

Study of heat shielding qualities of a brick wall corner with additional insulation on the brick

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Abstract. This work presents the theoretical investigations results for the brick wall thermal protection properties exterior corner with the insulated layer SUPERROCK mineral wool. As the outer corner of the enclosing structures has lower thermal protection properties than the other part of the wall, it needs additional insulation. Two variants of additional insulation were considered in the work, in the deepened outer surface and in the middle of the brick wall. In this case, the additional heater was not continuous, but divided into two parts and shifted from the corner. The length and volume of additional insulation for different variants were determined. The optimal variant of the proposed schemes was determined by the minimum volume of the heater and compared with the existing ones. The volume of additional insulation is set at 1 meter of the fence height. For the proposed variant of the location for the heater in the brick wall middle, its thickness in the brick cavity, the length and offset from the corner magnitude were determined. For a location-variant of the heater in the deepened on the outer surface of the fence bricklayer, the length of the additional insulation and its displacement from the corner were determined. The thickness of additional insulation was taken 130 mm (width of the brick and seam between the bricks). Studies were carried out for the first temperature zone.

1 Introduction

One of the way of saving the thermal energy going to the heating of buildings and structures is improvement the thermal units of enclosure constructions. One of such thermal units is the outer corner of the external enclosures. Typically, heat nodes are places with a lower heat transfer resistance than the main fence, and therefore contribute to increased heat loss. Improving the insulation of the outer corner of the brick wall is an urgent task. The optimal location and dimensions of additional insulation are determined. By the criterion of optimality, the minimum amount of additional insulation is adopted, at which the requirements of thermal protection are fulfilled.

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1.1 Review of recent research and publications sources

Many authors' works are dedicated to corners increasing heat shielding properties issue according to the norms requirements. Recently, the variants for insulation of the external brick walls corner were considered in the works [1-3]. In article [1] there is proposition of constructive solution in which additional insulation is located in the deepening of the brick wall from the outside. Such an arrangement of additional insulation, according to the authors, increases the temperature in the corner at 0.5 to 1.7 °C, which provides more comfortable indoor conditions. The authors obtained mathematical dependence, which allows to calculate the value of temperature in the corner without using numerical simulation and experimental methods, which simplifies the ad variant of engineering solutions.

The article [2] discussed variants to deepen in the external surface sections of window and door openings, exterior walls in the corners and at the level of overlap which placed an additional layer of insulation. According to the authors, the proposed constructive solutions can be used in the new construction and reconstruction of buildings. The considered constructive decisions do not complicate the process of execution of work and can be fulfilled with the appropriate qualifications of the workers. Additional insulation increases the value of the given resistance of the heat transfer of the wall and thereby reduces the heat loss. The economic efficiency of the proposed solutions for a two-story building with a capacity of about 1000 m³ is 20,000 UAH, which indicates the availability of its use in building practice.

In article [3], a method for locating thermoclines in places of special depressions of the walls from the outside of the corners, openings and the level of inter-floor overlap is proposed. The work limits the use of this method and provides constructive recommendations for the practical arrangement of nodes. The decrease in linear coefficients in the corners, in the openings and also in the joints of inter-floor overlap at 1.3 – 9.4 times is fixed. The minimum lengths of the thermocline, which is equal to the thickness of the wall, are substantiated. As a variant, an analysis of the location of the heater in the brick masonry in the area of the external corner is given.

In work [4], variants of additional insulation of the corner of frame-monolithic buildings were considered. [5-6] The influence of the mutual arrangement of the external corner of the house and the window opening on the temperature of the internal surface of the corner was considered in article [7-10]. Definition the parameters of thermal insulation in the foundation zone [11].

1.2 Previously unsolved assignment aspects of the general problem

In publications devoted to research ways to improve the heat shielding properties of corner to the heat transfer norms proposed use continuous additional layer of insulation located near external corner of the enclosure construction. The variant of dividing additional insulation into two parts and displacement it from the corner within the design scheme is not considered.

1.3 Setting objectives

Purpose of this work was to determine the optimal location and the possible minimum size of additional insulation, divided into two parts and shifted from the corner of the external brick wall within the design scheme. For optimality criterion was adopted minimum required capacity of additional insulation that provides thermal performance standards.

2 Basic material and results

In the works [1-3], proposed variants of additional insulation of the external corner of brick walls that are shown in Figure 1.

Studies were carried out for the 1st temperature zone. Enclosing structure of a wall of a residential building with a thickness of 510 mm. Heater insulation made of basalt mineral wool SUPERROCK with a density 135 kg/m³. The thickness of the main layer of the heater insulation is 90 mm, which ensures the implementation of the rules of thermal protection in the areas of walls without heat conductors.

