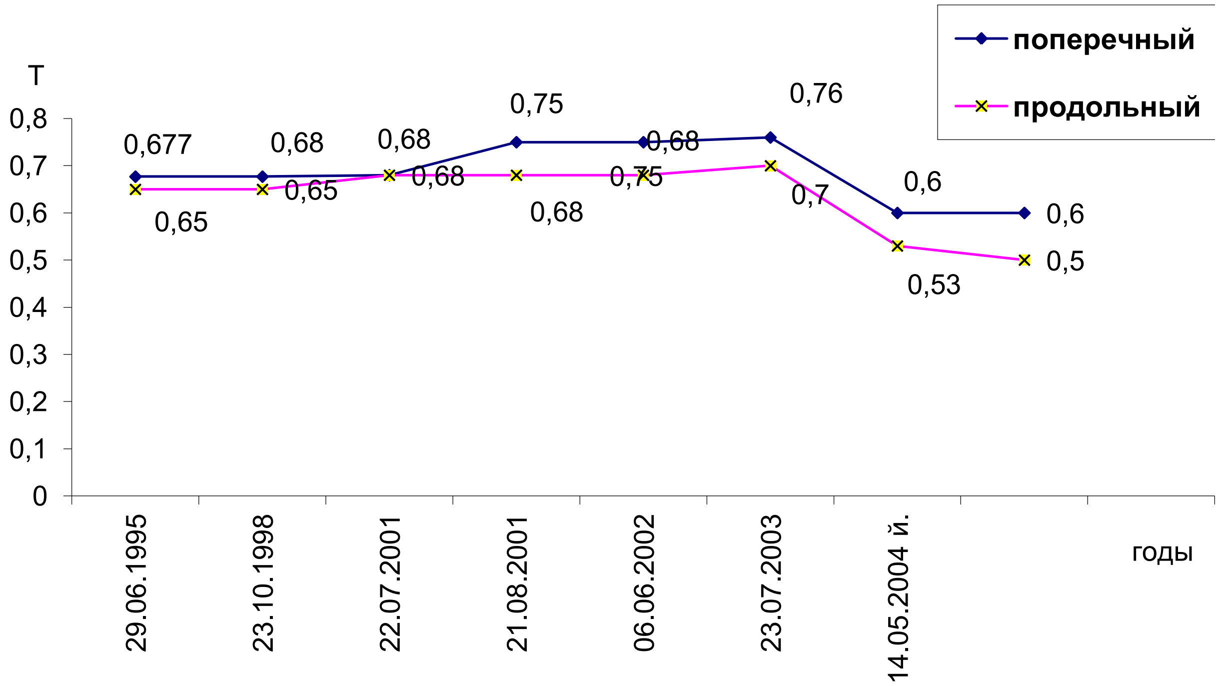

Рис. 1.

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УДК 620.91:697.1

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REDUCTION OF THERMAL TRANSMITTANCE THROUGH WALL PARAPET AND FLAT ROOF JUNCTION

Today the urgent issue is to increase the energy efficiency of buildings. Along with the thermal insulation of exterior walls, roofs, etc., due consideration should be given to thermal bridges that contribute to significant thermal losses of buildings. The article analyzes various strategies for minimizing heat losses through thermal bridges at junction between the parapet and the flat roof. As a result of thermal modeling the most optimal variant is offered.

***Key words**: thermal bridge, parapet to flat roof junction, linear thermal transmittance, transmission heat loss.*

На сьогодні актуальним питанням є підвищення енергетичної ефективності будівель. Поряд з теплоізоляцією зовнішніх стін, дахів тощо, також повинна бути приділена відповідна увага тепловим місткам, що сприяють значним тепловим втратам будівлі. У статті аналізуються різні стратегії мінімізації теплових втрат через теплові містки у місці сполучення парапету та плаского даху. В результаті теплового моделювання запропоновано найбільш оптимальний варіант.

