Masonry using "Termo Blok" blocks

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Abstract. The following article reviews a new masonry energy-efficient erection technology using hollow blocks termosblocks, which provides construction of vertically continuous and horizontally intermittent insulating layer. Thermal insolent insets are placed inside the inner cavities of the block. The study is aimed to establish the boundaries of using this technology. Therefore, central compression tests were conducted in order to determine the tensile strength of the block. Also, a reduced thermal resistance and energy-efficiency of a masonry fragment was calculated. In order to verify thermal engineering model, an experiment was conducted in which the temperature inside the structure was measured using contact temperature sensors. Additional control of temperature fields spreading was proceeded using thermal imager. On the basis of the obtained data, termosblocks masonry operational characteristics were estimated, and the study result was defined.

1 Introduction

1.1 Blocks description

Hollow block termosblocks are used for construction of single-layer barrier structures of external walls. Low mass and large size enable to increase the masonry erection speed in comparison with traditional technology of bricklaying.

Basic types of blocks that are widely used for masonry construction are presented in figure 1.

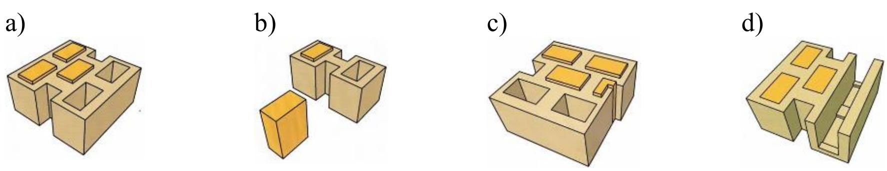


Fig. 1. The main common blocks types, where: a – main row, b – ½ main row of, c – corner block, d –forming rebar framework.

The variety of blocks enables to construct a wall that meets basic functional requirements. The main common block is a rectangular parallelepiped with internal cavities, which are positioned in three rows. Thermal insulating inserts are to be placed inside the inner cavities of the block. A special groove in the end face of the block ensures that thermal inserts of the middle row are placed with fixed distance. Two adjacent block's grooves form a cavity of the same size as an inner cavity of the block. Termosblocks can be manufactured using different concrete mixtures. It enables producing blocks with different technical specifications for various operating conditions [1-8].

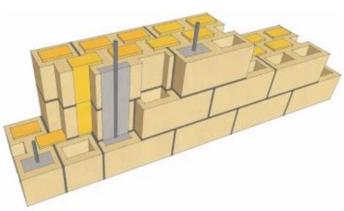
1.2 Bricklaying technology description

A significant profit of the following technology is the speed of masonry erection. Blocks are delivered to the construction site with preinstalled thermal insulating inserts. An insert is not firmly attached to the cavity wall, which is why it can move inside the cavity. The height of the heat-insulating insert exceeds the height of the block, by less than twice the thickness of the masonry mortar. Basic layer blocks are stacked on the prepared base and binded with masonry mortar to each other along the end faces.

The voids resulting from the blocks connection are to be filled with heat-insulating inserts. Upper layer blocks are stacked on top of the finished layer offset by half of the masonry module. It ensures matching positions of block's inner cavities in mating layers of masonry. As a result, basic layer heat-insulating inserts penetrate into upper layer block's cavities. It allows us to partially remove cold joints passing through the masonry joint material and increase thermal uniformity of structures [2].

Sometimes bulk insulating materials such as granulated polystyrene can be used to fill voids. Horizontal reinforcement is used to increase bearing capacity of the wall. It is impossible to use traditional reinforcement prefabricated grids. It implies the need of manufacturing of a special mesh rebar frameworks and supply them with the blocks as a kit. Internal cavities enable to use blocks as a permanent formwork during constructing monolithic columns inside the wall. Schematic masonry structure is presented in Figure 2.

a)



b)

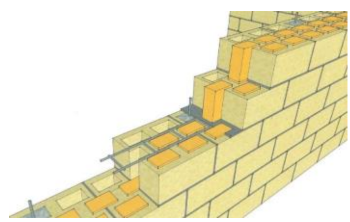


Fig. 2. Schematic masonry structure, where: a - the vertical reinforcement of columns, b - horizontal reinforcement rods.

2 Central compression tests

To establish the boundaries of using described blocks as carrier structures termosblocks were tested to determine tensile strength at a central compression. The test specimen was made of claydite-concrete with a set density $\rho = 1400$ kg/m^3 according with dimensions indicated in Figure 3. The cross sectional area of the block excluding voids is 857 cm^2.

