RIGA TECHNICAL UNIVERSITY

Faculty of Civil Engineering
Institute of Building Production

Mārtiņš Vilnītis
The doctoral program "Construction" PhD

THE RESEARCH OF THE THERMAL PERFORMANCE OF NEW GENERATION OF AUTOCLAVED AERATED CONCRETE WITH BULK DENSITY 350 - 400 kg/m^3

Civil Engineering Sector,

Construction Materials and Building Technologies Subsector

Summary of Doctoral Thesis

Scientific advisor

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PROMOTION WORK

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Doctor of Engineering Science Degree

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APPROVAL

I confirm that I have developed this thesis submitted to the Riga Technical University for doctoral degree. The dissertation is not submitted for any other university degree.

Mārtiņš Vilnītis ....(signature)

Date: September 28, 2010.

The Dissertation is written in Latvian. It contains: Introduction, 5 Chapters, Conclusion, Bibliography, 52 Figures; altogether 130 pages. Bibliography consists of 85 titles.

REVIEW OF THESIS

Subject Actuality

In view of the rapid pace of development and construction the range of materials offered in the Baltic Sea States market there arose questions about certain materials suitability for the construction in the climatic conditions of the Baltic region. In particular, there are discussions on the envelope of the new generation of light weight autoclaved aerated concrete blocks with the volume weight 350-400 kg/m^3 drying process and their impact on the building thermal properties.

To date there have been quite a lot of experimental studies on the outer walls of autoclaved aerated concrete blocks with the volume weight 500-700 kg/m^3, but mostly they do not comply with the construction in the wet climate regime, which is specific to the Baltic Sea region. In addition, carried out studies have not taken into account finishing layer effects on the autoclaved aerated concrete walls thermal processes. It can be concluded that the above studies do not comply with the real situation which is characterized by the construction works for technological sequence. This means that using the former research data only a partial picture of the flow of heat and moisture migration processes in the external walls made of the new generation of autoclaved aerated concrete blocks can be obtained.

Thesis Aim and Objectives

The given Doctoral Thesis aims to develop moisture migration and heat flow processes calculation model for the new generation of autoclaved aerated concrete blocks external walls and carry out the proposed calculation model pilot test in the Baltic States climate zone, taking into account practiced building technologies.

In view of the already known and studied amount of information there are specified tasks to achieve this aim. To achieve the set aim the following tasks are to be decided:

1. The process of cross-migration of moisture and heat flow within the demarcated outer wall construction of buildings and structures analysis.
2. Pilot studies on the migration of moisture and heat flow processes in the new generation autoclaved aerated concrete in external walls under the Baltic Sea countries climate regime.
3. Experimental data results processing, evaluation and interpretation.
4. The development of the methodology of moisture migration and heat flux process in the exterior walls made of autoclaved aerated concrete, based on fractal approach and the diffusion in autoclaved aerated concrete.

5. The development of the programs that simulate the migration of moisture and heat flow processes in the external walls of autoclaved aerated concrete.
6. Calculation and analysis of results obtained using the experimentally received data.
7. The development of recommendations for the next generation of autoclaved aerated concrete with the volume weight 350-400 kg/m³ to increase utilization efficiency.

Scientific Novelty of Thesis

PhD Work aims to obtain results which will have scientific and practical applicability, as well as provide answers to current issues related to the new generation of autoclaved aerated concrete with the volume weight 350-400 kg/m^3 used in exterior wall construction. Equivalent to the research subject - the migration of moisture and heat flow processes, building and structures construction and maintenance quality improvement, based on the experimental structure from the new generation of light weight autoclaved aerated concrete blocks with the volume weight 350-400 kg/m³ performance analysis results. During the research the calculation model for a new generation autoclaved aerated concrete block exterior wall moisture migration and heat-flow regime has been worked out.

With the wet material balanced state model, which depends on the ambient relative humidity cyclically changing temperatures (day and night cycle), it is necessary to formulate an unbalanced state of the modeling methodology for the new generation of autoclaved aerated concrete blocks. In the present Doctoral Thesis the new generation of autoclaved aerated concrete structure is viewed as a "layered" set, where the layers are put one above the other, and each of the "layers" corresponds to a specified pore size and layout. In this case, the moister located in a specific "layer" with the smallest pores to surface and evaporate from the material has to pass sequentially through the "layers" with bigger pores and, finally, move through seamless connected pores and reach the outer shell of the block. Thus, this "layer" collection shows a defined set of structural space, which is described by the structural variables.

On the basis of pore size and layout of the new generation of autoclaved aerated concrete there is worked out the proposed migration of moisture and heat flow process calculation model. In view of the developed autoclaved aerated concrete thermal properties calculation model adjustment options there can be obtained quite accurate results, which coincide with the experimentally obtained results. By contrast with the developed computer program one can simulate temperature distribution in the new generation of autoclaved aerated concrete thick walls, as well as moisture content and physical state of moisture. This enables you to perform calculations for various building types depending on different operating conditions.

