Analysis of the change of the specific heat loss coefficient of buildings resulted by the variation of the geometry and the moisture load

Ferenc Szodrai, Ákos Lakatos, Ferenc Kalmár

University of Debrecen, Faculty of Engineering, Department of Building Services and Building Engineering, Debrecen, Hungary

H-4028 Debrecen, Ótemető str. 2-4.

Tel: +36-52-415-155/77771

Fax: +36-52-415-155/77713

Email of corresponding author: alakatos@eng.unideb.hu

Abstract

Energy saving as well as energy-conscious installations and refurbishments of buildings became the most important actions to be achieved. The performance of a building can be significantly affected by climate. The significance of a ‘design with climate′ approach is highlighted in this study. This study highlights the impact of climate conditions (focusing on humidity and precipitation) on design decisions. The effect of the overall energy performance of the building is achieved by the architectural and technical solutions that have impact on performance. In this study nearly zero energy buildings were tested and presented built from different materials with different moisture load. As a result the change of the specific heat loss coefficient of buildings is presented in function of the building structure (wall and insulation), design (envelope surface to heated volume ratio) and moisture content. And last but not least suggestions will be given to help to choose the perfect structure from moisture resistant, geometry and cost-optimum points of view. The building envelope is the interface between the interior of the building and the outdoor environment. A building's energy consumption to a large extent depends on certain envelope design elements.

1. Introduction

According to the recast of the Energy Performance of Building Directive (EPBD) ‘Member States shall ensure both that by 31 December 2020, all new buildings are nearly zero-energy buildings (NZEB), and after 31 December 2018 new buildings occupied and owned by public authorities are nearly zero-energy buildings. The building sector has been identified as one of the key sectors for cost-efficient savings; at least 88–91% reduction is necessary in this field. In Hungary approximately 70-80% of the existing buildings need to be refurbished. One of the main tools for this is the thermal insulation of buildings. Nowadays the mainly used insulation materials are the foamy plastic based and the fibrous insulation materials, however, the use of the nano-based (aerogel, vacuum panel, ceramic) insulations is also widespread. By additional insulating one can not only reduce heat losses and therefore probably the energy bills of the buildings, but also can make his house more comfortable. Efficient building insulating can shorten the heating period and the effects of the thermal bridges can be reduced as well. Minimizing the energy and reducing the CO2 as well as the green house gases are well known concepts. Other reasons for the “thermal packing” of the buildings are the extension of the lifetime of the buildings, the protection of the bearing layer against the ice and mechanical impacts, furthermore the market value of the buildings is increasing too. [1-4] This article presents the change of the specific heat loss coefficient of a wall structure first by the variation of the envelope surface to heated volume (A/V) ratio and secondly by the moisture content of the materials. Specific heat loss coefficient points at which heat flux transported through the wall structure resulted by the temperature difference are taken for the unit heated volume. Various phenomena could occur which can modify the building’s thermal properties. One of them is the moisture load. In general terms, when a gas comes into contact with a surface of a porous media, molecules will adsorb on the surface in quantities that are a function of their partial pressure in the bulk. The measurement of the amount of gas adsorbed over a range of partial pressures at a single temperature results in a graph known as an adsorption isotherm. Sorption characteristics are important for the performance and durability of building materials, thermal insulators. Best insulation materials should have very low moisture-vapour permeability, where the condensation and the corrosion are minimized. Water taken up from the air can cause undesirable changes in the physical, chemical and mechanical properties of the solid materials. The effect of the moisture in the building physics properties of materials are clearly written in Ref [5-13]. Based on the review presented in Ref [14], it is important to note that most studies have grounded evidence of impacts of orientation on building energy consumption. The shape and size of a building can have an impact on energy consumption. Catalina et al. suggested that in order to minimise heat loss, a compact shape (e.g. a cube) is required. [15] In Ref [16] Marshall et al. shown that the savings have been to vary depending on the occupancy pattern. Negendahl et al. says that an integration of optimization algorithms can drastically change the usage of time within architectural design processes, allowing designers to focus their attention on taking informed design decisions in Ref [17]. Ref [18, 19] showed that Energy-saving strategies are different for existing and for new buildings and it depends on the on the level of technical development and economic considerations. However, from methodological and technical points of view, many studies used techniques that were still too slow with higher chances of making errors in the process of computations.

