Строительство уникальных зданий и сооружений. ISSN 2304-6295. 3 (78). 2019. 23-35

Construction of Unique Buildings and Structures

journal homepage: www.unistroy.spbstu.ru`

doi: 10.18720/CUBS.78.2

Энергоэффективный стеновой керамзитобетонный блок

Energy-efficient expanded clay concrete wall block

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КЛЮЧЕВЫЕ СЛОВА
керамзитобетон;
керамзитобетонные блоки;
стеновой материал;
проектирование блока;
несъемная опалубка;
испытания блока;
сравнение материалов;

KEYWORDS
expanded clay concrete;
expanded clay concrete blocks;
wall materials;
designing of a block;
fixed formwork;
testing of a block;
materials comparison;

АННОТАЦИЯ

На данный момент времени рынок стеновых материалов для малоэтажного коттеджного строительства остается весьма консервативен. Люди стремятся возводить стены коттеджей, используя всем привычные материалы – дерево (брус), кирпич, керамические, керамзитобенные или газобетонные блоки. В то же самое время относительно недавно появилась технология возведения стен коттеджей с помощью несъемной опалубки для бетона, которая совмещает в себе несущие, теплоизоляционные и ограждающие элементы одновременно. Целью данной работы является произведение анализа недочетов существующих блоков несъемной опалубки и с их учетом создание собственного блока несъемной опалубки, проведение его испытаний на прочность и сопротивление теплопередаче, а также анализа вышеупомянутых характеристик и их сравнение с наиболее распространенными энергоэффективными стеновыми материалами для коттеджного строительства, представленных на рынке Санкт-Петербурга. Сравнение с пятью наиболее распространенными энергосберегающими материалами показало, что запроектированный блок имеет гораздо более высокое значение R и одно из самых высоких значений прочности на сжатие. В дальнейшем планируется детально проработать состав материала, сделав блок более легким и прочным, а также продумать его форму для более удобной эксплуатации.

ABSTRACT

At the moment, the market of wall materials for low-rise cottage construction remains very conservative. People tend to erect the walls of cottages, using all the usual materials - wood (timber), brick, ceramic, gas concrete or aerated concrete blocks. At the same time, a relatively recently appeared technology of erecting walls of cottages with the help of a fixed formwork for concrete, which combines load-bearing, heat-insulating and enclosing elements at the same time. The aim of this work is to analyze the shortcomings of existing fixed formwork blocks and, taking them into account, create our own fixed formwork block, test its strength and heat transfer resistance, as well as analyze the above-mentioned characteristics and compare them with the most common energy-efficient wall materials for cottage construction presented on market of St. Petersburg. At the moment, the market of wall materials for low-rise cottage construction remains very conservative. People tend to erect the walls of cottages, using all the usual materials - wood (timber), brick, ceramic, gas concrete or aerated concrete blocks. At the same time, a relatively recently appeared technology of erecting walls of cottages with the help of a fixed formwork for concrete, which combines load-bearing, heat-insulating and enclosing elements at the same time. The aim of this work is to analyze the shortcomings of existing fixed formwork blocks and, taking them into account, create our own fixed formwork block, test its strength and heat transfer resistance, as well as analyze the above-mentioned characteristics and compare them with the most common energy-efficient wall materials for cottage construction presented on market of St. Petersburg. Comparison with the five most common energy-efficient materials showed that the designed block has a much higher R-value and one of the biggest values of compressive strength. In the future, it is planned to work out the composition of the material in detail, making it lighter and stronger. Besides that, it is planned to work out its shape, making the blocks convenient to operate.

Содержание

1. Introduction

At the moment, the market of wall materials for low-rise cottage construction remains very conservative. People tend to erect the walls of cottages, using all the usual materials - wood (timber), brick, ceramic blocks, expanded clay or aerated concrete blocks. At the same time, a relatively recently appeared technology of erecting walls of cottages with the help of a fixed formwork for concrete, which combines load-bearing, heat-insulating and enclosing elements at the same time.

