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Economic Justification of the Efficiency of the Optimal Warming of the Joint of Walls with the Basement Floor of Frame and Monolithic Buildings with the Aired Undergrounds in the North

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Abstract. An economic analysis was carried out using a program for calculating three-dimensional temperature fields of a fragment of a corner joint of walls with a basement of a building with aired undergrounds for various options. The temperature fields of the nodes are determined. Calculations showed that the use of a heat-efficient beam on supports leads to the temperature increase on an internal surface. A comparative estimate was also carried out to identify the cost-effectiveness of the options.

1. Introduction

Heat-conducting inclusions in the building's basement floor often cause the formation of uncomfortable temperature condition of the floor surface [1].

A significant reducing effect on the magnitude of the resistance to a heat transfer, heat loss and on the temperature regime of a room is provided by corner joints of enclosing structures [2-7]. At present time, for the construction of residential and public buildings, the technology of construction of a framework of monolithic reinforced concrete is widely used. Masonry is made of small concrete blocks on monolithic overlap within each floor, on which heat-insulating slabs are mounted from the outer side. At the same time, a heat-conducting inclusion "reinforced concrete overlap - masonry of small concrete blocks" [4] is formed on the basement floor that significantly reduces the heat transfer resistance of the "wall-basement floor" corner joint. The combined effect of a corner joint of the structures and the heat-conducting inclusion leads to significant decrease in temperature of an internal surface of the fences [8, 9].

2. Methods

For the assessment of thermal protection of an apartment building, field studies were carried out in February 2019. The external temperature during the survey period was -36.6 ° C. The Testo 435-4 device was used for the measurement of the indoor air temperature and the SATG-90 thermal imager was used for thermal imaging.

During field studies, fencing structures and building elements were surveyed for the determination of the quality of the heat insulation installation for the identification of heat loss through defects in thermal protection (see Fig 1a - 1d).

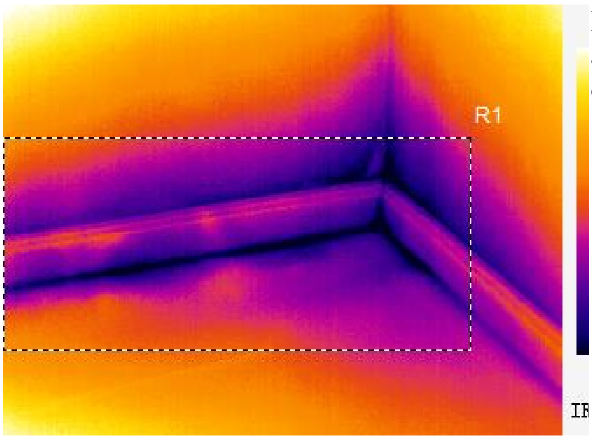

Figure 1a. Thermal image of the basement floor at the junction of the exterior walls of the 1st floor of the building.

Description of Fig 1a:
in the R1 area, temperature bridges at the joints of the exterior walls and the basement floor have been identified. The average temperature of the area is 12.7 ° C, the minimum temperature of the area is 5.4 ° C. Temperature of the indoor air at the time of the survey was 26.2 ° C.

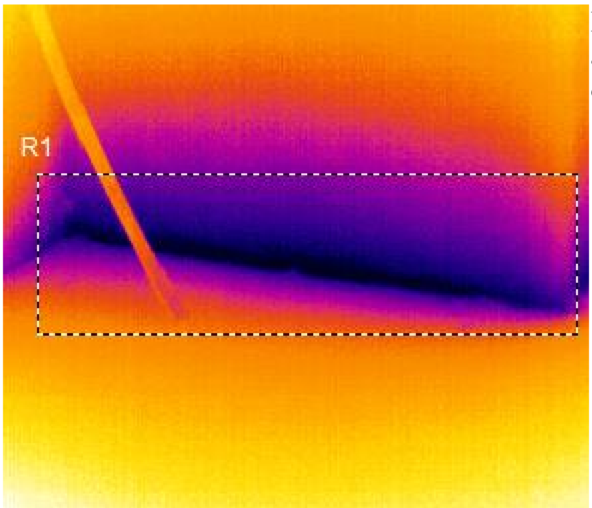

Figure 1b. Thermal image of the basement floor at the junction of the interior walls of the 1st floor of the building.

