ENERGY EFFICIENCY OF ENCLOSING STRUCTURE IN TEMPERATURE MODES

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Abstract. The scientific paper provides the optimal use of research increasing the energy efficiency of the thermal insulation shell of buildings, the features of constructive solutions for thermal insulation of buildings in the places where the structure adjoin are 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 protection, thermal resistance, ventilation.

1. Introduction

The purpose of the design and construction of energy efficient buildings is to efficiently use the energy resources spent on the energy supply of the building through the adoption of economically justified innovative solutions. The methodology for designing an energy efficient building should be based on a systematic analysis of the building as a single energy system. At the moment, there is no uniform classification of buildings for energy consumption. Energy efficiency of external building envelopes can be ensured through the use of facade systems that include mineral thermal insulation materials. As mentioned earlier, different thermal insulation materials have different vapor permeability and can prevent moisture transfer through the building envelope.

The territory of the Republic of Uzbekistan is not homogeneous in its climatic characteristics, which leads to some difference in the constructive solution of the external walls of buildings and junctions of building structures with external fences. First of all, this is reflected in the presence or absence of the heat-insulating layer, its material and thickness. However, in order to obtain a more holistic picture of the studies performed, in addition to the constructive solution of the outer walls of the building considered during the thermal imaging survey, the outer shell of the building, built according to the same project, but with insulation of the brickwork on the outside with a layer of basalt fiber insulation 80 mm thick (λ = 0.042 W / (m ∙ K)) Based on foreign experience, when calculating the nodes, thin non-metallic layers with a thickness of up to 1 mm (vapor barrier layer) and layers that insignificantly affect heat flows through the node were not taken into account - plaster layers made of cement sand mortar, located perpendicular to the heat flow.

According to the standard, the specific heat loss through the linear thermal bridge Ψj, W / (m ∙ K) is determined by the formula:

\[ \Psi_j = \frac{\Delta Q_j}{t_{in} - t_{out}} \]  

(1)

where,

\( t_{in}, t_{out} \) - design temperature of indoor and outdoor air, respectively, °C;

\( \Delta Q_j \) - additional heat losses through a linear thermal bridge of the j-th type per 1 running meter of the joint, W / m, is determined by the formula:

\[ \Delta Q_j = Q_j^1 - Q_{j,1}^2 \]  

(2)

here
\( \Delta Q^j \) - heat loss through the calculated section of the enclosing structure with a linear thermal bridge of the \( j \)-th type, per 1 running meter of the joint, \( W / m \), is determined by the results of calculating the temperature field:

\[
Q_{j,1}, Q_{j,2} - heat losses through flat thermotechnically homogeneous elements of the \( j \)-th linear thermal bridge, \( W / m \), included in the computational domain when calculating the temperature field, determined by the formulas:
\]

\[
Q_{j,1} = \frac{t_{in} - t_{out}}{R_{o,j,1} \cdot 1} \cdot S_{j,1}, \quad Q_{j,2} = \frac{t_{in} - t_{out}}{R_{o,j,2} \cdot 1} \cdot S_{j,2}
\]

where

- \( t_{in}, t_{out} \) - the same as in the formula (1);
- \( S_{j,1}, S_{j,2} \) - area of a flat thermotechnically homogeneous element of the \( j \)-th type included in the computational domain when calculating the temperature field, \( m^2 \);
- \( R_{o,j,1}, R_{o,j,2} \) - conditional resistance to heat transfer of a homogeneous part of a fragment of a heat-protective envelope of a building of the \( j \)-th type \( W/(m^2\cdot K) \).

