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:

$$\Psi_j = \frac{\Delta Q_j^L}{t_{in} - t_{out}}, \quad (1)$$

where,

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

ΔQ_j^L - 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:

$$\Delta Q_j^L = Q_j^L - Q_{j,1} - Q_{j,2}\ , \quad (2)$$

here

ΔQ_j^L - 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;

$Qj_{,1}$, $Qj_{,2}$ - 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:

$$Q_{j,1} = \frac{t_{in} - t_{out}}{R_{o,j,1} * 1m} * S_{j,1}, \quad Q_{j,2} = \frac{t_{in} - t_{out}}{R_{o,j,1} * 1m} * S_{j,2} \quad (3)$$

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 jth type included in the computational domain when calculating the temperature field, m²;

$R_{o,j,1}, R_{o,j,2}$ - 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/(m²·K).

Specific heat losses through the volumetric thermal bridge χk, W / K are determined by the formula:

$$\chi_k = \frac{\Delta Q_k^{\text{К}}}{(t_{\text{в}} - t_{\text{н}})}, \quad (4)$$

where

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

$Q_k^{\text{К}}$ – additional heat losses through the volumetric thermal bridge of the *k*- th type, W, are determined by the formula:

$$\Delta Q_k^{\text{К}} = Q_k^{\text{К}} - \sum Q_{k,i} - \sum(\Psi_{k,i} * l_{k,j}) \quad (5)$$

here

$Q_k^{\text{К}}$ - 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:

$$Q_{k,i} = \frac{t_{\text{в}} - t_{\text{н}}}{R_{k,i}} * S_{k,i} \quad (6)$$

where

$t_{в}$, $t_{н}$ – 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/(m²·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, m²;

$\Psi_{k,j}, l_{k,j}$ - specific heat losses, W / (m · 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 χm, W/K, is determined by the formula:

$$\chi_m = \frac{\Delta Q_m^p}{(t_{\text{в}} - t_{\text{н}})}, \quad (7)$$

where

t_{in} t_{out} – the same as in the formula (4);

ΔQ_m^p – additional heat loss through a point heat bridge of the m-th type, W, is determined by the formula:

$$\Delta Q_m^p = Q_m^p - Q_m, \quad (8)$$

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Q_m^p - heat loss through the enclosing structure with a point thermal bridge of the m-th type, W, is determined by the results of calculating the temperature field;

Q_m- heat loss through the enclosing structure without a point thermal bridge, W, is determined from the results of calculating the temperature field.

The heat flux according to the results of calculating the temperature field of the node of the enclosing structure with a thermal bridge is determined by the formulas:

$$Q = \alpha_{in} * S_{in} * (t_{in} - \tau_{in}^m), \; Q = \alpha_{out} * S_{out} * (t_{in} - \tau_{out}^m), \quad (9)$$

where

$\alpha_{in}, \alpha_{out}$- heat transfer coefficients of the inner and outer surfaces of the enclosing structures, respectively;

S_{in}, S_{out} - the area of the inner and outer surface of the calculated area (calculated area) of the enclosing structure, respectively, m²;

t_{in}, t_{out} - the same as in the formula (4);

$\tau_{in}^{m}, \tau_{out}^{m}$ - the average temperature of the inner and outer surfaces of the enclosing structure, respectively, ºC.

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 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

1. Lidelöw, Sofia, et al. "Energy-efficiency measures for heritage buildings: A literature review." Sustainable cities and society 45 (2019): 231-242.
2. Cioccolanti, L., Moglie, M., Mahkamov, K., Paksoy, H., Chen, C., Lin, J., & Damronsak, D. (2021, October). Analysis of labour market needs for engineers with enhanced knowledge in sustainable renewable energy solutions in the built environment in some Asian countries. In E3S Web of Conferences (Vol. 238, p. 07004).
3. Sayfiddinov S. Development of subsidence deformations of humidified loess under seismic influences. Monograph. Tashkent, 2019 - 162 p.
4. Sayfiddinov S., Miralimov M.M., Makhmudov S.M., Akhmadiyorov U.S. Modern Methods of Increasing Energy Efficiency of Buildings In The Republic Of Uzbekistan at the Design Stage, International Journal of Scientific and Technology Research 8,(11), pp. 1333–1336, November 2019.
5. Soares, N., Costa, J. J., Gaspar, A. R., & Santos, P. Review of passive PCM latent heat thermal energy storage systems towards buildings' energy efficiency. Energy and buildings, 59, (2013): 82-103.
6. Sayfiddinov S. "Transfer of heat through protective operated wall structures and their thermophysical calculation for energy efficiency". European Science Review 1.11-12 (2018): 79-80.
7. Harkouss, Fatima, Farouk Fardoun, and Pascal Henry Biwole. "Passive design optimization of low energy buildings in different climates." Energy 165 (2018): 591-613.
8. Kenisarin, Murat, and Khamid Mahkamov. "Passive thermal control in residential buildings using phase change materials." Renewable and sustainable energy reviews 55 (2016): 371-398.
9. Amirifard F., Seyed Amirhosain Sharif, Fuzhan Nasiri. "Application of passive measures for energy conservation in buildings–a review." Advances in Building Energy Research 13.2 (2019): 282-315.
10. Kenisarin, M. M., Mahkamov, K., Costa, S. C., & Makhkamova, I. (2020). Melting and solidification of PCMs inside a spherical capsule: A critical review. Journal of Energy Storage, 27, 101082.
11. F. Agyenim, N. Hewitt, P. Eames, M. Smyth. "A review of materials, heat transfer and phase change problem formulation for latent heat thermal energy storage systems (LHTESS)" Renewable Sustainable Energy Rev., 14 (2) (2010 Feb 1), pp. 615-628.
12. Shipacheva, E., R. Pirmatov, and D. Sharipova. "Exploration of heat transmission method in external enclosing structures of buildings under impact of solar radiation in the republic of Uzbekistan." International Journal of Scientific and Technology Research 8.12 (2019): 3415-3418.
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.
14. Sayfiddinov Sadriddin. Analysis of methods of heat engineering calculations of enclosing walls in Uzbekistan and abroad. Architecture and construction problems (Scientific and technical journal) Samarkand, 2019, №2. 57-61 pp.

15. Pirmatov R. Kh., Shipacheva E. V., Rashidov J.G. "On peculiarities of formation of the thermal mode in operating panel buildings." International Journal of Scientific and Technology Research 8.10 (2019): 2533-2535.
16. Anna, Dergunova, Piksaykina Anna, and Konin Maksim. "Energy Efficiency of Buildings for Various Purposes." Journal of Energy, Environmental & Chemical Engineering 4.3 (2019): 34.
17. Granqvist, Claes G. "Electrochromics and thermochromics: towards a new paradigm for energy efficient buildings." Materials Today: Proceedings 3 (2016): p 2-11.
18. Givoni B. Passive low energy cooling of buildings. John Wiley & Sons, 1994
19. . Guan, Xiaohong, Zhanbo Xu, and Qing-Shan Jia. "Energy-efficient buildings facilitated by microgrid." IEEE Transactions on smart grid 1.3 (2010): 243-252.
20. Balcomb, J. Douglas, ed. Passive solar buildings. Vol. 7. MIT press, 1992.
21. Shaumarov, S. S. "On a method for assessing the heat-shielding properties of external walls of buildings in use in railway transport." Asia Pacific Transport 2 (2018): 18-23.