Description of Fig 1b:
in the R1 area, a temperature bridge was identified at the junction of the basement floor and the inner wall structure. The average temperature of the area is 12.5 ° C, the minimum temperature of the area is 8.8 ° C. The temperature of the indoor air at the time of the survey was 21.7 ° C.

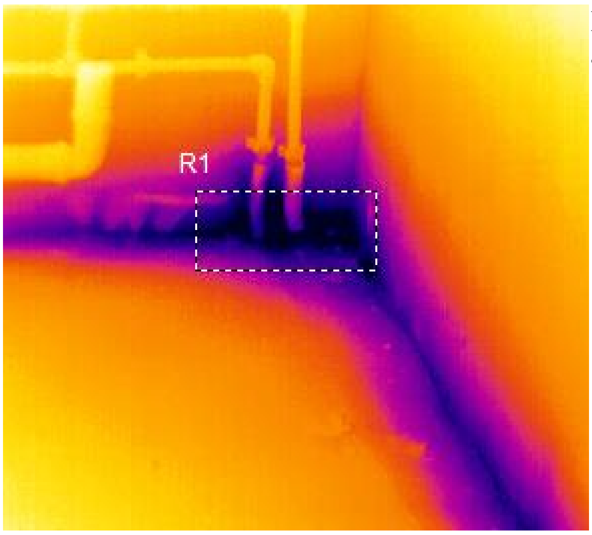

Figure 1c. Thermal image of the basement floor at the utilities exit on the 1st floor of the building.

Description of Fig 1c:
in the R1 area, a temperature bridge was identified at the junction of the basement floor and the internal wall structures at the site of the utillities exit. The average temperature of the area is 2.3 ° C, the minimum temperature of the area is -3.7 ° C. The temperature of the indoor air at the time of the survey was 20.2 ° C.

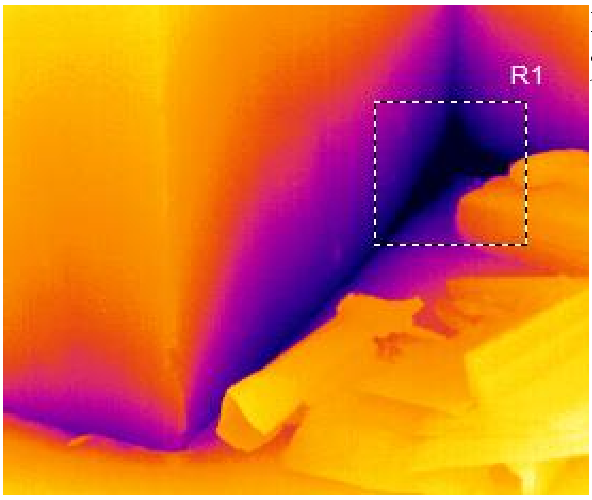

Figure 1d. Thermal image of a corner connection of a residential apartment on the 1st floor of a building

Description of the Fig 1d:
In the R1 area, a temperature bridge was identified at the junction of the basement floor with the outer and inner wall enclosures. The average temperature of the area is 8.0 ° C, the minimum temperature of the area is 1.3 ° C. The temperature of the indoor air at the time of the survey was 21.7 ° C.

3. Results

A constructive solution for the basement floor of the monolithically erected buildings was proposed, which significantly reduces the effect of heat conducting inclusion, for which a patent was obtained for a utility model (patent RU 117943 U1 E04B 2 00). When filling a monolithic basement floor, reinforced concrete local supports with a width equal to the width of a small concrete block are additionally provided. Reinforced concrete beams with the same width are laid on the supports. Masonry made of small concrete blocks is on the beams within the floor. Masonry is made directly on the interfloor overlappings on other floors. The remaining gap between basement floor and beam allows to place insulation between them (Fig. 2). The effectiveness of this solution was published in one of the previous article [4].

