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Methodology for Calculation of the Temperature Field in the External Fencing Structures of Buildings

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Abstract: The article studied the temperature regime of the junction of window blocks to the outer walls of buildings. The studies were carried out in natural conditions, theoretical calculations were made on them. Proposals have been developed to improve the temperature regime at the junctions of window blocks to the outer walls using extruded polystyrene foam.

Keywords: temperatures, buildings, window blocks, temperature field.

Introduction. One of the main directions of the state policy of the Republic of Uzbekistan in the field of rational use of energy are:

stabilization of production and consumption of energy necessary for the intensive development of the economy;

stimulation of the production of energy efficient and energy saving equipment and products with minimal energy consumption;

stimulating the development of energy-efficient, energy-saving and environmentally friendly technologies and industries.

Along with the growing demand for highly comfortable housing, awareness of the world's limited reserves of mineral fuels, water and other resources has brought a new impetus to interest in the concept of an energy efficient home and innovative holistic solutions suitable for both cold and hot and humid climates.

An approach that uses globally appropriate and applicable technologies, materials and systems for retrofitting, energy efficiency of buildings provides the opportunity not only to create structures with incredible design speed, but also to immediately provide comfort and sustainability in buildings unseen in many places on the planet.

In building thermal physics, forecasting the temperature and humidity conditions of building envelopes is carried out on the basis of solving differential equations of heat and mass transfer . The theoretical foundations of methods for calculating temperature and humidity conditions were laid by the works of V.N. Bogoslovsky, O.E. Vlasov, V.G. Gagarin, A.V. Lykov, V.D. ., Ushkova F.V., Fokina K.F., Franchuka A.U., Shklover A.M. and other scientists. The main technique used to solve the problems of building thermal physics is their numerical solution in finite differences. This is due primarily to the simplicity of approximating derivatives in differential equations.

Research Methodology. The research methodology of the article includes experimental measurements, theoretical calculations based on fixed differential equations, and optimization methods to propose solutions for improving the temperature profile.

Analysis and results. With a difference in air temperatures from one side of the fence to the other, the temperature line continuously decreases. Graphically, temperature changes during the passage of a heat flux through a flat homogeneous wall are shown in Fig. 1.

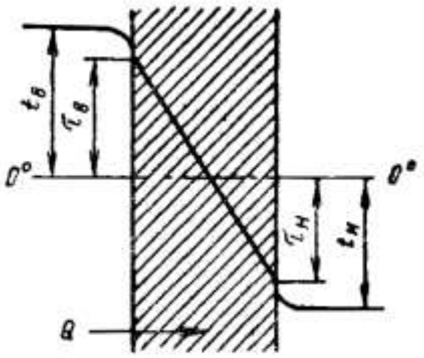

Fig 1. Change in temperature in a homogeneous wall

The air from the inside of the wall has a temperature $t_{\text{в}}$, and from the outside $t_{\text{н}}$, moreover $t_{\text{в}} > t_{\text{н}}$. The temperature line shows that the temperature drop occurs not only in the thickness of the wall, but also near its surfaces, since the temperature of the inner surface of the wall $\tau_{\text{в}} < t_{\text{в}}$and the temperature of the outer surface $\tau_{\text{н}} > t_{\text{н}}$. Since the temperature drop during the passage of the heat flow is caused by thermal resistances, it can be seen from the temperature curve that the heat transfer resistance of the fence consists of three separate resistances:

1) resistance to the transfer of heat from the internal air to the inner surface of the fence;
2) resistance to the passage of heat through the thickness of the fence itself;
3) resistance to the transfer of heat from the outer surface to the outside air;

Thus, the resistance to heat transfer of the fence can be expressed as the sum of these resistances:

$$R_{\text{о}} = R_{\text{в}} + R + R_{\text{н}} \qquad (1)$$

If the heat transfer resistances depend mainly on external factors and only to a small extent on the surface material of the fence, then the thermal resistance of the fence R depends solely on the thermal conductivity of the materials that make up the fence, as well as on the structure of the fence itself. To determine R it is necessary to know the coefficients of thermal conductivity λ of the materials that make up the fence, their location, as well as the dimensions of individual elements of the fence [13].