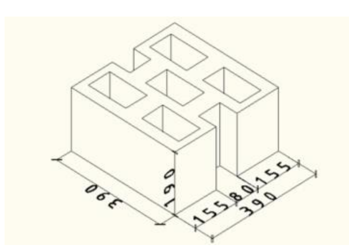


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Fig. 3. Test specimen dimensions.

Central compression tests were carried out using servo-hydraulic tensile-testing machine Instron 1000 HDX. The tests were conducted in accordance with the procedure described in GOST 8462-85 (Russian Standard) under the following conditions:

- Air temperature in the lab +20 °C
- Relative humidity of 65% lab
- Barometric pressure 760 mm Hg

Test results are presented in chart form and represent the change of stress-strain state of the specimen shown in Figure 4, tension equal to 4.94 MPa corresponds to destruction.

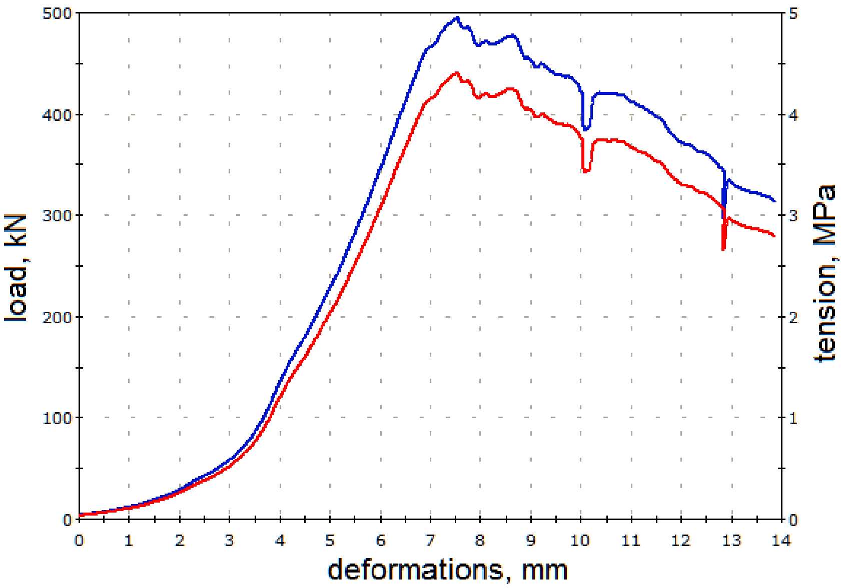

Fig. 4. Chart showing the change of stress-strain state of the sample.

Pictures made during test are shown in Figure 5.

a) b)

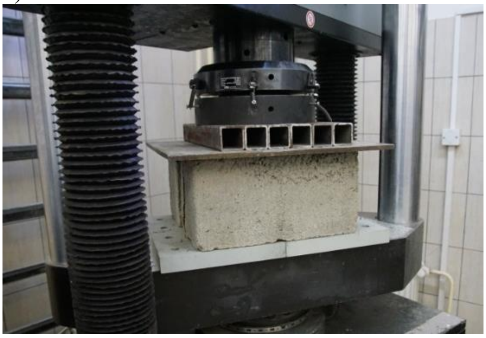

Fig. 5. Central compression test.

Taking into account the data above we can conclude that it is impossible to use "termoblocks" as carrier structures without erecting reinforced concrete columns in internal cavities of blocks. Despite that reinforced concrete columns increase bearing capacity of the wall, it creates a heterogenic temperature spreading along the inner surface of the structure.

3 Thermotechnical calculations

Thermal resistance calculation of different construction parts was proceeded using THERM 7.6 software to estimate thermotechnical heterogeneity of the brickwork. Overall energy efficiency assessment is presented as an analysis of reduced thermal resistance calculation in the cross section through the body of termosblocks.

Figure 6 represents geometric characteristics of the examined cross section. The optimum temperature for premises has been adopted as the inside air rated temperature during the cold time of year according to GOST 30494-2011 (Russian Standard) equal to + 20 °C. Outside air temperature corresponds to the temperature of the coldest five days with probability equal to 0.92 (92% probability) for Moscow conditions adopted according to SP 131.13330.2012 (Russian Standard) equals -25°C. The heat transfer coefficient of the inner and outer walls surfaces is adopted according to SP 50.13330.2012 (Russian Standard) and respectively equal 8.7 W/m^2·°C and 23 W/m^2°C.