Fixed formwork, in comparison with brick, aerated concrete, wood, and other materials, is a modern technology of walling. It is universal and reduces the risk of poor-quality work by minimizing the human factor. Also, in some cases, it can save money during the construction of buildings, by reducing the amount of construction work. For example, builders don't need to mount insulation, because it is already part of a fixed formwork. Fixed formwork is easy to install, as it usually consists of rectangular blocks with a groove-comb system. As a rule, it is made of concrete, expanded clay concrete with a heater in the form of polystyrene foam plates inserted inside the formwork itself. Despite all its advantages, this technology of walling is also imperfect and needs to be improved.

Before starting the design of the form and composition of the block, the problems of existing blocks of fixed formwork by manufacturers such as Durisol and Tecolit were studied in detail. It was found out that during the construction process, the blocks of the lower rows can crack and collapse when concrete is pouring onto them due to the pressure created by it. Besides, it is important to notice, that the sold blocks have quite a bad geometry whereupon the process of walling becomes more complicated. Moreover, bad blocks’ geometry leads to the formation of gaps between them. It should be noted that the design of the above blocks does not allow the use of any third-party insulation, excepting polystyrene foam, which is supplied. These shortcomings of existing blocks of fixed formwork for concrete will be taken into account when a new block will be designed.

Theoretical material about the production of expanded clay concrete and low-grade concrete is given in the articles [1-3].

Komissarenko B.S. and Balabanov M.C. described a technological technique that allows improving the physical, technical and operational properties of expanded clay concrete. It is the usage of deep vibrators. The design of such vibrator is described. It is shown that the usage of deep vibrators allows doubling the strength of the expanded clay concrete. [1]

Semikin P.V. processed the results of full-scale tests of expanded clay concrete samples. Multifactor mathematical models for the selection of expanded clay concrete composition have been built. [2]

Mamochkin S.A. conducted a similar study, where he identified the optimal composition of low-grade concrete and proposed a method of erecting wall structures from monolithic low-grade concrete using a universal fixed formwork. [3]

Theoretical material about the construction of walls using formwork is given in the articles [4-6].

Ryazanova G.N., Korotich I.O. and Prokopiev A.Y. outlined the issues that arise during the construction of external walls made of large-porous expanded clay concrete in a fixed formwork made of cement-bonded particleboards and the complexity of the technological problems associated with the processes of mixing and laying lightweight concrete mix into the formwork, solved by mathematical modeling methods. The main technological tasks in the construction of structures of large-porous expanded clay concrete were considered. Also, the specific volumes of aggregate and cement adhesive were estimated theoretically and numerically. The control parameters and functions for calculating the saturation depth of the aggregate grain are studied and the dependences of the relative impregnation depth dR / R on the effective porosity of various structures are derived. Conclusions about the further implementation of the adopted models and their study are drawn. [4]

The authors of the article “Quantitative and representative assessment of adherence to concrete formwork with and without coating" determined the specific adhesion stresses on the formwork sheaths using a new small peel test. They examined the correlation established between the signatures of formwork surfaces and concrete adhesion. Besides, they compared the uncoated and coated formwork shells and studied wettability using the sessile drop method to determine the level of capillary effect of concrete [5].

Theoretical material about the relevance of expanded clay concrete and similar materials is given in the articles [6-7].

The article “Prospects for the development of expanded clay production and structures based on it” shows the possibility of producing expanded clay with a density of 200 kg / m3 and the technology to produce expanded clay concrete products based on it. [6]

S. Rashidi, J.A. Esfahani, and N. Karimi have proven that porous materials used in dynamic insulation have significant potential for future research. Moreover, they found that inorganic porous insulators are prospective due to their favorable environmental characteristics. Finally, they said that more research is needed to determine the width of the porous substrate for cooling the roof [7].

Theoretical material about testing building materials and evaluating their characteristics is given in articles [8-15].

