Magazine of Civil Engineering

ISSN 2712-8172

journal homepage: http://engstroy.spbstu.ru/

DOI: 10.34910/MCE.109.7

Humidity regime in aerated concrete wall with finishing coating

V.I. Loganina , ***M.V. Frolov****

Penza State University of Architecture and Construction, Penza, Russia

**E-mail: mihail-frolovv@yandex.ru*

Keywords: Concretes, building materials, buildings, lime, energy efficiency, moisture

Abstract. The article estimates the influence of external finishing coating characteristics on the humidity regime in the walls of aerated concrete blocks with the density of 350–600 kg/m^3 (D350–D600 grades). The research is in demand due to the fact that condensation of excessive moisture in the enclosing structure is one of the most common reasons for the destruction of plaster coatings for walls of aerated concrete. To assess the humidity regime in the walls of aerated concrete, the temperature of the onset of moisture condensation t_{sk} was determined. The temperature of the onset of condensation t_{sk} is the temperature of the outside air: a temperature drops to this level causes formation of condensate in the enclosing structure. It was revealed that due to the use of the developed dry building mixture for D350–D600 concrete blocks finishing, moisture condensation begins at a significantly lower outdoor temperature. The moisture regime in the walls of D350–D600 aerated concrete blocks was studied for the conditions of various climatic zones on the example of three cities: Rostov-on-Don, Voronezh, Novosibirsk. A linear model is obtained that reflects the dependence of the temperature of the onset of condensation t_{sk} in the walls of D350–D600 aerated concrete blocks on the thermal properties of the wall material and the finishing layer.

1. Introduction

In accordance with the current regulatory documentation, the design of buildings should be carried out taking into account modern requirements for energy conservation [1–4]. Therefore, the development of new and improve old structures in order to increase their energy efficiency is a priority in the development of construction industry [5–8].

In recent years, aerated concrete has been increasingly used in the construction of external walls of buildings for various purposes [9, 10]. Such wide use of aerated concrete blocks is due to their good performance, low heat conductivity, high vapor permeability, relatively low cost, manufacturability of masonry and high labor productivity [11–13]. Using aerated concrete blocks of D300-D600 grades, it is possible to erect single-layer walls with sufficiently high heat-shielding properties.

A significant impact on the durability of operation of walls made from aerated concrete is exerted by the characteristics of the plaster compositions used for their decoration [14]. One of the most common reasons for the destruction of plaster coatings on aerated concrete is condensation of more moisture in the enclosing structure [15–18]. Moisture condensation in such enclosing structures occurs due to the significant difference in vapor permeability and thermal conductivity of the plaster coating and aerated concrete. To reduce the amount of condensing moisture in the enclosing structure, each subsequent layer in the direction from the internal surface to the external one should be characterized by greater vapor permeability and lower thermal conductivity compared to the previous layer. This requirement is rarely succeeded due to the fact that an increase in vapor permeability and a decrease in thermal conductivity of plaster coatings are associated with the appearance of an additional pore volume in their structure. That is

Loganina, V.I., Frolov, M.V. Humidity regime in aerated concrete wall with finishing coating. Magazine of Civil Engineering. 2022. 109(1). Article No. 10907. DOI: 10.34910/MCE.109.7

why the operational properties of the resulting coatings, their frost resistance and moisture resistance may significantly deteriorate.

In the course of previous studies, we developed a compounding heat-insulating dry building mixture (DBM), designed specifically for finishing aerated concrete blocks. The recipe contains fluffy lime, aluminosilicate ash microspheres, a modifying additive based on a mixture of hydrosilicates and calcium aluminosilicates, white cement, ground waste from the production of aerated concrete, Melflux 2651 F, VINNAPAS 8031 H, sodium oleate [19–23]. We assume that using this DBM it is possible to significantly reduce the possibility of condensation and minimize its amount.

The purpose of the work is to investigate the influence of the characteristics of the external finishing layer on the humidity regime in aerated concrete enclosing structure. To achieve this goal it is necessary to solve the following tasks:

- to assess the influence of the characteristics of the external finishing layer on the temperature of the beginning of moisture condensation on the walls of aerated concrete blocks of grades D350-D600;

- to study the humidity conditions in the walls of aerated concrete blocks of grades D350-D600 for the conditions of various climatic zones on the example of three cities: Rostov-on-Don, Voronezh, Novosibirsk;

- to develop a model reflecting the dependence of the temperature of the start of condensation in the walls of aerated concrete blocks of grades D350-D600 on the characteristics of the materials used in the construction of the wall.

2. Methods

A large number of works are devoted to the study of the humidity regime of the operation of walls made of aerated concrete blocks. The probability of moisture condensation is usually determined using the Fokin-Vlasov graphoanalytical method [24]. In this method, the distribution of E_i and e_i the thickness of the enclosure at a certain temperature t_{out} is constructed. When using this method, the amount of condensing moisture in the wall is determined for the accepted design temperature of the outside air t_{out}. For the calculated outdoor temperature in various studies, they take: the average temperature the period of the year with negative average daily temperatures, the average monthly temperature for December, January or February, the average temperature of the coldest five-day period.

The studies conducted in this work are based on the technique proposed by V.N. Kupriyanov. In accordance with this technique, to assess the probability of moisture condensation in the external enclosure, the temperature of the onset of condensation t_{sk} was determined [25]. To determine it in the studied building envelope, the profiles of the partial pressure of water vapor e_i and the pressure of saturated water vapor E_i were constructed in Fig. 1.