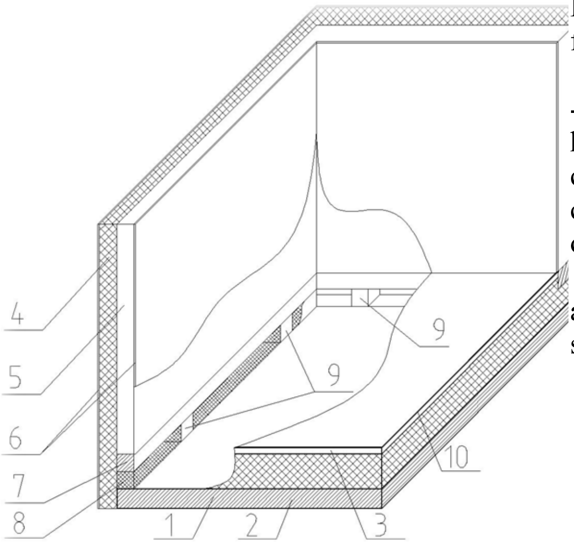

Figure 2. Fragment of the corner joint of external fences:

1 - monolithic reinforced concrete floor slab; 2 - heat insulation; 3 – cement and sand coupler; 4 - heat insulation; 5 - small concrete blocks; 6 – cement and sand mortar plaster; 7-reinforced concrete beam; 8 - heater; 9 - local supports made of reinforced concrete; 10 - linoleum.

Note: to show the placement of local supports and beams, some parts of the fences are not shown.

In the published article, a comparison is made of the proposed solution for insulating the joint between the walls and the basement floor (Fig. 2) with the method used by the builders at present time, when the masonry is done directly on the overlap, warmed by polystyrene foam and then applying plaster on its outer surface (Fig. 3). In addition, an option with masonry on overlap with additional warming from bottom with a basalt slab with a thickness of 0.15 m and a width of 0.5 m was considered (Fig. 4).

For options comparison, the fragment of a wall with a height of 2.9 m from the floor level and 3.0 m long was considered. When comparing options, overlap elements were not taken into account, as they remain unchanged. Only when considering the third option, additional heat insulation from basalt slabs of the edge of the basement floor was taken into account.

To assess the economic efficiency of the compared options, the WinRik program was used to estimate the cost by the base - index method with a correction factor for residential buildings in 2001 prices with conversion to current prices.

As the first option, a part of the wall with masonry, supported on a reinforced concrete beam with a section of 0.19x0.19 m and a length of 3m, was considered. The beam, in its turn, rests on two reinforced concrete supports with a size of 0.19 x 0.19 × 0.3 m. The grooves between the basement and the beam height of 0.3 m are filled with polystyrene foam. Also during the calculation, external and internal plaster and insulation of polystyrene foam was taken into account.

The second option is a solution of a wall of similar design, but the masonry of 3.37 m high was erected from the level of the ceiling (Fig. 3).

The third option differs from the second one in that along the edge of the basement floor from the bottom to the width of 0.50 m there is additional heat insulation from basalt slabs 0.15 m thick with a galvanized sheet cover (Fig. 4).

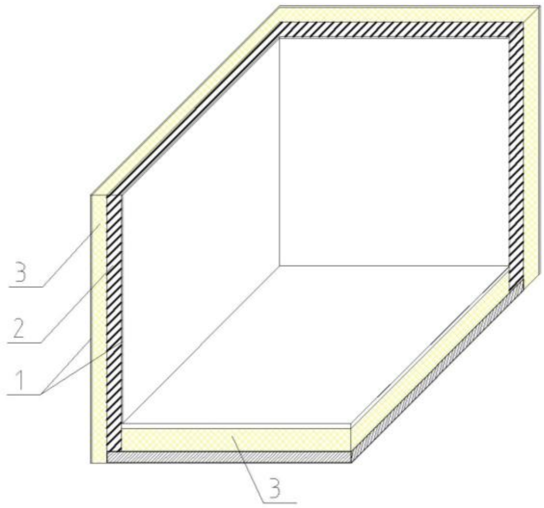

Figure 3. Option 2 of insulation joint between the wall and basement floor.