In the article “Heat transfer in building materials” several characteristic behaviors of building materials were identified, including thermal conductivity and emissivity. The article discusses new approaches to building materials (such as aluminum, brick, ceramics, cement, concrete, glass, marble, plaster and granite) to heat transfer and other related properties, and further discusses and classifies non-thermal and thermal properties of building materials. In conclusion, the review points to several important clues in future issues [8].

N.C. Balaji, Monto Mani, and B.V. Venkatarama theoretically investigated the dynamic thermal characteristics of building materials. Therefore, they studied the effect of various wall configurations, heat load, and heat transfer coefficient on the surface in time and reduction factors. They found that the thermal mass and thermal conductivity of the building material plays a major role in controlling the time lag and reduction coefficient. [9]

M.Z. Naser in his article deduced the properties of modern building materials at elevated temperatures. Moreover, he could modernize materials science and engineering in harsh environments. [10]

H. Sameer and S. Bringezu in their article calculated the input indicators of the life cycle with a modern database. Their methodology was applied for design with five options for exterior walls. The developed tool allows evaluating climate protection and resource efficiency. [11]

The article "Comprehensive correction of thermal conductivity of wet porous building materials with a static distribution of moisture and moisture transfer" proposed methods for calculating the thermal conductivity of wet building materials. Besides, the authors studied the effect of the hydrothermal medium on the thermal conductivity of materials. As a result, they corrected the thermal conductivity of wet porous building material. [12]

The authors of the article “Assessment of heat-resistant masonry from hollow expanded clay concrete stones” presented the results of an experimental study of the thermal conductivity of sandless expanded clay concrete and masonry from hollow expanded clay stone on a cement-sand mortar manufactured by Ecoresurs LLC (Togliatti). The thermal conductivity of the samples was studied according to the standard method in the laboratory of thermomechanical tests of the ASI SamGTU, using the calculation method according to the author's method using the THERM 6.2 computer program. [13]

Ivanov M.Y. and Porfiryeva E.N. gave the results and simulations of the tests of slabs made of expanded clay concrete. It was found that the bearing capacity corresponds to the design, the vertical deflection and the crack width do not exceed the maximum allowable. [14]

Zhirenko A.N., Kartsev N.V., and Krasnovsky R.O. compared the results of volumetric compression tests of heavy concrete and expanded clay concrete with the results of calculations according to phenomenological (N. I. Karpenko, B. V. Tyablikov) and structural (A. I. Markov) strength theories. Besides, they showed that for practical use, it is enough to predict strength with triaxial proportional compression according to the results of standard tests with uniaxial compression (margin of error 10–20%). [15]

Theoretical material about the analysis of the advantages and disadvantages of the use of expanded clay concrete in construction is presented in [16–20].

Bondar V.V. presented the accumulated global experience in the use of structural expanded clay concrete, including high-strength concrete (in the construction of civil and industrial buildings, hydraulic and bridge structures, in road construction). The main advantages and disadvantages were identified during the life cycle of objects - from the design stage to the operation. The requirements of the design standards in the Republic of Belarus and the world concerning the physicomechanical, technological properties of structural expanded clay concrete, their durability, differences from so-called normal (ordinary) density concrete are considered. The analysis of promising directions of the development of expanded clay and reinforced concrete considering the intensive development of building chemistry about the modification of concrete to increase their corrosion resistance, workability and compressive strength. The main issues that require additional theoretical and experimental studies are identified. [16]

Semenyuk S.D. and Moskalkova Yu.G. analyzed structural and operational advantages and disadvantages of expanded clay concrete. Research goals: development of methods for leveling the shortcomings of expanded clay concrete as a building material. Research hypothesis: the development of technologies and several technological methods, which will minimize the disadvantages of expanded clay concrete as an affordable structural material, while fully preserving its advantages. Research methods: scientific abstraction, analysis, and synthesis. Achievements: technological methods for minimizing the shortcomings of expanded clay concrete are proposed. [17]