***Ключові слова:** тепловий місток, сполучення парапету та плаского даху, лінійний коефіцієнт теплопередачі, втрати тепла.*

1. Introduction

In Ukrainian residential buildings, energy consumption due to heating and cooling accounts for more than 60% of the total energy use. Optimization of every element of building envelope should be investigated to improve whole building thermal performance and therefore reduce energy consumption, increase indoor comfort, and reduce risks of condensation and mold growth due to low interior temperature.

At the same time attention should be paid to the appropriate treatment of thermal bridges.

Thermal bridges are localized areas of low thermal resistance. Thermal bridges can occur at various locations of the building envelope.

Possible effects of thermal bridges are:

- increased heat loss through the wall, leading to higher operating costs;
- local cold or hot spots on the interior at the thermal bridge locations, leading to occupant discomfort and, in some cases, to condensation, moisture-related building damage, and health and safety issues.

The international standard EN ISO 10211 [1] deals with thermal bridges, but there are national standards available in nearly every European Member State that cover calculation, requirements and good practice solutions.

Although new buildings present high insulation levels, thermal bridges may affect heating needs for about 30% of the overall value [2]. In case of existing buildings, thermal bridges contribute to 23% of the total transmission heat loss of a building envelope. After renovation, thermal bridges account for only 10% if windows are re-located into additional external thermal insulation and balconies are rebuilt as best practice. Inversely, if the thermal bridges are not treated correctly during building renovation the impact of the thermal bridges might be up to 34%, depending on the wall insulation thickness [3]. This impact may reach up to 67% for a building with a hollow brick cavity wall [4].

At the same time, thermal bridge correction could determine an important reduction of the winter primary energy demand (25% for terraced houses, 17.5% for semi-detached house) with an overall annual energy savings about 8.5% [5].

Building's wall parapets are examples that cause thermal bridge effect and contribute to additional heat losses. Parapets commonly are exposed to the outside environment on both sides, and can act as a thermal fin, wicking heat up through the wall.

This paper analyses the parapet thermal bridging effect and provides a number of strategies in order to address the thermal bridge and improve the building's energy performance.

2. Materials and methods

2.1. Description of the simulated balcony slab junctions

Thermal performance of thermal bridges due to parapet-flat roof junction was analyzed with the two-dimensional (2D) steady-state finite element heat-transfer simulation program Psi-Therm 2D calibrated according to EN ISO 10211:2007 standard. The linear thermal transmittance of the thermal bridges Ψ, W/(m·K) was calculated using equation (1):

$$\Psi = L_{2D} - \sum_{j=1}^{N_j} U_j \cdot l_j \text{. W/(m·K)} . \qquad (1)$$

where L_{2D} is the thermal coupling coefficient obtained from the 2D calculation of the component separating the two environments being considered, W/(m·K); Uj is the thermal transmittance of the 1D component j separating the two environments being considered, W/(m^2·K); lj is the length over which the value Uj applies, m.

In the calculations of linear thermal transmittance, average values of internal surface resistance from the EN ISO 6946:2007 (2007) [6] standard were used.

Point thermal bridges are not taken into account in this paper.

The interior temperature set for simulation is 20°C, whereas the external temperature is -5°C. The simplified geometrical model of parapet–flat wall junction is shown in Fig. 1.