Specific heat losses through the volumetric thermal bridge \( \chi_k \), \( W / K \), are determined by the formula:

\[
\chi_k = \frac{\Delta Q^k}{(t_o - t_u)}
\]

where

- \( t_{in}, t_{out} \) - design temperature of indoor and outdoor air, respectively, \( ^\circ C \);
- \( Q^k \) - additional heat losses through the volumetric thermal bridge of the \( k \)-th type, \( W \), are determined by the formula:

\[
\Delta Q^k = Q^k - \sum Q_{k,i} - \sum (\Psi_{k,i} \cdot l_{k,i})
\]

here

- \( Q^k \) - heat loss through the enclosing structure with a volumetric thermal bridge of the \( k \)-th type, \( W \), is determined by the results of calculating the temperature field;
- \( Q_{k,i} \) - heat loss through the \( i \)-th flat thermotechnically homogeneous element of the volumetric thermal bridge, included in the computational domain when calculating the temperature field, \( W \), determined by the formula:

\[
Q_{k,i} = \frac{t_{in} - t_{out}}{R_{k,i}} \cdot S_{k,i}
\]

where

- \( t_{in}, t_{out} \) - the same as in the formula (4);
- \( R_{k,i} \) - resistance to heat transfer of a flat heat engineering homogeneous element of the enclosing structure of the \( i \)-th type, \( W/(m \cdot K) \);
- \( S_{k,i} \) - area of a flat thermotechnically homogeneous element of the enclosing structure of the \( i \)-th type, included in the computational domain when calculating the temperature field, \( m^2 \);
- \( \Psi_{k,i} \cdot l_{k,i} \) - specific heat losses, \( W / (m \cdot K) \), and the length of the \( k \)-th thermal bridge, \( m \), included in the calculated region of the temperature field of the bulk thermal bridge, respectively.

Specific heat loss through a point thermal bridge \( \chi_m \), \( W / K \), is determined by the formula:

\[
\chi_m = \frac{\Delta Q^m}{(t_o - t_u)}
\]

where

- \( t_{in}, t_{out} \) - the same as in the formula (4);
- \( \Delta Q^m \) - additional heat loss through a point heat bridge of the \( m \)-th type, \( W \), is determined by the formula:

\[
\Delta Q^m = Q^m - Q_m.
\]
\( \alpha_{\text{in}}, \alpha_{\text{out}} \) - heat transfer coefficients of the inner and outer surfaces of the enclosing structures, respectively; 
\( S_{\text{in}}, S_{\text{out}} \) - the area of the inner and outer surface of the calculated area (calculated area) of the enclosing structure, respectively, m²; 
\( t_{\text{in}}, t_{\text{out}} \) - the same as in the formula (4); 
\( \tau_{\text{in}}, \tau_{\text{out}} \) - the average temperature of the inner and outer surfaces of the enclosing structure, respectively, °C.

Results

The conditions of heat transfer on the surfaces of the models of structural units were set in the form of the calculated values of the ambient air temperature and the calculated heat transfer coefficients of the surfaces (boundary conditions of the third kind). At the boundaries of the design areas with zero heat flux, adiabatic conditions were assigned.

Conclusions

The temperature of the internal air when calculating the specific heat loss through the heat-conducting inclusions of the outer walls of residential buildings was taken equal to 20 °C (respectively, measured inside the apartment during a thermal imaging survey). The outside air temperature was taken to be equal to the average temperature of the coldest five-day supply period of 0.92, determined by KMK 2.01.01-94.

In the calculations, the following assumptions were made:
1. Fillings of openings (windows, balcony doors) were taken in the form of plates of constant thickness along the height and length of the opening. In calculating the heat flux through the thermal bridge, the heat flux through the filling of the opening was not taken into account.
2. Thin metal heat-conducting elements of the enclosing structure with a thickness of 2-5 mm, located in masonry with a thermal conductivity coefficient of 0.8 W/m °C and higher, were not taken into account.
3. Plaster layers made of cement-sand mortar and layers of vapor barrier located perpendicular to the heat flow were not taken into account.

References

13. Construction norms and regulations of Uzbekistan 2.01.18-18. Criteria of energy consumption for heating, ventilation and air conditioning of buildings and structures.