Kramarenko A.V., Putilova M.N., and Nikitina K.V. presented the results of testing expanded clay concrete of various classes in terms of compressive strength and density, formulas are proposed for determining the limits of the formation of micro- and macro cracks. Based on the research results, an empirical coefficient was introduced considering the density class of lightweight concrete in the calculation of microcrack formation. A technique is proposed for determining the upper and lower limits of microcrack formation for lightweight concrete of various classes in terms of compressive strength and density. The calculation is harmonized with the provisions of Eurocode 2. At the same time, good convergence with experimental data is ensured. [18]

The authors of “The effect of the pre-wetting level of expanded clay lime on early age-dependent autogenous shrinkage of lightweight aggregate from concrete” quantitatively investigated autogenous shrinkage of LWAC at an early age with different degrees of wetting of LWA when the same pure water-cement ratio (NWC) or the general water-to-water ratio was used cement (TWC). During the liquid phase and the skeleton formation phase, the positive effect of 24-hour pre-moistened expanded clay on early age-related autologous shrinkage of LWAC is evident. During the quenching phase, LWACs show small expansion strains. Therefore, autogenous shrinkage of LWAC at an early age decreases with increasing degree of expanded clay moisturization for the same NWC or TWC. [19]

Jianqing Gong, Wei Zeng, and Wenjie Zhang studied the effect of shrink reducing agent and polypropylene fiber on shrinkage of expanded clay concrete. This article reports on a study of the effect of shrink reducing agent (SRA) and polypropylene fiber (PPF), individually and in combination, on expanded clay concrete (CC). The results show the following: (1) CC mixed with one SRA leads to an early increase in micro-growth as the SRA content increases, while self-shrinkage and shrinkage during drying are reduced. (2) CC mixed only PPF, leads to early micro-expansion, self-shrinkage, and shrinkage during drying, decreases with increasing PPF content; the decrease in amplitude is large for early micro growth but insignificant for self-shrinkage and shrinkage during drying, and the decrease in shrinkage is smaller compared to SRA. (3) If SRA-PPF is added to the CC, both contribute significantly to shrinkage, shrinkage during drying and reduction. [20]

Theoretical material about the analysis of building materials used in low-rise construction, including expanded clay concrete, is presented in [21-26].

The authors of the article "Environmental impact assessment of the components of building envelopes of low-rise buildings" studied the environmental impact assessment of the components of enclosure structures for low-rise buildings. This article presents a comparison of the environmental impact of four different building construction systems that are widely used in the construction of energy-efficient homes in Central Europe: reinforced concrete, brick, cross-laminated wood, and wooden frame panels. The main properties of the wall and roof components were determined by the heat transfer coefficient, where their environmental efficiency was estimated using a lifecycle-based approach. The study shows the environmental impact of individual structural systems and alternative heat-insulating materials, as well as their impact on the environmental characteristics of building envelopes. Based on the comparison of the selected components, this study demonstrates that there is significant potential for improving the environmental potential of low-rise buildings by selecting the appropriate components and materials that support the energy performance of the building. Comparison of cladding components draws attention to critical materials by introducing guidelines for optimizing the environmental impact of building cladding components for sustainable low-rise buildings, especially considering the design phase. [21]

V. Venkateswara Rao, R. Parameshwaran and V. Vinayaka Ram examined PCM-based building materials for energy-efficient buildings. The review includes details regarding various combinations of the PCM solution, as well as information relating to the thermal and mechanical properties of the PCM solution. The selection and application of various combinations of PCM in buildings have been carefully considered in terms of porosity, auxiliary materials, thermal and structural properties. Also, the advantages and limitations associated with each type of solution for use as a PCM carrier were summarized. [22]

Wenxue Zhang, Jian Huang, Zengyin Li, and Chun Huang conducted a series of experiments in this study to determine the effect of various factors on lateral pressure. The results show that concrete settling, casting speed, and vibration mode can greatly affect the pressure. [23]

Druzhinina N.A. and Zubareva G.I. considered expanded clay concrete block, which allows you to quickly erect the walls of low-rise buildings and is widely used in housing construction. The block construct is described. The physical, thermomechanical and other properties of this material are discussed. The advantages of its use in the construction of walls are shown. [24]

