# Study on thermal physical detail of gas block wall structure without single source

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**Abstract.** This article presents the results of theoretical and experimental studies carried out at the physical heat level in a sample of an outer wall with a small block of a non-code gas block in order to improve the energy efficiency of the outer walls of newly built residential and public buildings. As a result of the studies, the overall thermal conductivity resistance of the outer wall consisting of a non-code small block block, the thermal conductivity coefficient of the wall layers, the temperature flow passing through the wall, the temperature in the wall layers and the heat resistance of the wall for the summer season were revealed. The theoretical thermophysical studies carried out are comparable to experimental studies on the wall model, recommendations have been developed to improve the energy efficiency of the external walls of buildings under construction on the basis of modern projects.

## 1. Introduction

In the majority of nations around the world, one of the pressing challenges is how much energy is used in buildings. In both commercial and residential structures, space heating and cooling account for up to 40% and 61% of the overall energy demand, respectively [1]. The building sector accounts for the largest portion of global energy usage, according to the International Energy Agency (IEA). The energy used for space heating and cooling is expected to be high by up to 12% and 37%, respectively, in 2050 [2] as a result of this trend continuing.

In accordance with the Action Strategy 2017-2021, developed by the President of the Republic of Uzbekistan Mirziyoyev Sh. M. And the decree of December 2016, the construction of residential and public buildings under new standard projects for low-income families in all regions of the republic began. For buildings of this type, thermal - physical - theoretical studies of external wall and roofing structures, the selection of energy-efficient building materials for external enclosing structures, their thermal and physical improvement, the creation of a normative microclimate in building farms, as well as the construction and design of energy-efficient residential buildings of this type are relevant. In addition, the thermal and physical characteristics of some domestic building materials and structures have not been fully studied. Therefore, designing energy-efficient buildings with external walls made of local materials, including non-homogeneous gas blocks, and increasing the thermal and physical energy efficiency of their external walls remains one of the urgent problems [3, 4, 5, 6].

The external wall structure consisting of a non-homogeneous gas block, which has not been studied in our country to date, was thermally improved and its constructive solution was developed. The thermo-physical properties of the developed non-homogeneous gas block external wall construction sample were fully studied as a result of theoretical and experimental experiments[7-12]. As a result of the conducted theoretical and practical thermal physical research, in order to increase the energy efficiency of the external walls, the cavities of small blocks consisting of five-cavity non-homogeneous gas blocks are filled with penoplex and heavy concrete. based on the results of theoretical and practical research. Scientifically based energy-efficient structural solutions for the external walls of the buildings being constructed based on modern projects are recommended.

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## 2. Materials and Methods

Thermal-physical properties of non-homogeneous external wall sample determined experimentally in laboratory conditions. In order to carry out thermal physical experiments on the sample of the external wall structure consisting of non-homogeneous gas blocks, wall gas block blocks with a density of 600-800 kg/m$^3$ were prepared at "MINTAQA BINO MARKAZI" LLC No. 5 and brought to the laboratory of the Department of Building and Construction Design of Samarkand State University of Architecture and Construction. The size of the blocks is 600x400x190 (h) mm. and they were installed in the climatic chamber of the laboratory room. During the installation of the wall sample, the cavities of gas block blocks were filled with penoplex and heavy concrete. Thermosensors were placed on the wall layers. Their picture and the circuit with the thermometers are shown in the following pictures.

**Fig. 1.** Installation of thermosensors on the external wall sample of non-homogeneous gas block and general view of the climate chamber

