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TESTING ICE IN THE HIGH ARCTIC

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ABSTRACT

The paper discusses the procedures used for strength and deformation studies of sea ice, and the extremely consistent field results obtained in the High Arctic. Emphasis is on the loving care to be given to specimen preparation.

RÉSUMÉ

Cette étude porte sur les méthodes utilisées dans les travaux de recherche portant sur la résistance et la déformation de la glace marine et les résultats extrêmement homogènes obtenus dans le Haut Arctique. L'accent est mis sur l'attention toute spéciale qu'il faut apporter à la préparation des échantillons.

Testing ice in the High Arctic

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The quality of ice, its thickness, and temperature are essential information in solving most engineering problems involving floating ice. Salinity, air porosity, grain structure, and cracks are important factors determining ice quality and have been dictated by past as well as prevailing climatological conditions. All influence both physical characteristics and mechanical properties.

It is difficult, and often impossible, to obtain such information for describing the physical state of a floating ice block or an ice sheet. Most working temperatures with ice are, in reality, very high as far as its material responses are concerned because the working temperatures are so close to its melting point. High temperature deformation and failure mechanisms play a dominant role in ice mechanics, and rate sensitivity of strength and other mechanical properties become predominant. The test conditions are complicated further by the fact that neither the experimentor nor most experimental tools are "comfortable" at the sub-zero ambient temperatures required in any studies of ice.

In spite of extensive efforts in laboratories and in the field to overcome these technical difficulties in investigating strength and deformation qualities of ice, discrepancies in the results are still too large. There is too much scatter, and there is too much disagreement among different sets of results. There is therefore a requirement to develop better techniques for testing ice, both in the controlled environment of the well-equipped laboratory, and under the adverse conditions encountered in the field.

The author twice spent a month at the High Arctic Weather Station at Mould Bay, Prince Patrick Island, N.W.T. (76°N; 119°20'W), in September-October 1981 and in June-July 1982. Both trips were made on behalf of a Canada-U.S.A. joint program known as the Radarsat/Firex Project. The primary objectives were to determine microwave properties of first-year and multi-year sea ice in natural conditions in the Arctic, information that was to be applied in a remote-sensing satellite. Extensive ground-truth observations were carried out to determine the physical characteristics of the various types of ice encountered and ultimately the investigations were extended to include the mechanical properties of these types of ice as well. Observations were made on rate sensitivity of uniaxial, unconfined compressive strength of freshly recovered first-year sea ice from Mould Bay and multi-year sea ice from a large floe of about 15 km diam found near the junction of Crozier Channel and McClure Strait.

The tests were conducted in a portable

room on the shore of Mould Bay. A commercial test machine (Soiltest CT405) designed for a load capacity of 50 kN was used. Large prismatic samples 50 x 100 x 250 mm were used to test ice oriented horizontally with respect to the ice cover. The samples were carefully machined with respect to the orientations of the grains. Tests were conducted over a wide range of displacement rates and temperatures, load was determined by a calibrated load cell, and strain was measured in the central area of the specimens, away from the end platens, with a pair of specially designed devices (1) mounted directly on the specimens (Fig. 1).

The rate sensitivity of strength, or the maximum stress, was analyzed on the basis of average stress rate as well as the average strain rate to peak stress because of earlier success in presenting results in this manner (2). Time and strain aspects of the test results indicated that extremely consistent results can also be obtained under field conditions.

References

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(2) Sinha, N.K. (1982) Constant strain- and stress-rate compressive strength of columnar-grained ice. J. Materials Science, 17 (3), p. 785-802.

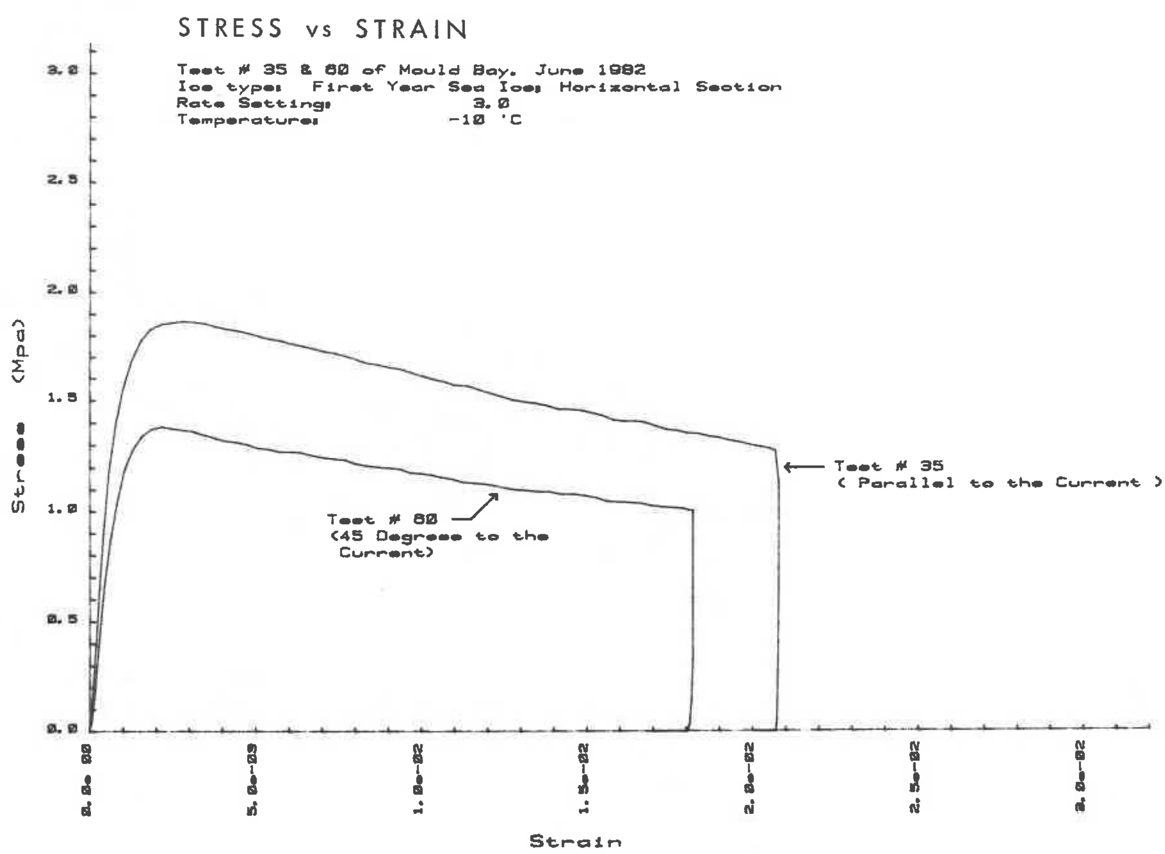

Fig. 1 Stress-strain relationships obtained on horizontally oriented samples of first-year sea ice from Mould Bay, with their long axis parallel and 45° to the direction of the tidal water current in the Bay. Both tests were performed under the same cross-head displacement rate.