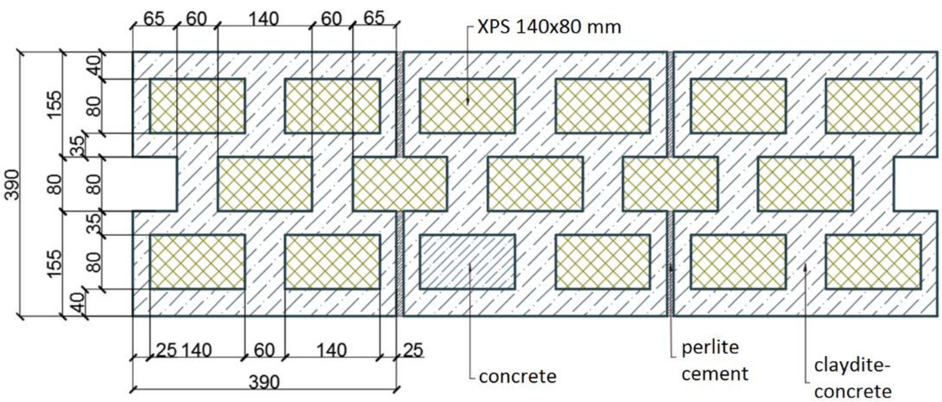

Fig. 6. Cross section scheme.

Materials heat transfer coefficients are adopted according to operating conditions B and are equal to (the following values):

- Claydite ρ = 1400 kg / m^3; λ = 0.55W/m·°C
- Perlite cement for masonry joints; λ = 0.35W/m·°C
- Extruded polystyrene; λ = 0.035W/m·°C
- Reinforced concrete; λ = 2.04W/m·°C
- Steel rebar; λ = 50W/m·°C

Thermotechnical modeling results are presented in figure 7. Minimal temperature of inner construction surface was 15.6 °C

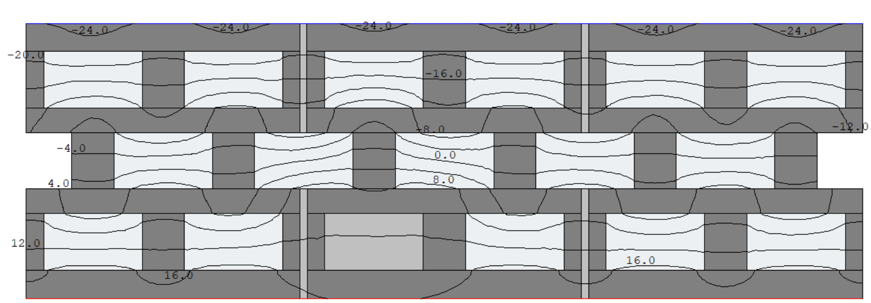

Fig. 7. Thermotechnical modeling of masonry blocks modeling results/ Isotherms inside the structure.

Boundaries of temperature zones, for determining the thermal resistance have been set on the basis of the obtained data. The boundaries of these zones are shown in Figure 8.

Zone №1 resistance outside the direct influence of the thermal joint

Zone №2 resistance in the zone of direct influence of the thermal joint

Zone №3 resistance of ½ of the reinforced block

Zone №4 resistance of ½ of block without reinforcement

Zone №5 reduced resistance of block without reinforcement

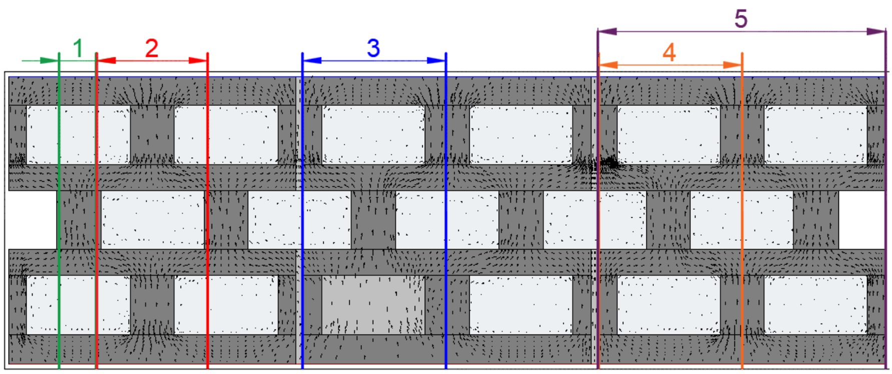

Fig. 8. Boundaries of temperature zones for the thermal resistance calculation.

