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Experimental Studies of Thermal Stresses in the Ice

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ABSTRACT

Results of in-situ measurements of mechanical stresses in a sea ice are presented. The stresses were artificially created without assistance of external forces. Definite disposition of thermal screens on an ice cover caused the appearance of corresponding field of thermal stresses. Temperature changes of 1°-2°C during several hours were fixed in an ice layer. Such experiments allow to correctly estimate ice loads on a structure.

INTRODUCTION

A thermal expansion of the ice cover induces adverse phenomena in ice engineering. The need to investigate thermal effects of this kind appears to be quite obvious, particularly in the design and management of offshore structures in closed water areas, restricting free thermal ice deformation and creating quasi-static ice pressure on the structure. The restrictions can also occur due to temperature gradient, ice anisotropy, geometric configuration influence. With specific structure, thickness, heat exchange conditions and responses at the ice cover edge, the pressure on the structure will depend on the amplitude of temperature oscillations, rate of its change at the current moment, duration of this change and the magnitude of the stresses themselves.

Due to various scales of changes of physico-mechanical parameters in the ice cover, as well as to the combined effect of different kinds of limitation, the investigation of its behaviour in the conditions of a thermal load by means of theoretical methods appears to be difficult. That, in its turn, leads to the prevailing use of field instrumental observations for this purpose.

There are only a few experimental studies of thermal deformations and strains in natural ice cover, well-known at present and shown by Bogorodsky (1974), Legenkov (1970), Ivchenko (1984), Frederking (1983) and Sukhorukov (1991). They do not provide a clear understanding of the essence, features and regularities of the phenomenon under consideration, particularly in the case of the sea ice. The complicated character of this task requires new experimental studies.

In this work the authors restricted themselves to experimental studies of the state of the ice cover under thermal stress in case of the simple combination of marginal and physical conditions. The objectives of the work were as follows:

1. To estimate the effect of various temperature limitations and geometric factors on the process of the ice cover deformation under thermal and mechanical loading.
2. To identify typical features of spatial-temporal distribution of mechanical stresses in boundary zones with the largest horizontal temperature gradient.
3. To establish relationships between mechanical and thermal characteristics with different schemes of thermal loading of the ice cover.
4. To test the methods of combined measurements of thermal and mechanical characteristics.

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KEY WORDS: Ice, thermal stress, experiment.

EXPERIMENTAL SETUP

For field studies in winter a measurement polygone was arranged on a flat snow-bare part of the sea ice cover of the Sakhalin shelf. Measurements of thermal stresses were carried out by means of small (up to 4 cm in diameter) thermally compensated sensors (SM) specially developed for the conditions of plastic-elastic ice cover behavior.

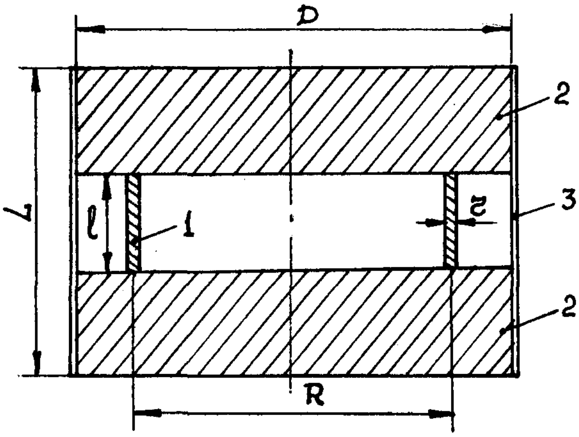

Fig. 1 Stressmeter (SM) measurements: D = 4 cm, L = 2.93 cm, R = 2.84 cm, 1 = 0.9 cm, r = 0.06 cm

The stressmeter is made of duralumin and has a flat shape: an elastic unit in the form of a hollow cylinder of constant cross section (1) is situated between two hard round plates (2). Isolation of the detector from the environment is ensured by a rubber cover (3). The detector is selective in the direction of the stress and has maximal sensitivity along the axis of the elastic unit. Its main dimensions have been calculated from the condition of an accordance between effective modulus of elasticity of the detector and Young's modulus of the ice. Sensors (tensoresistors) are glued to the inner surface of the cylinder. The electric signal is formed by the Wheatstone bridge with differential connection of the tensore-