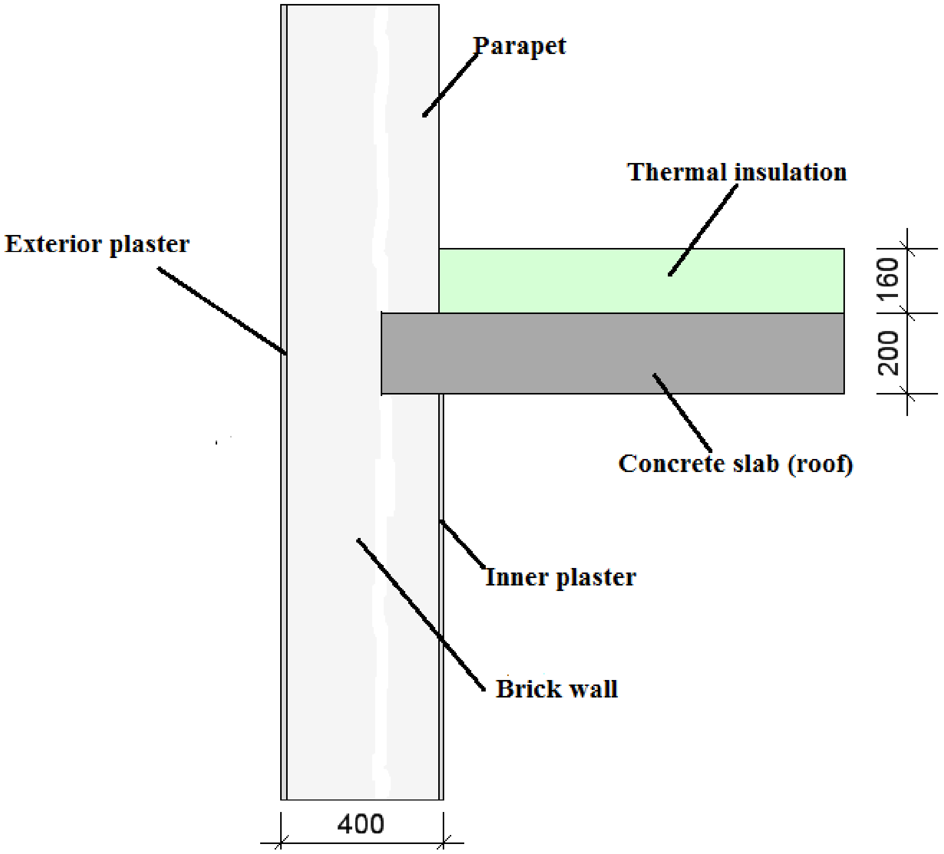

Figure 1. Simplified geometrical model of parapet-flat roof junction

The thermal properties of the junction materials are listed in Table 1.

Table 1. Thermal properties of the junction materials

Material	Thermal conductivity, W/(m·K)
Brick	0.68
Concrete	2.1
Thermal insulation	0.4
Ineer and exterior plaster	0.7

2.2. The proposed strategies to enhance thermal performance

The selected insulating material is 5 cm of mineral wool with a thermal conductivity of λ=0.04 W/(m·K).

Regarding the application of insulation such different options were analyzed:

- no insulation of external wall and parapet (existing configuration);
- option 1: external wall insulation (5 cm); insulation of exterior side of the parapet (5 cm);
- option 2: external wall insulation (5 cm); insulation of exterior, upper and inner side of the parapet (5 cm);
- option 3: external wall insulation (5 cm); insulation of exterior side of the parapet (5 cm); insulation of upper and inner side of the parapet (10 cm);

3. Results and discussion

The calculation showed that that the linear thermal transmittance of the junction “parapet-flat roof” for existing configuration is 0.56 W/m·K. The temperature profile is shown in Figure 2. It is seen that the lowest temperature at the ceiling-wall junction is less than 15^{0}C.