1 - cement-sand mortar plaster; 2 - small concrete blocks; 3 - heat insulation.

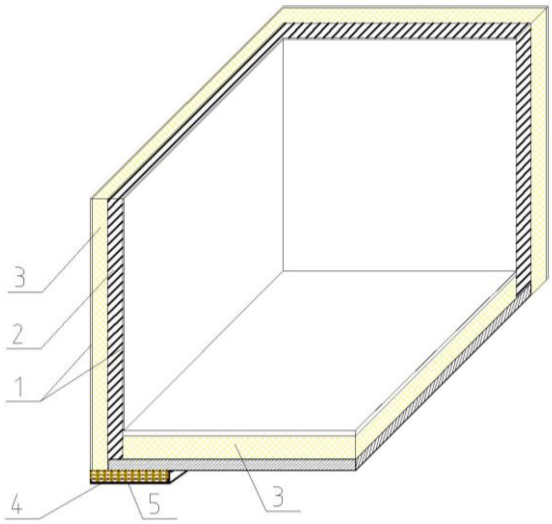

Figure 4. Option 3 of insulation joint between the wall and basement floor.

1 - cement-sand mortar plaster; 2 - small concrete blocks; 3 - heat insulation; 4-insulation of basalt slabs; 5 - galvanized sheet.

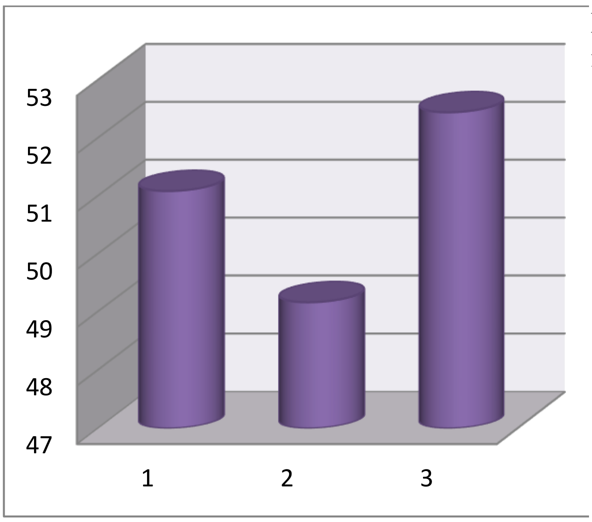

Figure 5. Graph comparing options for insulation in thousand rubles.

4. Discussion
The results of the estimated calculation showed (Fig. 5) that with the proposed heat-efficient solution of the joint of the wall and the basement floor, the wall design will be for 3,9% more expensive than with the 2nd option with masonry on the floor. Additional insulation of the ceiling from the outside (Fig. 4) will lead to a 6.676% rise in price. This increase in prices applies only to the wall structure within the ground floor. However, here it should be noted that with the second option, the temperature at the joint of the wall and the basement floor is below the dewpoint temperature [8], so if you comply with the requirements of "Thermal Protection of Buildings", then this constructive solution cannot be used in the construction of residential buildings. In the third option, these requirements are met (with the exception of the spatial angle [8]), but even if somehow we can ensure that the temperature in the spatial angle is higher than the dewpoint temperature, the solution is uneconomical (Fig. 4). It should be noted that heat engineering calculation of fences was carried out using two-dimensional and three-dimensional temperature field calculation programs for which certificates of state registration were obtained issued by Rospatent, which resulted temperatures on the inner surface at the joint between the outer wall and the basement floor, results of which can be seen in table 1, where it is possible to single out the clear superiority of the use of a heat-efficient beam.

Table 1

№	The temperature value at the joint of the basement floor with the outer wall, depending on the type of floor		
	Typical, ° C	With insulation from the bottom of overlap with length 500, 1000, 1500 mm, C	With a beam, ° C
1	+8,43	+11,96	+15,54
2		+12,07	
3		+12,14	

5. Conclusion
The analysis showed that the developed node of the basement floor and the outer wall has a higher technical and economic results than similar structural solutions used in the Republic of Sakha (Yakutia) at present time.

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