Проскуровскис А., Назинян Л.Г., Тарасова А.А., Беляева С.В. Энергоэффективный стеновой керамзитобетонный блок // Строительство уникальных зданий и сооружений. 2019. № 3(78). С. 23-35. DOI: 10.18720/CUBS.78.2

Mikhailov I.M. made a comparison of modern materials used in the construction of external walls in low-rise construction. The article describes and compares, according to various criteria, the basic materials for the construction of external walls in 305 low-rise buildings. The thermal conductivity coefficient for the fuser is calculated. The ideal point method was used to select the best option for the wall material. [25]

Nikonova E.V., Vechtomov P.O. and Ladny I.A. gave a comparative analysis of six types of enclosing structures for low-rise housing construction: brick masonry, foam block masonry, glued beam, wooden frame, LSTK - light steel thin-walled structures, as well as a relatively new material - a gluing panel with a high degree of factory readiness and allowing use substandard plywood in its composition. It can be adapted to the climatic conditions of the region, for example, contain a warming layer. The analysis was carried out on a five-point scale in the following groups of parameters: physical parameters, construction conditions, the presence of additional work and maintainability, economic parameters, probabilistic indicators. The obtained results made it possible to recommend a glue-veneer panel for widespread use in individual housing construction; after emergencies when it is required to quickly build suitable dwelling houses; for the construction of buildings in hard-to-reach areas. [26]

Theoretical material about the analysis of effective building materials is presented in articles [27-30].

The authors of the work “Effect of composition on the strength of modified expanded clay concrete” investigated the effect of the composition of modified expanded clay concrete on its strength. Due to the introduction of fiber, the tensile strength of concrete in bending increases, and the compressive strength remains practically unchanged. The studied expanded clay concrete can be recommended for thin-walled constructions of civil buildings, as well as transport and hydraulic structures, including floating ones. [27]

Paschal Chimeremeze in his study analyzed and tested the experimental side of expanded clay concrete made of lightweight basalt fiber when exposed to heat. It can be seen from the experimental results that both basic materials can resist to heat at the extent that proved and confirmed the thermal properties of the two main materials. You need to know that the percentage of basalt fiber in concrete plays a major role in the thermal resistance of concrete. [28]

The authors of the article “Inverse engineering approach to determine the elastic properties of lightweight expanded clay” investigated a reverse engineering method for determining the elastic properties of cellular materials. FEA procedures are used to determine the basic elastic constants of the simulated LECA spheres under uniaxial compression. These routines are used to update routines and are compared with experimental data to evaluate Young's modulus and Poisson's ratio. It is reported that the particle diameter plays an important role due to a change in the ratio between the thickness of the outer layer and the porous internal structure. Young's modulus for particles with a diameter of 5.08, 7.59, and 10.65 [mm] is defined at 200, 280, and 640 [MPa], respectively. The Poisson's ratio of the particles is estimated at 0.34, 0.36 and 0.36. [29]

Muhammad Riaz Ahmad and Bing Chen prepared a low-melting foam concrete aggregate (LAFC), obtained by mixing stable foam, expanded clay aggregate (ECA) and silica (SF) as the main raw material. The prepared LAFC mixtures were tested for mechanical, thermal, sorption and heat-resistant properties. The results showed that an increase in foam volume from 0% to 20% significantly improved the flowability of LAFC mixtures and were assigned to a high stable index of visual stability. The compressive strength of LAFC mixtures decreased from 24.75 MPa to 21.10, 15.95 and 12.05 MPa, respectively, when the foam volume increased from 0% to 10, 15 and 20%. The thermal conductivity of LAFC mixtures was 0.84, 0.77, 0.65, and 0.53 W · m-1K-1 for foam volumes of 0, 10, 15, and 20%, respectively. Adding SF improves the strength and thermal conductivity of LAFC blends. The sorption coefficient and porosity of LAFC gradually increased from 0.22 to 0.85 kgm-2min-0.5 and 25.68–39.74% due to an increase in the volume of foam from 0% to 20%. However, the incorporation of SF decreased the sorption and porosity of LAFC. The influence of high temperature was more pronounced on the compressive strength of LAFC compared to the density of LAFC. [30]

However, despite a large amount of research devoted to these topics, the topic of expanded clay concrete blocks used as a fixed formwork for concrete has not yet been fully disclosed.