If the fence in thickness consists of several consecutively placed homogeneous layers of different materials located perpendicular to the direction of the heat flow, then the thermal resistance of the fence will be equal to the sum of the thermal resistances of all its layers. Therefore, for a multilayer fence, its thermal resistance is determined by the formula

$$R = R_1 + R_2 + R_3 + \cdots + R_n = \frac{\delta_1}{\lambda_1} + \frac{\delta_2}{\lambda_2} + \frac{\delta_3}{\lambda_3} + \cdots + \frac{\delta_n}{\lambda_n}. (2)$$

where R_1, R_2... - thermal resistance of individual layers; δ_1, δ_2... - thicknesses of individual layers in m ; λ_1, λ_2... - coefficients of thermal conductivity of materials of individual layers; n - the number of layers that make up the fence.

When using this formula, it must be remembered that the layer thicknesses δ must be taken in meters.

Formula (2) shows that the thermal resistance of the fencing layer is directly proportional to its thickness and inversely proportional to the thermal conductivity of its material; thermal resistance of the fence does not depend on the order of the layers. However, other thermotechnical indicators of the fence, such as heat resistance, temperature distribution in the fence and its humidity regime, depend on the order of the layers. Therefore, to facilitate calculations of the heat resistance and humidity regime of fences, the numbering of the layers is carried out sequentially from the inner surface of the fence to the outer.

Using formula (2), it is possible to determine either the thermal resistance of a given fence, or the thickness of one of its layers, at which the fence will have a given value R or R_o. In the last last case, the unknown value in formula (2) will be the thickness δ of one of the layers, which serves as an insulating layer of the fence.

Multilayer structures represent the most common type of fencing in the construction industry.

Reduced resistance to heat transfer R_0 takes into account the presence in the fence of heat-conducting inclusions that are heterogeneous in area of the fence and is determined as follows.

If the structure is single-layer or consists of **n** homogeneous layers, then the value of R_0 is determined by the formula:

$$R_0 = \frac{1}{\alpha_{в}} + \sum_{i=1}^{n} R_i + \frac{1}{\alpha_{н}}, \ (3)$$

where: $\boldsymbol{\alpha}_{\mathbf{in}}$, $\boldsymbol{\alpha}_{\mathbf{in}}$ - heat transfer coefficients of the inner and outer surfaces of the building envelope, W / (m $^{2}\cdot^{o}$ C);

$\mathbf{R}_{\mathbf{i}}$ - thermal resistance of each of the layers of the structure, m $^{2}\cdot^{o}$ C / W.

If a multilayer building envelope has a layer (layers) consisting of sections of different materials, then its reduced resistance is determined in the following sequence:

a) For each inhomogeneous layer, find the area-weighted average value of the thermal conductivity coefficient, W / (m $\cdot^{o}$ C) according to the formula:

$$\lambda_{\text{i.y}} = f_1 \cdot \lambda_1 + f_2 \cdot \lambda_2 + \cdots + f_{к} \cdot \lambda_{к}, \ (4)$$

where $\boldsymbol{\lambda}_{\mathbf{1}}$, $\boldsymbol{\lambda}_{\mathbf{2}}$, ..., $\boldsymbol{\lambda}_{\mathbf{k}}$ are the thermal conductivity coefficients of various sections in the selected layer, W / (m $\cdot^{o}$ C);

$\mathbf{f}_{\mathbf{1}}$, $\mathbf{f}_{\mathbf{2}}$, ..., $\mathbf{f}_{\mathbf{k}}$ - the fraction of the layer area occupied by a material having the appropriate thermal conductivity,

and calculate the conditional thermal resistance of the inhomogeneous layer:

$$R_{\text{i.y}} = \frac{\delta_i}{\lambda_{\text{i.y}}} \qquad (5)$$

The currently existing computer programs Therm or Temper -3 d , with which the calculation is performed, have accompanying technical documentation and provide the ability to calculate a two-dimensional (flat) or three-dimensional (spatial) temperature field, heat flows in a given area of enclosing structures under stationary heat transfer conditions .

The input of initial data is carried out either in graphical form (from the screen of a monitor, scanner, graphic or design file), or in the form of tabular data and provides the ability to set the required characteristics of materials and boundary conditions of the calculated structure in a given area.