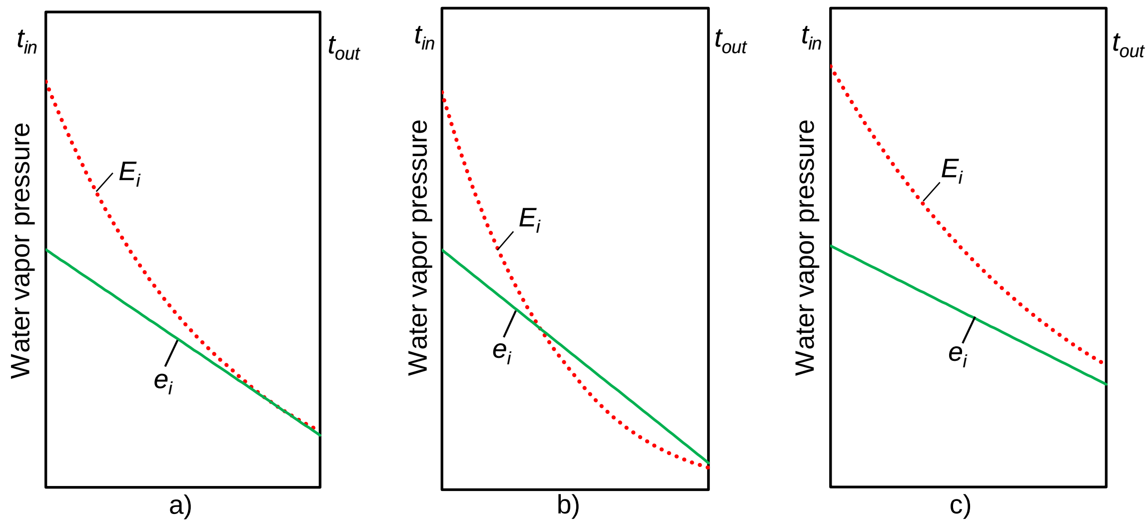

Figure 1. The determination method t_{sk}: a) $t_{out} = t_{sk}$; b) $t_{out} < t_{sk}$; c) $t_{out} > t_{sk}$.

The pressure of saturated water vapor E_i was determined by the temperature profile in accordance with the dependencies:

$$E_i = 610.5\exp\left(\frac{17.269 \cdot t_i}{237.3 + t_i}\right), t \geq 0\ °C; \tag{1}$$

$$E_i = 610.5\exp\left(\frac{21.875 \cdot t_i}{265.5 + t_i}\right), t \geq 0\ °C; \tag{2}$$

The temperature of the start of condensation t_{sk} was considered such an outdoor temperature at which the condition is satisfied:

$$e_i = E_i \tag{3}$$

For a mathematical explanation of the dependence of the temperature of the start of condensation t_{sk} on the characteristics of the outer finishing layer, we will use a generalized structural parameter k_{gdp} determined by the formula:

$$k_{gdp} = \frac{R_{Pi} / R_{Po}}{R_{Ti} / R_{To}} \tag{4}$$

where R_{Pi} is vapor resistance of layers located from the inner surface of the enclosure to the border of the plaster coating / aerated concrete, (m^2·h·Pa)/mg;

R_{Po} is vapor resistance of the whole enclosure, (m^2·h·Pa)/mg;

R_{To} is thermal conductivity of layers located from the inner surface of the enclosure to the border of the plaster coating / aerated concrete, (m^2· ºC)/W;

R_{Ti} is thermal conductivity of the entire enclosure, (m^2· ºC)/W.

In the work, the impact of the external finishing coating on t_{in} for the walls of buildings located in Rostov-on-Don, Voronezh, Novosibirsk is assessed.

The calculated parameters of the internal air are adopted according to Russian Set of Rules SP 50.13330.2012. Thermal protection of buildings. Updated edition of Russian Construction Norms and Rules SNiP 23-02-2003" for residential buildings: temperature t_{in}=20.0 °C relative humidity φ_{in}=55%.

The calculated parameters of the outdoor air are taken in accordance with the requirements of SP131.13330.2018 "SNiP 23-01-99* Construction climatology" (Table 1).

Table 1. Design parameters of outdoor air.

City	Heating period z_{hp}, day	Average temperature of the heating period, t_{hp} °C	Degree-day of the heating period °C·day	Humidity zone
Rostov-on-Don	166	-0.1	3336.6	Dry
Voronezh	190	-2.5	4275.0	Dry
Novosibirsk	222	-8.1	6238.2	Dry

The design of the wall under study is shown in Fig. 2.

For interior decoration of aerated concrete blocks, cement-slag plaster was used, layer thickness 0.01 m (Figure 1, layer 1). For exterior decoration of aerated concrete blocks, three types of DBM were used, layer thickness 0.01 m (Figure 1, layer 3): cement-sand plaster; Knauf GRUNBAND: developed by DBM. The thermal conductivity of the materials λ was determined on the samples 10×10×2.5 cm in size using an ITP-MG4 "100" device. Vapor permeability coefficient of materials μ was determined for each material according to Russian State Standard GOST 25898-2012. Building materials and products. Methods for determining vapor permeability and resistance to vapor permeability." Tests to determine the coefficients of vapor permeability and thermal conductivity were carried out for each material on 6 samples. The characteristics of the materials are presented in Table 2.

Characteristics of the materials are presented in Table 2.

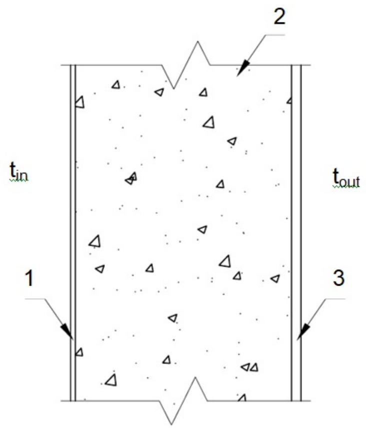

Figure 2. The design scheme of the wall envelope:
1 – layer 1, interior decoration; 2 – layer 2, aerated concrete; 3 – layer 3, exterior finish.

