Research on problems of panel buildings

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Abstract. The purpose of the study is to identify and reveal the main problems arising from the operation of panel buildings, to determine the location of the leakage of joints in panel buildings and to analyze the economic effect of a thermal imaging survey with subsequent repair. The main results of the research consist in analyzing the types of joints of large-panel buildings and their features as well as in conducting the thermal imaging survey of interpanel joints for heat loss and identifying the most problematic areas, according to the results of which heat loss is formed through the vertical and horizontal joints between the panels, as well as at the junction points of the windows. According to the results, the economic effect of the thermal imaging survey shows that the additional costs of paying for heat before overhaul due to the deterioration of the thermal protection quality are many times greater than the cost of the thermal imaging survey, taking into account the additional costs of eliminating thermal protection defects.

1. Introduction

The operation of multi-family residential buildings is technically and technologically complex. The main purpose of building maintenance is compliance with regulatory regimes that allow preserving the integrity and performance of structural elements of the building, decorative finishes and engineering systems. The most problematic, in terms of protection of the internal microclimate, are panel buildings. This happens because potholes and cracks, in which moisture penetrates over time, ice can form between the panels. Therefore, it is especially important to pay attention to the condition of the seams [1-7].

Defects and damage to the outer walls of large-panel buildings are the result of the deformation of their individual elements. The main defects occur when precipitation enters the joints of the panels, and alternately freezing and thawing moisture in the joints. There is a decrease in the heat-shielding properties of the enclosing exterior walls, which entails a decrease in the comfortable, optimal temperature inside the building during the winter period and an increase in the energy consumption for heating.

To prevent these undesirable phenomena, work is done to restore the tightness of the joints of buildings [8-17].

The main causes of deterioration of tightness are production and technological and climatic qualities.

Production and technological factors include:
• the deviation of the size of wall panels from the design dimensions as a result of their manufacture in production (when mounting such panels, the design dimensions in the nodes of the joints are violated);
• violation of regulatory requirements during installation works (deviation from the vertical, displacement, distortions, change in the size of the joints of some due to an increase or decrease of others, etc.);
• change of linear dimensions of the joints due to creep and natural shrinkage of concrete wall panels (1.5-2.0 mm per joint).

Climatic factors:
• alternate process of freezing and thawing of water trapped in the interpanel joint;
• change of the geometric dimensions of the joints as a result of temperature fluctuations (0.5-1.0 mm per joint);
• ultraviolet radiation and solar radiation of the joints.

2. Research methods

Proper, qualified thermal imaging inspection of large-panel buildings reveals violations of the insulation of joints, leading to deterioration of the indoor climate, moisture penetration and the formation of dampness, as well as to the enhanced work of heaters and air conditioners [18,19]. Particular danger is the freezing of the joints of the panels, constant moisture, which leads to a decrease in the strength of the building structures, reducing its service life. To avoid such unpleasant consequences, timely sealing of panel joints in panel houses or repair of panel joints is necessary. A thermal imaging survey was carried out, which comprehensively solves key problems in the leveling of heat losses. Shooting allows to reveal: drafts; places where insulation is not enough; masonry defects; the consequences of poor installation of windows and doors; not tight joints and much more (Figure 1).

![Thermographic images. Outdoor temperature -10 °C.](image)

In the course of the study, the temperature fields on the screen of the thermal imager are presented as an image with different gradations of brightness. Different colors correspond to different
temperatures. Thermal imagers have a mechanism for illuminating isothermal surfaces, the output
signal is directly related to the measured temperature of the surface under study.

According to the results of the study of thermal parameters of enclosing structures and the
microclimate of the apartment premises, it was found that the temperatures in the above areas do not
meet the regulatory requirements of SNiP 23-03-2003 "Thermal protection of buildings". The
temperature difference between the air temperature in the room and the wall surface temperature
should be within 4 °C. Temperatures in heat conduction areas should be above the dew point
temperature. When recalculating the obtained results into calculated \( t_0 = -32 \, ^\circ C, t_1 = + 21 \, ^\circ C \), the
temperatures in the surveyed areas will be below the dew point temperature, that is, below 11, 12 °C.

3. Results and discussion
The economic effect of the results of a thermal imaging survey of large-panel buildings can be
assessed by carrying out appropriate calculations using the example of a 5-access 10-storey residential
building with a building volume of 54 thousand m3 of heated part.

The average market cost of thermal imaging inspection of thermal protection is 270,000 rubles for
this house.

Calculations are made for the following conditions:
- Estimated internal air temperature = 21 °C.
- Actual outdoor temperature = -10 °C.
- The average actual temperature of the outdoor air of the heating period in the year = -5.2 °C.
- The duration of the heating period in the year for the city of Kazan = 215 days.
- The current tariff for thermal energy in the 1st quarter of 2019 is 1691.38 rubles / Gcal.
- Periodic overhaul (according to VSN 58-88) = 20 years.

When conducting a thermal imaging survey of the quality of thermal protection of a building, the
following defects were identified:
1. General defects caused by technological violations of the production of building materials and
structures used in the construction of walls of buildings.

Calculation of the damage caused by the defect:
- Required heat transfer wall resistance = 3.45 m² °C / W.
- The total surface area of the external walls of the building = 8700 m².
- The reduced resistance to heat transfer of the wall in the reference zone without local defects
  = 2.2 m² °C / W.
- Additional heat loss through the walls due to a general reduction in the quality of thermal
  protection
  \[
  \frac{8700 \times (3.45 - 2.2)}{(3.45 \times 2.2) \times (21 - (-5.2))} \times 31 \times 215 \times 0.86 / 1,000,000 = 215.17 \text{ Gcal / year.}
  \]

- Additional costs for payment of heat before the overhaul
  \[
  215.17 \times 1691.38 \times 20 = 7,278,684.7 \text{ rubles.}
  \]

2. Local defects caused by technological violations of construction and installation of structures
during the construction of the walls of buildings:
a) Local violation of installation technology and exterior wall structures.