The presentation of calculation results provides the possibility of visualizing the temperature field, determining the temperature at any point in the calculated area, determining the total incoming and outgoing heat fluxes through specified surfaces.

The disadvantage of Therm is the presentation of the results in its own format, which allows you to analyze the results only in the built-in post-processor of the program. The Temper-3d program allows you to perform calculations of 2- and 3-dimensional temperature fields of enclosing structures. To work, Temper-3d requires a certain configuration of computer hardware, which limits the launch of the program on a number of computer systems. In addition, the program is paid, which is not always acceptable for scientific research. However, the main disadvantage of both programs is that the source code is closed, which does not allow them to be modified and thus adjusted to specific specific tasks.

To calculate the temperature field of the junctions (mounting joints) of window blocks to the wall, a rectangular grid was used (Fig. 2). By placing the grid threads more densely in the field area in which we are most interested in the temperature distribution, for example, in places of heat-conducting inclusions, and more rarely in the rest of the field area, it was possible to significantly reduce the number of grid nodes, and, consequently, the number of calculation equations. With a rectangular grid, the heat transfer coefficients between nodes were determined taking into account the area over which heat is transferred [13]; field size in *z* direction taken equal to 1 *m* . In this case, if the grid nodes lay in the region of one material having a thermal conductivity coefficient λ (uniform field), then according to Fig. 2, the following values of the heat transfer coefficients between the node with temperature τ_x and neighboring nodes:

to node 1 - the heat transfer area will be: $F_1 = \frac{\Delta_{y_1}+\Delta_{y_2}}{2}$; heat transfer coefficient $k_{x-1} = \frac{\lambda}{\Delta_{x_1}} F_1$;

to node 2 - $F_2 = \frac{\Delta_{x_1}+\Delta_{x_2}}{2}$; $k_{x-2} = \frac{\lambda}{\Delta_{y_2}} F_2$;

to node 3 - $F_3 = F_1$; $k_{x-3} = \frac{\lambda}{\Delta_{x_2}} F_3$;

to node 4 - $F_4 = F_2$; $k_{x-4} = \frac{\lambda}{\Delta_{y_4}} F_4$;

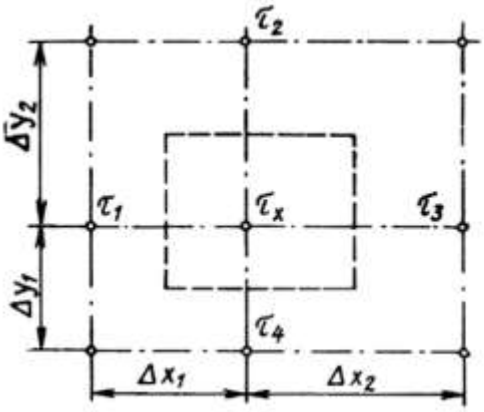

Figure 2. Scheme for calculating a flat temperature field when applying a rectangular non-uniform grid.

the same way as with a square grid, but with their multiplication by the corresponding heat transfer areas *F* in *m2* .

Temperature field calculations were made by the integration method as follows. We preliminarily set some arbitrary temperature values at all grid nodes. Then, according to formula (6), the temperature values at all nodes were sequentially calculated, replacing the previous values with the obtained temperature values until the temperature at each node of the field grid began to satisfy the corresponding equations at given air temperatures on one and the other side of the fence.

$$\tau_{x,y} = \frac{k_{x-\Delta}\tau_{x-\Delta,y}+k_{y+\Delta}\tau_{x,y+\Delta}+k_{x+\Delta}\tau_{x+\Delta,y}+k_{y-\Delta}\tau_{x,y-\Delta}}{k_{x-\Delta}+k_{y+\Delta}+k_{x+\Delta}+k_{y-\Delta}}. \qquad (6)$$

The calculation process could be considered complete only when, within the specified accuracy, the temperatures remained constant at all grid nodes. The duration of the calculations depended on how correctly the initial temperatures were set.

The temperature field obtained for the given values of the temperatures of the indoor and outdoor air was easily recalculated for other values of these temperatures, based on the fact that the temperature difference between any point of the field and the indoor or outdoor air changed in proportion to the change in the temperature difference between the indoor and outdoor air.