Table 2. Characteristics of the materials used in the wall.

Material	The average density of the material, kg/m^3	Coefficient of thermal conductivity λ_A, W/(m·K)	Vapor permeability coefficient μ, mg/(m·h·Pa)
cement slag plaster	1200	0.470	0.140
AAC D350	350	0.130	0.250
AAC D400	400	0.140	0.230
AAC D500	500	0.180	0.200
AAC D600	600	0.220	0.170
cement-sand plaster	1800	0.760	0.090
Knauf GRUNBAND	1100	0.350	0.100
being developed DBM	650	0.155	0.150

To simplify the work, the following conventions are used for the various designs of enclosing structures:

$$x / y / z \tag{5}$$

where x is first letter in city name (Rostov-on-Don – R; Voronezh – V; Novosibirsk – N);

y is aerated concrete density, kg/m^3;

z is the density of the outer finishing layer, kg/m^3.

3. Results and Discussion

Based on the climatic conditions of the cities of Rostov-on-Don, Voronezh and Novosibirsk, the minimum allowable wall thickness from aerated concrete grades D350, D400, D500, D600 was previously determined (Table 3).

Table 3. Aerated concrete layer thickness, m.

City	AAC brand			
	D350	D400	D500	D600
Rostov-on-Don	0.35	0.35	0.45	0.55
Voronezh	0.40	0.40	0.50	0.60
Novosibirsk	0.50	0.50	0.65	0.75

The choice of these cities is due to the fact that the parameters of the outdoor air in the cold season for these cities are characteristic of the widest list of climatic regions in which energy-efficient buildings using single-layer aerated concrete walls can be built.

The city of Rostov-on-Don is located in zone IIIB according to Russian Set of Rules SP 131.133300.2018. This climatic subarea is characterized by average monthly air temperature in January ranging from -5 °C to 2 °C. The results of studies to determine the temperature of the start of condensation in the walls for the city of Rostov-on-Don are presented in Figure 3.

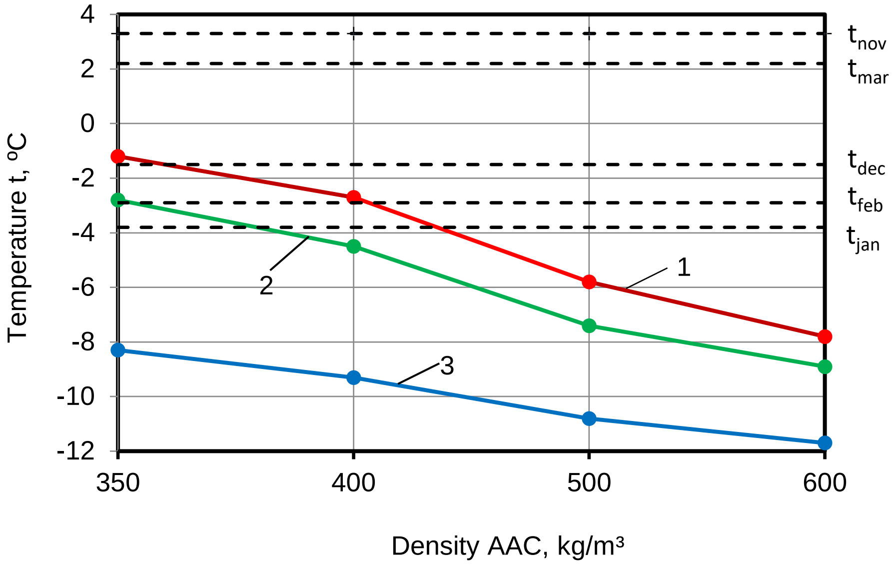

Figure 3. Dependence of the temperature of the start of condensation t_{sk} on the density of aerated concrete for the city of Rostov-on-Don: 1 – cement-sand plaster; 2 – Knauf GRUNBAND; 3 – developed by DBM.

It was found that moisture condensation in the R/350/1800 design begins at a temperature of –1.5 °C (Figure 3, curve 1). When using instead of cement-sand plaster DBM Knauf GRUNBAND, the temperature of the start of condensation t_{sk} decreases by only 1.4 °C (to –2.9 °C) (Figure 3, curve 2); when using the developed DBM, the temperature of the start of condensation t_{sk} decreases by 6.8 °C (to –8.3 °C) (Figure 3, curve 3).

With an increase in the density of aerated concrete, the start temperature of condensation t_{sk} decreases It should be noted that the temperature of the start of condensation t_{sk} in walls finished with cement-sand plaster or DBM Knauf GRUNBAND, to a much greater extent depends on the density of aerated concrete. Condensation start temperature t_{sk} in the enclosing structure R/350/1800 is 6.3 °C higher than the temperature of the beginning of condensation t_{sk} in the enclosing structure R/600/1800. Condensation start temperature t_{sk} in the enclosing structure R/350/650 is 3.3 °C higher than the temperature of the start of condensation t_{sk} in the enclosing structure R/600/650.