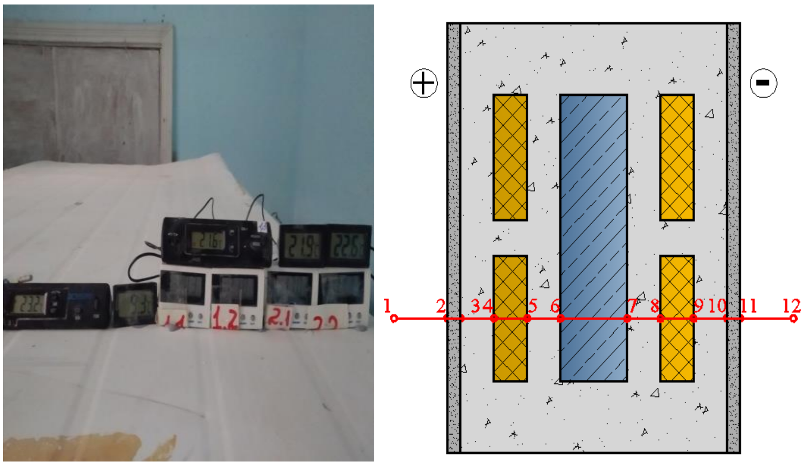


**Fig. 2.** Thermosensors in the wall sample and their placement scheme

**Experiment procedure. Experimental heat-physical studies include:**

1. Selection of energy-efficient local building material for the exterior wall as a result of research;
2. Determining the heat transfer coefficient of the gas block material with a selected density of 800kg/m$^3$;
3. Opening 1 large and 4 small holes from gas block material with selected dimensions of 600x400x190(h) mm;
4. Build a 1.2x1.2x0.4 wall model from prepared 5-hole gas block samples;
5. Fill the 4 small holes of the prepared wall model with penoplex and the remaining 1 large hole with heavy concrete;

6. When filling the cavities with penoplex and heavy concrete, pouring thermosensors into the layers;
7. After a certain period of time, after the wall model has dried, build an artificial climate chamber;
8. Installation of a heating and cooling device in the constructed artificial chamber;
9. After the artificial chamber is ready, start the cooling device;
10. 3 days after the start of the cooling device, take a count and record it in the journal every 3 hours;
11. Counting for three days.

The size of the non-homogeneous wall sample is 1200x1200x400 mm. Winter thermal physics laboratory experiments were conducted from May 1 to May 4, 2022. The calculated thermal-physical properties of a wall consisting of a non-homogeneous gas block are presented in Table 1.

**Table 1.** Thermal-physical parameters of the outer wall of non-homogeneous gas blocks

| Layer name | Thickness, m | Heat transfer coefficient, W | Density, kg/m$^3$ | Heat absorption coefficient W/m$^2$ $^0$C | Heat transfer resistance; R, m$^2$ $^0$C/W | Thermal inertia; D |
|---|---|---|---|---|---|---|
| Cement-sand plaster | 0,02 | 0,76 | 1800 | 9,6 | 0,026 | 0,37 |
| Gas block | 0,40 | 0,22-0,33 | 600-800 | 3,36-4,92 | 1,8-1,2 | 6,04 |
| Penoplex | 0,05 | 0,029-0,031 | 35-45 | 0,03-0,032 | 1,56 | 0,05 |
| Heavy concrete | 0,10 | 1,74-1,92 | 2400-2500 | 16,77-17,98 | 0,052 | 0,93 |
| Cement-sand lime plaster | 0,03 | 0,7 | 1700 | 8,95 | 0,043 | 0,38 |

The process of experimentally determining the thermal-physical properties of an external wall sample consisting of non-homogeneous gas blocks in laboratory conditions is presented in the following pictures.

## 3. Results and Discussion

Results of thermal physical experiments. A wall sample made of non-homogeneous gas block blocks was installed in the laboratory of the "Building and Construction Design" department in April 2022. Thermal-physical practical experiments on the installed wall sample were conducted in May 2022. As a result of the experiments, the following were determined from the main thermal-physical parameters:

1. Temperature in wall layers consisting of non-homogeneous gas block blocks;
2. Temperature in the room where the experiment is being conducted;
3. Outdoor temperature;
4. Heat flow (quantity) passing through the wall sample;
5. Heat transfer coefficient of the layer materials that make up the external wall sample.