Calculation of the amount of damage from additional heat losses caused by the defect:
- Increased heat loss in the zone of defective joints between the panels by 15%.
- The total area of defects is 525 m².
- The reduced resistance to heat transfer of the wall in the reference zone without local defects
  = 2.2 m² °C / W.
- Additional heat loss through defective joints between panels
  \[
  15\% \times 525 \times (21 - (-5.6)) \times 31 \times 215 \times 0.86 / (2.4 \times 1000000) = 4.93 \text{ Gcal / year.}
  \]
• Additional costs for payment of heat before the overhaul
  = 4.93 × 1691.38 × 20 = 166 770.1 rubles.

b) Local violations of the technology of execution of joints and joints of wall structures, leading to
a violation of the sanitary and hygienic safety requirements of the home.

The calculation of the amount of damage from the additional cost of eliminating security breaches
caused by the defect:
• The total length of the seams, where it is necessary to perform the opening of the old seam,
  complete replacement of insulation and sealing = 5250 r.m.
• The specific costs of performing the opening of the old seam, the complete replacement of the
  insulation and sealing (work and materials) = 400 rubles / running meter.

  The total area of the walls where interior wall lining is necessary to eliminate the identified defect
  = 5250 m².
• The specific cost of the interior lining (work and materials) = 120 + 150 = 270 rubles / m².
• Total expenses for elimination of the violation = 5250 × 400 + 5250 × 270 = 3 571 500 rub.

3. General defects caused by technological disruptions in the production of insulating glass used in
filling the openings of buildings.

• Required heat resistance of the window according to the project = 0.6 m² °C / W.
• The total surface area of windows and balcony doors of the building = 1940 m².
• Actual heat transfer resistance of the window according to test results = 0.47 m² °C / W.
• Additional heat loss through the walls due to a general reduction in the quality of thermal
  protection
  = 1940 × (0.6 − 0.47) / (0.6 × 0.47) × (21 − (−5.6)) × 31 × 215 × 0.86 / 1,000,000
  = 136.36 Gcal / year.

• Additional costs for payment of heat before the overhaul
  = 136.36 × 1691.38 × 20 = 4,612,731.5 rubles.

4. Local defects caused by violations of the technology of installation of window blocks and filling
of light openings of buildings.

a) Local violation of installation of window blocks, causing increased heat loss.

Calculation of the amount of damage from additional heat losses caused by the defect:
• Increase heat loss in the defect zone by 56%.
• The total area of defects is 129 m².
• The reduced heat transfer resistance of the window in the reference zone without local defects
  = 0.47 m² °C / W.
• Additional heat loss through windows in defective areas
  = 56% × 129 / 0.47 × (21 − (−5.6)) × 31 × 215 × 0.86 / 1,000,000 = 23.435 Gcal / year.

• Additional costs for payment of heat before the overhaul
  = 23.435 × 1691.38 × 20 = 792 749 rubles.

b) Local violation of the technology of execution of junction points and adjustment of window
block structures, resulting in violation of the sanitary and hygienic safety requirements of the dwelling.

The calculation of the amount of damage from the additional cost of eliminating violations caused
by the defect:
• The number of valves that need to be adjusted to eliminate the identified defect = 500pcs.
• The specific cost of adjusting the valves for free running and pressing = 500 rubles for the
  sash.
• Total expenses for elimination of the violation = 500 × 500 = 250,000 rubles.

Conclusion on the economic effect of the results of thermal imaging of large-panel buildings.
The total amount of damage is given in the table 1.
Table 1. The total amount of damage.

| Defect group                                                                 | Constructions          | Cost, rub.      |
|------------------------------------------------------------------------------|------------------------|-----------------|
| 1. Additional costs for payment of heat before overhaul due to deterioration in the quality of thermal protection, uncompensated by the elimination of local defects | walls in general       | 7 278 684,7    |
|                                                                               | walls in areas of local defects | 166 770,1    |
|                                                                               | windows in general     | 4 612 731,5    |
|                                                                               | windows in areas of local defects | 792 749    |
| 2. Additional costs for the elimination of defects in thermal protection, resulting in violation of sanitary and hygienic safety requirements of the home | TOTAL Walls            | 12 850 935,3  |
|                                                                               | Window                 | 3 571 500      |
|                                                                               |                        | 250 000        |
|                                                                               | TOTAL                  | 3 821 500      |
|                                                                               | The average market cost of thermal non-destructive testing of thermal protection of a building | 270 000      |
|                                                                               | The average market cost of thermal non-destructive testing of the building, taking into account the additional cost of eliminating defects in thermal protection | 4 091 500      |

From the diagram (Figure 2) it can be seen that the cost of thermal imaging and the elimination of defects in thermal protection in the long term will block the cost of additional heating. Thus, the implementation of the survey and repair work, after the detection of defects, is the most rational and cost-effective solution. It should be noted that after performing repair work, problems with unstable temperature with constant drops, high humidity which is the main cause of fungus, mold and dampness inside the apartments will disappear [20].

4. Conclusions
1. A thermal imaging survey of the building was conducted, the main problem areas were identified.
2. The results of the survey showed the economic effect: the additional costs of paying for heat before the overhaul due to the deterioration of thermal protection, uncompensated by the
elimination of local defects amounted to 12,850,935.3 rubles, while the cost of thermal imaging, taking into account additional costs defects in thermal protection amounted to 4,091,500 rubles. From this it follows that the cost of thermal imaging and the elimination of defects in thermal protection in the long term will block the cost of additional heating.

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