IOP Conf. Series: Materials Science and Engineering **251** (2017) 012070 doi:10.1088/1757-899X/251/1/012070

Impact of moisture content in AAC on its heat insulation properties

S Rubene[1] and M Vilnitis[1]

[1]Riga Technical university, Faculty of Civil Engineering, Construction Technology department
6A Kipsalas Street, Riga, LV-1658, Latvia

E-mail: sanita.rubene@rtu.lv

Abstract. One of the most popular trends in construction industry is sustainable construction. Therefore, application of construction materials with high insulation characteristics has significantly increased during the past decade. Requirements for application of construction materials with high insulation parameters are required not only by means of energy saving and idea of sustainable construction but also by legislative requirements. Autoclaved aerated concrete (AAC) is a load bearing construction material, which has high heat insulation parameters. However, if the AAC masonry construction has high moisture content the heat insulation properties of the material decrease significantly. This fact lead to the necessity for the on-site control of moisture content in AAC in order to avoid inconsistency between the designed and actual thermal resistivity values of external delimiting constructions. Research of the impact of moisture content in AAC on its heat insulation properties has been presented in this paper.

1. Introduction

One of the most popular trends in construction industry is sustainable construction. Therefore, application of construction materials with high insulation characteristics has significantly increased during past decade. Requirements for application of construction materials with high insulation parameters are required not only by means of energy saving and idea of sustainable construction but also by legislative requirements. Latvian national construction norms [1] define normative thermal transmittance values, which have to be calculated based on thermal conductivity values of the building components.

At present, most designers or consultants focus only on the thermal performance of buildings based on experiment or simulation analysis frequently without considering the moisture effect. However, moisture has a big influence on the thermal characteristic of building materials and heat transfer processing. The history of the research on the couple of heat and moisture (HM) transfer is older than 50 years. There are several models to describe the HM transfer process and solving methods. However, till now, there is no any theory that could cover all situations for HM transfer in porous materials, due to the kinds of assumption and complicated system. Meanwhile, kinds of hygrothermal characteristics need to be input into the models, which probably limit solving the mathematic model [2, 3, 4].

Autoclaved aerated concrete (AAC) is a load bearing construction material, which has high heat insulation parameters. However, if the AAC masonry construction has high moisture content the heat insulation properties of the material decrease significantly due to its porous structure. The impact of moisture content in AAC on its thermal conductivity properties for thermal resistance calculations of the building envelope can be assessed by methodology stated in ISO 6946:2007 [5].

This fact lead to the necessity for the on-site control of moisture content in AAC in order to avoid inconsistency between the designed and actual thermal resistivity values of external delimiting constructions.

2. Materials and Methods

Aerated concrete is basically a mortar with pulverized sand or industrial waste like fly ash as filler, in which air is entrapped artificially by chemical (metallic powders like A1, Zn, and H_2O_2) or mechanical (foaming agents) means, resulting in a significant reduction in density [6].

Aerated concrete falls into the group of cellular concrete (microporite being the other one). The main advantage of aerated concrete is its lightweight, which optimises the design of supporting structures including the foundation and load bearing walls. Aerated concrete provides a high degree of thermal insulation and considerable savings in material due to the porous structure. Aerated concrete can be obtained with a wide range of densities e.g. 300± 1800 kg/m3, thereby offering flexibility in manufacturing products for specific applications (structural, partition and insulation grades) [7].

However, the porous structure of the AAC lead to accumulation of high moisture content if the material is used for construction in wet conditions and therefore the designed heat resistivity values of the material decrease significantly.

In order to detect the impact of moisture content in insulated wall constructions three types of wall models were prepared and theoretical calculations of thermal transmittance values of the relevant constructions calculated (table 1).

Table 1. Calculated thermal transmittance values of wall specimen.

Layer	**Thickness of layer** d, m	**Thermal conductivity** λ, W/(mxK)	**Thermal resistance** R_T, (m^2 x K) / W	**Thermal transmittance of the construction** U_c, W / (m^2*K)
		Wall S-1		
External surface			0,040	**0,1910**
Plaster	0,002	0,900	0,002	
Mineral wool insulation	0,100	0,037	2,630	
AAC masonry	0,300	0,100	2,500	
			0,130	
		Wall S-2		
External surface			0,040	**0,1885**
Plaster	0,002	0,900	0,002	
Polystyrene insulation	0,100	0,036	2,630	
AAC masonry	0,300	0,100	2,500	
			0,130	
		Wall S-3		
External surface			0,040	**0,3740**
Plaster	0,002	0,900	0,002	
AAC masonry	0,300	0,100	2,500	
			0,130	

In order to model the deviations of the thermal transmittance values of the designed wall construction specimen caused by the impact of moisture content in the AAC masonry elements, the drying process of the specimen by application of electrical impedance spectrometry (EIS) [8].