According to the thermal resistance calculation results using THERM 7.6 software the following result was obtained:

$R_1 = 3.10 m^2 \cdot °C/W$

$R_2 = 1.88 m^2 \cdot °C/W$

$R_3 = 1.90 m^2 \cdot °C/W$

$R_4 = 2.18 m^2 \cdot °C/W$

$R_5 = 2.20 m^2 \cdot °C/W$

$R_0 = 2.06\ m^2 \cdot °C/W$

4 Climate chamber tests

Tests on similar cross section constructions were conducted in order to confirm the results of thrmotecnical modeling. A wall of 4 termosblocks wide and 7 termosblocks high was erected on the test bench KS 3025/650. Construction materials are similar to the ones were used for model construction. One of the inner cavities was reinforced and filled with concrete.

The contact temperature sensors were placed into masonry joint between fourth and fifth block layers, as well as inside block's inner cavities. Temperature measurement was conducted using a digital thermometer USB MP707R and thirteen digital temperature sensors DS18B20. Images made during the construction of the structure are presented in Figure 9. The scheme of the sensors placement inside the structure is presented in Figure 10.

Curing of concrete and masonry mortar was held at room temperature. At the end of incubation period test bench refrigerators got involved into the process. Recording of the data from temperature sensors started as soon as thermal flows stabilized. During the whole fourteen day period of measurements within the test bench maintained at a temperature of -22±1.5 °C.

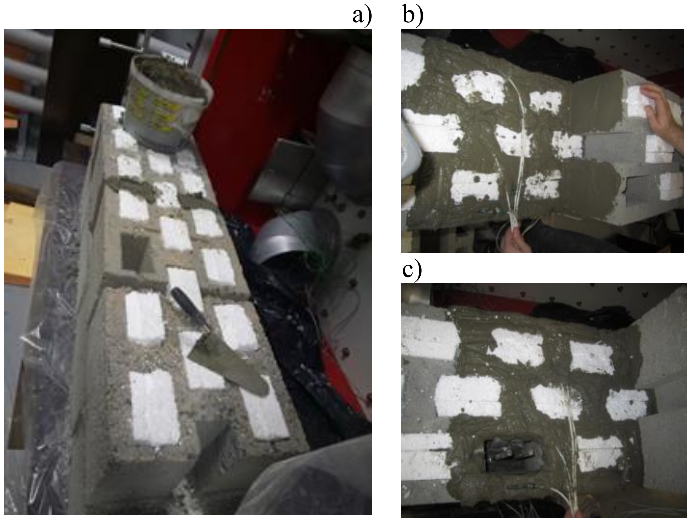

Fig. 9. Masonry erection.

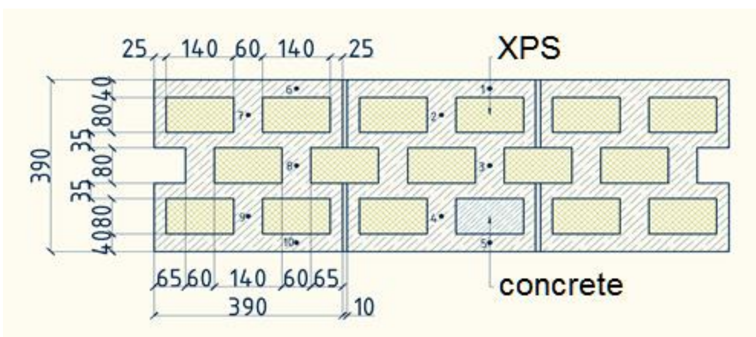

Fig. 10. The scheme showing the sensors placement inside the structure, where: a – inside a msonry joint.

The average temperature inside the lab during the fourteen days testing period was 20 °C. The temperature measurement results are presented in Table 1.

Table 1. Temperature measurement results.

	29.05	**30.05**	**01.06**	**05.06**	**07.06**
1	-17.56	-16.56	-16.94	-18.56	-18.87
2	-8.25	-8.19	-8.44	-9.88	-9.75
3	2.75	2.94	2.56	0.81	1.00
4	12.00	12.00	11.63	9.81	10.50
5	14.81	14.88	14.44	12.63	13.56
6	-17.31	-16.25	-16.56	-18.44	-18.50
7	-8.88	-8.81	-9.00	-10.31	-10.31
8	2.00	2.25	1.94	0.25	0.56
9	11.50	11.50	11.08	9.25	9.25
10	17.31	17.19	16.83	14.63	14.63
11	-5.48	-5.19	-6.08	-8.06	-8.16
12	12.69	12.75	12.44	10.56	11.25
13	14.06	14	13.5	11.63	12.56

Thermal imaging using FLUKE Ti 50FT-10/20 was made during the test in order to illustrate the thermal fields spreading. Thermal imaging results are presented in Figure 11.