Practical Value of Thesis

The main practical effect of the Doctoral Thesis is the experimental result of the voluminous data base for the new generation of autoclaved aerated concrete thermal properties in the Baltic Sea States climatic regime. It should be noted that, while performing the above described tasks, there has been acquired three significant specialties. First of all, explored outer wall is made of a new generation of autoclaved aerated concrete blocks with the volume weight 350-400 kg/m^3 with a seam adhesive. Second, the experiment has been carried out in Tallinn, which is characteristic of a moist climatic regime. And, thirdly, the walls are set up with both internal and external finishing layers, what affects both the temperature of the wall and the thermodynamic parameters. Directly all three these factors assign value to the experiments from practical application point of view.

The study results can be used to complement the Latvian Building Code LBN 002-01 "Building Envelope Heating." This will give a more accurate insight into the aerated concrete walls during the drying and heating processes, the inherent construction of the Baltic republics climate.

The results can be used by a real object technical monitoring using non-destructive testing methods. While the experimental results obtained for different finishes and water vapor resistance factor effects on the aerated concrete walls during the drying process can be successfully used for various thermal calculations.

Developed within the present Work computer program can be successfully used for calculations of various thermal envelopes, made of a new generation of autoclaved aerated concrete blocks.

In the Work interest assessment there are emphasized three main results of application areas in which they can be successfully used:

- Practical importance - the voluminous data base for the new generation of autoclaved aerated concrete exterior wall moisture migration and heat flow processes, and developed proposals for changes in the Latvian Building Code LBN 002-01 "Building Envelope Heat"
- Scientific role - developed and experimentally proved new generation of autoclaved aerated concrete block exterior wall moisture migration and heat flow regime calculation model.

- Pedagogical value - a lecture course on the exterior wall envelope thermal characteristics of the supplement.

The Following Results Set For the Defense

- For the first time there have been obtained voluminous experimental data on the migration of moisture and heat flow processes mutual interaction in the external walls made of the new generation autoclaved aerated concrete blocks with the volume weight 350-400 kg/m^3 in the Baltic States climate zone.
- There has been studied various finishes water vapor resistance factor influence on both the next generation of autoclaved aerated concrete walls drying process and operating parameters.
- Moisture migration process in the relationship with thermal processes in the external walls made of autoclaved aerated concrete blocks with the volume weight 350-400 kg/m^3 depending on the orientation of the facade has been studied.
- There has been created and experimentally proved moisture migration and heat flow processes calculation model for the new generation of autoclaved aerated concrete external walls.
- There have been developed proposals for changes in the Latvian Building Code LBN 002-01 "Building Envelope Heating.

The Composition and Amount of Work

The Paper consists of five chapters, conclusion and bibliography.

Scope of Work: 130 pages, 52 Figures, 4 Tables, bibliography containing 85 names.

The present Doctoral Thesis research findings have been reported and discussed in 5 international conferences:

- 4-я Международная научно - практическая конференция "Опыт производства и применения ячеистого бетона автоклавного твердения" (Minsk, Belarus, May, 2006)
- 2-я Международная научно - практическая конференция "Ячеистые бетоны и силикатный кирпич в современном строительстве технология производства, опыт использования" (Kiev, Ukraine, March, 2007)
- 48th RTU International Scientific Conference (Riga, October, 2007)
- 11th International Conference, Heat Transfer, 2010 (Tallinn, Estonia, July 14-16, 2010)

- 1st Central European Symposium on Building Physics (Cracow, Poland, September 13-15, 2010)

Research problems and results are set out in 6 publications (see p. 22)

CONTENT OF WORK

Chapter 1 summarizes the bibliographic sources of information on the Thermal processes, building envelope, existing studies, their results and challenges.

Experimentally the main patterns and mechanisms of heat and moisture transfer of a porous material are identified. Practical experience has shown that porous materials cannot be separated from the moisture diffusion of heat flow, and heat and moisture flow processes should be considered as an inseparable link. Therefore, the moisture migration process description of porous materials is used in methods and approaches, which are used in the heat transfer process studies. It is necessary to trace the flow of heat and moisture migration process in demarcated structures to reveal the main regularities to be followed in the construction perspectives for the optimal use of the new generation of autoclaved aerated concrete.

Chapter 2 gives a theoretical basis of heat flow and moisture migration processes in autoclaved aerated concrete exterior wall envelope. This Chapter summarizes and analyzes the autoclaved aerated concrete envelope constructions heat and moisture regime calculation method.

Heat flow and moisture migration processes in autoclaved aerated concrete building envelope issues are dealt with fairly extensively in the technical scientific literature. Particular attention in this Paper is on the cellular structures and sutures quality impacts on the technological and thermal properties, in particular, the frost resistance of materials.

The main heat propagation mechanisms are three:

1. Heat transfer (heat is often transmitted to the molecules colliding by chaotic thermal motion. Heat dissipation describes the Fourier equation).

2. Convection (heat is transferred to the mass flow). Described by Newton's law of cooling.

3. Thermal radiation (heat is transferred in the form of electromagnetic radiation). Described by Stephen-Bolcmana law.

By contrast moisture transfer processes in porous materials are distributed in a variety of different mechanisms: diffusion, thermo-diffusion, baro-diffusion, superficial diffusion, moister flow, thermo-capillary flow, capillary transfer, and so on. It should be noted that not all of the moisture transfer mechanisms represent a significant proportion of the total water flow in the material. At low moisture content material transfer is basically steam. In addition, generally, the moisture transfer mechanism is diffusion. In the diffusion process water vapors in the air filling pores of the material from the area of high concentration to the area with low humidity levels. As moisture transfer potential is adopted moisture concentration in the pores of a material.