For rectangles containing only one material, $k = \lambda / \Delta$, where λ is the thermal conductivity of the material, Δ is the distance between grid nodes in *m* . If a node with a temperature $\tau_{x,y}$ lies in a plane adjacent to the air medium, then the heat transfer coefficient to air will be equal to the corresponding value of the heat absorption coefficient α_{in} or heat transfer α_n . In this case, the values *k* to neighboring nodes lying in this plane are taken with a coefficient of 0.5 on the basis that in the direction to these nodes the heat transfer through the material will occur only over an area equal to half of the rectangular grid, and through the air, in which the second half of the rectangle will be there will be no heat transfer.

Conclusion/Recommendations. Based on the analysis of methods for calculating the temperature in the thickness of the building envelope, the following conclusions can be drawn:

1) Far from the junction of the window block, i.e. at a distance of 1-1.5 meters from this place to calculate the temperature along the thickness of the wall, you can use the formulas given in KMK 2.01.04-97 *.

To calculate the temperature at the junction of the window block to the outer wall, the temperature field calculation method based on the finite difference method should be used. In this case, it is recommended to place the grid threads more densely in the area of the field of the junction node, and more rarely in the rest of the field, significantly reducing the number of grid nodes, and, consequently, the number of calculation equations.

References :

1. Закон Республики Узбекистан «О рациональном использовании энергии» № 412-I от 25 апреля 1997 года.
2. Борискина И. В., Плотников А. А., Захаров А. В. Проектирование современных оконных систем гражданских зданий / Издательство ассоциации строительных вузов. Москва. 2000 г.
3. Зенкевич О. Конечные элементы и аппроксимация / О. Зенкевич, К. Морган; Перевод с английского под ред. Н.С. Бахвалова. - М.: Мир, 1986. - 318 с.
4. Д.Б.Рустамова, М.Махмудов. Повышение энергоэффективности зданий. Монография. LAMBERT Academic Publishihg. 978-620-3-92503-6.
5. Д.Б. Рустамова. Особенности эксплуатации малоэтажных зданий из сендвич-панелей. Монография. LAMBERT Academic Publishihg. 978-620-2-67226-9
6. Кривошеин А.Д. К вопросу о расчете приведенного сопротивления теплопередаче ограждающих конструкций / А.Д. Кривошеин, С.В. Федоров / / Инженерно-строительный журнал.-2010. - №8. - С.21-27.
7. Лутц М. Программирование на Python / М. Лутц; Перевод с английского, под ред. М. Деркачева. - Санкт-Петербург: Символ-Плюс, 2002.-1136 с.
8. По материалам доклада док. Гельмута Хоенштайна (Dr. Helmut Hohenstein), на GLASS PERFORMANCE DAYS 2007, Тампере, Финляндия
9. Протасевич А.М. Строительная теплофизика ограждающих конструкций и микроклимат помещений / А.М. Протасевич. – Минск : БНТУ, 2016. – 452 с.
10. B.M.Norqulov., S. K.Xidirov., D. Tadjieva., P. Nurmatov., J.Suyunov. Study of kinematic structure of low flood of water supply facilities. AIP Conference Proceedings **2612**, 020017 (2023); https://doi.org/10.1063/5.0124148
11. B.M.Norqulov., S. K.Xidirov., D. Tadjieva., P. Nurmatov., J.Suyunov., D.B.Rustamova. Determination of dynamic forces affecting floating structure in pump station water supply channel. AIP Conference Proceedings **2612**, 020020 (2023); https://doi.org/10.1063/5.0124144
12. 12 Матёкубов, Б. П., & Саидмуродова, С. М. (2022, August). КАМ СУВ ТАЛАБЧАН БОҒЛОВЧИ АСОСИДАГИ ВЕРМИКУЛИТЛИ ЕНГИЛ БЕТОНЛАР ТЕХНОЛОГИЯСИНИ ҚЎЛЛАНИЛИШИ. In *INTERNATIONAL CONFERENCES* (Vol. 1, No. 15, pp. 103-109).
13. Inatillayevich, G. O., & Pulatovich, M. B. Analysis of Underground Projects of Energy Efficient Low-Rise Residential Buildings Built on Highly Flooded Soilshttps. *doi. org/10.31149/ijie. v4i9, 2156.*
14. Bolikulovich, K. M., & Pulatovich, M. B. (2022). HEAT-SHIELDING QUALITIES AND METHODS FOR ASSESSING THE HEAT-SHIELDING QUALITIES OF WINDOW BLOCKS AND THEIR JUNCTION NODE WITH WALLS. *Web of Scientist: International Scientific Research Journal*, *3*(11), 829-840.
15. Matyokubov, B. P., & Saidmuradova, S. M. (2022). METHODS FOR INVESTIGATION OF THERMOPHYSICAL CHARACTERISTICS OF UNDERGROUND EXTERNAL BARRIER STRUCTURES OF BUILDINGS. *RESEARCH AND EDUCATION*, *1*(5), 49-58.

