	10,5mm	16,1mm	4000 kg	10500 kg
5	13mm	4 May	11,2mm	16,1mm	6500 kg	10500 kg
	Total Force				11400	23700

It is also possible to calculate the ice break force using formula

$$F = \tau * A, \quad (2)$$

where τ – shear stress due to wind action; A – area of an ice flow.

The shear stress could be found as,

$$\tau = c * \rho * u^2, \quad (3)$$

where c = 0,008 – is a drug coefficient; $\rho = 1$ kg/m^3 – air density; u – wind speed [m/s].

Analysis of weather data and pictures allowed getting information about size of ice flow (assumed to be rectangular 300m*600m) and winding speed (average maximum wind speed was 13m/s). Chains #3,4,5 were stretched on 21 of May. On this date the last weak shackles were destroyed. So we consider that the force was maximum. Using formulas (2) and (3) the force will be around F = 24000kg.

This small investigation about ice action on harbor structures shows that big gravity structures are not significantly affected by ice, while small and light ones (e.g. floating) could be. That is why particular attention should be paid to determine possible scenarios of interaction between ice and structure, to evaluate average ice force.

REFERENCES:

1. K.V. Høyland, 2004, Internal Report, UNIS.