The main role of the moisture transfer process description is played by two factors: first - moisture transfer potential appropriate choice with a gradient determining the intensity of the process, and secondly - corresponding humidity transfer coefficient selection, which is corrected for this potential and has sense in process physics. Nowadays experimental moisture transfer studies, including the transfer coefficient determination, are reduced to the moisture content and temperature field measurements.

Unbalanced thermodynamics allows studying the moisture migration and heat flow processes in the new generation of autoclaved aerated concrete building envelope non-stationary modes, which non-stationary degree can be characterized by the hysteresis loop area. In addition, hysteresis loops can be created combining different variables, such as humidity and temperature or heat flow and heat conduction coefficient of the effective value.

As one of the best known non-stationary mathematical methods is the method developed by K.F. Fokin, called a” sequential wetting method." V.N. Bogoslovski introduced relative humidity potential of the concept, which characterizes not only material but also the air humidity conditions. Currently this method is recommended for the envelope material moisture assessment. Today, envelope heat - moisture regime is calculated using the method of potential moisture further developed by A. G. Perehozencev and S.V. Kornijenko. The European Union countries majority of the calculation methods consider as the main mechanism of moisture transfer the water vapor diffusion. As one of widely used nowadays in the heat - moisture regime calculation methods can be mentioned the model developed by the scientist H.M. Kunzel, German Institute of Building Physics. The proposed calculation method describes moisture transfer in porous building materials as a flow of liquid water and a vapor water flow. Recently, there has been actively developed reconstruction algorithms transfer coefficient with the inverse method of solving the tasks. Estimates of the outgoing data serve the measured temperature and moisture fields in the experiment material sample.

Chapter 3 describes the experimental results of the thermal processes in the external walls made of the new generation of autoclaved aerated concrete blocks obtained during the research.

Unlike previous experiments the studies in the present Thesis were carried out in the new generation of autoclaved concrete blocks with the volume weight 350-400 kg/m^3 external walls thermal processes under the humid climate regime building conditions, which are characteristic of the Baltic States region. There were created the facade fragments (Fig. 1) of the aerated concrete blocks with the volume weight ~ 380 kg/m^3 buildings south and north sides in which for about 2.5 years there were recorded moisture migration and heat flow processes. That wall was constructed using the blocks moisture of which is similar to the practical block moisture, and approximately one year after the start of construction of the building there were made up both the internal and the external finishing layers. Building indoor climate in the mode of living was kept in accordance to customary standards of a dwelling house, and all the measurement data collected and stored on electronic media.

Figure 1. Wall fragment, formed from new generation of autoclaved aerated concrete blocks

During the experiment, fixed-time conditions are considered in fig. 2, where indoor performance is marked with the symbol s, while the symbol v means parameters outside the room.