16. Egamova, M., & Matyokubov, B. (2023). WAYS TO INCREASE THE ENERGY EFFICIENCY OF BUILDINGS AND THEIR EXTERNAL BARRIER STRUCTURES. *Eurasian Journal of Academic Research*, *3*(1 Part 1), 186-191.
17. Nosirova, S., & Matyokubov, B. (2023). WAYS TO INCREASE THE ENERGY EFFICIENCY OF EXTERNAL BARRIER CONSTRUCTIONS OF BUILDINGS. *Евразийский журнал академических исследований*, *3*(3), 145-149.
18. Egamova, M., & Matyokubov, B. (2023). IMPROVING THE ENERGY EFFICIENCY OF THE EXTERNAL WALLS OF RESIDENTIAL BUILDINGS BEING BUILT ON THE BASIS OF A NEW MODEL PROJECT. *Евразийский журнал академических исследований*, *3*(3), 150-155.
19. Носирова, С. А., Рустамова, Д. Б., & Эгамова, М. Т. (2021). ЭНЕРГИЯТЕЖАМКОР УЙЛАР-ЎЗБЕКИСТОННИНГ ЯҚИН ЙИЛЛАРДАГИ ЭНГ АСОСИЙ ШИОРИ. *Журнал Технических исследований*, *4*(2).
20. Makhmudov, M., & Rustamova, D. (2021). UNIFORMITY CHECK OF THE THERMAL CONDUCTIVITY COEFFICIENT OF BRICK AND PLASTER USED IN THE MANUFACTURE OF FRAGMENTS OF EXPERIMENTAL WALLS FOR STUDYING HEAT PROTECTIVE QUALITIES. *Journal of Advanced Scientific Research (ISSN: 0976-9595)*, *1*(1).
21. Mahmudov, M., Rustamova, D., & Nosirova, S. (2021). Empirical dependence of sorption humidity of keramzybeton concrete on relative humidity of air. *European Journal of Research Development and Sustainability (EJRDS) Available Online at: https://www. scholarzest. comVol*, *2*.
22. Рустамова, Д. Б., & Носирова, С. А. (2020). СЭНДВИЧ ТИПИДАГИ ЗАМОНАВИЙ ЙИҒМА ТАШҚИ ДЕВОРЛАРНИНГ ИСТИҚБОЛЛИ КОНСТРУКТИВ ЕЧИМЛАРИ. *Журнал Технических исследований*, *3*(6).
23. Rustamova, D. B., & Egamova, M. T. (2022). THEORETICAL BASIS OF INCREASING ENERGY EFFICIENCY IN RESIDENTIAL BUILDINGS. *Journal of Advanced Scientific Research (ISSN: 0976-9595)*, *2*(1).
24. Саидов, Б. М., & Рустамова, Д. Б. (2021). ГИДРОТЕХНИК ИНШООТЛАР ХАВФИНИ ТАҲЛИЛ ҚИЛИШ. *Журнал Технических исследований*, *4*(2).
25. Khayitov, M. B. (2021). THERMAL INSULATION MATERIALS: ADVANTAGES AND PRODUCTION. *Theoretical & Applied Science*, (1), 375-378.
26. Bolikulovich, K. M. (2023). STUDY OF THE THERMAL CONDITIONS OF CONNECTIONS OF WINDOW BLOCKS TO A WALL. *Gospodarka i Innowacje.*, *33*, 323-327.
27. Shodiyev, K. (2021). On Methods of Searching for Generalized Solutions of Simple Differential Equations. International Journal of Innovative Analyses and Emerging. Technology, 1(5), 51.