It was established that in the walls of aerated concrete blocks of grades D500 and D600, conditions for the formation of condensate will not be created. In the walls of aerated concrete blocks of grades D400, plastered with a cement-sand composition, condensate will precipitate at average monthly temperatures in January and February. In the walls of aerated concrete blocks of grades D350, plastered with a cement-sand composition, condensate will precipitate at average monthly temperatures in December, January and February. Condensation will form in the walls of aerated concrete blocks of D350 grades, plastered with DBM Knauf GRUNBAND, at average monthly temperatures in January and February. Thus, for the conditions of the city of Rostov-on-Don, the use of the developed DBM can significantly improve the humidity regime in the walls of aerated concrete blocks of grades D350 and D400.

The city of Voronezh is located in zone IIB according to Russian Set of Rules SP 131.133300.2018. This climatic subarea is characterized by average monthly air temperature in January, ranging from -14 °C to -4 °C. The results of studies to determine the temperature of the start of condensation in the walls for the city of Voronezh are presented in Figure 4.

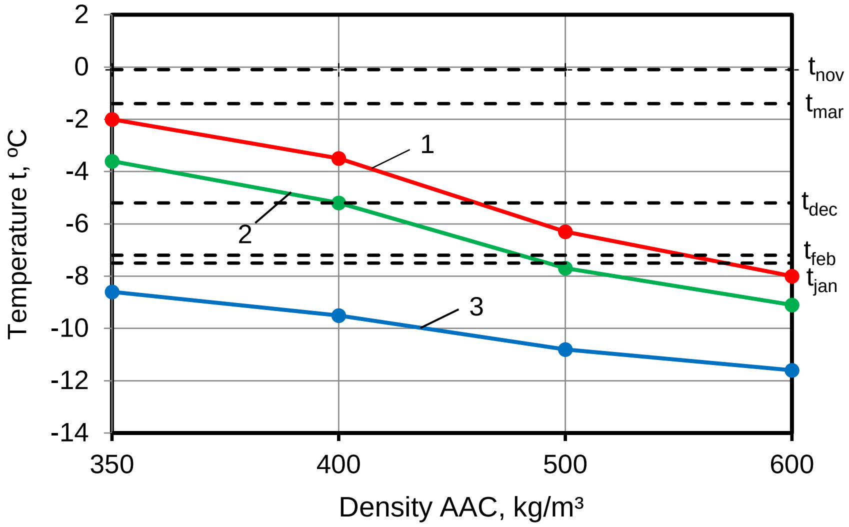

Figure 4. Dependence of the temperature of the start of condensation t_{sk} on the density of aerated concrete for the city of Voronezh: 1 – cement-sand plaster; 2 – Knauf GRUNBAND; 3 – developed by DBM.

It was established that in the walls of aerated concrete blocks of grades D350, D400, plastered with a cement-sand composition or DBM Knauf GRUNBAND, condensate will precipitate at average monthly temperatures in December, January and February (Figure 4, curve 1.2). In the walls of aerated concrete blocks of grades D500, plastered with a cement-sand composition, condensate will precipitate at average monthly temperatures in January and February. Thus, for the conditions of the city of Voronezh, the use of the developed DBM can significantly improve the humidity regime in the walls of aerated concrete blocks of grades D350, D400, D500.

The city of Novosibirsk is located in zone IB according to Russian Set of Rules SP 131.133300.2018. The air temperature in January ranges from -14 °C to -28 °C. The results of studies to determine the temperature of the start of condensation in the city of Novosibirsk are presented in Figure 5.

It was established that in the walls of aerated concrete blocks, regardless of the type of plaster coating used, condensation will occur at average monthly temperatures in December, January and February. At the same time, in the walls of aerated concrete blocks of grades D350, D400 and D500, plastered with a cement-sand composition or DBM Knauf GRUNBAND, conditions will also be created for the formation of condensate at average monthly temperatures in March and November (Figure 5, curve 1.2). When using the developed DBM, the conditions for the formation of condensate in November and March will not be created (Figure 5, curve 3).

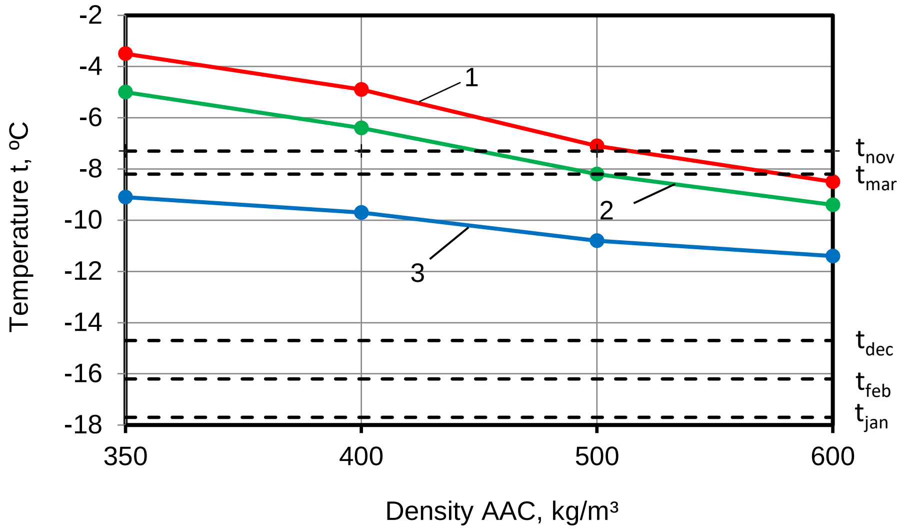

Figure 5. Dependence of the temperature of the start of condensation t_{sk} on the density of aerated concrete for the city of Novosibirsk: 1 – cement-sand plaster; 2 – Knauf GRUNBAND; 3 – developed by DBM.

