International Journal of Offshore and Polar Engineering (ISSN 1053-5381)

Vol. 17, No. 3, September 2007, pp. 169–175

Flexural Strength of Drifting Level First-year Ice in Barents Sea

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The Arctic and Antarctic Research Institute (AARI) has performed ice research work in the Barents Sea during the last 10 years (1996-2006). In the course of this work, a great amount of material was collected on the flexural strength of drifting first-year sea ice through 138 cantilever beam tests and many tests of small discs. This paper presents the results of data analysis for level ice; this analysis was performed separately for the southeastern and northeastern regions of the Barents Sea. The influence of different ice characteristics exerted on flexural strength is studied (temperature, salinity, brine volume, etc.). We analyzed the relation between the full-scale flexural strength of the ice cover as determined by the results of the cantilever tests, and the strength corresponding to the tests of small specimens. While the cantilever tests cut out of the entire ice thickness are the most reliable method of ice flexural strength determination, these experiments are the most labor-intensive, so the trial was made to obtain empirical relations between the physical properties of ice, the strength of small specimens and the full-scale flexural strength of level ice.

INTRODUCTION

Over the last 10 years, AARI has conducted a number of comprehensive ice research expeditions in the Barents Sea. Oil and gas industries gave the main impetus for this work because the designers of shelf hydrotechnical structures such as ice-resisting platforms, underwater pipelines, terminals, etc. need data on environmental conditions—starting with sea ice. The history of these expeditions as well as some results are given in various reports, publications and presentations delivered at international scientific conferences (Danilov et al., 2003; Naumov et al., 2003; Stepanov et al., 2003; Stepanov and Kubyshkin, 2003; Kubyshkin and Skutina, 2004). As a result, a large amount of data has been collected concerning different sections of sea ice studies and polar oceanography, including the physical and mechanical characteristics of the sea ice of the Barents Sea.

Lately we have observed a rapid increase of commercial activities on the Arctic Shelf which require serious scientific summarizing and analysis of the collected data. Thus, we are committed to presenting the most important results of the work we conducted to the scientific community. Nowadays this necessity is also due to the approach of the International Polar Year, one of whose tasks is to coordinate the efforts of scientists, scientific groups and organizations from various countries for the exploration and study of the polar regions.

This article analyzes and sums up the information on the flexural strength of level sea ice. It uses only the latest data collected during sea expeditions to the southeastern and northeastern parts of the Barents Sea during 1996–2006.

The peculiarity of drifting ice is that the variability of its main characteristics is greater than that of fast ice. The ice texture is often characterized by haphazard alternation of ice layers, according to the different conditions of ice formation. It is not typical, according to Tsurikov's definition (1976), for profiles of ice salinity to prevail in drifting ice. Such a combination of anomalies of physical characteristics significantly increases the random constituent of the variability of drifting ice strength.

It is well known that bending is a complex deformation where simultaneous stretching and compression of different ice layers occurs. In the case of ice, the difference between the deformation modulus at compression and at stretching results in the displacement of the neutral line from the centre of gravity of the tested sample. In turn, this at-large variability of sea ice characteristics results in the increase of dispersion of flexural ice strength. This fact was reflected in the research.

During the discussion of 2003 expedition results, an honoured Russian expert on sea ice voiced the idea that today the traditional methods for defining the mechanical characteristics of sea ice (in particular, those bending tests of ice described in this article) have become obsolete and out-of-date since the majority of sea ice characteristics can be calculated on the basis of various empirical formulae. We acknowledge that in the 1980s and 1990s there was significant progress in the world's sea ice studies, and that many new dependencies of various characteristics of sea ice—its thickness, temperature, salinity, brine volume, etc.—were obtained. However, we totally disagree with the above opinion. We consider that the collection of data in poorly studied Arctic districts using the traditional tests of sea ice mechanical properties will continue to be an appropriate part of ice studies for a long time.

OVERVIEW OF FIELD TESTS

The field tests shown below were performed in 2 districts of the Barents Sea (Fig. 1): In the northeastern part, and in the southeastern part which is also known as the Pechora Sea due to some special features of its physical and geographic conditions, hydrological and ice regimes. Table 1 shows the terms of ice studies conducted in each area. All the work was performed in April and May when the thickness and area occupied by ice in the Barents Sea reach the maximum values.

It is known that at the end of April and beginning of May the Barents Sea faces the transition from the winter climate to the summer climate. Fig. 2 shows a histogram of air temperature during field work. This transition has been completely reflected in the research results: Ice studies were performed on both winter ice with a clear positive temperature gradient and evenly warmed

Received May 1, 2007; revised manuscript received by the editors July 26, 2007. The original version (prior to the final revised manuscript) was presented at the 17th International Offshore and Polar Engineering Conference (ISOPE-2007), Lisbon, July 1–6, 2007.
KEY WORDS: Flexural ice strength, cantilever beam test, disc test, ice temperature, ice salinity, ice density, ice porosity.