The purpose of this article is to analyze the shortcomings of existing fixed formwork blocks and, taking them into account, create our fixed formwork block, conduct its strength and heat-transfer resistance tests, as well as analyze the above characteristics and compare them with the most common energy-efficient wall materials for cottage construction presented on the market of St. Petersburg.

2. Test methods of expanded clay block of fixed formwork

When designing the shape of the new block, the shortcomings of the existing blocks were taken into account, the block design was improved, which allowed to significantly improve its characteristics.

Firstly, the thickness of the outside walls of the block was increased from 30 mm, as it was done for the “Durisol” and “Tecolit” blocks to 40 mm. Due to this change, the thickness of the block will slightly increase, but its rigidity will increase significantly.

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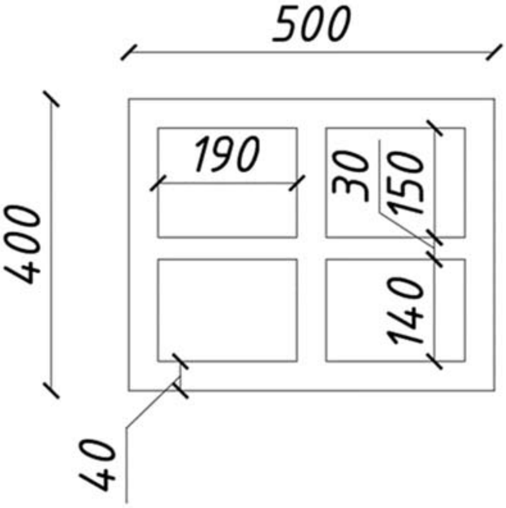
Secondly, a 30 mm thick partition was added to the block structure, thereby separating the cavity for pouring concrete from the cavity for installing heat-insulating material. This refinement allowed us to expand the range of heat-insulating materials installed in the block. Moreover, with an increase in the strength of the block itself, it can be used as self-supporting without the use of concrete, to create a monolithic reinforced concrete core inside, and all 4 cavities can be used to install heat-insulating material.

Thirdly, the material for manufacturing the block was changed. This, together with structural modifications, will increase the strength and rigidity of the block. The composition of the expanded clay mixture was selected in such a way as to obtain the optimal strength value. The weight of the block was not taken into account. Drawing of the designed block is presented below (Pic. 1).



Pic. 1. Drawing of a designed block

The next step was to create forms for filling blocks. OSB boards with a thickness of 10 mm were used as the material for their manufacture. As a result, 3 forms were created. They are presented in the photo below (Pic. 2).

Pic.2. Formworks for designed blocks

As a result, three expanded clay concrete blocks were obtained. One of them is presented below (Pic. 3).

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Pic. 3. One of the designed expanded clay concrete blocks.

Cast blocks were tested for compression. Also, this expanded clay composite was tested for thermal conductivity and mass gain in a humid environment.

According to GOST R 57349-2016 / EN 772-1: 2011 cast blocks were tested on a P-250 hydraulic press. Previously, the surface of the block was leveled using gypsum. A photograph of the aligned block installed in the press is shown below (Pic. 4).