The dependence of the condensation start temperature t_{sk} on the generalized design parameter k_{gdp} was studied for the studied enclosures made of aerated concrete blocks finished with a cement-sand composition (Figure 6).

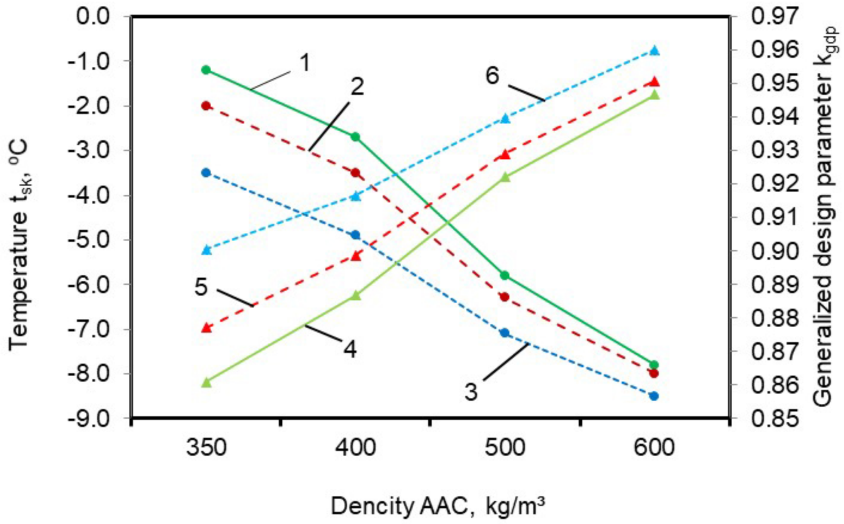

Figure 6. Dependence of the temperature of the start of condensation t_{sk} and generalized design parameter k_{gdp} on the density of AAC for walls, plastered developed by cement-sand plaster: 1 – Rostov-on-Don (t_{sk}); 2 – Voronezh (t_{sk}); 3 – Novosibirsk (t_{sk}); 4 – Rostov-on-Don (k_{gdp}); 5 – Voronezh (k_{gdp}); 6 – Novosibirsk (k_{gdp}).

The walling R/350/1800 is characterized by the lowest value of the generalized design parameter k_{gdp} = 0.861 (Figure 6, curve 4). Accordingly, this enclosure is characterized by the highest temperature at the start of condensation t_{sk} = -1.2 °C (Figure 6, curve 1). The condensation start temperature t_{sk} for enclosures V/350/1800 and N/350/1800, respectively, is -2.0 °C and - 3.5 °C (Figure 6, curve 2, 3). Smaller t_{sk} values for walls V/350/1800 and N/350/1800 are explained by large k_{gdp} values for these enclosures, equal to 0.877 and 0.901, respectively (Figure 6, curve 5,6). The same materials were used in the construction of the walls R/350/1800, V/350/1800, N/350/1800 and the different k_{gdp} values are explained by different wall thicknesses and, as a result, different fractions of the thickness of the external plaster coating from the total wall thickness. In the enclosure R/350/1800, the proportion of the thickness of the cement-sand plaster in the total wall thickness is 5.26 %, in the enclosure V/350/1800 – 4.65 %, in the enclosure N/350/1800 – 3.77 %.

The walling N/600/1800 is characterized by the highest value of the generalized design parameter k_{gdp} = 0.960 (Figure 6, curve 6). Correspondingly, this enclosure is characterized by the lowest condensation start temperature t_{sk} = -8.5 °C (Figure 6, curve 3). The condensation start temperature t_{sk} for the walling N/600/1800 is 7.3 °C lower than the condensation start temperature t_{sk} for the R/350/1800 fencing, the value of the generalized design parameter is higher by k_{gdp} 0.099. This is due to the fact that the difference in the values of thermal conductivity and vapor permeability coefficients between D600 aerated concrete blocks and cement-sand plaster is less significant compared to the difference in the thermal conductivity and vapor permeability coefficients between a D350 aerated concrete blocks and cement-sand plaster. The μ/λ ratio for aerated concrete blocks of the D350 grade is 1.92, for aerated concrete blocks of the D600 grade – 0.77, for cement-sand plaster – 0.12. This is also explained by the fact that in the wall N/600/1800 the proportion of the thickness of the cement-sand plaster in the total wall thickness is only 2.56 %. For the same reasons, the start temperature of condensation t_{sk} for enclosures made of aerated concrete blocks of grades D600 is less dependent on the city where the building is located compared to enclosures made of aerated concrete blocks of grades D350.

The dependence of the condensation start temperature t_{sk} on the generalized design parameter k_{gdp} for the studied enclosures from aerated concrete blocks trimmed with Knauf GRUNBAND DBM was investigated (Figure 7).

