

ENERGY-EFFICIENT EXTERNAL WALLS MADE OF T-SHAPED THERMAL BLOCKS: THERMAL ANALYSIS AND PERFORMANCE ASSESSMENT

<https://doi.org/10.5281/zenodo.19125747>

Khaitov Maruf Bolikulovich

doctoral student (PhD),

direction 05.09.01 – “Structures, buildings and constructions”

Samarkand State University of Architecture and Civil Engineering

Email: xaitov.maruf@samdaqu.edu.uz

ORCID: 0000-0002-1692-5302

Annotation

Improving the energy efficiency of buildings is a key area of development in modern construction science. A significant portion of heat loss in buildings occurs through the external enclosing structures, particularly masonry walls with mortar joints, which form so-called thermal bridges. This paper examines a promising wall system based on T-shaped thermal blocks with an internal thermal infill made of basalt insulation. The design's unique geometry eliminates vertical joints in the masonry, thereby reducing heat loss.

This article presents the results of a thermal analysis of a wall structure, including numerical modeling of the temperature field and heat flow distribution. The results are compared with the characteristics of traditional wall materials – aerated concrete and large-format ceramic blocks. It is shown that the use of T-shaped thermal blocks reduces the impact of thermal bridges and improves the energy efficiency of the building envelope.

The results of the study demonstrate the potential of this technology for use in the construction of energy-efficient buildings in the climatic conditions of the Republic of Uzbekistan.

Key words

energy efficiency of buildings, external walls, heat transfer, thermal bridges, thermal blocks, basalt insulation.

Introduction

In recent decades, the issue of energy conservation in construction has become particularly pressing. According to international energy organizations, buildings consume a significant portion of the energy produced. According to statistics from the International Energy Agency (IEA), the construction sector accounts for

approximately 36% of global energy consumption and approximately 37% of global CO₂ emissions.

One of the main reasons for increased energy consumption in buildings is heat loss through the building envelope. Exterior walls can account for up to 30–45% of a building's heat loss, especially if the structure contains thermal bridges.

Thermal bridges occur in the following cases:

- the presence of mortar joints with high thermal conductivity;
- heterogeneity of the wall structure;
- contact of structural elements with different thermal conductivity coefficients.

Particularly significant influence is exerted by vertical mortar joints in masonry, the thermal conductivity of which is significantly higher than the thermal conductivity of modern thermal insulation materials.

In the Republic of Uzbekistan, energy saving issues are regulated by a number of regulatory documents, including: the Law of the Republic of Uzbekistan "On Energy Saving", KMK 2.01.04-97* "Thermal Engineering of Buildings", SHNK 2.01.04-2018 "Thermal Protection of Buildings", etc.

According to these standards, enclosing structures must provide the required thermal resistance and prevent the formation of moisture condensation on the inner surface of the walls.

In this regard, innovative design solutions for wall blocks aimed at reducing heat loss are of particular interest. One such solution is the T-shaped thermal block, whose design significantly reduces thermal bridges in the masonry.

The design concept of a T-shaped thermal block

A T-shaped thermal block is a structural element with complex geometry, consisting of a cement-sand shell and an internal thermal insulation layer. Structurally, the block includes: - an outer shell made of cement-sand mortar; - a system of internal partitions; - a thermal insulation core made of basalt insulation.

Unlike traditional blocks, the T-block design creates a break in the vertical mortar joints, which eliminates direct heat flow through the vertical mortar joint.

This geometry creates a labyrinthine heat transfer path, resulting in increased heat flow and decreased thermal conductivity. Experimental block samples are shown in Figures 1 and 2.