Pic. 4. Leveled block under the press

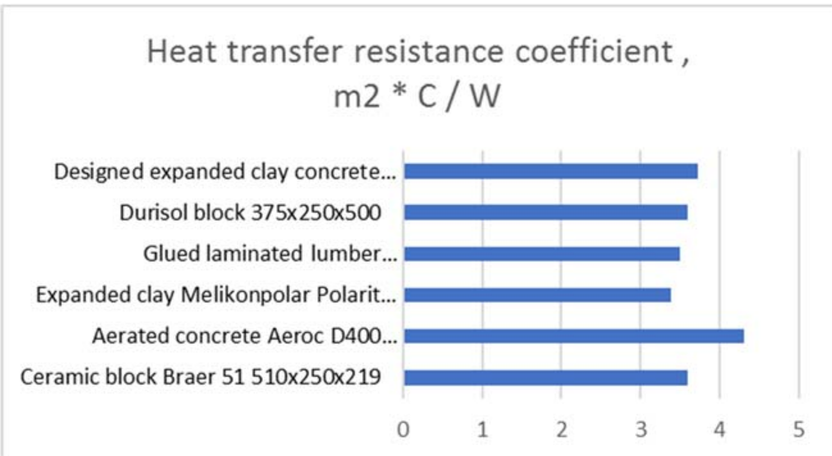
Further, the obtained expanded clay concrete mixture was tested for thermal conductivity according to GOST 7076 on a PIT 2.1 device. The value of thermal conductivity obtained during testing was 0.862 W / m * K for a plate of a composition made by us with a thickness of 40 mm and dimensions 300x300 mm. Thus, when calculating the coefficient of heat transfer resistance for the designed unit without taking into account the heat-insulating material, we obtain a value of 0.127 m2 * K / W. From the data obtained, it can be concluded that blocks without thermal insulation do not have insufficient thermal insulation properties to satisfy any standards. However, if we assume that two cavities 140 mm thick will be filled, for example, with PSB-S-25 foam with a thermal conductivity coefficient of 0.039 W / m * R, then the heat transfer resistance coefficient will already be 3.72 m2 * K / W. If you fill all four cavities with the aforementioned heat-insulating material, then the coefficient of resistance to heat transfer will already be 7.56 m2 * K / W.

Pic. 5. Thermal conductivity test of expanded clay mixture plate

3. Results and Discussion

3.1. Comparative analysis of the characteristics of energy-efficient wall materials and the designed block

Firstly, the designed block takes into account thermal insulation in 2 cells from 4 (R = 3.72 m2 * C / W) and will be compared with competitors in terms of R-value. In the process of studying the market of wall materials for cottages, the most frequently used and energy-efficient ones were selected. Wall materials were considered as energy-efficient if they meet the minimum requirements for the R-value for a residential building in St. Petersburg, according to SNiP 23-02-2003, and were also declared energy-efficient by their manufacturers. As a result, 5 materials were selected: expanded clay concrete multi-slotted stone Polarit Comfort 400 (R = 3.38 m2 * C / W), ceramic block Braer 51 510x250x219 (R = 3.6 m2 * C / W), glued laminated lumber 350x350x6000 mm EB sort 1-2 GOST 8486 (R = 3.5 m2 * C / W), aerated concrete Aeroc 400x250x625 (R = 4.3 m2 * C / W) and cement-woodchip blocks Durisol with a heat transfer resistance coefficient R = 3.59 m2 * C / W.



Pic. 6. Heat transfer resistance coefficients of selected materials

According to the diagram, aerated concrete Aeroc, designed block, ceramic block Braer 51 and cement-woodchip block Durisol have the highest R-values, whereas the lowest R-values are in the glued laminated lumber and the expanded clay concrete multi-slotted stone Polarit Comfort respectively.