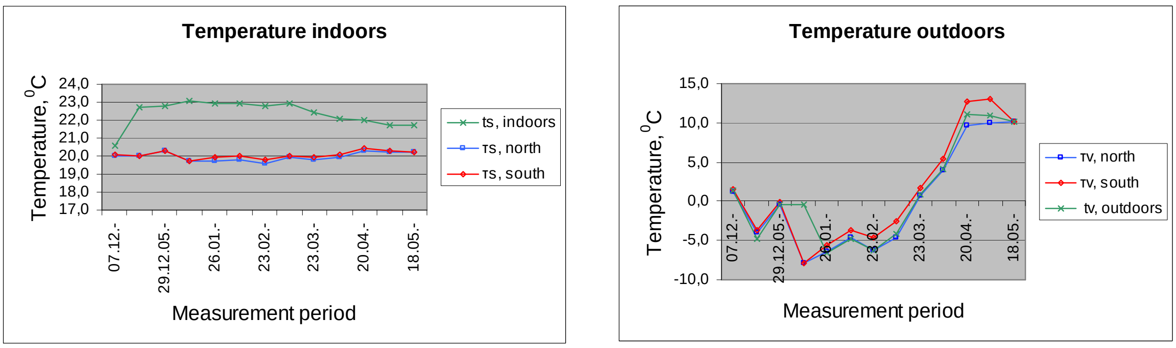

Figure 2. A detailed description of the weather during the experiment

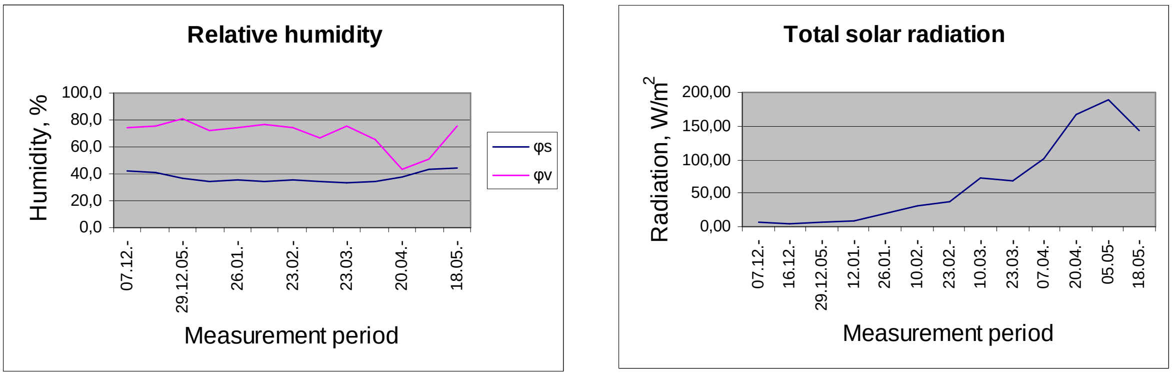

Figure 2. A detailed description of the weather during the experiment

The heat flow was measured with help of device ALMEMO – 2290-8 with feeders FQA017C and FQA019C. The surface temperature of both experimental walls was also measured, using HOBO type logger. Performed wall surface temperature measurements are gathered and displayed in Fig.3. Since the temperature deflections of inner surface within a year is not observable, only southern and northern wall surface temperature difference is plotted.

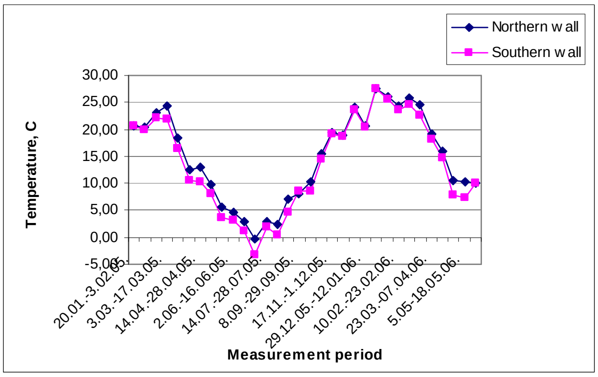

Figure 3. Temperature of autoclaved aerated concrete wall external surface

Performed heat flow measurements are gathered and displayed in Fig.4. While analyzing the acquired experimental data, it can be concluded that heat flow through autoclaved aerated concrete wall is directly related to the moisture distribution in the wall, external wall surface temperature diferences and solar radiation.

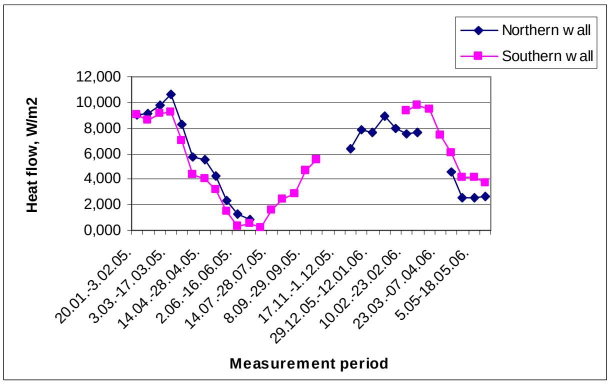

Figure 4. Heat flow through autoclaved aerated concrete wall

From the wall there were taken samples which humidity met the European standard EN 1353 methodic. The samples were taken from the middle part of the wall with a step (wall thickness) 50 mm. Under the requirements of the standard the samples were weighed immediately after their removal (wet basis) and, immediately upon removal from the drying chamber, where they reached constant weight. The samples were taken from both the south and the north wall fragments eight times. The results are collected and displayed in fig.5.

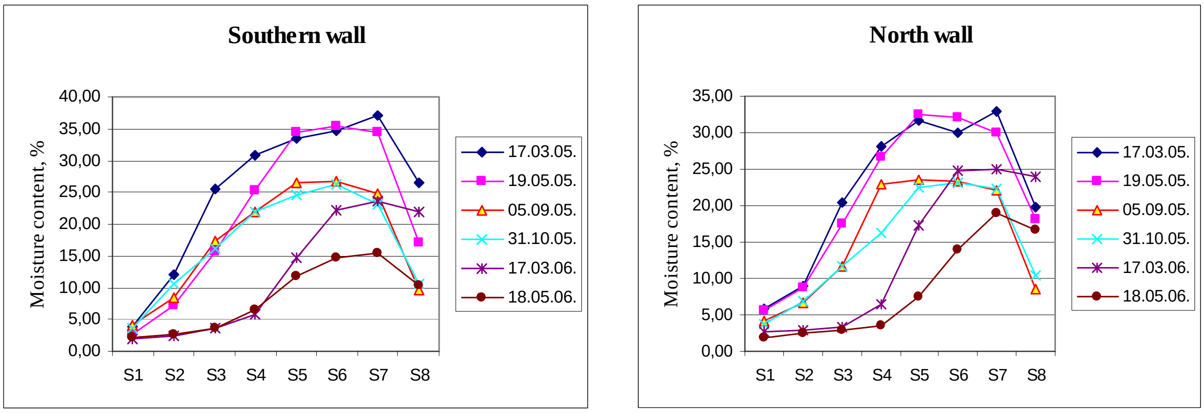

Figure 5. Moisture distribution in autoclaved aerated concrete external wall thickness

Moisture distribution in southern and northern walls is different, but both fronts average humidity is very similar. This is explained by two factors. The first is that about a year later there was made the internal and external decoration of the wall, which affected the movement of moisture. The second factor is solar activity, which increased the south wall surface temperature and contributed to the drying process to a greater extent than it occurred in the northern wall.