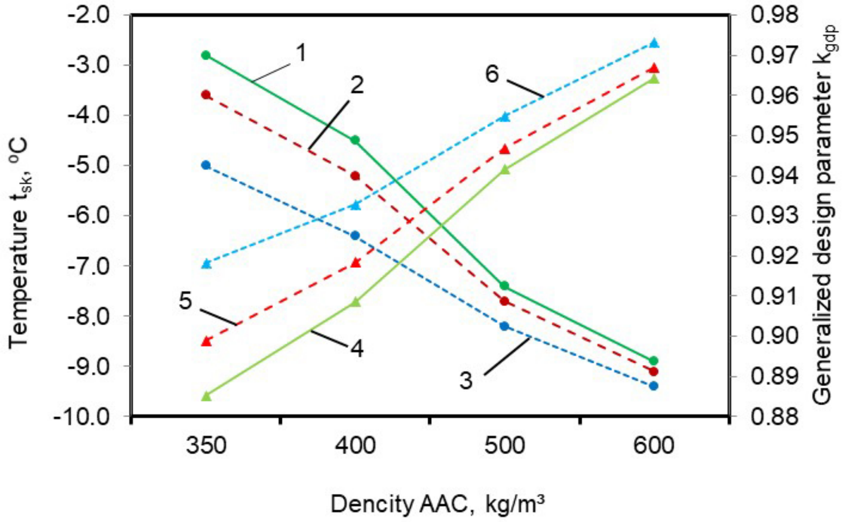

Figure 7. Dependence of the temperature of the start of condensation t_{sk} and generalized design parameter k_{gdp} on the density of AAC for walls, plastered developed by Knauf GRUNBAND: 1 – Rostov-on-Don (t_{sk}); 2 – Voronezh (t_{sk}); 3 – Novosibirsk (t_{sk}); 4 – Rostov-on-Don (k_{gdp}); 5 – Voronezh (k_{gdp}); 6 – Novosibirsk (k_{gdp}).

The main dependences typical for walls finished with cement-sand plaster were confirmed for walls decorated with DBM Knauf GRUNBAND. The maximum temperature at which condensation began was obtained for the R/350/1100 enclosure and amounted to -2.8 °C (Figure 7, curve 1), which is 1.6 lower than tsk for the R/350/1800 enclosure. The minimum temperature for the start of condensation was obtained for the N/600/1100 enclosure and amounted to -9.6 °C (Figure 7, curve 1), which is 1.1 °C lower than t_{sk} for the N/600/1800 enclosure. The values of the generalized design parameter for the enclosures trimmed by Knauf GRUNBAND DBM vary in the range k_{gdp}=0.885–0.973. The results are explained by higher vapor permeability and lower thermal conductivity of coatings based on Knauf GRUNBAND DBM in comparison with cement-sand plaster.

The dependence of the condensation onset temperature t_{sk} on the generalized design parameter k_{gdp} for the enclosures from aerated concrete blocks trimmed by the developed DBM was studied (Figure 8).

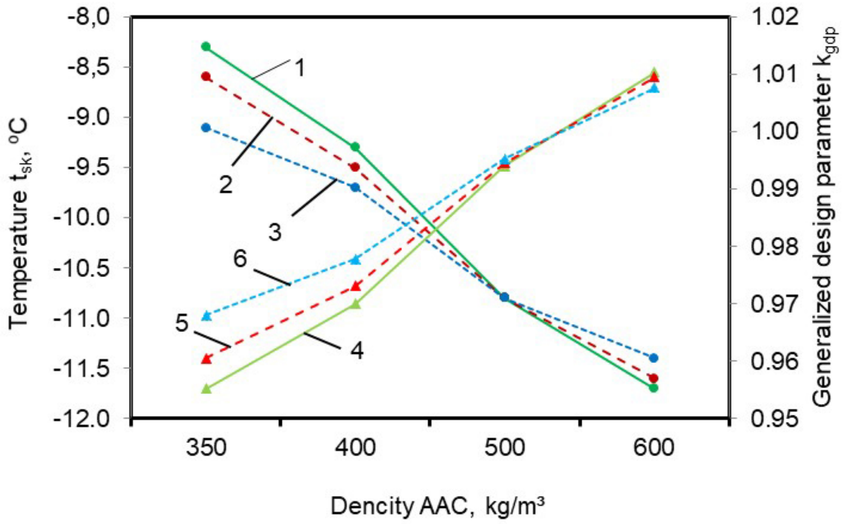

Figure 8. Dependence of the temperature of the start of condensation t_{sk} and generalized design parameter k_{gdp} on the density of AAC for walls, plastered developed by DBM: 1 – Rostov-on-Don (t_{sk}); 2 – Voronezh (t_{sk}); 3 – Novosibirsk (t_{sk}); 4 – Rostov-on-Don (k_{gdp}); 5 – Voronezh (k_{gdp}); 6 – Novosibirsk (k_{gdp}).

When using the developed DBM, the temperature of the start of condensation t_{sk} varies from -8.3 °C to -11.6 °C. A significant decrease in t_{sk} compared to enclosures finished with cement-sand plaster and DBM Knauf GRUNBAND is explained by an increase in the values of the generalized design parameter k_{gdp}, which varies in the range of 0.955–1.010. The t_{sk} values of the enclosures R/500/650, V/500/650 and N/500/650 are very close, which is explained by the close k_{gdp} values for these enclosures.

It has been established that the use of the developed DBM for enclosures R/500/650, V/500/650 and N/500/650 allows to lower the temperature of the start of condensation t_{sk} to values lower than would be without using the developed finishing coating. This conclusion can be made on the basis that the k_{gdp} values for these enclosures are higher than 1.

To develop a mathematical model that reflects the dependence of t_{sk} on the characteristics of the materials used in the construction of the wall, we construct the dependence of t_{sk} on k_{gdp} for 36 enclosures considered in the work (Figure 9).

