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CALCULATION OF ELEMENTS OF BARRIER CONSTRUCTION FROM CLIMATE PARAMETERS

Nurova Oliya
Tursunov Shavkat
Karshi Engineering and Economics Institute

Annotation. In this article, as a result of the study of thermophysical processes in barrier constructions, thermophysical properties of building materials, their design methods have been developed. It was shown to determine the formula for the amount of heat flow based on Foure's law.

Keywords: calculated temperature, thermal resistance, external barrier construction, homogeneous and non-homogeneous construction, heat transfer coefficient, total resistance to heat transfer, thermal inertia.

One of the important tasks of the planned building is to protect the people in it and the production equipment located in it, as well as the people in it from the adverse effects of the climate. This is achieved by creating a microclimate in the room that fully meets technical and functional requirements.

The quality of the microclimate is determined by a number of functional, sanitary and hygienic requirements. The natural air environment around us is very variable, and these changes have a great impact on the physiological state of a person.

The artificial environment created in the rooms should meet the requirements of the human body for air temperature, relative humidity, and level of cleanliness. Building constructions located on the borders of the natural environment and the artificial environment created by man and separating them are called barrier constructions.

Roof and inter-floor coverings are horizontal barrier structures, walls and windows are vertical barrier structures. Barrier constructions can be divided into single-layer and multi-layer constructions depending on the number of material layers in them.

If the construction or its separate layers consist of the same type of material at the boundary of this layer, it is called a homogeneous construction. If the construction or its separate layer is made of different materials, it is called non-homogeneous construction (Fig. 1 and 2).

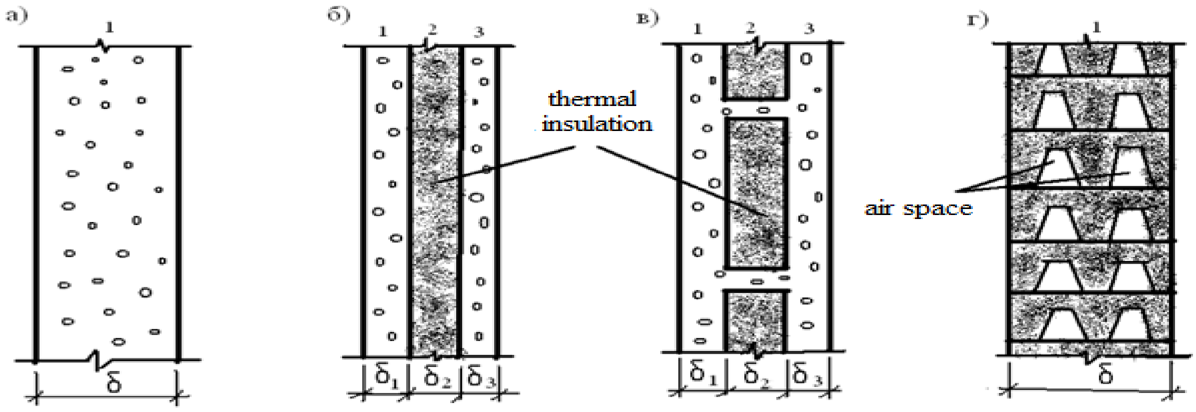

Figure 1. Solutions of external wall constructions: a - one-layer homogeneous construction; b - a multi-layer structure consisting of homogeneous layers; v - non-homogeneous multi-layer construction; g is a one-layer inhomogeneous structure.

As a result of studying thermophysical processes in barrier constructions, thermophysical properties of building materials, their design methods have been developed. Thermophysical requirements for barrier structures are of great importance. Because the sanitary properties of the created environment, the durability of the constructions, the amount of energy used for heating the room mainly depend on the thermophysical properties of the barrier constructions.

