Study of heat shielding qualities of brick wall angle with additional insulation located on the outside fences

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Abstract. The results of theoretical studies of heat-shielding properties of the angle of external wall a residential building are presented. The brick wall thickness of 510 mm was considered. The studies were performed for the I-st temperature zone of Ukraine. Heat insulation was located on the external side of enclosure. Thermal protection problems of the angle are consideration of the impact of heat-conductive inclusion on adjusted heat transfer resistance of enclosure. Conductive inclusion on the external angle area is its configuration. An additional layer of insulation in the angle area is necessary to use for bringing the level of thermal protection of angle area to the standards. The results of calculations of two-dimensional temperature fields were used for the analysis of thermal protection. Two options for additional insulation were studied. The first option: continuous strip insulation covering the external wall angle. Another one provides division of additional insulation layer into two parts and displacement them from the angle within the design scheme. Studies were performed for different thickness of additional insulation. There was additionally taking into account the value of insulation displacement from the angle for the second option. The optimal location and size of additional insulation were determined. The minimum amount of additional insulation under which the thermal protection requirements are performed was accepted like optimality criterion.

1 Introduction

One of the main tasks of designing external fencing structures of residential buildings is to provide a normalized level of heat shield. Herewith in the determination of thickness of the insulation in external walls the seats with heat conductive inclusions, in which the level of heat shield usually less than in areas without them are ignore. Areas with heat conductive inclusions include the following: place of relying on the wall of overlap constructions or balcony plate, walls abutment to windows or balcony doors, external wall angle. Ignoring the properties of these areas leads to higher overall heat loss through external fencing structures. Besides high heat, losses in these places there are such negative phenomena as

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lowering the temperature of the inner wall surface and increase amplitude of oscillations the temperature on this surface. Increasing of heat shielding properties of external wall angle is possible through its additional insulation.

1.1 Review of the recent studies and publications

Work of many authors dedicated to issue of increasing heat shielding properties of angles to the requirements of norms [1-3]. So, in [4-6] described variants of additional insulation on the external side by increasing the thickness of the primary insulation in the area of building angle. The option of internal insulation is also considered in this article. The variants of additional insulation of frame-monolithic buildings angle are considered in [7]. The impact of the relative position of the external building angle and window aperture on the temperature of the internal surface angle was considered in [8].

1.2 Assignment aspects of the general problem unsolved earlier

In publications dealing with the study of ways to improve the heat shielding properties of angle to the heat transfer norms, the use continuous additional layer of insulation located on the external surface of the fence was proposed. The option of separation of additional insulation into two parts and displacement it from angle within the design scheme is not considered. No recommendation was given concerning the ratio of the thickness to length of the additional insulation layer under which material expenses will be minimal.

1.3 Setting objectives

The objective of this work was determining the optimal location and the possible minimum size of additional insulation in the external brick wall angle under which heat shielding conditions will be performed. Minimal required capacity of additional insulation adopted like criterion of optimality.

2 Basic material and results

The construction of a brick wall with external insulation is shown in Fig. 1. Fencing layers located on the external side insulation have no significant effect on the heat-shielding properties of the fence due to little thickness. That is why in the calculations they are changed to a layer of cement-sand mortar with the thickness of 5 mm. A leveling layer of cement-sand mortar between the insulation and brickwork the thickness of 5 mm is added.

Characteristics of materials of the fencing structure layers are shown in Table 1.

Table 1. Characteristics of materials of the fencing structure layers.

Fencing structure layers	Density, kg/m ³	Thickness, m	Thermal conductivity, W/m·K
Sand-lime mortar	1800	0.02	0.93
Brick	1800	0.51	0.81
Cement-sand mortar	1600	0.005	0.81
SUPERROCK Basalt mineral wool	135	90	0.035
Cement-sand mortar	1600	0.005	0.81

Fig. 1. The construction of a brick wall with external insulation. 1- insulation; 2 - steel net; 3 - primer coat; 4 - leveling coat; 5 - decorative plaster; 6 - facade paint; 7- steel rock bolting; 8 - brick wall.

The thickness of the base layer of insulation defined by the heat engineering calculation for residential building in the I-th temperature zone is 90 mm.

Adjusted heat transfer resistance of external angle is determined on the basis of temperature field calculations. Options for offered additional insulation angle are compared with the scheme provided by A. Prischenko in [4-5] (Fig. 2).

Fig. 2. Options for additional insulation angle according to the source [4-5].

Studies have shown that the minimum capacity of additional insulation (to meet the requirements of heat shield) will be determined for thickness of 40 mm and length (from the angle) of 1840 mm. In other words, additional insulation length is close to the length of the design scheme. The minimum capacity of additional insulation was 0.14 to 1 m high of the wall. The temperature field of angle for this option is shown in Figure 3.