Moreover, we would like to show the effect of the A/V ratio in the specific heat loss coefficient as well. To put it simply we present predictions based on measurements and calculations by the effect of the moisture content in the external walls. Moisture load has different effect on the materials so we altered the structure of the facade and made investigated materials. During our measurements at first four different insulation materials: mineral wool, extruded polystyrene (XPS), expanded polystyrene (EPS) 30 and grey EPS, then the mainly used building materials: solid brick, gypsum board, lightweight concrete, corkboard and foam concrete were wetted. [7-10] The change in the thermal conductivity in function wetting time was investigated for all materials. For the measurements we used a desiccator (Venticell 111) apparatus to dry the samples and a climatic chamber (Climacell 111) to wet the materials. To attain the different moisture levels, the materials were kept in the climatic chamber at 90% relative humidity and at 293 K temperature for 4, 8, 12, 16 and 20 hours. To measure the thermal conductivity, a Holometrix 2000 type heat flow meter was used. This apparatus is intended to determine the thermal conductivity of building materials in accordance with standard ASTM C518 and ISO 8301 protocols. In the calculations we also presented wettings up to forty-hours with 4 hours steps, for this the functions were extended with extrapolation. When only the desiccator was utilized we assumed the material “dry state” since there was no moisture load. [29-33, 27]

2. Materials and methods

In this article the wetting of the building and insulation materials for 4, 8, 12, 16, and 20 hours at 293 K and 90 % relative humidity in a climacell climatic chamber is presented. From the measurement results we reached three different characteristics for the thermal conductivity changes in function of moisture content and wetting time. [7-10] They are the constant, linear and exponential type functions. These values are presented in Table 1-3. The thermal conductivities of the XPS, solid brick and corkboard did not show relevant changes in function of the moisture load/wetting time. So for the calculations we used the average value of the measured ones (for all wetting times) and considered them to be constant.

The changes in the thermal conductivity of plasterboard and lightweight concrete showed linear dependency. This change can be described with the following function:

$$\lambda_{tj}=\lambda_0+t*A_1 \qquad (1)$$

where

λ_0 is the material thermal conductivity at dry state [W/mK],
A_1 is the constant of the linear fit,
t is the wetting time [h],
λ_{tj} thermal conductivity at a given wetting time [W/mK].

Moreover, exponential thermal conductivity changes can be found for foam concrete, mineral wool, EPS 30 and grey EPS, where their thermal conductivity change can be calculated at given time with the following function

$$\lambda_{tj}=\lambda_0+A_1*\exp(t/t_1) \tag{2}$$

where
λ_0 - is the material thermal conductivity at dry state [W/mK],
A_1 - [W/mKh],
t_1 - is a constant of the exponential fit [h],
t - is the wetting time [h],
λ_{tj} - thermal conductivity at a given wetting time[W/mK]. [7-10]

2.1. Validation of the measurement

Fort the validation of the measured values we have to make few notes. The thermal conductivity of the Mineral wool, EPS30, Grey EPS, Plasterboard, XPS and corkboard can be found in different articles as well in Ref [20-23]. The foam concrete that we used for the measurements was a “Ytong” product which thermal conductivity was guaranteed by the manufacturer. The validation of the thermal conductivity of the solid brick and the lightweight concrete needed clarification. The solid brick was exclusively manufactured in a special shape for our measurements, also the clay that were the brick made of had better thermal conductivity value than the solid bricks in general.

3. Calculations

3.1. The building energetic regulation in Hungary

In 2006 the Minister without portfolio brought to Hungary the regulation explaining how to determine the energetic properties of the buildings. It contained the requirement for the building energetic properties. These main properties are the overall heat transfer coefficient, the specific heat loss coefficient and the primary energy demand. Furthermore, one can find suggestions both for the building service system and for the compactness and geometry of the buildings. In 2014 the Minister for Interior affairs in his 20th regulation modified the above mentioned requirements. The requirements both for the overall heat transfer coefficient and for the specific heat loss coefficient, moreover for the primary energy demand became much stricter. In Hungary the requirements for the annual specific heat loss capacity and primary energy demand are given in the function of the envelope surface to heated volume (A/V) ratio running from 0 to 1.4. In this article we investigate a nearly zero energy building (NZEB) with its requirements for the specific heat loss capacity written in regulation of the Minister of Ministers no. 39/2015. [13]