Obtained experimental data allows drawing conclusions on autoclaved aerated concrete walls thermal performance under conditions that are very close to the actual building. As a result, there has been acquired an extensive measurement database, which provides a more complete picture of the autoclaved aerated concrete envelope thermal characteristics of the Baltic Sea region-specific operating conditions.

To determine directly the impact of the external finishes on the moisture migration in autoclaved aerated concrete external walls additional experiment with 15 pairs of samples with different finishes was fulfilled fig.6. One of the prepared sample pairs was without decoration, while the other sample pairs were with various combinations of the finishing from the company SAKRET materials - KAM, BG, CLR, GAM, PG, LH, silicate earth, silicate paint, SBR2 and MRP2. Prepared samples were weighed before finishing deposition and after finishing deposition and dried four months under natural conditions. During the experiment, a sample lost 0.64 kg from the original weight on average and actually reached equilibrium moisture in each of new generation of autoclaved aerated concrete sample.

Figure 6. Autoclaved aerated concrete blocks samples with different finishes

Autoclaved aerated concrete block samples with different external finishes drying dynamics is shown in the fig.7. The difference between the weight of the block of the experiment at the beginning and at the end of the experiment (moisture weight) was compared and is presented in a logarithmic scale. It is seen that the model drying process can be reasonably well described by the graphs of the exponential functions. Basing on the experimental results it can be concluded that the finish material effect on the new generation of autoclaved aerated concrete outer walls drying process is significant because the difference between the sample without finishing (marked line) and with different Sakret finishing combination drying time is approximately 2.5 times. The analysis of different finishes material combination effects on moisture migration in the experiment shows that it is not so efficient because changes in the average size are within 10 per cent limit.

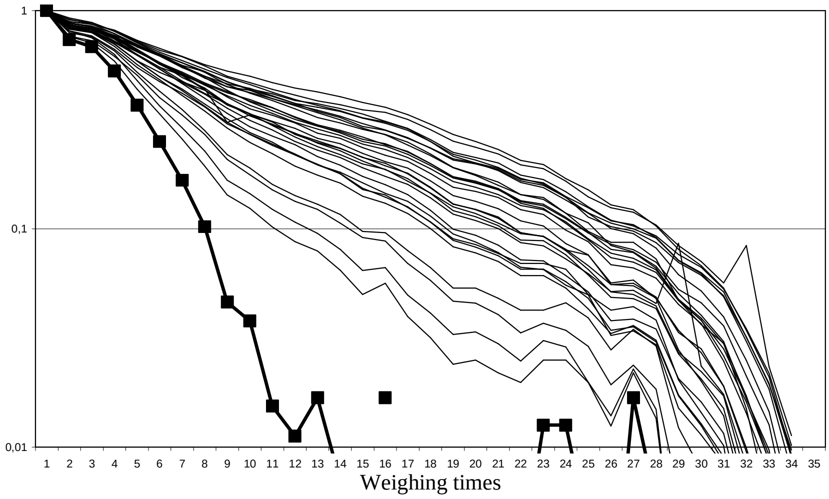

Figure 7. Drying dynamics of the autoclaved aerated concrete block samples with different finishes between the weighing times

From the experimental results, it can be concluded that the external wall finishes are preferably fulfilled after the first heating season with a finishing material which water vapor permeability factor - μ is equivalent to μ value of the new generation of autoclaved aerated concrete material.

Chapter 4 describes the heat flow and moisture migration process measurement model presented by the Promotion Paper.

Calculation program is made on the basis of a 'multilayer' model material when every its 'layer' locates volumetrically in one and the same part of autoclaved aerated concrete. Proposed model consists of three layers. First layer is a joined open pore system that is filled with humid air, can be taken as an external layer that exchanges moisture with the surrounding environment. In this layer moisture transfer processes takes place at the expense of water vapour diffusion in the air and open pores ventilation, which are comparable in impact. In the second layer moisture transfer processes takes place in straight connection with the system of fine pores that are open only partly. In this second layer moisture sorption and desorption takes place according to sorption - desorption curve. Thus the second layer, which consists of fine partly open, non-aerated pore system, while in equilibrium with moist air, completing the first round of connected pores, absorb humidity in range from 3.5% to 6%.

The third layer in the model should be used for a comprehensive description of moisture transfer processes as in autoclaved aerated concrete block moisture directly after its production can reach up to 40% of the equilibrium moisture content in excess of the depicted border situation in the sorption - desorption curve. This is special taking into account the time intervals that are significantly smaller than the aerated concrete material drying out full time (2 to 3 years). Conditionally the third layer can be considered to consist of closed pores, which are separated from the second layer of the pores with a solid substance layer. These pores, partly filled in with the moisture after autoclaved aerated concrete production, and then transfer the moisture to the second layer pores with a speed that is proportional to the relative humidity difference between the second and the third layers