According to the indicators obtained as a result of practical experiments, heat-physical calculations were performed in the following order:

The heat transfer resistance of the barrier structure was calculated according to the following formula:

$$R = R_B + R_K + R_H = \frac{t_B + \tau_H}{q_\Phi} + \frac{\tau_K + \tau_H}{q_\Phi} + \frac{\tau_H + t_H}{q_\Phi} \tag{1}$$

here $R_B$ and $R_H$ is the thermal conductivity resistance of the inner and outer surfaces of the barrier structure, (м$^2$ $^0$C)/ Vt; $R_K$- thermal resistance of the same type of fencing zone, (м$^2$ $^0$C)/ Vт; $t_B$ва $t_H$ – values of indoor and outdoor air temperature measurements for the accounting period, respectively, $^0$C; $\tau_B$ and $\tau_B$ – values of measurement of internal and external surfaces, respectively, for the accounting period, $^0$C; $q_\Phi$- the average real density of heat flows for the accounting period, Vt/m$^2$;

The thermal resistance of individual layers of the barrier structure is determined according to the following formula:

$$R_{c\Delta} = \frac{\Delta\tau}{q_\phi} \tag{2}$$

here $\Delta\tau$ - temperature difference at the layer boundaries, $^0$C;

In order to compare the actual values of the thermal conductivity of the materials used in the construction with the design values, the thermal conductivity of the layer material is determined according to the following formula.

$$\lambda = \frac{\delta}{R_{c\Delta}} \quad (3)$$

here δ – layer thickness, м.

The results of measuring the temperatures in the layers of the wall sample consisting of a non-homogeneous gas block (for the winter season) are presented in table-1. Using this application, we determine the thermal resistance of individual layers of the wall sample using the above formula. These calculations are presented in a 3-3 section. The results of calculations for sections 1-1 and 2-2 are presented in the appendix.

$$R_И = \frac{tu + \tau u}{q_ф} = \frac{0,6}{5,12} = 0.117 м^{2°}C/Вт; \quad R_1 = \frac{0.26}{5,12} = 0.051 м^{2°}C/Вт;$$

$$R_2 = \frac{1,27}{5,12} = 0.248 м^{2°}C/Вт; \; R_3 = \frac{6,13}{5,12} = 1,198 м^{2°}C/Вт$$

$$R_4 = \frac{0,6}{5,12} = 0,117 м^{2°}C/Вт; \; R_5 = \frac{0,7}{5,12} = 0.137 м^{2°}C/Вт;$$

$$R_6 = \frac{0,8}{5,12} = 0,156 м^{2°}C/Вт; \; R_7 = \frac{7,19}{5,12} = 1,41 м^{2°}C/Вт;$$

$$R_8 = \frac{0,91}{5,12} = 0,178 м^{2°}C/Вт \; R_т = \frac{1,09}{5,12} = 0,213 \; м^{2°}C/Вт$$

$$\sum R_{УМ} = 3,825 \; м^{2°}C/Вт;$$

We determine the average value of heat transfer resistances for sections 1-1, 2-2, and 3-3:

$(R_{1-1} + R_{2-2} + R_{3-3})/3 = (3,092 + 3,252 + 3,825)/3 = 3,39$ (м$^2$. $^0$C)/ Вт

**Table 2.** 3-day average results of measuring temperatures in layers of gas block, penoplex and heavy concrete sections

| The number of sensors / A day | Average value | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1- day | Average | 24,0 °C | 23,21 °C | 22,98 °C | 21,24 °C | 15,74 °C | 15,12 °C | 14,21 °C | 13,61 °C | 6,82 °C | 5,44 °C | 4,07 °C | 4,34 °C |
| 2- day | Average | 23,8 °C | 23,3 °C | 23,06 °C | 21,34 °C | 15,69 °C | 15,02 °C | 14,14 °C | 13,51 °C | 6,73 °C | 5,42 °C | 4,53 °C | 3,78 °C |
| 3- day | Averag e | 23,48 °C | 22,98 °C | 22,68 °C | 20,91 °C | 15,07 °C | 14,56 °C | 14,25 °C | 13,08 °C | 5,08 °C | 5,04 °C | 4, 03 °C | 3,58 °C |
| Total daily average | | 23,76 °C | 23,16 °C | 22,9 °C | 21,63 °C | 15,5 °C | 14,9°C | 14,2°C | 13,4°C | 6,21 °C | 5,3°C | 4,21 °C | 3,9 °C |