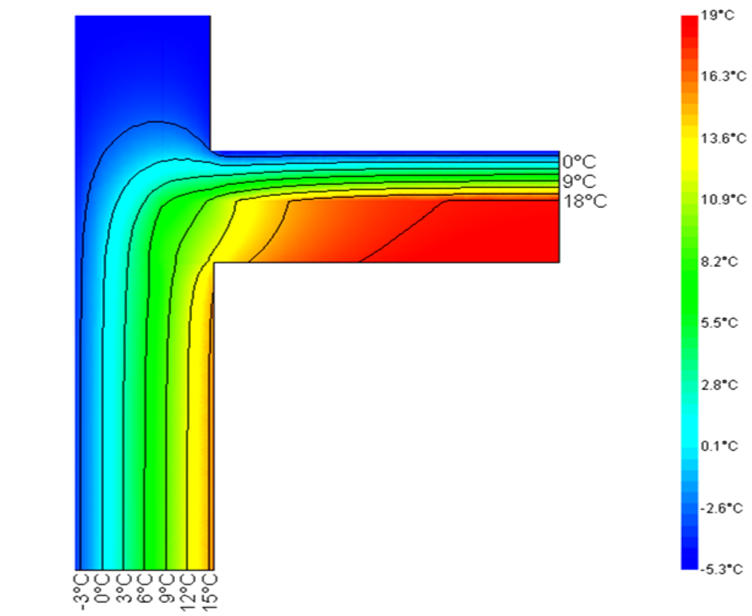

Figure 2. Temperature distribution at the junction (existing condition)

The insulation of external walls with 5 cm of mineral wool decreases the U-value of plane elements. But, at the same time, the thermal transmittance of the junction ‘parapet-flat roof’ decreases very slightly. The calculation shows that in this case the thermal transmittance constitutes 0.48 W/m·K. The temperature profile is shown in Figure 3. The application of the external wall insulation allows to increase the lowest inner surface temperature up to 15 ^{o}C.

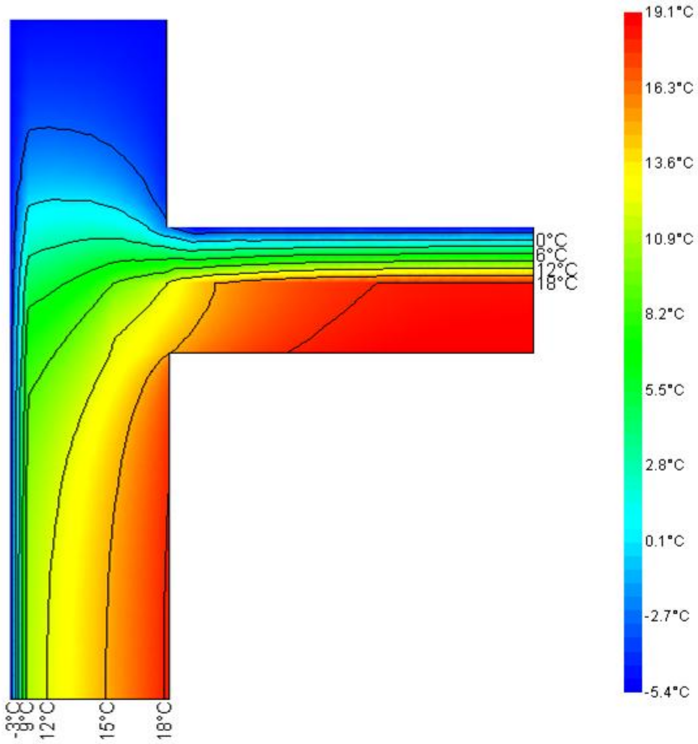

Figure 3. Temperature distribution at the junction (option 1)

The results of calculation of linear thermal transmittance in the case of insulation of the external wall as well as the exterior, upper and inner side of the parapet shows that the thermal transmittance decreases much more and reaches 0.37 W/m·K. The temperature profile is shown in Figure 4. The modeling results shows that the lowest inner surface temperature at the ceiling-external wall junction is greater than 15 °C.

Finally, the calculation of linear thermal transmittance of the joint "parapet-flat roof" for option 3 gives the lowest value of 0.33 W/m·K, however the magnitude of the linear thermal transmittance only slightly differs comparing with the above option. The modeling results are presented in Figure 5.