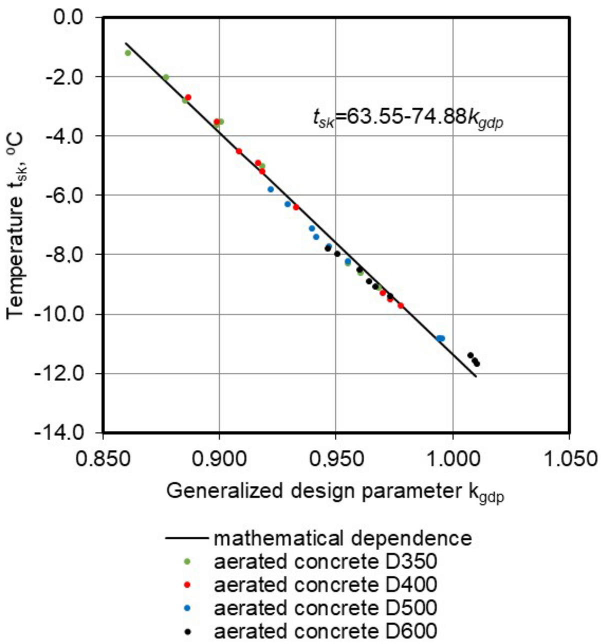

Figure 9. The dependence of the temperature of start of condensation t_{sk} from the generalized design parameter k_{gdp}.

As a result of the analysis of Figure 9, the following linear dependence of the start temperature of condensation t_{sk} on the generalized structural parameter of the fencing k_{gdp} was obtained:

$$t_{sk} = 63.55 - 74.88k_{gdp} \tag{6}$$

Analyzing equation 6, we can conclude that it allows to characterize the studied building envelopes with a fairly high accuracy. It should be noted that a quadratic dependence was obtained in paper of Kupriyanov V.N. [26]. The dependence obtained in this work makes it possible to more accurately determine t_{sk}. The deviations of the t_{sk} values calculated by the formula from the t_{sk} values determined during the research ranged from 0.00 to 0.49 °C. The deviation of the values calculated by the formula proposed by Kupriyanov V.N. from those obtained during the research is 0.3–5.The results obtained are in good agreement with other studies on this topic [27].

4. Conclusions

1. It was revealed that due to the use of the developed DBM for finishing concrete blocks of D350-D600 grades, moisture condensation begins at a significantly lower outdoor temperature. The condensation onset temperature t_{sk} for walls made of aerated concrete blocks finished with developed DBM varies from -8.3 °C to -11.7 °C, finished with Knauf GRUNBAND DBM from -2.8 °C to -9.4 °C, finished with cement-sand plaster from -1.2 °C to -8.5 °C.

2. Based on the studies, it was found that for cities located in climatic zones with an average monthly temperature of the coldest month above minus 14 °C, it is possible to use effective single-layer walls made of aerated concrete blocks of grades D350-600. When using DBM, allowing to obtain coatings characterized by values of thermal conductivity and vapor permeability close to aerated concrete blocks D350-600, in these walls conditions will not be created for the loss of a large amount of condensate. When erecting single-layer enclosing structures from aerated concrete blocks of D350-600 grades in the walls, conditions will be created for a large amount of condensate to fall out for the climatic conditions of cities located in areas with an average monthly temperature of the coldest month below minus 14 °C.

3. A linear dependence is obtained that reflects the relationship between the temperature of the start of condensation t_{sk} in the walls of aerated concrete blocks of grades D350-D600 on the generalized structural parameter of the fencing k_{gdp}. On the basis of the developed model, it is possible to rather easily and quickly evaluate the effect of the characteristics of the external finishing coating on the humidity conditions in the walls of aerated concrete blocks.