**Table 3.** The result of thermal physical experiments conducted on a sample of an external wall consisting of gas blocks with non-homogeneous pores filled with penoplex and heavy concrete. In the example of aerated concrete, penoplex and heavy concrete section

| Naming | Temperature; $^0C$, | Temperature difference at the boundaries of construction layers, $^0C$ | Barrier construction layers Heat transfer resistance, $m^2 \cdot {}^0C/Vt$ | | Layer thickness, м. | Construction layers Heat transfer coefficient, $Vt/m \cdot {}^0C$ | |
|---|---|---|---|---|---|---|---|
| | | | Experimental | Accounting | | Experimental | Accounting |
| Indoor air | 23,76 | - | - | - | - | - | - |
| Inside | $\tau_B = 23,16$ | 23,76-23,16=0,6/5,12 | $R_в = (t_в - \tau_в)/q = 0,117$ | $R_в = 0,115$ | | | |
| The temperature at the boundary of gas block with internal plaster. | $\tau_1 = 22,9$ | $\tau_B - \tau_1 = 23,16 - 22,9 = 0,26/5,12$ | $R_1 = (\tau_B - \tau_1)/q = 0,051$ | $R_1 = 0,029$ | $\delta_1 = 0,02$ | $\lambda_1 = 0,39$ | $\lambda_1 = 0,7$ |
| The temperature at the boundary of the pinoplex with the gas block. | $\tau_2 = 21,63$ | $\tau_1 - \tau_2 = 22,9 - 21,63 = 1,27/5,12$ | $R_2 = (\tau_1 - \tau_2)/q = 0,248$ | $R_2 = 0,151$ | $\delta_2 = 0,05$ | $\lambda_2 = 0,20$ | $\lambda_2 = 0,33$ |
| The temperature at the boundary of the gas block with penoplex. | $\tau_3 = 15,5$ | $\tau_2 - \tau_3 = 21,63 - 15,5 = 6,13/5,12$ | $R_3 = (\tau_2 - \tau_3)/q = 1,198$ | $R_3 = 1,72$ | $\delta_3 = 0,05$ | $\lambda_3 = 0,041$ | $\lambda_3 = 0,029$ |
| Temperature at the boundary of heavy concrete with gas block. | $\tau_4 = 14,9$ | $\tau_3 - \tau_4 = 15,5 - 14,9 = 0,6/5,12$ | $R_4 = (\tau_3 - \tau_4)/q = 0,117$ | $R_4 = 0,151$ | $\delta_4 = 0,05$ | $\lambda_4 = 0,42$ | $\lambda_4 = 0,33$ |
| Temperature at the boundary of gas block with heavy concrete. | $\tau_5 = 14,2$ | $\tau_4 - \tau_5 = 14,9 - 14,2 = 0,70/5,12$ | $R_5 = (\tau_4 - \tau_5)/q = 0,137$ | $R_5 = 0,052$ | $\delta_5 = 0,1$ | $\lambda_5 = 0,73$ | $\lambda_5 = 1,92$ |
| The temperature at the boundary of the pinoplex with the gas block. | $\tau_6 = 13,4$ | $\tau_5 - \tau_6 = 14,2 - 13,4 = 0,80/5,12$ | $R_6 = (\tau_5 - \tau_6)/q = 0,156$ | $R_6 = 0,151$ | $\delta_6 = 0,05$ | $\lambda_6 = 0,32$ | $\lambda_6 = 0,33$ |
| The temperature at the boundary of the gas block with penoplex. | $\tau_7 = 6,21$ | $\tau_6 - \tau_7 = 13,4 - 6,21 = 7,19/5,12$ | $R_7 = (\tau_6 - \tau_7)/q = 1,41$ | $R_7 = 1,72$ | $\delta_7 = 0,05$ | $\lambda_7 = 0,035$ | $\lambda_7 = 0,029$ |
| The temperature at the border of gas block and external plaster. | $\tau_8 = 5,30$ | $\tau_7 - \tau_8 = 6,21 - 5,30 = 0,91/5,12$ | $R_8 = (\tau_7 - \tau_8)/q = 0,178$ | $R_8 = 0,151$ | $\delta_8 = 0,05$ | $\lambda_8 = 0,28$ | $\lambda_8 = 0,33$ |
| Temperature at the outer surface. | $\tau_9 = 4,21$ | $\tau_8 - \tau_9 = 5,30 - 4,21 = 1,09/5,12$ | $R_9 = (\tau_8 - \tau_9)/q = 0,213$ | $R_9 = 0,026$ | $\delta_9 = 0,02$ | $\lambda_9 = 0,091$ | $\lambda_9 = 0,76$ |
| Outside air | 3,90 | - | - | - | - | - | - |
| | | | **$R_y$ = 3,825** | **$R_y$ = 4,266** | | | |