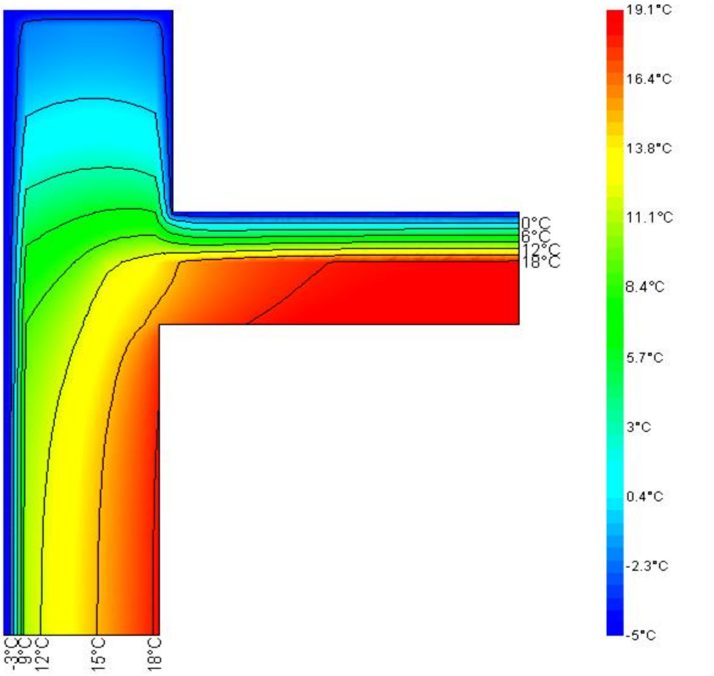

Figure 4. Temperature distribution at the junction (option 2)

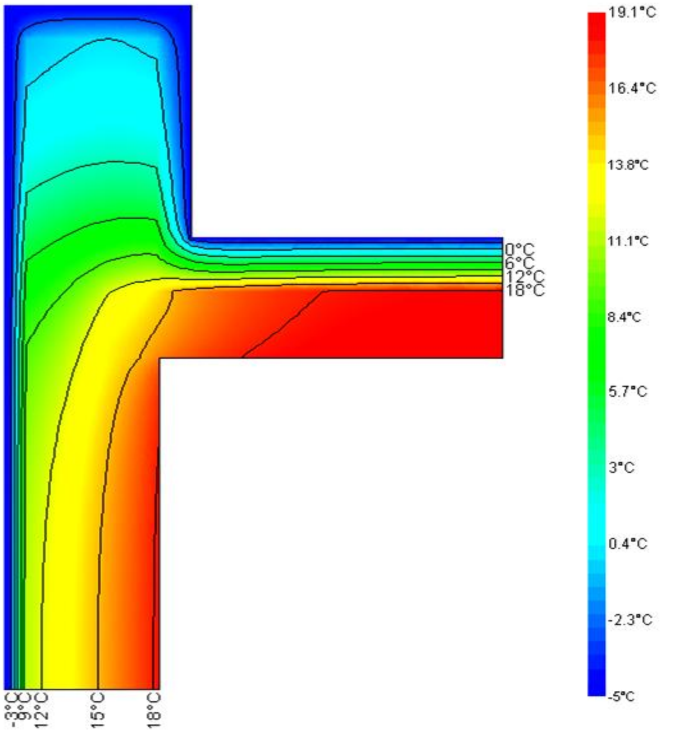

Figure 5. Temperature distribution at the junction (option 3)

The most effective way to minimize the heat transmittance of structural components (balconies, parapets, canopies) penetrating the insulation layer of an envelope is to thermally separate the exterior structure from the interior structure with the help of thermal breaks. But such approach may be inappropriate in retrofitting old buildings.

Conclusions

In this work, various insulation strategies have been analyzed by thermal modeling of parapet-flat roof junction. Results show that the simultaneous insulation of the external walls as well as exterior, upper and inner sides of the parapet to be a valid alternative in order to achieve energy savings. It may be said that the case of a single (exterior) sided insulation of parapet is practically ineffective. So, the parapet should be insulated from all sides to maintain an uninterrupted insulation boundary between the interior of the building and the outdoor environment. This significantly reduces heating and cooling loads, and virtually eliminates the potential for condensation on the underside of the roof slab.

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