Autoclaved aerated concrete material elemental part moisture transfer process equation system can be written as follows:

$$\frac{\partial}{\partial t}\omega_3 = -D_{32}(\omega_{20} - \omega_2)\text{, if } \omega_3 > 0\text{, } \frac{\partial}{\partial t}\omega_3 = 0 \text{ if } \omega_3 = 0 \tag{1}$$

$$\frac{\partial}{\partial t}\omega_2 = -\frac{\partial}{\partial t}\omega_3 - P_{10}{}^{-1}D_{21}(p_{10} - p_1) \tag{2}$$

$$\frac{\partial}{\partial t}p_1 = D_{11}\frac{\partial^2}{\partial x^2}p_1 - V_x\frac{\partial}{\partial x}p_1 - D_{21}(p_1 - p_{10}) \tag{3}$$

where t – time, $\omega_3(\vec{x})$ – moisture content %, $D_{32}(T)$ – diffusion coefficient, between the autoclaved aerated concrete 2nd and 3 ‘layers’, $\omega_{20}(T)$ – 2d layer final moisture content (about 10%), $\omega_2(\vec{x})$ – moisture content %, P_{10} [Pa] – the ratio which depends on the number of open interconnected pores in autoclaved aerated concrete material elemental part, $D_{21}(T)$ – diffusion coefficient in the second layer of pores, $p_{10}(\omega_2, T)$ – saturated water vapour pressure, attributable to non-aerated open pores, $p_1(\vec{x})$ – saturated water vapour pressure attributable to open connected (aerated) pores, $D_{11}(T)$ - diffusion coefficient in the open, connected pores, V_x – velocity of air flow through the pores in the direction of the exposed surface of the wall, $T(\vec{x})$ – temperature.

Without taking into account the complex and distinctive autoclaved aerated concrete pore structure, size $P_{10}(\vec{x}, T)$ can be expressed as follows:

$$P_{10}(\vec{x}, T) = \frac{p_1}{\omega_2}\frac{p_{10}(T)}{}\left(\frac{RT}{m_u}\right)\rho_u K_1^{-1} = \frac{m_g\rho_u}{m_u\rho_g K_1}P_0 \approx 6000P_0\text{,} \tag{4}$$

if $K_1 \approx 0.2$

where R = - universal gas constant, m_u = 18 – molar weight of the water molecule, ρ_u - water density in the liquid state, m_g = 29 – molar weight of the air, ρ_g - air density, P_0 - atmospheric pressure, $K_1 \approx 0.2$ - indicative amount of open interconnected pores in autoclaved aerated concrete material elemental part

Moisture transfer equations (1) – (3) should be supplemented with a start and boundary conditions and heat transfer equations. Drawing up heat transfer equations the heat that arises from moister evaporation is not taken into account. It is feasible considering the fact that the autoclaved aerated concrete wall drying process takes place over several years, while the temperature variation in wall thickness is diminishing in a few days. However, drawing up these equations, the enthalpy of melting of ice should be taken into account, because the speed in which the water turns into ice (moves into another state) is not limited to moisture transfer velocity in autoclaved aerated concrete material pores.

Taking into account mentioned below, the heat transfer equations for autoclaved aerated concrete external walls can be written as follows:

$$\frac{\partial}{\partial t} q(T,\omega) = \vec{\nabla}\left[L(T,\omega)\vec{\nabla}T\right] \tag{5}$$

$$L(T,\omega) = L_0 + L_T(T - T_0) + L_\omega \omega \tag{6}$$

$$q(T,\omega) = (T - T_0)(q_T + q_\omega \omega) + q_\lambda \omega \Phi(T - T_0)\,,\ \Phi(x) = \begin{vmatrix} 0 & ,\, x < 0 \\ 1 & ,\, \mathrm{x} \geq 0 \end{vmatrix} \tag{7}$$

where $\omega = \omega_2 + \omega_3$ - moisture content %, $q(T,\omega)$ - heat flux, $L(T,\omega)$ - thermal conductivity, T_0 - water freezing point 0°C, L_T, L_ω, q_T, q_ω - coefficients of the linear approximation, but q_λ - enthalpy of melting of ice.

Developed in the Promotion Work non-linear system of equations (5) - (7) is different from already existed linear heat flow equation systems in the fact that the proposed equations can consider the fact that the boundary between frozen and liquid moisture in autoclaved aerated concrete material varies depending on the outdoor temperature. In fact, it is possible to simultaneously solve two equations for heat flow, the pores of the concrete with moisture in liquid and frozen state, as well as to take into account the fact that the boundary between these physical states changes in space and time. In turn, each of the above material layers can be solved with linear heat flow equation answering short time intervals. It should be noted that each of the layers of material should be used with its own, different rate depending on the liquid physical state, and the layer borders must take into account both moister and ice-melting effect.

On the basis of already known heat and moisture transfer processes equations is created a model in which an autoclaved aerated concrete external wall is dealt with as a homogeneous structure made up of heterogeneous separate layers. Each of these heterogeneous layers has different properties, which determine the aerated pore structure and the initial moisture of the material. Unlike previously made exterior wall thermal properties calculations models, in this case is used material structural (internal) variable value that estimates the above described material heterogeneous layer interaction in the light of separate moisture migration processes in each layer.

