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INCREASING THE ENERGY EFFICIENCY OF HEAT-INSULATING BUILDINGS

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Abstract. The research paper provides directions of increasing the energy efficiency of heat-insulating buildings have been investigated, the features of constructive solutions for thermal insulation of buildings in the places where the structure are adjacent have been determined. The analysis of heaters, which are most common, including in the nodal joints of the heat-insulating shell of buildings, has been carried out.

Keywords: energy efficiency, thermal resistance, thermal protection.

Introduction

The problem of thermal protection of building envelopes in order to save energy resources has been relevant in recent decades, but it became especially noticeable when prices for thermal and electrical energy began to rise.

A significant number of buildings in Uzbekistan have heat-shielding shells with low resistance to heat transfer, which leads to significant losses of heat energy.

Resistance to heat transfer characterizes the thermal protection of individual building encloses and is a standardized indicator. Based on the standardized values of this value, conclusions are often drawn about the level of energy saving of buildings and comparisons of this level are made in Uzbekistan and other countries.

The reduced thermal resistance of a non-uniform enclosing structure (a multi-layer stone wall of lightweight masonry with an insulating layer, etc.), W/(m^2·K), according to KMK 2.01.04-2018 “Building heat engineering” is determined as follows:

a) by planes parallel to the direction of the heat flow, the enclosing structure is conventionally cut into sections, of which some sections can be homogeneous (single-layer) - from one material, and others heterogeneous - from layers of different materials, and thermal resistance of the enclosing structure R_a, W/(m^2·K), is determined by the formula

$$R_a = \frac{F_1+F_2+\cdots+F_n}{\frac{F_1}{R_1}+\frac{F_2}{R_2}+\cdots+\frac{F_n}{R_n}} \qquad (1)$$

where F_1, F_2,.., F_n – the area of individual sections of the structure (or part of it), m^2;

R_1, R_2, ..., R_n – thermal resistance of the specified individual sections of the structure, W/(m^2·K).

b) by planes perpendicular to the direction of the heat flow, the enclosing structure (or part of it, adopted to determine R_a) is conventionally cut into layers, of which some layers can be homogeneous - from one material, and others non-uniform - from single-layer sections of different materials. The thermal resistance of heterogeneous layers is determined by the formula (1) and the thermal resistance of the enclosing structure R_b – as the sum of thermal resistances of individual homogeneous and heterogeneous layers.

Reduced thermal resistance of the building enclose, W/(m^2·K), should be determined by the formula:

$$R_k^{res} = \frac{R_a+2R_б}{3} \qquad (2)$$

If the value of R_a exceeds the value of R_b by more than 25% or the enclosing structure is not flat (has protrusions on the surface), then the reduced thermal resistance of such a structure should be determined based on the calculation of the temperature field as follows:

based on the results of calculating the temperature field at t_{in} and t_{out}, the average temperatures of the internal $t_{in\ ave}$ and t_{out} are determined. outdoor $t_{out\ ave}$ surfaces of the enclosing structure and the value of the heat flux is calculated by the formula:

$$q^{calc} = \alpha_{in}(t_{in} - \tau_{in\ ave}) = \alpha_{out}(\tau_{in\ ave} - t_{out}) \qquad (3)$$

where α_{in}, – heat transfer coefficient of the inner surface of the enclosing structures, W/(m^2·K), accepted by KMK 2.01.04-2018;

t_{in} – design temperature of indoor air, ºC, taken in accordance with the design standards of the corresponding buildings and structures;

t_{out} – estimated winter temperature of the outside air, °C, equal to the average temperature of the coldest five-day period with a provision of 0.92 according to KMK 2.01.04-2018;

α_{ter} – heat transfer coefficient (for winter conditions) of the outer surface of the enclosing structures, W/(m²·K).

Reduced thermal resistance of structures, W/(m²·K), is determined by the formula:

$$R_{\text{к}}^{res} = \frac{\tau_{\text{в ср}} - \tau_{\text{н ср}}}{q^{\text{расч}}} \quad (4)$$

Reduced resistance to heat transfer R_o, W/(m²·K), heterogeneous building envelope should be determined by the formula:

$$R_0 = \frac{(t_{\text{в}} - t_{\text{н}})}{q^{calc}} \quad (5)$$

where t_{in}, t_{out} – the same as in the formula (3);

q^{calc} – the same as in the formula (3).

It is allowed to take the reduced resistance to heat transfer Ro of the outer panel walls of residential buildings equal to:

$$R_0 = R_0^{cond} \cdot r \quad , \quad (6)$$

where r - the coefficient of thermal engineering uniformity of the enclosing structures, determined, must be not less than the values given in KMK 2.01.04–2018.

Internal surface temperature τ'_{in}, °C, the enclosing structure (for heat-conducting inclusion) must be taken on the basis of the calculation of the temperature field of the structure.