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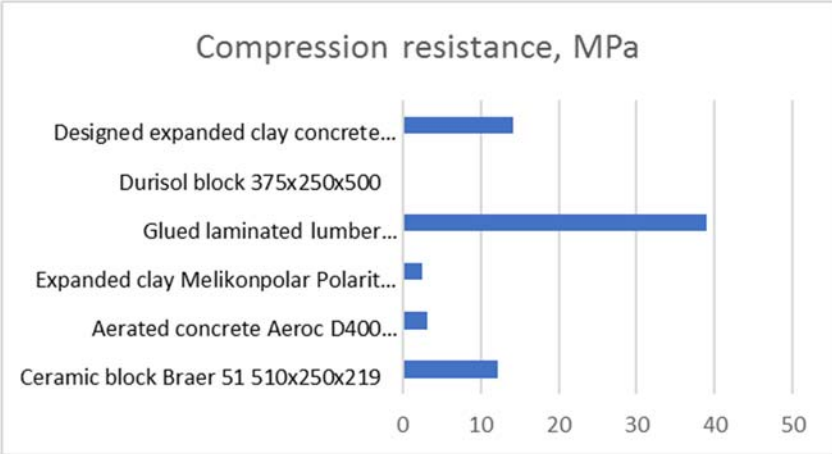

Plc. 7. Compression resistance values

The second selected parameter for comparison is the compression resistance. The designed block is characterized by compression resistance of 14.1 Mpa, while expanded clay concrete multi-slotted stone Polarit Comfort is only 2.5 Mpa. Ceramic block Braer 51 is 12.26 Mpa, the glued laminated lumber is 39 Mpa, which is much greater than aerated concrete Aeroc (3.14 Mpa). Unfortunately, this indicator was not specified for cement-woodchip blocks Durisol.

The graph clearly shows that Melikonpolar expanded clay blocks have the smallest compressive strength, as well as aerated concrete Aeroc, which holds the second position. Oppositely, glued beams, Braer ceramic blocks and the designed block are the most durable.

3.2. Data comparison with literary sources

The article “Comparison of modern materials used in the construction of external walls in low-rise buildings” [25] presents the values of heat transfer resistance for a thermal block and expanded clay concrete block with insulation and cladding. These values are 4.99 and 3.85 m2 * C / W respectively. The designed block has a heat transfer resistance of 3.72 m2 * C / W when filling two cells with a heater and 7.56 m2 * C / W when filling with a heater all four cells. Based on these values, we can conclude that installing the insulation in its two cells, the designed block becomes comparable in terms of the heat transfer resistance to the insulated and faced expanded clay concrete block, which values for the heat transfer coefficient are presented in Mikhailov's article. However, if we consider the case when all four cells of the designed block are filled with a heat-insulating material, then its heat transfer resistance coefficient (7.56 m2 * C / W) significantly exceeds the same values of thermal block.

Mamochkin S.A. in his article “Low-grade monolithic concrete for low-rise buildings” [3] presented the values of density and thermal conductivity for low-grade concrete compositions. Density starts from 650-900 kg / m3, thermal conductivity coefficient starts from approximately 0.15-0.25 W / (m * C). Our block has a much higher coefficient of thermal conductivity due to its density, which is equal to 1800 kg / m3, however, in the future, it is planned to reduce this value to achieve optimal indicators of the weight of the block and its thermal conductivity.

4. Conclusions

1. Comparison of the heat transfer coefficient of the designed unit with the five most common energy-efficient materials on the St. Petersburg market showed that according to this indicator, the designed unit with two cells filled with heat-insulating material loses only to Aeroc 400x250x625 aerated concrete blocks.

2. If we consider that the block is strong enough to not fill two of its cells with concrete during low-rise construction, then we can assume that all four cells will be filled with PSB-S-25 foam and then its heat transfer resistance coefficient will be 7.56 m2 * K / W, which is much more than any of the above materials.

3. When comparing the compressive strength of the above-mentioned materials, we can conclude that the designed block significantly loses to glued laminated timber, however, it significantly exceeds Polarit Comfort 400, Aeroc 400x250x625 expanded clay and concrete slabs and slightly Braer 51 510x250219 ceramic blocks.

In the future, it is planned to work out the composition of the material in detail, making it lighter and stronger. Besides, it is planned to work out its shape, making the blocks convenient to operate.

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Proskurovskis, A., Nazinyan, L., Tarasova, A., Belyaeva, S. Energy-efficient expanded clay concrete wall block. Construction of Unique Buildings and Structures. 2019. 3(78). Pp. 23-35. DOI: 10.18720/CUBS.78.2