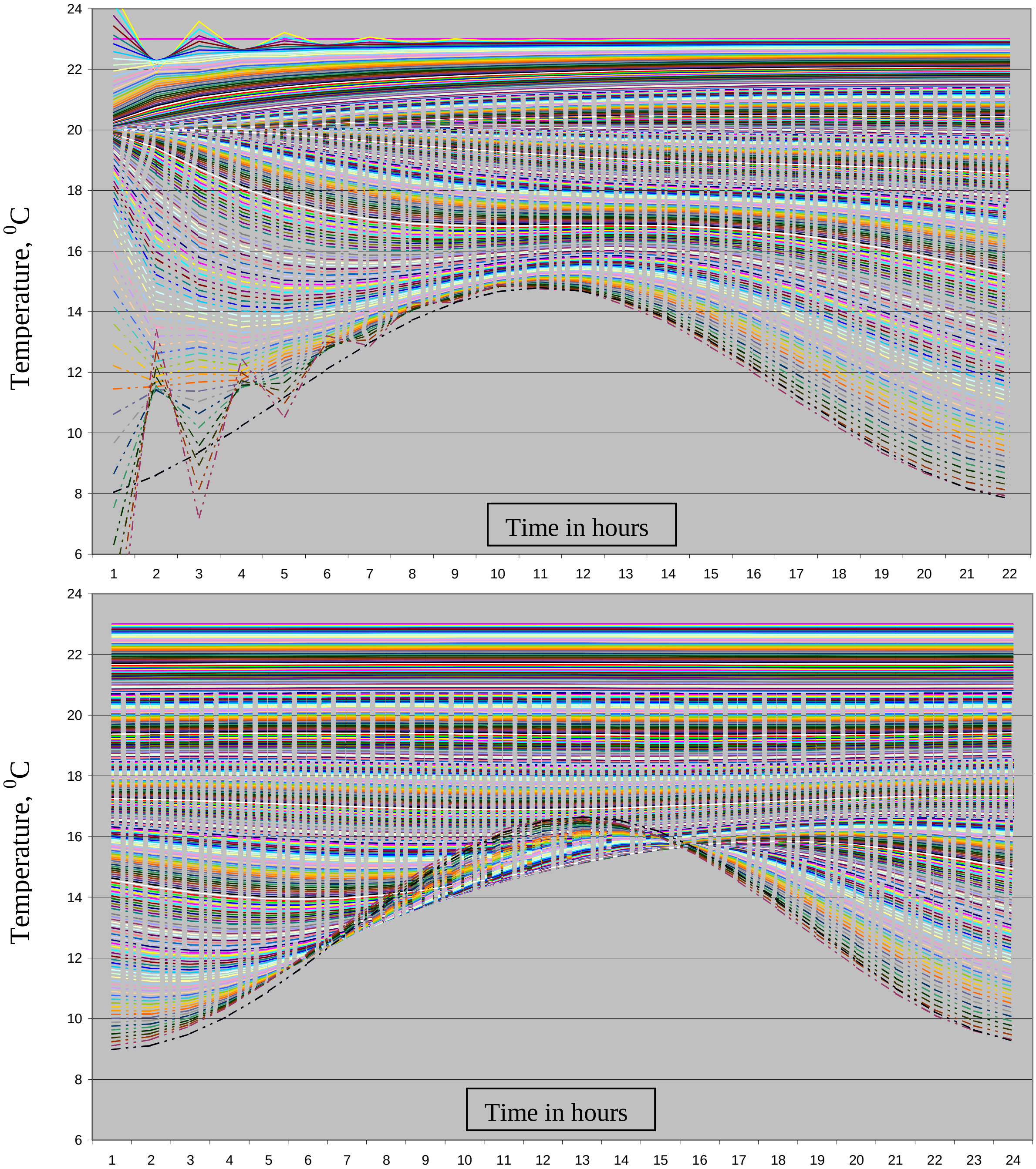

Figure 8. The temperature calculation during the 1st day (top) and 10 days (bottom) after installing a block wall. Block initial temperature 20°C, room temperature 23°C, the thickness of the block chosen - equal to 375 mm. The calculation is fulfilled with Krank-Nicholson scheme with parameters θ = 0.6, with a time step of 3600 seconds and the step depth of 1.5 mm.

Taking into account all of the proposed above, the model for the calculation of autoclaved aerated concrete external wall thermal properties can be regarded as analytically empirical where are made analytical equations for a separate layer, while their interactions (both in space and in time) is calculated with the numerical method.

Figure 8 shows aerated concrete block layers separated by a distance of 1 mm, the there has been made the calculation during temperature change using indirect Krank-Nicholson scheme application. The air temperature outside can be made with a step function - a step change in 1 hour, a step in solving heat conduction equation has been chosen equal to 1 second. There is calculated an error margin that is caused by the initial temperature collapse and almost completely disappears faster than in 12 hours.

Figure 9. Moisture distribution in autoclaved aerated concrete outer wall. On the x-axis there is the distance from the inner to the outer surface of the wall. On the y axis there is time from the outer wall construction time up to 2 years.

It is worth noting that in Fig.8 at the bottom (Interval from 15th to 16th hours) there is a constant temperature zone formation, a width of 150 mm. Temperature waves, taking into account the phase and amplitude, can create an interesting area, which is not significant in terms of use, because the issue does not apply to the task solution.