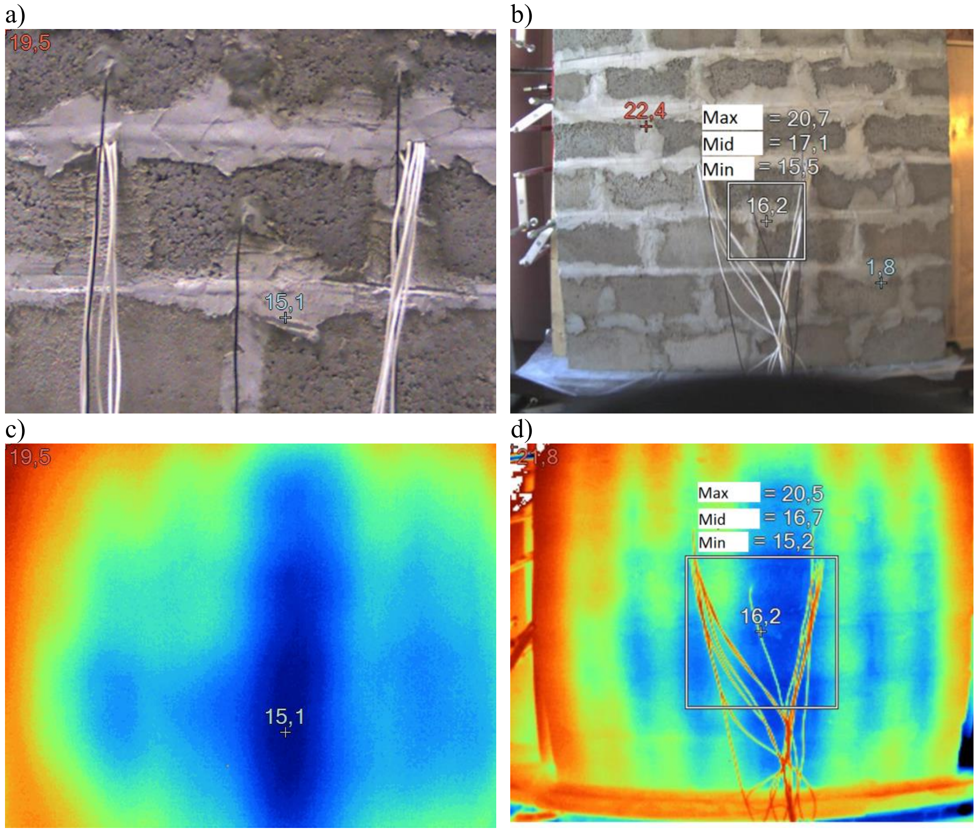

Fig. 11. Thermal imaging results.

The test results perfectly correlate with thermotechnical modeling results, which enables to confirm the above thermal resistance calculation results.

5 Conclusions

1. On the basis of the above data we can conclude that the tested construction is non-compliant of energy efficiency requirements set out in SP 50.13330.2012 (Russian Standard) for conditions of Moscow. The maximum permitted temperature difference between the internal air and the structure surface set out in SP 50.13330.2012 (Russian Standard) is exceeded under the coldest five days conditions for Moscow, when block's internal cavities are filled with reinforced concrete. Based on the study results the reviewed masonry erection technology can be used for external walls construction in individual housing, industrial buildings and certain types of public and administrative buildings.
2. It is impossible to use termosblocks without erecting reinforced concrete columns in internal cavities of blocks as a load-bearing structure for constructions higher than two story building, due to insufficient bearing capacity of the reviewed block.

6 Recommendations

It is necessary to point out that above stated problems have a number of technologically simple solutions, which may expand the boundaries of using the reviewed technology. For example, thermal resistance can be increased by including an additional row of insulation, thereby increasing the block thickness. Using this solution the block's mass has to remain at the same level because it provides the high speed of masonry erection, which is why it is necessary to reduce the block's height. Construction of additional external insulating layer above the masonry is another solution. It allows using reviewed technology for curtain walls construction; however an additional insulating layer has a negative impact on work performance speed. In this case the reviewed technology loses its advantages over the traditional curtain wall erection technology using lightweight concrete and ceramic blocks.

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