

## Examination of Factors Affecting Total Ice Load Using Medium-scale Field Indentation Test Data

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### ABSTRACT

A series of ice indentation tests has been performed since the winter of 1996 at Lake Noto in Hokkaido as part of the JOIA project (JOIA reports 1996-99). The main factors affecting total ice load ( $F$ ) on a structure were investigated using data derived under systematic test conditions, using natural sea ice. The width ( $W$ ) of the model structure, ice thickness ( $h$ ), indentation speed ( $V$ ) and uni-axial compressive strength ( $\sigma_c$ ) are the major factors influencing ice load on a structure with a vertical face. This paper determines that indentation pressure ( $P_i$ ) depends on ( $W/h$ ), ( $V/h$ ) and ( $h$ ). It also describes the pressure distribution examined by the 2-dimensional panel sensor, which can measure pressures in 2112 points at once, depending on various indentation speeds.

### INTRODUCTION

In progress since 1995, the JOIA project undertakes to determine the scaling effect of ice load. In medium-scale field indentation tests (MSFIT), as a part of the project, a lot of local ice-load data as well as total ice-load data was obtained through load cells attached to a 100-mm-wide surface panel of a model structure in contact with an ice sheet. In the winter of 1998, a 2-dimensional panel sensor that can measure pressures of around 1936 points (44 rows, 44 columns) per panel (smaller panel) was also used to determine the ice failure pattern in addition to local ice pressures. These results were reported in Takeuchi et al., 1997, 1998, 1999; Saeki et al., 1998; and Sodhi et al., 1998. Width ( $W$ ) of the model structure, ice thickness ( $h$ ) and indentation speed ( $V$ ) were varied as main parameters influencing total ice load and ice failure mode in the test series. In particular, in the 1999 winter tests, thicker ice and a wider range of indentation speeds were considered, and also a larger 2-dimensional panel sensor was attached to measure ice pressures for thicker ice. In this paper, the effects of main factors on total ice load were investigated from MSFIT data.

### TESTS

All tests in winter 1999 were conducted at Futamigaoka harbor, facing Lake Noto. The test apparatus is the same as that reported in a previous paper (Akagawa et al., 1999). The dimensions of the model structure are shown in Fig. 1. The width ( $W$ ) is 60 cm. Stainless steel panels 10 cm and 5 cm in width and 70 cm in height have load cells which can measure ice forces in 3 directions ( $x$ ,  $y$  and  $z$ ) and moment with respect to the  $y$ -axis. Each panel is completely independent from its neighbors. The load cell numbers are shown in Fig-1. A 2-dimensional panel sensor 48 cm wide by 44 cm high is also attached to the surface of the panel from one end of the model structure. The panel can measure pressures at 2112 grid points over an area of 100 mm<sup>2</sup>. In all tests, the panel is covered by a sheet made of Teflon to prevent the sheet from failing during indentation tests. The displacements rate of a servo-controlled jack, acceleration, inclination of model structure, and ice strength were measured in all tests as was done in previous tests. Test conditions of winter 1999 are shown in Table 1. Test conditions before 1998 were reported in Nakazawa et al., 1999.

### TOTAL ICE FORCE

Results of the winter 1999 tests are shown in Table 2. The time series of total ice force are shown in Fig. 2a~f. The initial shapes of an ice-sheet leading edge for these are irregular and do not give the first peak force for higher indentation speeds ( $V$ ). Characteristics of the time series vary depending on ( $V$ ). Time series for smaller ( $V$ ) show a gradual increase in total ice

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