Figure 9 shows the simulation results - the moisture distribution in the new generation of autoclaved aerated concrete thick walls. The halftone image allows you to see the space and moisture during the drying process of autoclaved aerated concrete outer wall. Brightness characterizes humidity, white - maximum moisture, black - dry material.

The proposed calculation model considers autoclaved aerated concrete porous properties in order to more accurately describe the heat transfer and moisture migration processes in the new generation of autoclaved aerated concrete exterior walls in the building envelope under various operating conditions. In the calculation it is possible to consider different diffusion processes in the outer wall thickness, influence of climatic conditions, as well as factors of the interaction between walls during the drying process.

Equations (1) - (7) and the relationship $D_{11}(T)$, $D_{21}(T)$, $D_{32}(T)$, $\omega_{20}(T)$, $p_{10}(\omega_2, T)$, $L(T,\omega)$, $c(T,\omega)$ make a complex nonlinear system of equations that can be successfully used in the forecast on the new generation of autoclaved aerated concrete thermal processes both in time and space, different functions in buildings, using a variety of decorative materials and simulation of climatic conditions.

Chapter 5 summarizes the recommendations of research results for practical use.

The resulting experimental and modeling analysis of the results led to the conclusion that they are qualitatively and quantitatively comparable with each other. It is possible, using the autoclaved aerated concrete thermal properties model calculation adjustment options developed by the present Thesis, to get a relatively accurate result, which coincides with the experimentally obtained results.

The developed computer program is applicable to various stages of operation from the autoclaved aerated concrete block construction and reaches equilibrium moisture. Throughout this period it is possible to simulate the temperature distribution in the new generation of autoclaved aerated concrete thick walls, as well as moisture content and physical state of moisture. It is possible to perform calculations for various types of buildings and living quarters and storage facilities, as well as rooms with high moisture content.

Experimentally obtained results show that the new generation of autoclaved aerated concrete external walls weight of moisture (w, %) in the Baltic countries climatic zone is the range from 4 to 6%. Latvian Building Code LBN 002-01 states various construction materials and insulation materials weight moisture w per cent while thermal inertia calculating for the autoclaved aerated concrete material 12%. In view of the developed by the Thesis results, LBN 002-01 for the new generation of autoclaved aerated concrete with the volume weight 350-400 kg/m^3 wet weight w is 5%.

It is experimentally found that connection of the new generation of autoclaved aerated concrete blocks for external walls single envelope with the adhesive does not support the so-called "cold bridges" seams. Therefore, in walls thermo technical calculations it is not necessary to take into account the correction factor $\Delta\lambda$ w, which is evaluated by joint effects depending on the thermal conditions of work in accordance with the LBN 002-01.

It is recommended to start the construction of exterior walls from the new generation of autoclaved aerated concrete in late spring. During summer autoclaved aerated concrete walls dry quickly and at the time of autumn rains before the accession date the building has a roof structure to cover the walls to sufficiently protect them from possible wetting. Until the beginning of the first heating period the building heating system should be installed to allow winter indoor temperature to be maintained in a positive mode. The autoclaved aerated concrete walls still intensively drying in the first heating season, it is desirable not to make external finishing. For the new generation of autoclaved aerated concrete exterior wall finishes should be used those materials in which water vapor resistance factor μ does not exceed 15.

CONCLUSION

As a result of the Promotion Work the following main conclusions have been obtained:

1. There has been created and experimentally proved moisture migration and heat flow processes calculation model for the new generation of autoclaved aerated concrete external walls for the Baltic States region specific operating conditions.
2. The proposed calculation model considers autoclaved aerated concrete as a material with the porous nature to enable the most accurate description of the heat and moisture transfer processes in the external wall structures under various operating conditions. While calculating it is possible to estimate separate diffusion processes in the outer wall thickness, climatic conditions effects, as well as mutual interaction of factors in external walls drying process.

3. Autoclaved aerated concrete wall moisture monitoring can be made precisely by cutting samples and weighing them. However, the moisture sample curve, using sensors FH 646-1, does not give accurate results if the material humidity is above 10%.
4. The external and internal finishes being made, autoclaved aerated concrete wall drying process slows down, so it is recommended to use external finish materials with the water vapor resistance factor μ value close to the new generation of autoclaved aerated concrete water vapor resistance factor of $\mu = 6$.
5. Autoclaved aerated concrete exterior wall finishes should be applied before the second heating season, as the humidity from the closed pores has shifted almost entirely to the semi-open pores and closed pores humidity do not come back anymore.
6. It is found experimentally that the connection of the new generation of autoclaved aerated concrete blocks for external walls single envelope with adhesive does not support the so-called "cold bridges" seams. Therefore, making thermodynamic calculations of autoclaved aerated concrete walls with the volume weight <400 kg/m^3, it is not necessary to take into account the correction factor $\Delta\lambda_w$, which evaluates joint effects of non-ventilated element according to LBN 002-01 Annex Table 2.
7. Experimentally obtained results show that the new generation of autoclaved aerated concrete external walls moisture weight (w, %) in the Baltic countries climatic zone is in the range from 4 to 6%. Supplement LBN 002-01 Annex Table 5 with a new position of autoclaved aerated concrete with the volume weight 350-400 kg/m^3 dry weight, w, % value 5%.

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