3.1.1. The overall heat transfer coefficient

The amount of the heat going through a building envelope can be found by the overall heat transfer coefficient of the wall structure (U-Value). The U-value is the reciprocal value of the total thermal resistance of the wall structure.

$$U=1/R_j \tag{3}$$

$$R_j=1/h_e+\Sigma j(d_j/\lambda_{tj})+1/h_i \tag{4}$$

where

h_i; h_e - internal and external surface heat transfer coefficient [W/m^2K],

d_j - thickness of a layer [m],

λ_{tj} - thermal conductivity at a given wetting time [W/mK],

R_j - heat resistance of a structure [m^2K/W],

U- heat transfer value of a structure [W/m^2K].

The main aim of our article is to show the influence of the (A/V ratio) and the wetting time in the specific heat loss capacity of buildings with different structures. The present applicable U-values for NZEB buildings are the following:

U_{Wall}=0.24 W/m^2K heat transfer value of the wall,

U_{Door}= 1.45 W/m^2K heat transfer value of the door,

U_{Window}= 1 W/m^2K heat transfer value of the window,

U_{Floor}= 0.3 W/m^2K heat transfer value of the floor,

U_{Roof}= 0.17 W/m^2K heat transfer value of the roof.

The transmission heat loss trough the surface of the floor can be disregarded though we have to calculate with the linear heat transfer coefficient. During the calculations the MSZ EN ISO 10211 standard helped us. The linear heat transfer coefficient of the floor of the building is 0.85 W/mK.

For the base calculations these values were fixed, however, U_{wall} was varied by the function of the wetting time.

3.1.2. Transmission losses

The transmission heat losses can be divided into two main parts: the surface and to the linear heat losses. During the calculation of the heat losses of the surfaces we used the following equation:

$$A_j*U_j=A_{Wall}*U_{Wall}*(1+\chi)+A_{Roof}*U_{Roof}+A_{Windows}+U_{Windows}+A_{Door}*U_{Door} \quad (5)$$

where

A_j - represents the area of a part of the building [m^2]

U_j - the heat transfer value of a part of the building [W/m^2K].

χ - linear heat loss correction factor

Linear heat losses were only appeared at the exterior walls and around the building. For the wall a linear heat loss correction factor was used with a value of 0.15. Moreover for the linear heat loss of the floors we multiplied the length of the perimeter of the building with linear heat transfer coefficient of the floors.

3.1.3. Annual solar gain

The annual solar gain was calculated by the simplified calculation method of the regulation. To simplify the calculations, we considered that every windows solar gain was equal with the north orientation.

$$Q_{SD}= \Sigma A_{Windows}*g* \varepsilon*Q_{TOT} \quad (6)$$

where

$A_{Windows}$ - the surfaces of the windows [m^2]

g - glazing correction factor, for triple glazed windows 0.50

ε - buildings structure coefficient, for heavy built building is 0.75 and for light built is 0.5

Q_{TOT} - specific internal solar energy gain, for north orientation is 100 [kWh/m^2]

3.2. Specific heat loss coefficient

The specific heat loss coefficient consists two different part: transmission part and the solar gain. The calculation method was previously presented and by the following equation it can be calculated.

$$q=1/V*(\Sigma(A_j*U_j)+\Sigma(l*\Psi)-Q_{SD}/72hK) \ [W/m^3K] \qquad (7)$$

where

V - is the heated volume of the building [m^3]

A_j - is the heated external surface of a part of the building [m^2]

U_j - is the heat transfer coefficient of a part of the building [W/m^2K]

l - is the length of the heat loss (the perimeter of the building) [m]

Ψ - linear heat transfer coefficient [W/mK]

Q_{SD} - annual solar energy gain [kWh/a]

q - specific heat loss coefficient [W/m^3K]

72hK – the thousandth of standardized heat bridge value of the heating season in Hungary. [13, 24, 25]

3.3. Geometry of the building

To show the influence both of the moisture load and the A/V ratio in the specific heat capacity, we have created a hypothetic building. The A/V ratio of the building was changed by following some restrictions.

