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Ice Load Equation for Level Ice Sheet

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ABSTRACT

A series of Medium Scale Field Indentation tests (MSFIT) has been performed as part of the JOIA project, and the influence of model structure width (W), ice thickness (h), indentation speed (V) and uniaxial compressive strength (σ_c) on ice load have been examined. The global ice load (F_t) equation for level ice is derived from MSFIT data and factors incorporated into the equation are determined based on the main parameters (V), (h), (W) and (σ_c).

INTRODUCTION

As a part of the project, a lot of local as well as global ice load data has been obtained since 1996 from medium-scale field indentation tests (MSFIT) under various test conditions of indentation velocity $\{V\}$, ice thickness $\{h\}$, and model structure width $\{W\}$ with a rectangular face. A 2-dimensional panel sensor that can measure pressures at many points over a small area was also used to determine the ice failure pattern in addition to local ice pressures. These results were reported in Akagawa et al., 1999, 2000; Nakazawa et al., 1999; Saeki et al., 1998; Sodhi et al., 1998; and Takeuchi et al., 1997, 1998, 1999, 2000, 2001. Two types of ice deformation and failure are observed depending on $\{V/h\}$. The boundary between these types is located at 3×10^{-3} (1/s) of $\{V/h\}$. Multi-failure of an ice sheet occurs under the condition of $\{V/h\} > 3 \times 10^{-3}$ (1/s), called the brittle range, and nonsimultaneous transmission of the ice force on a structure at different positions predominates. On the other hand, under the condition $\{V/h\} < 3 \times 10^{-3}$ (1/s), called the ductile range, ice deforms simultaneously even at the irregular leading edge of an ice sheet; simultaneous transmission of the ice force predominates over the structure. In this paper, an equation is proposed for estimating the global ice force in both the ductile and brittle ranges, and a process is performed for determining factors incorporated into the global ice force equations in both ranges.

ICE/STRUCTURE INTERACTION MODEL

When an ice sheet with an irregular leading edge interacts with a structure (Fig. 1), 2 types of deformation and failure occur, depending on $\{V/h\}$. When $\{V/h\}$ is larger than 3×10^{-3} (1/s), ice fails in a nonsimultaneous manner with increasing $\{W/h\}$ (Figs. 1 and 2a). A unit of interaction between ice and structure transmits a force to a structure at salient parts of the leading edge of an ice sheet, and the shape irregularity makes force transmission nonsimultaneous at different interaction areas. The size of a unit of interaction has a range of values and is approximately $\{h \times h\}$ from the correlation coefficient between ice forces (Takeuchi et al., 1999). Thus, the total number n of unit interactions over the structure is:

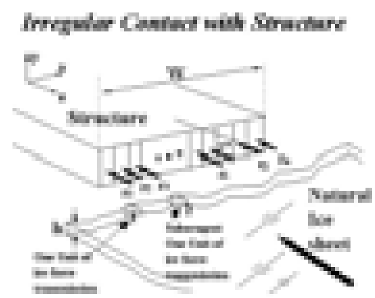

Fig. 1 Ice/structure interaction

$$n = \frac{W \times h}{h \times h} = \frac{W}{h} \tag{1}$$

The global instantaneous ice force acting on a structure is given by:

$$F_t(t) = \sum_{i=1}^{n_e} F_i(t) \tag{2}$$

where $F_i(t)$ is the instantaneous local force acting on the contact zone A_f and n_e is the number of contact zones interacting with the structure. The local force $F_i(t)$ is written as:

$$F_i(t) = P_i(t) A_f \tag{3}$$

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KEY WORDS: Ice load, sea ice, panel sensor.