Natural researches of temperature condition of an external wall with LSK

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Abstract. Research is conducted in the field of thermophysics of the protecting designs. In the article a question the possibilities of loss of condensate on metal profiles in a wall from the easy steel thin-walled structures (ESTWS) in areas with sharply continental climate are considered. Results of on-site investigations of buildings with a framework from LSTK and laboratory experiments of a fragment of a wall with a heater from mineral wool are given. The purpose of laboratory researches is studying of heterogeneity of distribution of temperature on an internal surface of a wall and on profile section. Influence of thermoprofiles on temperature condition of a design of an external wall, with a framework from LSTK and a heater from mineral wool is considered. Experiments showed that in the section of a thermoprofile there are three temperature zones. External located from a surface to the punched openings, average - between openings, and internal from openings to a profile side. Sharp temperature drop is observed only in an average zone. The external zone of a profile is overcooled up to the temperature close to temperature of external air. Results of on-site investigations of the building with walls from LSTK to Kyzyl the Republic of Tyva revealed condensate traces in a wall. Calculations for definition of a dew point on a profile are carried out and the possibility of loss of condensate in the overcooled zone is revealed. Recommendations about elimination of a possibility of loss of condensate on a metal surface are made.

1. Introduction
Lightweight Steel-framed Construction (LSF), are increasingly used in the construction of not only industrial buildings but also public and residential buildings throughout Russia. This is primarily due to such qualities as reduced construction time, by reducing the weight of load-bearing elements of the frame, reducing the cost of shipping during the construction in remote areas.

The frame of such buildings consists of horizontal and vertical girders, is made of a thin U or Z-shaped metal profiles. Sheet thickness of sections is usually 1 - 2 mm with a maximum mass per unit of length of 0.075 kN/m. This is a relatively new design scheme with the functional and technological qualities, which are much different from our usual designs. The strength and stiffness of LSF is quite well studied and their properties are described in articles and books [1 - 7]. Problems of enclosing structures with the use LSF studied much less[ 2, 8].

The main problem with supercooled regions within the wall, the so-called "thermal bridges". This is because the thermal conductivity of the metal profile, which is inside the insulation of the building envelope, three orders of magnitude greater than adjacent insulation.
To reduce the influence of thermal bridges and significantly increase the thermal resistance applied perforation of the profile of the longitudinal hole with offset step, which reduce the direct conduction. Profiles with such a perforation is called "thermal profile" or TPP. In the paper[6] deals with the effect of thermal profile on temperature field in the wall on the example of specific constructions of external walls of civil buildings constructed in severe climatic conditions. Numerical calculations have shown that the perforation of the profile leads to the formation of three temperature zones within the section of the profile. This is the zone adjacent to the outer and inner part of the wall and the area between the perforations. On the outer surface, in the area of thermo, a temperature decrease compared with the area of insulation to 8 °C, and the difference between the air temperature and the surface profile is up to 10 °C. In the area adjacent to the outside wall, there is a significant sub-cooled portion of the profile at a temperature of about -35 °C.

Suggested that at high daily temperature fluctuations of outdoor air and on the profile in the area adjacent to the outer part of the wall can lead to condensation on the surface of the profile. This article discusses the possibility of condensation in the wall of Problems of enclosing structures with the use LSF studied much less in the building, located in the city of Kyzyl, Republic of Tyva. The starting point was the material in-situ survey of the building with walls of Problems of enclosing structures with the use LSF studied much less and laboratory study of a fragment of the wall.

2. Laboratory studies

To study the temperature distribution through the thickness of the walls of the laboratory investigations of the wall in the lab "Translucent structures and facade systems"). Samples for testing were manufactured in the factory of "Arsenal ST". According to the technical specifications of the manufacturer samples of the profile were marked as follows: AI PS 15045-1,2 mark 350. (Fig.1). The experiment was conducted on models collected on the basis of structures with profiles Problems of enclosing structures with the use LSF studied much less established by 600 mm with filling of cotton wool rockwool. (Fig.2) the Sensors were installed on the junctions of outer and inner parts of the walls and, mainly, in the area between the perforations. Cooling chamber, which belonged to model the building envelope, cooling the surface throughout the test to -20 °C. The Second wall surface was left at room temperature of +18 °C. Readings from sensors ds18b20 recorded before the establishment of the stationary regime.

Figure 1. Metal profiles, perforated AI PS 150-45-1,2.

Figure 2. A fragment of a wall with profiles lsts with sensors on the profiles and in the insulation.
According to schedules (Fig. 3) made by results of laboratory experiment it is visible that temperature drop in the zone filled with mineral wool between profiles, rather uniform. And in a thermoprofile zone temperature drop is observed with jumps. Perforation of a profile leads to formation of three temperature zones. These are two external zones located between walls and a zone of perforation and also the internal zone located within perforation of a profile.