The increase of the A/V of the single floor building starts from 10 m width and 10 m length. During the calculations the length was increased up to 200 m. The change of the geometry was done step by step. The internal height of a single floor was 2.7 m and the increase in the height was executed by adding one more level with 2.7 m height to the building, at a same time the length of the building was increased with 20 m. According to this the roof area and the size of the perimeter of the building was also changed. The internal height and width of a single floor was kept to constant. The size of the door was not changed during the growth. Furthermore, we decided that the buildings have only one entrance independently from its volume. The surface of the door was 2.4 m^2. Accepting and applying the above mentioned method we were able to generate various A/V ratios. However, the buildings require additional modifications when their size increases. Buildings require a minimal amount of glazed surfaces (without frames). The glazed surface should be at least 12.5 % of the heated base area.

The surface of the facade was calculated by dividing the area of the door and the windows from the multiplication of the perimeter and interior height of the building. The floor and the flat roof were waterproofed, since they had no effect in their thermal properties. The values for their thermal performance was taken up to constant value fulfilling the requirement see in section 3.1.1.

3.4. The wall structures

As a base of the investigation of the wall structures we wetted and then measured the thermal conductivities of the individual wall elements. Three different types of construction materials (brick, lightweight concrete and foam concrete) were used as a base wall with their measured moisture contents and changing thermal conductivities. Here has to be mentioned that five independent measurements were done after wetting, repeated three times. The final value was the average these 15 values. [10, 26, 27] They were combined with mineral wool, grey EPS, EPS 30, XPS, plasterboard and with corkboard. From the presented materials with their combinations we created hypothetically a light built structure and several heavy built structures. The light built structure was a simple standard wall. It had 2.4 cm plasterboard at the exterior side and 1.2 cm at the interior side filled with 18 cm thick mineral wool. The heavy built structures were built once from 0.5 cm thick corkboard as an interior protection and from 30 cm loadbearing material (lightweight concrete or foam concrete) and a layer of insulation, secondly during the analysis of the solid brick as a loadbearing material 38 cm thickness was applied.

For the analysis we varied the thickness of the insulation. The starting point (initial thickness) of the insulation in totally dry state was the thickness for fulfilling the requirements for the U-value of a nearly zero energy building (U_{wall}=0.24 W/m^{2}K). [13] Here has to be mentioned that the variable thickness has limitations, since the manufacturer cannot produce insulations in every desired size, since the calculated thickness was rounded up for each insulation material. In table 4, one can see the used thickness of the insulation in cm with the tested constructions materials. Here has to be noticed and explained that in the 3rd line and 2nd column of the table one can found 10 cm. It means, if we create a wall structure, with the above mentioned method for a 38 cm thick brick wall we need 10 cm thick grey EPS to fulfil the U_{wall}=0.24 W/m^{2}K requirement.

In table 5 one can see the calculated U-values of each created structures. Here has to be emphasized that we have investigated 16 different wall structures (15 heavyweight and a lightweitght). One can see that the with the above mentioned method we can reach in dry state the best wall with combining 12 cm XPS with 38 cm thick brick wall.

From the table it can be seen that the minimum requirement was exceeded in two cases (for the Grey EPS in combination with brick and lightweight concrete) where the heat transfer value was above the requirement with a minimal amount (1-3x10^{-3}). But those values were also considered to be adequate. There was an additional light built structure with the heat transfer value of 0.2 W/m^{2}K. We can assume that the standard light built structure easily satisfies the requirement for walls.

4. Results and discussion

4.1. Investigation of the specific heat loss coefficient

The specific heat loss value was calculated for every wall structure combination. For every layer combination we calculated in function of the q between dry state to forty-hour wetting time and in function of the changing A/V ratio.

From the calculated q values in function of the wetting times and A/V ratios, we created surface diagrams. Also according to the regulation of the Minister of Internal affairs we have determined the maximum q value that should not be exceeded. This maximum q value will be represented by a grey transparent layer (see e.g.: Figure 1-10) The following figures when the surface diagram is above the grey layer represent the values that are exceeding the required value of the specific heat loss for the building.

We built up the maximum q value layer with the following equations.