For these dimensions of additional insulation:

- $R_{\Sigma red} = 3.305 m^2 - W K > R_{q min} = 3.3 m^2 - W K ;$

- $\Delta t_{red} = 1.5\text{ }^{\circ}\text{C} < \Delta t_{s.h} = 4\text{ }^{\circ}\text{C}$;
- $\tau_{in,min} = 16.9\text{ }^{\circ}\text{C} > t_{dew} = 10.7\text{ }^{\circ}\text{C}$.

Fig. 3. The temperature field of angle with a solid layer of additional insulation.

The proposed option of additional insulation with a shift from the wall angle is shown in Figure 4.

Fig. 4. The proposed option of additional insulation with a shift it from the wall angle.

The options of additional insulation layer with a thickness of 60 mm, 50 mm, 40 mm and 30 mm were considered.

The length of the design scheme is not enough to meet the requirements of heat shield at a thickness of additional insulation 30 mm.

The last option of the location of additional insulation, at each of its thickness, is when it coincides with the edge of design scheme.

As shown in Table 2, the optimal option (minimum capacity of insulation) was additional insulation angle with layer thickness of 40 mm, a length of 1700 mm at its location on the edge of design scheme (at a distance of 160 mm from the wall angle).

Table 2. The results of the study of heat-shielding properties of the angle by the proposed scheme, at a thickness of additional insulation 50 mm.

Scheme	Thickness of additional insulation layer	Distance from angle, mm	Length of additional insulation, mm	Adjusted heat transfer resistance	Capacity of additional insulation, m ³	Percentage of capacity of additional insulation by the scheme according to the source [4, 5], %
According to the source [4, 5]	40	0	1830	3.305	0.1448	100
Proposed	60	50	1450	3.308	0.174	120
		100	1410	3.311	0.1692	117
		150	1380	3.307	0.1656	114
		200	1360	3.308	0.1632	113
		250	1340	3.306	0.1608	111
		300	1320	3.304	0.1584	109
		350	1300	3.304	0.156	108
		400	1290	3.305	0.1548	107
		450	1270	3.3005	0.1524	105
		500	1260	3.305	0.1512	104
		550	1250	3.307	0.15	104
		600	1230	3.3007	0.1476	102
		660	1220	3.305	0.1464	101
	50	50	1580	3.3004	0.158	109
		100	1540	3.3007	0.154	106
		150	1510	3.301	0.151	104
		200	1490	3.303	0.149	103
		250	1470	3.303	0.147	102
		300	1450	3.301	0.145	100
		350	1440	3.307	0.144	99
		400	1420	3.304	0.142	98
		450	1400	3.302	0.14	97
		480	1390	3.303	0.139	96
	40	50	1780	3.303	0.1424	98
		100	1740	3.304	0.1392	96
		160	1700	3.302	0.136	94

The temperature field of option for the location of additional insulation shown in Figure 5.

Fig. 5. The temperature field of wall area with additional insulation length of 1700 mm and thickness of 40 mm at a distance of 160 mm from the angle (on the edge of design scheme).

A graph of temperature distribution on internal surface of the wall area is shown in Figure 6.

Fig. 6. A graph of temperature distribution on internal surface of the wall area with additional insulation length of 1700 mm and thickness of 40 mm at the distance of 160 mm from the angle (on the edge of design scheme).

At these sizes and location of additional insulation:

$$R_{\Sigma \text{ red}} = 3.302 \text{ m}^2 - W \text{ K} > R_{q \text{ min}} = 3.3 \text{ m}^2 - W \text{ K} ;$$

$$\Delta t_{\text{red}} = 1.5 \text{ }^{\circ}\text{C} < \Delta t_{s.h} = 4 \text{ }^{\circ}\text{C} ;$$

$$\tau_{in.min} = 16.9 \text{ }^{\circ}\text{C} > t_{dew} = 10.7 \text{ }^{\circ}\text{C} .$$

All heat shielding requirements are fulfilled.

3 Conclusions

With decreasing the thickness of additional insulation layer its capacity needed to meet the heat shielding requirements is decreases.

With displacement of additional insulation layer from the wall angle, its capacity necessary to meet the heat shielding requirements is decreases.

The lowest capacity of additional insulation needed to meet the heat shielding requirements is observed at its location on the edge of design scheme.

The lowest capacity of additional insulation will be at its least possible thickness and

location on the edge of design scheme.

For the considered construction of external wall insulation and applied insulation according to the scheme when it consists of two parts shifted from the wall angle, decreasing of the capacity of additional insulation is 6% compared with the scheme when a continuous strip insulation covering angle.

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