3. Description of the experiment

For the particular experiment three AAC masonry wall constructions with dimensions 1200x600x250mm (length x height x thickness) were used and the composition of the wall structure was relevant to those stated in table 1. Afterwards, the two insulated specimens and the third one not insulated were plastered on the external surface of the wall structure. Thus, a model of the construction phase considering the completed cladding of the masonry structure as well as completed external finishing of the wall, have been simulated (Figure1).

Figure 1. Sample constructions on stand.

Monitoring of the drying process throughout the cross section of the constructions was performed by application of EIS for 12 weeks in laboratory conditions with air Rh in range of 60-80% and the average temperature in range from 18 to 25°C. Such conditions comply with average weather conditions on construction site in Northern European summers when the building envelope is not fully closed and heating of the building has not begun. The same drying conditions were maintained for all specimens [9].

As a result moisture distribution charts throughout the cross section of the specimen were obtained (Figure 2.-Figure 4.)

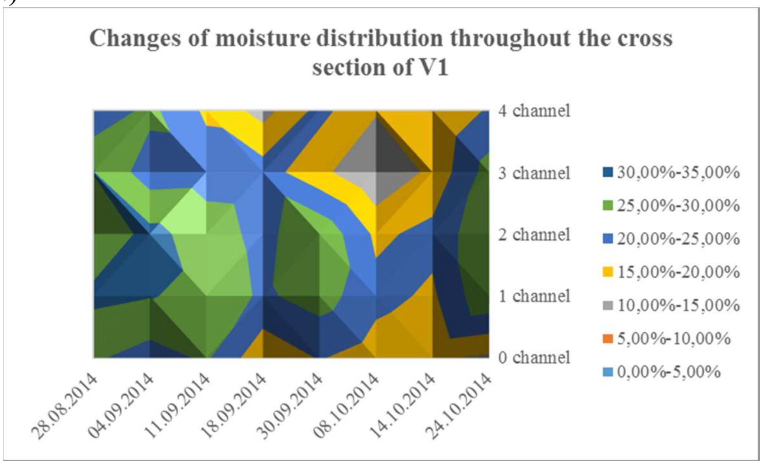

Figure 2. Changes of moisture distribution throughout the cross section V1 of S-1 specimen construction during the experiment.

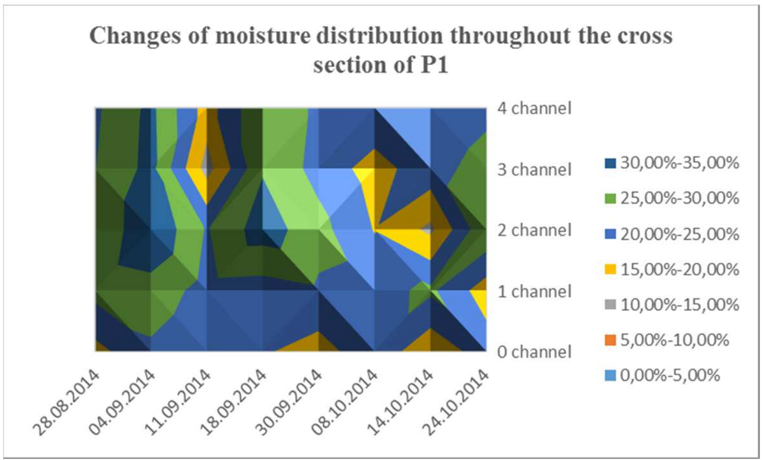

Figure 3. Changes of moisture distribution throughout the cross section P1 of S-2 specimen construction during the experiment.