The requirements for the (q) of a NZEB building are the following:

$$A/V \leq 0.3 \qquad q = 0.12\ \mathrm{W/m^3K} \tag{8}$$

$0.3 <= A/V <= 1.3 \qquad q=0.05143+0.2296*(A/V)\ W/m^3K \qquad (9)$

$A/V >= 1.3 \qquad q=0.28\ W/m^3K \qquad (10)$

It can be seen that this q value is proportional with the A/V value and it is independent from the wetting time.

To be much more picturesque and to simplify the reference to the material combinations we have created Table 6. In this table we can see the construction materials in combination with the insulations. Moreover, there was an additional layer (the lightweight one), and it was marked with number 16.

In Figures 1-10 the relationship between the plane of the requirement (grey surface) and the surface of the generated specific heat losses can be seen. These results can be separated into three groups by their adequacy. The first type is where the generated surface has a relevant break through the requirement plane. This case happens by combinations with numbers 1, 6, 11, 16 and it can be seen in the following figures. Here has to be mentioned that all of them have a relevant jump (inflexion) in the q versus A/V surface function after 20 hours of wetting. Noteworthy that the lightweight structure breaks through the reference area soon; furthermore, in the end significant increase in the q versus A/V ratio function can be found. Here has to be mentioned that the q value goes up to 1.4 W/m^3K, in contrast to the requirement value (0.28). Here has to be emphasized that Figures 1 to 4 present wall structures insulated with mineral wool. The huge jump in the specific heat loss coefficients of these structures (1, 6, 11. 16) after wetting can be owed to the sensitivity of the mineral wool for taking up water [9, 10, 12].

The second type where the penetration of the q versus A/V surface functions in the requirement plane happens after long wetting hours. The cases are the following: 3, 8, 12, 13, 14 and 15. They can be seen in Figures from 5 to 10. The break out for cases 8 and 13 happens after 25 hours of wetting; moreover, for the others much longer wetting time is necessary to produce the same. In Figures 7, 9 and 10 one can see that almost the total q versus A/V ratio surface is under the requirement plane, since these structures (with cases 12, 14 and 15) are reasonable structures. These walls are the foam concrete based walls covered with XPS and corkboard. Figure 8 shows that nearly the half of the surface area refutes the requirement; moreover, in this group this structure (12) has the highest specific heat loss coefficient. The structures with numbers 3, 8, 12, 14 and 15 have their maximum in the specific heat loss coefficient less than 0.5; however, this is almost the double of the requirement.

The third type is where the structures were insensitive to the wetting caused changes, were water resistant, they were not affected by the moisture load. To put it simply, it means there were no intersection between the plane and the requirement just if the A/V was over 1.0. These cases were the: 2; 4; 5; 7; 9; 10. (see Figure 11). Here has to be noticed that the q breaks through the requirement, however, neither the moisture nor the wetting time has effect in the change of the specific heat loss coefficients, but the A/V ratio has. Interestingly, q is driven out from the requirement by only the change of the A/V ratio.

As the summary of our research we have to mention the following observations. As it was previously mentioned, the greatest jump and change in the specific heat loss coefficients happened by the structures insulated with mineral wool. When this material was applied the specific heat loss exceeded the requirement in the first twenty-twenty four hours. The EPS 30 also happened to be sensitive to wetting but in this case the change only occurred after at least thirty-six-hour wetting. This material generated an interesting characteristic feature, changed the specific heat loss of the building but in the figures it can be clearly seen that it was independent from the A/V ratio.

Among the load bearing materials only the foam concrete had noticeable water up taking property. It has to be mentioned that it only breached the requirement layer after the thirty-six-hour wetting, too.

With these deductions we could say that moisture load has significant affects in the specific heat loss values. The most significant change was found by the light built structure, where the q in function of the A/V ratio during the wetting changed by at least 624%. This percentile number is the average of the change in the specific heat loss coefficients in function of the wetting and the A/V ratio. The other significant changes are presented in Table 7. In this table we can see the smallest and the greatest increase during the wettings. Where the value is 0, it means that there was no change with the moisture load.

We can conclude that by choosing the structures from water resistant point of view, the best choice can be first the XPS and the corkboard, followed by the grey EPS. The behaviour of the EPS 30 and mineral wool as insulation is nearly the same. Another observation is that the building with higher A/V ratio even reached higher values.