The proposed additional insulation variants were compared with those given in [1-3] (Fig.º1).

For variants given in [1-3] the minimum possible length of additional insulation was determined at which the requirements of thermal protection are fulfilled.

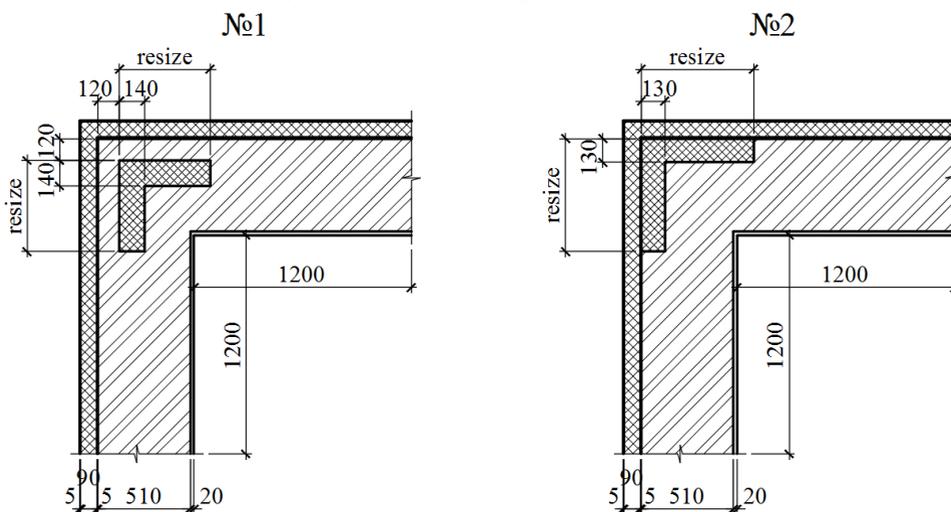


Fig. 1. Additional insulation of the external corner of brick wall by [1-3]. 1 – deep in the brickwork; 2 – in the deepening from the outside.

Figure 2 shows the variants for additional insulation that are offered.

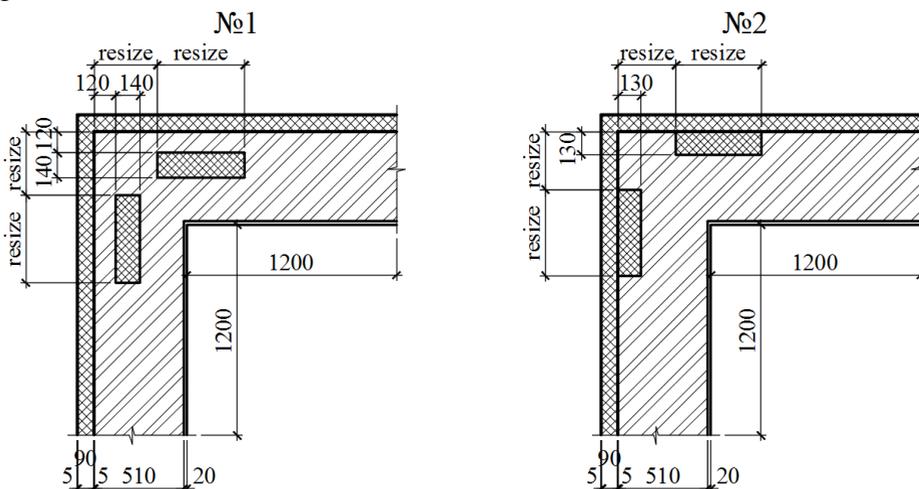


Fig. 2. Additional insulation of the external corner of brick wall that are offered. 1 – deep in the brickwork; 2 – in the deepening from the outside.

Under the scheme number 1, the length of additional insulation was taken (multiple sizes of the brick, taking into account the seams between the bricks), from 270 mm to 920 mm, with a graduation of 130 mm. The reduced resistance of the heat transfer of the calculated wall section was determined on the basis of the calculation of temperature fields. The results of the studies are presented in Table 1.

According to [6], for the external walls of residential buildings in the 1st temperature zone, the following requirements of thermal protection must be fulfilled: $\tau_{(b.min)} > t_p = 10.7 \text{ }^\circ\text{C}$.

As can be seen from Table 1, the second and third heat protection requirements are fulfilled at all lengths of additional insulation. The graph shown in Figure 3 allows you to determine the length of additional insulation in which the first requirement is fulfilled.

Table 1. Heat protection properties of the calculated area of the external corner according to the scheme of additional insulation N°1.