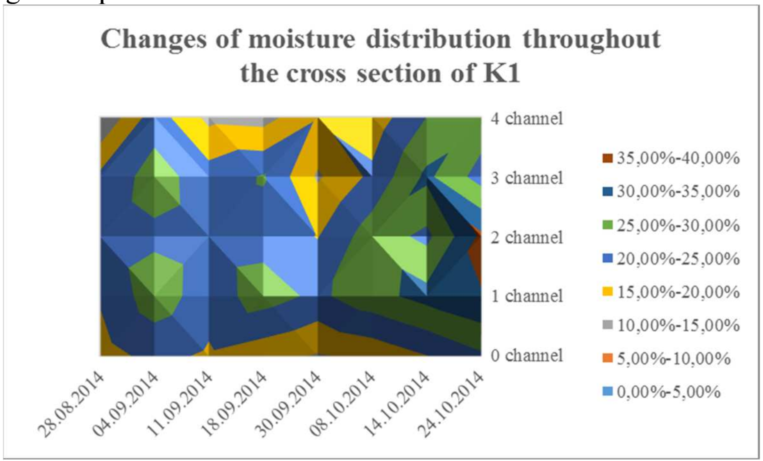

Figure 4. Changes of moisture distribution throughout the cross section K1 of S-3 specimen construction during the experiment.

After the data about moisture content in the wall specimen was obtained the impact of the moisture content in AAC on the thermal transmittance value of the wall construction was assessed by methodology stated in ISO 10456:2007 “Building materials and products — Hygrothermal properties — Tabulated design values and procedures for determining declared and design thermal values” [10].

4. Results

Modelling of the changes of thermal transmittance values of the wall specimen described in Table 1 due to the changes of thermal conductivity changes of AAC were performed and the results of the thermal transmittance deviations of the wall constructions have been displayed in Figure 5-Figure 7.

The results of the modelling prove the assumptions stated in the first two paragraphs of the paper as well as the results of the researches by Shui Yu *et.al.* [2, 11], therefore, the necessity of the monitoring of moisture content in AAC masonry constructions during the construction period in order to avoid sealing of extensive amounts of moisture in the wall constructions are of great importance. In case the moisture content control is omitted the calculated thermal transmittance values of the building envelope can vary from the actual values up to two times higher values. Particular risk in such situations can be applicable to external delimiting constructions from AAC with no additional heat insulation layer as it is displayed in Figure 7, where the inclination of the impact graph is the highest due to the fact that the AAC is the only material, which grants the insulation of the delimiting construction.

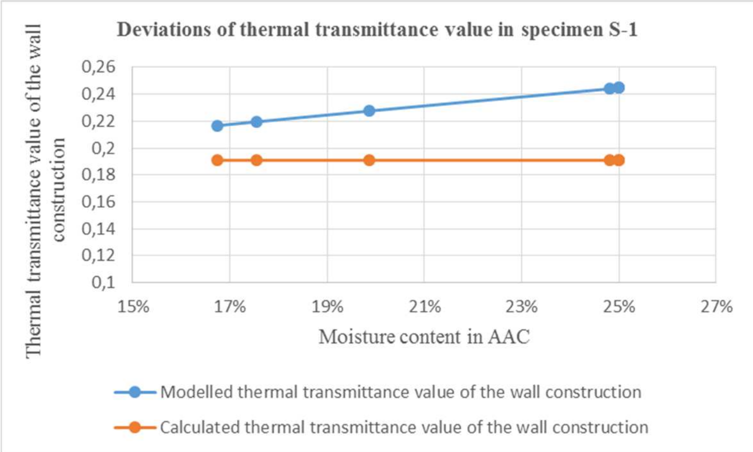

Figure 5. Deviations of thermal transmittance values of specimen S-1.

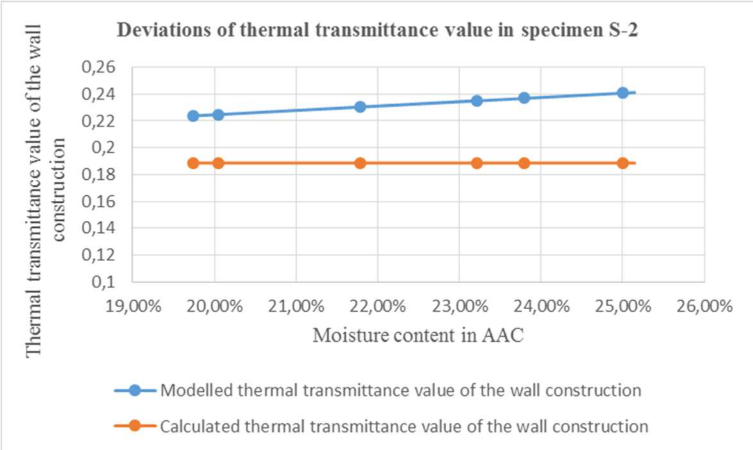

Figure 6. Deviations of thermal transmittance values of specimen S-2.