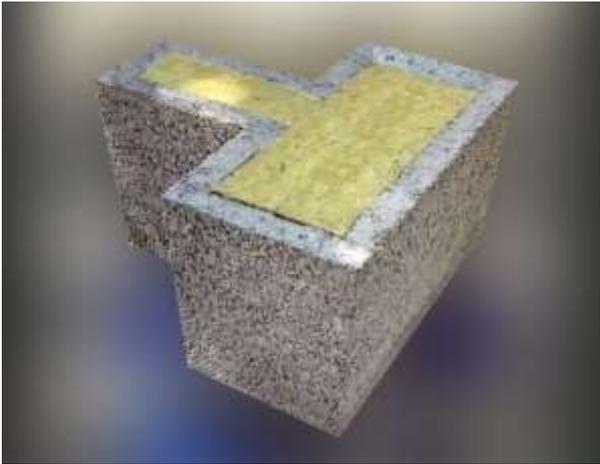


Fig. 1. T-shaped thermal block with basalt insulation

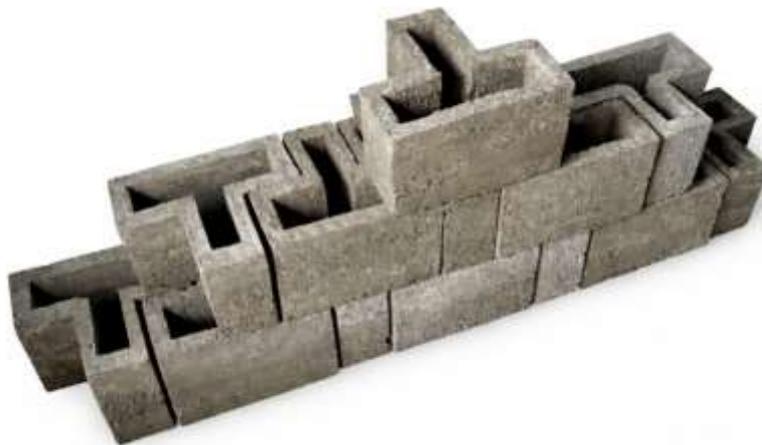


Fig. 2. Shell of a T-shaped thermal block without insulation

Materials and thermal characteristics

The construction of a wall made of T-shaped thermal blocks includes several layers with different thermal-physical characteristics.

Material	Thermal conductivity
plaster	0.7 W/m·°C
cement-sand shell	0.76 W/m·°C
basalt insulation	0.038 W/m·°C

Basalt thermal insulation has a number of advantages:

- low thermal conductivity;
- non-flammability;
- high durability;
- resistance to biological influences.

The use of this material allows to significantly increase the thermal resistance of the wall.

Methodology of heat engineering calculations

The thermal efficiency of the structure was assessed based on the calculation of heat transfer resistance.

The total heat transfer resistance is determined by the expression:

$$R = \Sigma (\delta/\lambda)$$

where δ is the layer thickness, λ is the thermal conductivity coefficient.

The heat transfer resistance was calculated for two cross-sections of a T-shaped thermal block structure (one with a 200mm thick insulator and one with a 7.5mm thick insulator). The following conditions were used: Samarkand, outside air temperature -15°C , inside air temperature 20°C , and relative humidity 55%.

The calculation was performed using an online calculator on the SMARTCALC.RU website, which is based on current GOST and SNIIP standards.

The results of calculating the heat transfer resistance of the block cross-section where the thickest layer of insulation (200 mm) is located are shown in the table below.

Layers of construction (from inside to outside)

No.	Thickness, mm	Material	λ	R	Tmax	Tmin
		Resistance heat perception		0.11	20.0	19.3
1	20	Complex (sand, lime, cement) solution	0.7	0.03	19.3	19.1
2	25	Cement-sand solution	0.76	0.03	19.1	18.9
3	200	Mineral (stone) wool 75-120 kg/m ³	0.038	5.26	18.9	-14.3
4	25	Cement-sand solution	0.76	0.03	-14.3	-14.5
5	20	Complex (sand, lime, cement) solution	0.7	0.03	-14.5	-14.7
		Resistance heat transfer		0.04	-14.7	-15.0
Thermal resistance of the enclosing structure:				5.39		
Thermal resistance of the enclosing structure [R]:				5.54		
Required thermal resistance						
Sanitary and hygienic requirements [Rc] –				0.60		
Standardized value of element-by-element requirements [Rэ] –				1.40		
Basic value of element-by-element requirements [RT] –				2.22		

Sanitary and hygienic requirements: $R > R_c$

The enclosing structure meets sanitary and hygienic standards for thermal protection. Element-by-element requirements: $R > R_T$

The building envelope meets thermal insulation standards regardless of other requirements. The thermal insulation resistance exceeds R_T by **2.49** times. This level of thermal insulation is justified if the heating system's energy source is extremely expensive or the goal is to build a passive house. In other cases, the cost of achieving this level of thermal insulation may be economically unjustified.