For heat-conducting inclusions given in KMK 2.01.04–2018, the temperature τ'_{in}, °C, allowed to define:

for non-metallic heat-conducting inclusions - according to the formula:

$$\tau'_{\text{в}} = t_{\text{в}} - \frac{n(t_{\text{в}} - t_{\text{н}})}{R_0^{cond}\alpha_{\text{в}}}\left[1 + \eta\left(\frac{R_0^{cond}}{R_0} - 1\right)\right] \quad (7)$$

for metallic heat-conducting inclusions - according to the formula:

$$\tau'_{\text{в}} = t_{\text{в}} - \frac{(t_{\text{в}} - t_{\text{н}})}{R_0^{cond}\alpha_{\text{в}}}\left(1 + \xi R_0^{\text{усл}}\alpha_{\text{в}}\right), \quad (8)$$

where R'_o, – resistance to heat transfer of the building envelope, W/(m²·K), respectively, in places of heat-conducting inclusions and outside these places, determined by the formula (2);

η, ξ – coefficients adopted by KMK 2.01.04–2018.

Methods of research

Requirements for the resistance to heat transfer of enclosing structures exist in all European countries, and the presence of European standards indicates the possibility of taking into account the influence of thermal bridges. However, there are still quite a lot of problems with the implementation of the method for calculating the reduced resistance to heat transfer taking into account heat engineering in homogeneities.

According to the normative requirement, the reduced resistance to heat transfer of a non-flat or heat-engineering non-uniform enclosing structure $R_o^{\text{пр}}$, W/(m²·K), is determined by the formula:

$$R_0^{\text{пр}} = \frac{1}{\frac{1}{R_0^{\text{усл}}} + \Sigma\, l_j\, \psi_j + \Sigma\, n_k\, \chi_k} = \frac{1}{\Sigma a_i U_i + \Sigma\, l_j\, \psi_j + \Sigma\, n_k\, \chi_k} \quad (9)$$

where $l_{j,}$ n_k – geometric characteristics of elements, determined for a specific project;

$\Psi_{j.}$ – specific heat losses through linear inhomogeneity, W/(m·K);

χ_k – specific heat losses through a point inhomogeneity, W/(m·K);
$R_0^{\text{усл}}$ – area-averaged conditional resistance to heat transfer of a fragment of a building's heat-shielding envelope or a dedicated enclosing

constructions, W/(m²·K);

Heat transfer coefficient along the surface of the structure (without heat-conducting inclusions) U, W/(m²·K), is calculated by the formula:

$$U = \frac{1}{R_0^{cond}} = \frac{1}{\frac{1}{\alpha_{\text{в}}} + \Sigma\left(\frac{\delta}{\lambda}\right) + \frac{1}{\alpha_n}} \quad (10)$$

Additional heat losses passing through the thermal engineering inhomogeneities of the fence are determined by the formula:

$$\Delta\, U = \Sigma l_j \psi_j + \Sigma n_k \chi_k \quad (11)$$

According to the method for determining the values of ψ and χ, based on calculations of two-dimensional and three-dimensional temperature fields using computer programs. To simplify the calculations of the values of ψ and χ, a manual has been developed containing their values for typical nodes of enclosing structures.

However, in order to use this technique in the conditions of the Republic of Uzbekistan, it is necessary to compile your own catalog of nodes of external enclosing structures that correspond to the technical solutions of buildings located in seismic areas of construction, different climatic zones and with different levels of thermal protection, and then calculate the specific heat loss for the installed cold bridges.

Determination of heat fluxes passing through real fencing nodes using the analytical method is rather difficult. In this regard, various approximate methods are widely used, one of which is the finite element method.

For the numerical implementation of the modeling of temperature fields, computer programs based on the finite element method are widely used. However, as you know, any numerical method gives results with varying degrees of accuracy, which determines the interest of scientists in establishing the degree of accuracy in calculating heat fluxes and temperature fields.

The most famous and widespread at the moment is the method, which is based on the finite element method and the use of enclosing structures for calculating the temperature fields.

Results

The technique allows calculating the temperature fields of complex junctions of enclosing structures and non-uniform fences with heat-conducting inclusions. At the same time, the program has a number of disadvantages: the complexity of constructing the initial geometric model of structures and the limitation of the working versions of the program to 160 thousand nodes of the computational grid, which often forces us to resort to strong simplifications of the model on complex structures of modern buildings.

The use of modern computer programs and the latest techniques allows us to develop the most effective technical solutions to increase the thermal protection of external fences with thermal bridges.

Due to the fact that numerous thermal bridges are concentrated in the constructive solution of buildings, this can lead to damage not only to the enclosing, but also to the supporting building structures. Intense heat flows through heat-conducting inclusions cause such negative phenomena as:

- the formation of condensation on the surface of the fences inside the room, especially in the area of the corners, leading to the formation of mold;

- a decrease in the level of comfort of premises in both summer and winter as a result of overheating or significantly low internal temperature;

- increase in operating energy consumption for heating and air conditioning of buildings.

Conclusion

Consequently, making decisions to eliminate cold bridges contributes not only to energy efficiency, but also to the preservation of human health. In addition, the elimination of cold bridges creates the preconditions for the long-term preservation and functional reliability of buildings. In order to avoid risk, even during the design and construction of buildings, it is necessary to study in detail all cold bridges and the degree of their negative impact, in order to then eliminate the negative consequences with the help of appropriate measures.

It is possible to avoid the negative influence of cold bridges through the use of effective facade thermal insulation, which can normalize the temperature and humidity conditions of the premises.

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