Length of additional insulation, mm	$R_{\Sigma \text{ red}}, \text{m}^2\text{K/W}$	$\Delta t_{\text{red}} \text{ }^\circ\text{C}$	$\tau_{(b.min)} \text{ }^\circ\text{C}$
270	2.636	1.8	16.4
400	2.719	1.8	16.8
530	2.832	1.7	17.4
660	2.971	1.6	17.8
790	3.133	1.5	18.1
920	3.317	1.5	18.2

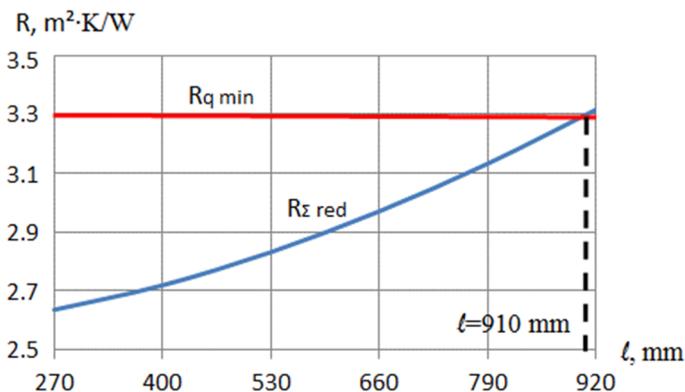


Fig. 3. Determination of the minimum length of additional insulation in which the first heat protection requirement is fulfilled.

As can be seen from Figure 3, the minimum length of additional insulation at which the first heat protection requirement is fulfilled is 910 mm. At this length, the additional heat insulation was 0.2352 m^3 per 1 m of height of the fence.

Similar studies have been performed for scheme 2. In considering this scheme, the length of additional insulation was taken (multiple sizes of the brick, taking into account the seams between the bricks), from 390 mm to 910 mm, with a graduation of 130 mm. The results of the research are presented in Table 2.

As can be seen from Table 2, the second and third heat protection requirements are also fulfilled at all lengths of additional insulation.

Table 2. Heat protection properties of the calculated area of the external corner according to the scheme of additional insulation N°2.

Length of additional insulation, mm	$R_{\Sigma \text{ red}}, \text{m}^2\text{K/W}$	$\Delta t_{\text{red}}, ^\circ\text{C}$	$\tau_{(\text{B.min})}, ^\circ\text{C}$
390	2.803	1.7	16.7
520	2.909	1.7	17
650	3.032	1.6	17.3
780	3.175	1.5	17.5
910	3.337	1.4	17.6

The graph shown in Figure 4 allows to determine the length of additional insulation in which the first requirement is fulfilled

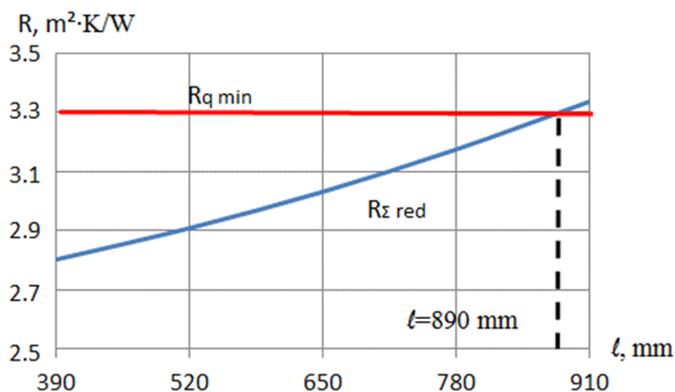


Fig. 4. Determination of the minimum length of additional insulation in which the first heat protection requirement is fulfilled.

As can be seen from Figure 3, the minimum length of additional insulation at which the first heat protection requirement is fulfilled is 890 mm. At this length, the capacity of additional insulation was 0.2145 m³ per 1 m of height of the fence.

The capacity of additional insulation at its location in the deepness of the brickwork is less than when located in the deepening of the outside. That is, it is more expedient to approach it to the internal surface of the enclosure. But this worsens the humidity of the heater insulation. In addition, it is inappropriate to located the heater insulation in the zone of slabs peeling on the walls.

The variant of proposed additional insulation of the corner of the brick wall involves separating the heater insulation into two parts and shifting it from the corner (Figure 2). For a more accurate determination of the optimal value of the shifting of additional insulation, the value of the shifting was taken a multiple of 10 mm (not a multiple size of the brick). The optimal result was the result of which the capacity of additional insulation was minimal.

According to a variant N°1 (Figure 2) additional insulation thickness taken from 140 mm (total cavity filling) to 30 mm. At the same time, the width of the cavity in which the additional insulation was arranged remained constant and equaled 140 mm. That is, with a decrease in the thickness of additional insulation, a closed air layer appeared. Length of insulation taken so that provides thermal performance requirements.