Heat - the heat transfer resistance determined as a result of physical experiments, the relative error of which compared with the calculated heat transfer resistance did not exceed 8% with the probability of reliability.
We calculate the thermal conductivity coefficients of construction layer materials determined as a result of experiment.

$$\lambda_1 = \frac{\delta_1}{R_1} = \frac{0{,}02}{0{,}051} = 0{,}39\ \text{Вт/м°C};\ \lambda_2 = \frac{\delta_2}{R_2} = \frac{0{,}05}{0{,}248} = 0{,}20\ \text{Вт/м°C};$$
$$\lambda_3 = \frac{\delta_3}{R_3} = \frac{0{,}05}{1{,}198} = 0{,}041\ \text{Вт/м°C};\ \lambda_4 = \frac{\delta_4}{R_4} = \frac{0{,}05}{0{,}117} = 0{,}42\text{Вт/м°C};$$
$$\lambda_5 = \frac{\delta_5}{R_5} = \frac{0{,}10}{0{,}137} = 0{,}73\ \text{Вт/м°C};\ \lambda_6 = \frac{\delta_6}{R_6} = \frac{0{,}05}{0{,}156} = 0{,}32\ \text{Вт/м°C}.$$
$$\lambda_7 = \frac{\delta_7}{R_7} = \frac{0{,}05}{1{,}41} = 0{,}035\ \frac{\text{Вт}}{\text{м}}\text{°C};\ \lambda_8 = \frac{\delta 8}{R_8} = \frac{0{,}05}{0{,}178} = 0{,}28\text{Вт/м°C};$$
$$\lambda_9 = \frac{\delta_9}{R_9} = \frac{0{,}02}{0{,}213} = 0{,}091\text{Вт/м°C}.$$

Above, as a result of thermal-physical experiments, the temperature difference at the boundary of the structural layers, the resistance of the layer material to heat transfer and the heat transfer coefficients are shown in Table 3.
In order to compare with the heat-physical indicators determined from practical experiments, we also put the heat transfer resistances and heat transfer coefficients of the theoretically determined construction in this table.
It is known from the table that the experimentally determined total resistance to heat transfer in a wall sample consisting of a non-homogeneous gas block $R_y$= 3,825 ($m^2\ {}^0C$)/ Вт, and theoretically determined heat transfer resistance is equal to $R_y$= 4,266 ($м^2\ {}^0C$)/ Вт. The experimentally determined heat transfer resistance of the wall sample is 10% less than the calculated heat transfer resistance. The main reason for this was excess moisture in the sample of the gasblock block installed in the climate chamber. It contains large-sized small holes, and its heat transfer coefficient is also large. For calculations, the heat transfer coefficient taken from QMQ 2.01.04 – 18 is equal to 0.22-0.33 W/($m^2\ {}^0C$). As a result of the experiment, the heat transfer coefficient of the non-homogeneous gas block block is 0.32-0.42 W/($m^2\ {}^0C$). In addition, the density of gas blocks is 600-800 kg/$m^3$.
The density of the gas block listed in QMQ 2.01.04–18is 600-800 kg/$m^3$. So, the greater the density, the greater its heat transfer coefficient [13, 14].

## 4. Conclusion

The average experimental heat transfer resistance determined by the gas block, penoplex and heavy concrete section of the non-homogeneous gas block wall sample that we recommend is 3,825 ( $m^2$. ${}^0C$)/W, fully meeting the requirements of the first, second and third level of thermal protection specified in QMQ 2.01.04-18 answers.
It also leads to savings in excess and additional energy, money and labor costs.
By providing a moderate microclimate in the room, it positively affects people's living and working activities.
This framework enables the design and construction of low-rise energy-efficient residential and public buildings in the community.

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