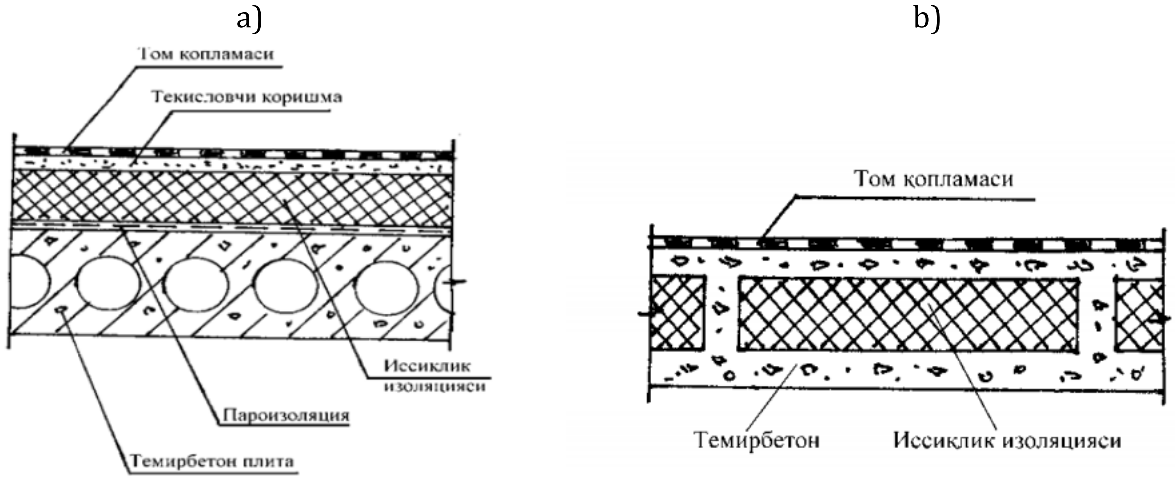

Figure 2. Solutions of roof structures:
a - non-homogeneous multi-hole reinforced concrete slab roof.
b - non-homogeneous three-layer reinforced concrete slab roof;

In the barrier structure, when the temperature of the separating air environments is different and this condition does not change over time, a heat flow from the hot surface to the cold surface occurs (Fig. 3).

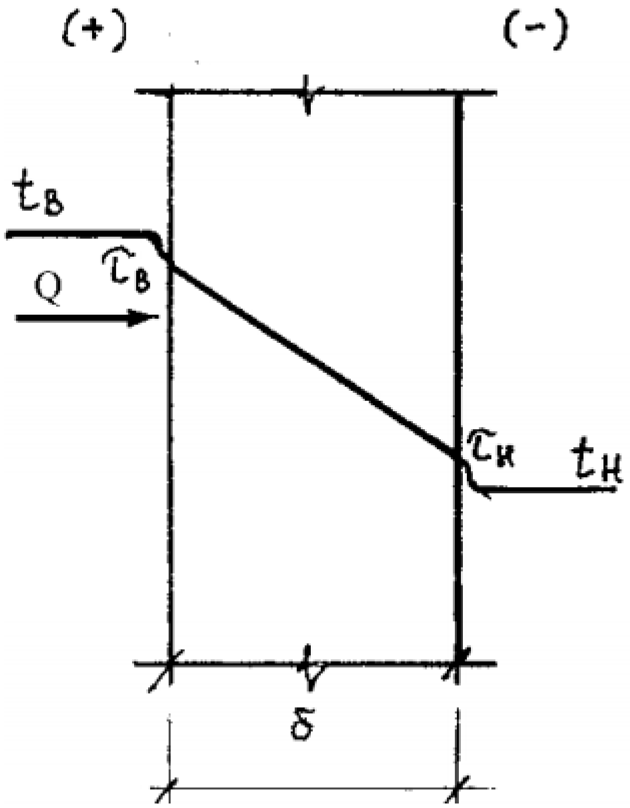

Figure 3. The scheme of the temperature changes according to the structure when the heat flow occurs.
According to Foure's law, the amount of this heat flow can be determined using the following formula:

$$Q = (\tau_B - \tau_H) \cdot \frac{\lambda}{\delta}, \quad (1) \qquad (1)$$

Q —When the temperature difference $\tau_{B-}\tau_H = 1^{\circ}$C and the thickness of the structure is 1 m, it can be determined from equation (1) that = λ. That is, the coefficient of thermal conductivity of the material is the amount of heat that passes through a homogeneous barrier structure with a thickness of 1 m, with a temperature difference of 1 °C on the opposite surfaces. The heat transfer coefficient of the material depends on its physical and chemical structure, density, temperature and humidity. When humidity increases, λ increases.

It is known that the moisture level of the material is closely related to the humidity of the environment. Therefore, in the calculations, the value of λ is taken depending on the humidity regime of the room and the wetness or dryness of the construction area. The purpose of thermophysical calculation of barrier structures is to ensure that they have certain thermophysical properties and qualities. The thermophysical quality of the external barrier structure is characterized by its total resistance to heat transfer R. Let's see what elements R_o consists of: as shown in Fig. 2, the temperature decreases from the T_b value to the tH value during the heat transfer through the barrier structure.