Similar distribution of temperature is received as a result of the numerical calculations given in work [8].

![Temperature distribution](image)

**Figure 3.** Temperature distribution on the profile and between the profiles

Laboratory experiments of a fragment of a wall, as well as, showed numerical calculations, that punching of a profile leads to formation of three temperature zones within profile section.

These are the zones adjoining external and internal part of a wall and a zone of perforation of a profile. In a zone, adjoining external part there is an overcooling of a profile on a site, located between perforation and a surface of facing.

**Conducted examination**

The present section contains materials on heattechnical inspection of external walls of the building located Kyzyl, the Republic of Tyva. At the time of the conducted examination of part of a wall was open. At visual survey, in an opening zone, change of color of material and change of its structure (reduction of density) testifies to.( fig.4). It was the cause for research of an opportunity formation of condensate in a wall.

Climatic characteristics of climate Kyzyl, Republic of Tyva.
1. Air temperature of the coldest five-day week, -47 °C.
2. Average monthly air temperatures of the coldest month, -28.6 °C (Jan.)
3. Maximum amplitude of air temperature of the coldest month, 22.3 °C
4. Average monthly relative humidity of air of the coldest month, -73%
3. Field surveys and calculations

This section contains materials for thermal inspection of exterior walls of buildings located in Kyzyl, Tuva. During surveys of the exterior walls on the object, Kyzyl, Republic of Tuva was made the autopsy section of the facade from the designs of LSTC. By visual inspection, autopsy, traces of wet insulation, as evidenced by the color change material and changing its structure (decrease in density).

The composition of walling (figure 5):
1. External rendering (reinforced, mineral)
2. Plaster base
3. Metal upright Mineral wool insulation
4. Vapor barrier
5. Internal fireproof plaster board.

As this work is continuation [8], results of the numerical calculations received in the previous work are given here. In model in difference from natural supervision profiles had two rows of perforation. Space between profiles are filled the mineral wool with $\lambda = 0.04 \text{ W/m.K}$. On the upper bound temperature of $-45 \, ^\circ\text{C}$ and $R_{\text{out}} = 0.04 \, \text{m}^2 \cdot \text{K/W}$ is set, and on the lower bound - $T=+20\, ^\circ\text{C}$ and $R_{\text{in}} = 0.12 \, \text{m}^2 \cdot \text{K/W}$ indoors is set. On lateral borders - heat exchange is equal to zero. The temperature field of a site of a wall with a thermoprofile is presented in fig. 5.

Discussion

Daily change of air temperature proceeding from climatic characteristics - $T_{\text{max}}=-17.4\, ^\circ\text{C}$, $T_{\text{min}}=-40\, ^\circ\text{C}$.

Considering the maximum amplitude of the air temperature of 22,3 °C it is possible to consider that the speed of change of air temperature will make more than 1 °C in an hour. Under such circumstances temperature of a metal profile will be lower at daily temperature increase of air at the expense of a high thermal capacity of metal.

Absolute humidity of air at $-17.4\, ^\circ\text{C}$ and 73% $e = 1.33 \times 73 = 0.971 \, \text{g/m}^3$ that corresponds to $T=21\, ^\circ\text{C}$ dew point. That is if temperature in the overcooled zone is lower than $-21\, ^\circ\text{C}$, then on a metal profile condensate will drop out. From the temperature field, (see of fig. 5) it is visible that temperature in the overcooled zone matters from $-30\, ^\circ\text{C}$ to $-40\, ^\circ\text{C}$, at air temperature $-45\, ^\circ\text{C}$. The difference makes from 5 °C to 15 °C. At air temperature increase the profile will not manage to get warm and loss of condensate is quite possible.
Conclusions

- Perforation of the profile leads to the formation of three temperature zones within the section of the profile. This is the zone adjacent to the outer and inner part of the wall to the perforation, and the perforation zone.
- In the middle area, the thermal resistance of the profile significantly more than in the border zones through the perforations of the profile. In this area there is the main change in the temperature.
- In extreme areas of temperature changes insignificantly, while the temperature in the mineral wool varies uniformly throughout its thickness. The temperature in the zone adjacent to the outer surface of the wall close to the outdoor temperature, and differs from it due to the heat resistance and plating resistance to heat transfer from the outside air. In numerical calculations it is different to 9 °C and was -36 °C.

Figure 5. Temperature field section of the wall with the thermal profile
• The increase in ambient air temperature above the surface temperature profile during the day can lead to condensation in the wall. This is typical for climate zones with daily fluctuations of ambient temperatures.
• To reduce the likelihood of condensation on the metal profile inside mineral vity you must install an additional layer of insulation on the outside to reduce the temperature difference and increase the temperature profile adjacent to the outer surface.

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