4.2. Investigations on cost effectiveness

To be much more precise by selecting the most appropriate structure a cost analysis was carried out as well. In Table 8 calculated investment costs for each combination can be found. The specific cost given for 1 m^2 contains the construction prices as well. Table 7 in combination with Table 8 could give us the correct answer for choosing the best structures during the design of a building.

From Tables 7 and 8 Figure 12 was created. On the graph one can see the average percentile change during the wetting from 0-40 hours compared to the value after 0 h wetting in the specific heat loss coefficient and the specific cost for each structure from 1 to 16. One can observe that structure number 16 (lightweight structure) has relatively low specific cost; parallel to it the increase in the specific heat capacity is extremely high. We should mention here that structures 5, 10, 15 (with corkboard) have relatively high prices, but the structures can be thought to be reasonable from the thermal performance point of view. The structures numbered with 1, 6, 8, 11 and 13 have acceptable costs, however, the change in their specific heat coefficient is significant, more than 100%, due to the behaviour of mineral wool and EPS 30. The structures with labels 2, 4, 7 and 9, the combinations of the grey EPS and XPS with solid brick or lightweight concrete, could be the perfect choice with their acceptable costs and perfect stability. The results from Figure 12 belong to structures with label 3, 12 and 14; they are put in the mid-range.

Conclusions

In this article the change of the specific heat loss coefficient of key building structures in function of the A/V ratio after wetting is presented. By changing the geometry (A/V ratio) and the materials more than 300 building structures were investigated. The role of insulation materials in the building energy and moisture balance is more significant compared with the other materials of the building structures. Furthermore, the moisture has effect in several factors used in indoor environment e.g.: in mean radiant temperature, by changing the thermal conductivity of the wall, and this way changing the indoor air quality. The high moisture load will require the change of the above mentioned methods. Moisture is a common cause of building degradation. In fact, much of what we know about applied building science today originates from early studies investigating moisture impact on buildings. These estimations based on the laboratory measurements of these values of the insulating materials are very important either for the manufacturers or for the contractors, planners and designers. In this paper optimisation processes have been applied at the design stage to many aspects of buildings related to the wall structures.

- With the above mentioned method more than 300 nearly zero energy buildings were investigated from the following aspects: changes in the specific heat loss coefficients, in the surface to heated volume ratio and in costs.
- Based on the measurements of the changes in the thermal conductivities of construction and insulation materials after wetting, the change in the overall heat transfer coefficient and the change in the specific heat loss coefficient were given. New equation and functions were given as well.
- 16 different constructions were created by combining the tested materials.
- We have shown that the lightweight structure can be the cheapest but the worst choices.
- We have to mention here that application of corkboard will increase the costs.
- Acceptable stability and performance can be reached by the application of the XPS and EPS with foam concrete as well.
- We have stated that from our structures the best choice would be the combinations of the grey EPS and XPS with solid brick or lightweight concrete.

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Nomenclature

ε - buildings structure coefficient, for heavy built building is 0.75 and for light built is 0.5

Ψ - linear heat transfer coefficient [W/mK]

λ_0 is the material thermal conductivity at dry state [W/mK]

λ_{ti} thermal conductivity at a given wetting time [W/mK]

χ - linear heat loss correction factor

A_1 is a proportional coefficient that was concluded from our previous paper [W/mKh]

A_j - is the heated external surface of a part of the building [m^2]

A/V the ratio of the heated surface and heated volume d - thickness of a layer [m]

g - glazing correction factor, for triple glazed windows 0.50

h_e - external surface heat transfer coefficient [W/m^{2}K]

h_i - internal surface heat transfer coefficient [W/m^{2}K]

l - is the length of the heat loss (the perimeter of the building) [m]

q - specific heat loss coefficient [W/m^{3}K]

Q_{SD} - annual solar energy gain [kWh/a]

Q_{TOT} - specific internal solar energy gain, for north orientation it is 100 [kWh/m^2]

R - heat resistance of a structure [m^{2}K/W]

t is the wetting time [h]

t_1 - exponential coefficient that was concluded from our previous paper [h]

U - the heat transfer value of a part of the building [W/m^{2}K]

V - is the heated volume of the building [m^3]

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Tables:

Table 1. Constant thermal conductivities

Material	Thermal conductivity [W/mK]	Standard error
XPS	0.0403	$4.17855 \cdot 10^{-4}$
Solid brick	0.3622	0.045583
Corkboard	0.043963	0.001033

Table 2. Linearly changing thermal conductivities

Material	Thermal conductivity [W/mK]	A_1 [W/mKh]	r^2
Plasterboard	0.13891	0.00141	0.87669
Lightweight concrete	0.37156	0.00318	1

Table 3. Exponentially changing thermal conductivities

Material	Thermal conductivity [W/mK]	A_1 [W/mKh]	t_1 [h]	r^2
Foam concrete	0.09934	0.02088	11.73072	0.91821
Mineral wool	0.03907	0.000299	3.87821	0.9873
EPS 30	0.04535	0.000143	5.01863	0.88334
Grey EPS	0.044	-0.011	-2.64488	0.46379

Table 4. Thickness of the applied insulations

	Solid brick [38 cm]	Lightweight concrete [30 cm]	Foam concrete [30 cm]
Mineral wool [cm]	12	13	6
Grey EPS [cm]	10	10	5
EPS 30 [cm]	14	14	7
Yellow XPS [cm]	12	14	6
Corkboard [cm]	11.5	13.5	7

Table 5. Initial heat transfer values of the hypothetic wall structures in dry state

	Solid Brick	Lightweight concrete	Foam concrete
Mineral wool [W/m^{2}K]	0.24	0.228	0.232
Grey EPS [W/m^{2}K]	0.241	0.243	0.233
EPS 30 [W/m^{2}K]	0.239	0.24	0.232
Yellow XPS [W/m^{2}K]	0.218	0.219	0.23
Corkboard [W/m^{2}K]	0.239	0.24	0.229

Table 6. Number of the examined combinations (The structures)

	Solid Brick	Lightweight concrete	Foam concrete
Mineral wool	1	6	11
Grey EPS	2	7	12
EPS 30	3	8	13
Yellow XPS	4	9	14
Corkboard	5	10	15

Table 7. The average percentile change in the specific heat loss

	Solid Brick	Lightweight concrete	Foam concrete
Mineral wool [%]	132	228	305
Grey EPS [%]	12	18	79
EPS 30 [%]	99	150	242
Yellow XPS [%]	0	2.7	56
Corkboard [%]	0	3.1	53

Table 8. Specific cost of the structures

Solid Brick	Lightweight concrete	Foam concrete

Mineral wool [EUR/m^2]	109	82	72
Grey EPS [EUR/m^2]	100	72	67
EPS 30 [EUR/m^2]	94	71	68
Yellow XPS [EUR/m^2]	115	92	75
Corkboard [EUR/m^2]	507	551	317

Plasterboard and mineral wool [EUR/m^2]	25

Figure captions:

Figure 1. Graph of the q - A/V - wetting time function of the Solid brick structure insulated with Mineral wool (structure 1)

Figure 2. Graph of the q - A/V - wetting time function of the Lightweight concrete structure insulated with Mineral wool (structure 6)

Figure 3. Graph of the q - A/V - wetting time function of the Foam concrete structure insulated with Mineral wool (structure 11)

Figure 4. Graph of the q - A/V - wetting time function of the lightweight structure, Mineral wool insulation with Plasterboard (structure 16)

Figure 5. Graph of the q - A/V - wetting time function of the Brick structure insulated with EPS 30 (structure 3)

Figure 6. Graph of the q - A/V - wetting time function of the Lightweight concrete structure insulated with EPS 30 (structure 8)

Figure 7. Graph of the q - A/V - wetting time function of the Foam concrete structure insulated with Grey EPS (structure 12)

Figure 8. Graph of the q - A/V - wetting time function of the Foam concrete structure insulated with EPS 30 (structure 13)

Figure 9. Graph of the q - A/V - wetting time function of the Foam concrete structure insulated with XPS (structure 14)

Figure 10. Graph of the q - A/V - wetting time function of the Foam concrete structure insulated with Corkboard (structure 15)

Figure 11. Graph of the q - A/V function of the type 3 materials at forty-hour wetting time.

Figure 12. The specific cost and percentile changes of the specific heat loss coefficients of the structures.