The results of the study of heat-shielding properties of the corner at a thickness of additional insulation of 140 mm are given in Table 3. As can be seen from Table 2, the optimal shifting value of additional insulation from the wall corner is 100 mm.

Table 3. The research results of heat-shielding properties of the corner of the proposed scheme with additional insulation thickness of 140 mm.

Scheme	The value of the shifting of additional insulation from the corner, mm	Length of additional insulation, mm	The reduced resistance of heat transfer, m ² K/W	Capacity of additional insulation, m ³
Present in [1-3] (without separation heater insulation)	0	910	3.302	0.2352
Proposed (heater insulation consists of two parts)	50	860	3.301	0.2327
	90	830	3.305	0.2299
	100	820	3.301	0.228
	110	820	3.308	0.2287
	130	820	3.309	0.2295
	150	900	3.311	0.252

The fulfillment of the requirements of thermal protection provides the length of the heater insulation of 820 mm. The capacity of insulation at 1 m of the height of the fence is 0.228m³. This is 3% less than the additional insulation scheme without dividing it into two parts and shifting from the corner that given in [1-3].

The research results of the heat-shielding properties of the corner at a thickness of additional insulation from 140 mm to 30 mm are shown in Table 4. The capacity of additional insulation is set at 1 m of the height of the fence.

Table 4. The research results of heat-shielding properties of the corner of the proposed scheme with additional insulation thickness from 140 mm to 30 mm.

Thickness of additional insulation, mm	The optimum value of the shifting of additional insulation from the corner, mm	Length of additional insulation, mm	The reduced resistance of heat transfer, m ² K/W	Capacity of additional insulation, m ³
140	100	820	3.301	0.228
130	100	820	3.3	0.2116
120	100	840	3.301	0.2
110	110	860	3.306	0.1883
100	110	890	3.304	0.1771
90	120	920	3.301	0.1652
80	120	970	3.305	0.1548
70	120	1030	3.307	0.1438
60	120	1110	3.307	0.1328
50	120	1210	3.301	0.1206
40	130	1360	3.303	0.1087
30	0	1500	3.301	0.0891

From Table 4 it is seen that there is the smallest amount of additional heater with its thickness of 30 mm without shifting from the corner. The length of the heater insulation, which ensures the implementation of the conditions of thermal protection is 1500 mm (throughout the length of the calculation scheme). Figure 5 shows the scheme of the optimal location of the heater insulation in the corner according to the proposed scheme of additional insulation №.1.

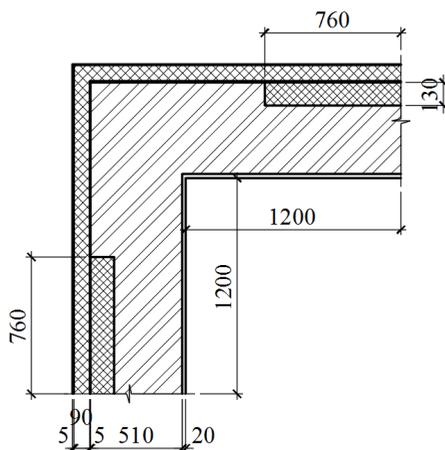


Fig.6. Scheme of the optimal location of the heater insulation in the corner according to the proposed scheme of additional insulation N^o.2.

The performed studies have shown that the smallest capacity of additional insulation is observed at its location along the edge of the calculation scheme. The length of the additional insulation is 760 mm.

Figure 6 shows the scheme of the optimal location of the heater insulation in the corner according to the proposed scheme of additional insulation N^o.2.

The scheme shown in Figure 6 allows to reduce the capacity of additional insulation at 8% compared with the scheme with full filling of the cavity between the layers of the brick that given in [1-3].

3 Conclusions

1. With the application of additional insulation of the corner of the scheme N^o.1 with a decrease in its thickness and corresponding increase in length, the capacity of insulation needed to meet the requirements of thermal insulation decreases. The best result gives an even distribution of the heater insulation within the limits of the calculation scheme.

2. The smallest capacity of additional insulation is observed at its thickness of 30 mm, if it is located throughout the length of the calculation scheme without shifting from the corner.

3. Such an arrangement of an additional insulation, and the use of a closed air layer, can reduce its capacity at 62% compared with the scheme with the full filling of the cavity insulation between the layers of brick that given in [1-3].

4. The smallest capacity of additional insulation when using additional insulation of corner scheme No. 2 observed when it is on the edge of the settlement scheme.

5. Such an arrangement of an additional heater allows to reduce its capacity at 8% compared with its arrangement according to the scheme that given in [1-3].

6. From the two schemes considered, the scheme N^o.1 is more optimal where the capacity of additional insulation is less.

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