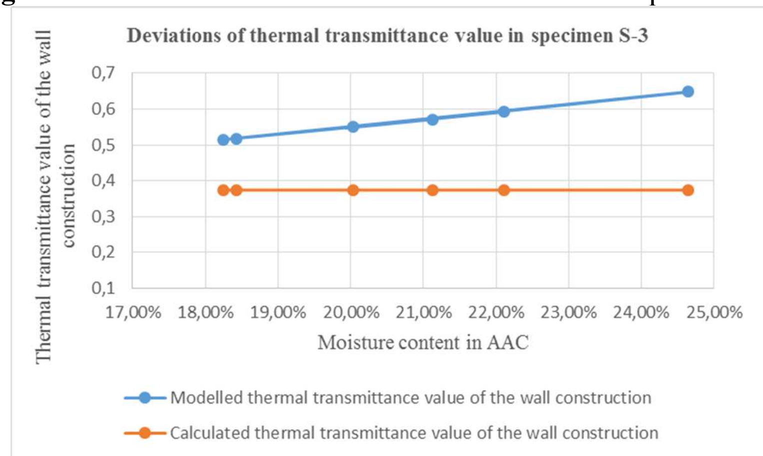

Figure 7. Deviations of thermal transmittance values of specimen S-3.

5. Conclusions

The moisture content of AAC and insulation material of external delimiting constructions have significant impact on its drying speed and therefore on the moisture distribution throughout the cross section of the wall construction. Furthermore, it influences the heat resistivity properties of the wall construction, therefore should be considered during the design phase in order to avoid situations when the building envelope is not able to reach designed insulation parameters.

IOP Conf. Series: Materials Science and Engineering **251** (2017) 012070 doi:10.1088/1757-899X/251/1/012070

Therefore, it is necessary to perform moisture content measurements of AAC during the construction phase in order to control the actual performance of the construction in terms of moisture content. In opposite case significant deviations between designed and actual performance of the building envelope will be observed and may lead to maintenance problems of the building structure.

References

[1] Latvian building normative LBN 002-15 “Heat engineering of external delimiting constructions”
[2] Shui Yu, Xu Zhang, Guohui Feng, 2014, Applicability of Vapor Transport Theory for Common Wall Types in Mixed Climate Zone of China, Proceedings of the 8th International Symposium on Heating, Ventilation and Air Conditioning, Lecture Notes in Electrical Engineering 263, DOI: 10.1007/978-3-642-39578-9_42
[3] Yu S, Bomberg M, Zhang X, 2012, Integrated methodology for evaluation of energy performance of the building enclosures: part 4-material characterization for input to hygrothermal models. J Build Phys 35(3):194–212
[4] ASHRAE, 2006, A Thermal and Moisture Property Database for Common Building and Insulation Materials, RP-1018, ASHRAE Transactions, Vol. 112(2), pp 485–497
[5] ISO 6946:2007 Building components and building elements Thermal resistance and thermal transmittance Calculation method
[6] Vos, B.H., 1965, Non-Steady-State Method for the Determination of Moisture Content in Structures. Humidity and Moisture 4, 35–47
[7] Parilkova, J., et al., 2011, Monitoring of Changes in Moisture Content of the Masonry due to Microwave Radiation Using the EIS Method. EUREKA 2011, Brno, ISBN 978-80-214-4325-9
[8] Rubene, Sanita. Methodology for Detection of Moisture Distribution throughout the Cross Section of Autoclaved Aerated Concrete Masonry Constructions by Application of EIS Method. PhD Thesis. Rīga: [RTU], 2016. 112 p.
[9] Rubene, S., Vilnītis, M., Noviks, J. Impact of External Heat Insulation on Drying Process of Autoclaved Aerated Concrete Masonry Constructions. IOP Conference Series: Materials Science and Engineering, 2015, Vol.96, Iss.1, pp.1-8. ISSN 1757-8981. e-ISSN 1757-899X. Available from: doi:10.1088/1757-899X/96/1/012059
[10] ISO 10456:2007 “Building materials and products — Hygrothermal properties — Tabulated design values and procedures for determining declared and design thermal values”
[11] Shui Yu, Xu Zhang, Guohui Feng, 2014, Comparing Condensation Theory with Hygrothermal Models for the Mixed Climate Region of China, Proceedings of the 8th International Symposium on Heating, Ventilation and Air Conditioning, Lecture Notes in Electrical Engineering 263, DOI: 10.1007/978-3-642-39578-9_9