ALGORITHMIZATION OF CALCULATIONS OF THE TEMPERATURE CONDITIONS OF THE FOUNDATIONS OF BUILDINGS AND STRUCTURES

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The selection of the design and principle of construction of buildings and structures, especially in regions with a rigorous climate, is determined in many respects by the temperature conditions of the soil foundations which are formed during unsteady heat transfer in the system atmosphere—soil—structure. This process is calculated by methods of mathematical modeling of physical fields on electric and hydraulic integrators. We developed a method of calculating the temperature conditions of freezing and thawing soil foundations on a digital computer.

The method consists in algorithmization of the solution of the nonlinear differential equation of thermal conductivity which is reduced to a system of linear finite-difference equations, each of which described a change of temperature at one of n nodal points of the region considered:

\[ \frac{\Delta t}{\Delta \tau} = \frac{\Delta Y}{R_{v}^{y} + R_{l}^{y}} + \frac{\Delta X}{R_{v}^{x} + R_{l}^{x}} + \frac{\Delta Y}{R_{v}^{x}} + \frac{\Delta X}{R_{l}^{x}}, \]

where \( t \) is temperature in °C; \( \tau \) is time in hours; \( X \) and \( Y \) are coordinates of the point in meters; \( R_{v}^{y} \) and \( R_{l}^{y} \) are thermal resistances in vertical and horizontal directions equal respectively to \( \Delta X/2k \Delta Y \) and \( \Delta Y/2k \Delta X \) in \( m^{2} \cdot \text{deg} \cdot \text{h}/\text{kcal} \); \( k \) is the coefficient of thermal conductivity in kcal/m \cdot \text{deg} \cdot \text{h}; \( C \) is volume heat capacity in kcal/m \(^3\) \cdot \text{deg}; \( W \) is the heat of ice formation in kcal/m \(^3\) \cdot \text{h}.

System of Eqs. (1) is solved by the net-point method for which purpose the investigated region is divided into blocks of finite size with the thermophysical characteristics concentrated in their centers. The result of the solution is a temperature field obtained at each step \( \Delta t \) in the frozen and thawed zones linked by one or more curvilinear boundary lines (isotherms) \( t_{z} \). The position of the isotherms is determined by the quantity of heat \( W \) liberated during freezing or absorbed during thawing in comparison with the total quantity of heat of ice formation \( V \).

Fig. 1. Block diagram of algorithm.
The algorithm consists of six main blocks (Fig. 1): input of initial information; assignment of boundary conditions; control of conditions \( t = t_0 \), \( w = v \), and \( w = 0 \); selection of heat-transfer conditions at the surface; calculation of temperatures and internal heats. In developing the algorithm we accepted the following premises:

a) the soil freezes and thaws with the formation of a boundary between the frozen and thawed zones;

b) migration and percolation of moisture are absent;

c) the thermal properties of the soil at the phase boundary change abruptly.

Thus the temperature field in a two-dimensional region formed during unsteady heat transfer in the system atmosphere-soil-structure and in the presence of internal heat sources and sinks at one or more phase boundaries is subject to calculation.

The algorithm, compiled in ALGOL–60 universal programming language, is implemented as a working program obtained after its translation in machine codes. Programs have presently been obtained for the M-20, M-220, and BESM–4 digital computers. Human participation in the solution of the problem amounts to preparing the initial information and entering it into the reader.

The following boundary conditions can be assigned at the boundaries of the region: on the upper boundary, two conditions of the third kind \( t = f(x) \) and \( t = \varphi(x) \) and one of the fourth kind \( t = t_0 \); on the lower boundary, one of the first kind \( t = \psi(x) \); on the side boundaries, the condition of zero-equality of the horizontal heat fluxes. In this case the surface of the region can be exposed or heated with two types of insulation: \( R_1 \) in the section of action of boundary condition \( t_1 \) and \( R_2 \) in the section of action of condition \( t_2 \). The change of the boundary conditions and insulation can be given with any degree of detail (daily, by ten-day periods, monthly) in the form of tables of the temperature values \( t_1 \), \( t_2 \), and \( t_3 \) and of thermal resistances \( R_1 \) and \( R_2 \).

This algorithm was used at the Siberian branch of the All-Union Scientific-Research Institute of Transportation Construction, at the All-Union Scientific-Research Institute of Transportation Construction, and