References

1. Choi, Y. hee, Song, D., Seo, D., Kim, J. Analysis of the variable heat exchange efficiency of heat recovery ventilators and the associated heating energy demand. Energy and Buildings. 2018. 172. Pp. 152–158. DOI: 10.1016/j.enbuild.2018.04.066.
2. Harmati, N., Jakšić, Ž., Vatin, N. Energy consumption modelling via heat balance method for energy performance of a building. Procedia Engineering. 2015. 1(117). Pp. 791–799.
3. Blengini, G.A., Di Carlo, T. Energy-saving policies and low-energy residential buildings: An LCA case study to support decision makers in piedmont (Italy). International Journal of Life Cycle Assessment. 2010. 15 (7). Pp. 652-665.
4. Taylor, T., Counsell, J., Gill, S. Energy efficiency is more than skin deep: Improving construction quality control in new-build housing using thermography. Energy and Buildings. 2013. No. 66. Pp. 222-231
5. Kovacic, I., Waltenbereger, L., Gourlis, G. Tool for life cycle analysis of facade-systems for industrial buildings. Journal of Cleaner Production. 2016. Vol. 130. Pp. 260–272. DOI: 10.1016/j.jclepro.2015.10.063.
6. Petritchenko, M.R., Nemova, D.V., Kotov, E.V., Tarasova, D.S, Sergeev, V.V. Ventilated facade integrated with the HVAC system for cold climate. Magazine of Civil Engineering. 2018. No. 1. Pp. 47–58. DOI: 10.18720/MCE.77.5.
7. Ananin, M., Perfilyeva, N., Vedishcheva, I., Vatin, N. Investigation of different materials usage expediency for a low-rise public building from the energy efficiency standpoint. IOP Conf. Series: Materials Science and Engineering. 2018. No. 365
8. D'Alessandro, F., Baldinelli, G., Bianchi, F., Sambuco, S., Rufini, A. Experimental assessment of the water content influence on thermo–acoustic performance of building insulation materials. Construction and Building Materials. 2018. No. 158. Pp. 264–274. DOI: 10.1016/j.conbuildmat.2017.10.028
9. Tasdemir, C., Sengul, O., Tasdemir, M.A. A comparative study on the thermal conductivities and mechanical properties of lightweight concretes. Energy and Buildings. 2017. Vol. 151. Pp. 469–475. DOI:10.1016/j.enbuild.2017.07.013
10. Qu, X., Zhao, X. Previous and present investigations on the components, microstructure and main properties of autoclaved aerated concrete – A review. Construction and Building Materials. 2017. Vol. 135 Pp. 505–516. DOI:10.1016/j.conbuildmat.2016.12.208
11. Vatin, N.I., Gorshkov, A.S., Korniyenko, S.V., Pestryakov, I.I. Potrebitelskiye svoystva stenovykh izdeliy iz avtoklavnogo gazobetona [The consumer properties of wall products from AAC]. Stroitelstvo unikalnykh zdaniy i sooruzheniy. 2016. No. 1. Pp. 78–101. (rus)
12. Narayanan, N., Ramamurthy, K. Structure and properties of aerated concrete: A review. Cement and Concrete Composites. 2000. 22 (5). Pp. 321–329.
13. Kočí, V., Maděra, J., Černỳ, R. Exterior thermal insulation systems for AAC building envelopes: Computational analysis aimed at increasing service life. Energy and Buildings. 2012. No. 47. Pp. 84–90.
14. Pastushkov, P.P., Grinfel'd, G.I., Pavlenko, N.V., Bespalov, A.E., Korkina, E.V. Raschetnoe opredelenie ekspluatacionnoj vlazhnosti avtoklavnogo gazobetona v razlichnyh klimaticheskih zonah stroitel'stva [Estimated determination of operational humidity of autoclaved aerated concrete in various climatic zones of construction]. 2015. No 2. Pp. 60–69. (rus)
15. Koudelka, T., Kruis, J., Maděra, J. Coupled shrinkage and damage analysis of autoclaved aerated concrete. Applied Mathematics and Computation. 2015. No. 267. Pp. 427–435. DOI: 10.1016/j.amc.2015.02.016
16. Nizovtsev, M.I., Stankus, S.V., Sterlyagov, A.N., Terekhov, V.I., Khairulin, R.A. Determination of moisture diffusivity in porous materials using gammamethod. International Journal of Heat and Mass Transfer. 2008. No. 51. Pp. 4161–4167
17. Yao, X.L., Yi, S.Y., Fan, L.W., Xu, X., Yu, Z.T., Ge, J. Effective thermal conductivity of moist aerated concrete with different porosities. Zhejiang Daxue Xuebao (Gongxue Ban). Journal of Zhejiang University (Engineering Science). 2015. 49(6). Pp. 1101–1107. DOI: 10.3785/j.issn.1008-973X.2015.06.014.
18. Rubene, S., Vilnitis, M., Noviks, J. Frequency Analysis and Measurements of Moisture Content of AAC Masonry Constructions by EIS. Procedia Engineering. 2015. No. 123. Pp. 471–478. DOI: 10.1016/j.proeng.2015.10.096
19. Loganina, V.I., Frolov, M.V. Research of Cracking Resistance of Thermal Insulation Coatings for Aerated Concrete. Materials Science Forum. 2019. No 974. Pp. 458-463. DOI:10.4028/www.scientific.net/MSF.974.458.
20. Loganina, V.I., Frolov, M.V. Heat-insulating Finishing Composition of the Optimal Structure with Microspheres. IOP Conf. Series: Materials Science and Engineering. 2019. 471(3). DOI:10.1088/1757-899X/471/3/032010
21. Loganina, V., Frolov, M., Fediuk, R. Developed Heat-insulating Dry Mortar Mixes for the Finishing of Aerated Concrete Walls. Magazine of Concrete Research. February 18. 2020. Pp. 1-45. DOI:10.1680/jmacr.19.00446
22. Loganina, V.I., Kislitsyna, S.N., Frolov, M.V. Addition on the Basis of Mix of the Synthesized Hydrosilicates of Calcium and Aluminosilikates for Dry Building Mixtures. 2016. Procedia Engineering. 150. Pp. 1627–1630. DOI: 10.1016/j.proeng.2016.07.141
23. Loganina, V.I., Frolov, M.V., Skachkov, Yu. P. Substantiation of selection of components at creation of thermal insulating dry building mixtures. International Journal of Engineering and Technology. 2018 Vol. 7. No. 4. Pp. 4341-4344. DOI: 10.14419/ijet.v7i4.10393

24. Korniyenko, S.V. O primenimosti metodiki SP 50.13330.2012 K raschetu vlazhnostnogo rezhima ograzhdayushchikh konstruktsiy s multizonalnoy kondensatsiyey vlagi [On the applicability of the methodology of SP 50.13330.2012 to the calculation of the humidity regime of building envelopes with multizone moisture condensation]. Stroitelstvo i rekonstruktsiya. 2014. 2(55). Pp. 29–37. (rus)
25. Petrov, A.S., Kupriyanov, V.N. Determination of Humidity Conditions of Enclosing Structures by the Color Indicator Method. IOP Conference Series: Materials Science and Engineering, December 2018. Vol. 463, Iss. 2. DOI: 10.1088/1757-899X/463/2/022064
26. Petrov, A.S., Kupriyanov, V.N. About operational factor influence on vapor permeability of heat-insulating materials. International Journal of Pharmacy and Technology. 2016. Vol 8, Iss. 1. Pp. 11248-11256.
27. Vatin, V.I., Gorshkov, A.S., Glumov, A.V. Vliyaniye fiziko-tekhnicheskikh i geometricheskikh kharakteristik shtukaturnykh pokrytiy na vlazhnostnyy rezhim odnorodnykh sten iz gazobetonnykh blokov [The influence of physical, technical and geometric characteristics of stucco coatings on the humidity conditions of homogeneous walls of aerated concrete blocks]. Magazine of Civil Engineering. 2011. 1(19). Pp. 28–33. (rus)

Contacts:

Valentina Loganina, loganin@mail.ru
Mikhail Frolov, mihail-frolovv@yandex.ru