The results of calculating the heat transfer resistance of the block cross-section where the thickest layer of insulation (75 mm) is located are shown in the table below.

Layers of construction (from inside to outside)

No.	Thickness, mm	Material	λ	R	Tmax	Tmin
		Resistance heat perception		0.11	20.0	18.3
1	20	Complex (sand, lime, cement) solution	0.7	0.03	18.3	17.9
2	150	Cement-sand solution	0.76	0.20	17.9	15.1
3	75	Mineral (stone) wool 75-120 kg/m ³	0.038	1.97	15.1	-13.5
4	25	Cement-sand solution	0.76	0.03	-13.5	-14.0
5	20	Complex (sand, lime, cement) solution	0.7	0.03	-14.0	-14.4
		Resistance heat transfer		0.04	-14.4	-15.0
Thermal resistance of the enclosing structure:				2.26		
Thermal resistance of the enclosing structure [R]:				2.42		
Required thermal resistance						
Sanitary and hygienic requirements [Rc] –				0.60		
Standardized value of element-by-element requirements [Rэ] –				1.40		
Basic value of element-by-element requirements [RT] –				2.22		

Sanitary and hygienic requirements: $R > R_c$

The enclosing structure meets sanitary and hygienic standards for thermal protection. Element-by-element requirements: $R > R_T$

The enclosing structure meets thermal protection standards regardless of other requirements.

To analyze the temperature distribution in the wall in more detail, numerical simulation of heat transfer was performed.

The simulation showed that: - the temperature of the inner surface is about 18-19°C; - the temperature of the outer surface is about -14°C; - the minimum temperature values are observed in the zones of structural inhomogeneities.

Graphical analysis of the temperature field shows a smooth change in temperature through the thickness of the wall.

The calculation results indicate that: - the inner surface of the wall remains above the dew point temperature; - there is no risk of moisture condensation under normal operating conditions.

Heat flow analysis showed that the main heat flow passes through areas with the lowest thermal resistance. However, the shape of the T-shaped block results in:

- an extension of the thermal path; - a redistribution of the heat flow; - a reduction in the intensity of heat transfer through the masonry.

Thus, the block geometry plays a key role in reducing heat loss.

The main operational advantages of a wall made of T-shaped thermal blocks include: - Reduction of thermal bridges - The absence of through vertical seams significantly reduces heat loss.

- Increased energy efficiency - The design ensures a stable temperature regime inside the premises.

- Durability - Basalt insulation retains its properties for a long time.

- Structural stability - The cement-sand shell ensures high strength of the block.

Conclusion

The study showed that the use of T-shaped thermal blocks is a promising way to improve the energy efficiency of buildings.

Key findings:

- the geometry of the block eliminates heat loss through vertical seams;
- the thermal characteristics of the structure comply with modern standards;
- numerical modeling confirms the effectiveness of the design;
- the use of this technology can reduce the energy consumption of buildings.

The development of such design solutions can play an important role in the formation of an energy-efficient building environment.

LITERATURE:

1. O'zbekiston Respublikasi "Energy tejash to'g'risida" gi qonuni.
2. KMK 2.01.04-97* Thermal engineering of buildings.
3. IIIHK 2.01.04-2018 Thermal protection of buildings.
4. International Energy Agency. World Energy Outlook.
5. ISO 6946: Thermal resistance of building components.
6. Straube J. Building Science for Building Enclosures.
7. Ozel M. Thermal performance of insulated walls.
8. European Commission. Energy performance of buildings directive.
9. EN ISO 10211 Thermal bridges in building construction.
10. Kalamees T. Thermal bridge analysis.
11. Cabeza L. Advances in building thermal energy storage.
12. Bolikulovich K. M., Bakhodirovna R. D. Methodology for Calculation of the Temperature Field in the External Fencing Structures of Buildings. – 2023.

13. Bolikulovich K. M., Po'latovich M. B. CALCULATION OF THE TEMPERATURE FIELD OF EXTERNAL ENCLOSING STRUCTURES USING THE FINITE DIFFERENCE METHOD //Innovative: International Multidisciplinary Journal of Applied Technology (2995-486X). - 2024. - C. 165-169.

Internet site

<https://www.smartcalc.ru/thermocalc>