# FORECASTING THE STRUCTURE AND STRENGTH OF ICE ON SOLID SURFACES

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Abstract. Experimental and theoretical investigations have made it possible to define more exactly some features of ice formation on solid surfaces.

The metastable state of water extends to $-39°C$. Icing on solid surfaces does not need such supercooling of water. The necessary water supercooling depends mainly on the material of the solid body and the roughness of its surface. The presence of a large number of micro-roughnesses of various form and size causes the simultaneous appearance of many crystals the growth of which leads to the formation of the primary ice layer. The shape and orientation of crystals of the primary ice layer on a solid surface are determined by the material and structure of the solid and by the surface roughness. The number of crystals on the unit surface $N = A \times 10^{k\Delta T}$, where $A$ and $k$ are coefficients determined by solid material and surface roughness and $\Delta T$ is the water boundary supercooling. The growth of the primary ice layer is followed by an increase of cross-section of some crystals at the expense of the contraction and disappearance of the other ones. The greater the supercooling of the water and the higher the temperature gradient of the ice layer the greater the growth rate of crystals. Under high temperature gradients most of the crystals have their axes directed parallel to the freezing surface. With low temperature gradients and lower supercooling the crystals have a fabric with *c*-axes directed perpendicular to the surface of freezing.

Knowledge of these features of ice formation processes makes it possible to solve the problem of ice formation with a planned structure and strength and to forecast the structure and strength of ice on structures.

# MODEL EXPERIMENTS TO DETERMINE ICE FORCES ON CONICAL STRUCTURES

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Abstract. Reduced-scale experiments were conducted in 1971 to study the forces experienced by conical structures during encounters with uniformly thick fields of ice. The tests were conducted in a model basin which was designed to test the behavior of ships and floating platforms in ice. A liquid nitrogen spray system was used to produce fields of high-salinity, fine-crystalline, ice which has the properties of elastic modulus and strength scaled down substantially below full-scale values.

Models representing conical-shaped structures to 1/50 and 1/100 scale were mounted onto a three-component load transducer which was fixed to a towing carriage. A total of 20 tests were conducted during which 45° cones of diameter 25 cm, 50 cm, and 100 cm were moved through uniform ice with thicknesses in the range 1.9 to 6.8 cm. Ice strength (in flexure) varied in the range 0.01 to 0.41 bar. Enough data were collected to derive a first approximation to an empirical solution for the forces exerted against a cone as a function of ice thickness $h$, flexural strength $\sigma_f$, and cone diameter $D$. The small-scale tests results were compared with one current mathematical model and found to predict higher values of horizontal force than the mathematical model.