The difference $(t_{B-}\tau_B)$ between the temperatures of the internal air in the room and the internal surface of the structure is due to the resistance of the internal surface to heat absorption RB, and the difference between the temperatures of the external surface and the external air $(\tau_H - t_H)$ is due to the resistance of the external surface to heat release R_H .

R_B and R_H are the values of heat transfer coefficients α_B and α_H of the inner and outer surfaces in W/m^2. °C is related as follows:

$$R_{B=}\frac{1}{\alpha_B} \quad \text{va} \quad \text{RH} = \frac{1}{\alpha_H} \qquad (2)$$

Also, the difference between the temperatures of the inner surface and the outer surface occurs due to the thermal resistance of the structure R_K. The total resistance of the barrier structure to heat transfer is equal to the sum of all the considered resistances, i.e.:

$$R_{0=}R_B + R_K + R_H = \frac{1}{\alpha_B} + R_K + \frac{1}{\alpha_H} \qquad (3)$$

The thermal resistance of the structure RK is determined differently for different structures. The thermal resistance RK of a single-layer homogeneous barrier structure is directly proportional to the thickness δ and inversely proportional to the material thermal conductivity coefficientλ, i.e.

$$R_K = \frac{\delta}{\lambda} \qquad (M^2 \cdot C/BT) \qquad (4)$$

In fact, based on Foure's law, we can write:

$$Q = \frac{t_{B-}t_H}{R_0} \qquad (5)$$

$$Q = \frac{t_{B-}\tau_B}{R_B} \qquad (6)$$

The following formula follows from equations (5) and (6):

$$R_0 = \frac{t_{B-}t_H}{t_{B-}\tau_B} \qquad (7)$$

In the cold period of the year, the temperature of the inner surface of the structure τ_B is always lower than the indoor air temperature in the room.

But it is necessary to ensure that the value of τ_B is not lower than the dew point. Otherwise, condensate will form on the inner surface of the structure. This is not allowed according to sanitary and hygienic requirements. Therefore

$(t_{B-}\tau_B) = t_H$ value is normalized. Based on the formula (7), replacing R_0^{TP}, the following formula is recommended for determining R_0^{TP}:

$$\frac{1}{\alpha_B}$$

$$R_0^{TP} = \frac{(t_{B-}t_H)}{\Delta t^H \cdot \alpha_B} \qquad (M^2 \cdot C/BT) \qquad (8)$$

where n is the coefficient taking into account the position of the outer surface of the barrier structure relative to the outside air; t_B- is the calculated temperature of the indoor air, °C, depending on the function of the room, it is taken from the regulatory documents; t_B- is the calculated temperature of the outside air oS, depending on the value of the barrier thermal inertia D, it is accepted for the area where the building will be built. The greater the thermal inertia of the barrier structure, the greater the resistance to changes in the temperature state of the structure itself when the temperature of the air environment changes. The opposite can be observed in structures with low thermal inertia. The value of thermal inertia D for a homogeneous one-layer barrier structure is determined as the multiplication of the thermal resistance R by the heat absorption coefficient S of the material. that is: $D = R \cdot S$ (9)

The thermal inertia D of a multi-layer structure consisting of homogeneous materials is equal to the sum of the thermal inertia of individual layers, i.e.:

$$D = R_1 \cdot S_1 + R_2 \cdot S_2 + \cdots + R_n \cdot S_n = \sum R_i \cdot S_i \qquad (10)$$

Here $R_1, R_2, ..., R_n$-the technical resistance of individual layers is determined using the formula (4)

$S_1, S_2, \dots, S_n$- are determined. The calculation temperature of the outside air in the formula (8) is taken as follows:

When D≤1.5, the average temperature of the coldest days is 0.98 t_H^1;

When 1.5 ⍰ D ⍰ 4, the average temperature of the coldest days is 0.92. When t_H^1 is 4<D≤7, the three coldest days are 0.92 average temperature t_H^3

D>7; and the average temperature of the coldest five days is 0.92 t_H^5

The average temperature of the coldest three days t_H^3 , the average temperature of the coldest days t_H^1 and the average temperature of the five coldest days t_H^5 is defined as the average arithmetic value. For a properly designed barrier structure, the following condition is fulfilled, viz

$R_0 \geq R_0^{TP}$ (11)

Based on this condition, there is an obstacle in the design practice

the thickness of the structure or, if it is multi-layered, the thickness of a single layer (usually a layer of thermal insulation) is determined.

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