COMPARATIVE ANALYSIS OF INSULATIONS LOCATED HORIZONTAL ON THE FLOOR AND/OR VERTICAL BESIDE THE FOUNDATION BOTH WINTER AND SUMMER CONDITIONS

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Abstract

At the design process of buildings, beside the reduction of heating energy demand, particular account shall be taken on the adaptation of passive cooling strategies, which provide appropriate heat comfort in summer period without any cooling energy consumption.

The paper focuses on the heat flow through the ground. Two case studies are introduced where the floor on the ground were insulated with the insulations located horizontal on the floor and/or vertical beside the foundation.

The result of comparative analysis of calculated and measured data shows that the vertical insulation of floor has significant positive effect on summer heat comfort with some negative effect on calculated heating energy demand.

Keywords: *passive cooling, climate change, energy, dynamic energy simulation, heat bridge*

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1 Problem statement

To provide the thermal comfort in summer period with mechanical systems have several disadvantages like increase of energy consumption, or increase of the external temperature, which increase the need of cooling. A possible solution to avoid the negative impacts of mechanical cooling systems is to apply the principles of passive cooling design strategies, like increase the heat storage capacity, ventilation, shading, etc.

According to a calculation from 2007, the insulation method of ground floor has significant effect on internal thermal comfort in summer period in case of single family houses. [2] The monitoring results of two buildings and further calculations prove the correctness of the previous calculations.

2 Method and results

To study the working hypothesis as a case study, two implemented buildings were analysed. The first house is a two-storey residential house the second is a single-story one.

Both houses are well insulated: the average U-value is 0,295 W/m^2K at the first house and 0,261 W/m^2K at the second one. The first house is heated mainly with tile stove and the DHW is supplied by a gas boiler. The second house is heated with a gas boiler and the DHW is produced by the gas boiler and solar collectors. [3,4] (Fig.1, Fig. 2)

Fig. 1 *First case study house in Magyarkút*

Fig. 2 *Second case study house in Mány*

The operational energy consumptions were calculated according to the Hungarian energy calculation method. Solar gains and degree days were calculated with the detailed method as well as other parameters with the simplified method. [1] In both cases the relevant properties of building materials were taken into account according to the DIN 4108-4 standard (thermal conductivity, density, specific heat capacity). The data of fuel consumption was collected as yearly consumption at the first building and as daily consumption at the second building. The highest and lowest internal and external temperatures were registered at the second building. The measured values were in both cases lower as the calculated ones. (Tab. 1)

Tab. 1 *Comparison of calculated and measured energy consumption data [kWh/m²a]*

	First house		**Second house**	
	Calculated	**Measured**	**Calculated**	**Measured**
Net heating energy demand	49		45,33	
Primary heating energy demand	61,43	54,2	53,74	
Primary energy demand of DHW	50,71	28,5	18,33	
Primary energy demand of heating and DHW	112,14	82,7	72,06	63,52

Beside the Hungarian official energy calculation the first building was studied also with Energy Plus v2.0.0 dynamic building simulation software. The main focus of this investigation was on the internal thermal comfort in summer period. The number of "unpleasant hours" (when the calculated PMV>1,08) were calculated along with the examination of different variations of ground floor-, wall-, internal floor, and roof constructions. The floor on the ground was insulated with the EPS insulation located horizontal on the floor and/or XPS insulation vertical beside the foundation. Energy Plus simulations indicated that the vertical insulation of ground floor significantly reduces the number of "unpleasant hours" downstairs, as well as slightly increases the heating energy demand of the whole building. [2] The best solution is that, when beside the vertical placed 12 cm XPS insulation, 4-6 cm EPS insulation is installed horizontally. In that case the number of unpleasant hours is almost zero and the heating energy demand is low. (Fig. 3)

The second building was analysed with Heat2 v6.0 two-dimensional heat-transfer software. Analysis was made according to the standard EN ISO 10211. [5] Two possibilities of the insulation of the floor on the ground were investigated:

- a) horizontal insulation: 20 cm PS placed in the layer of the floor,

- b) vertical insulation: 7 cm PS placed in the layer of the floor and 12 cm XPS placed beside the foundation.

Two kinds of simulations were performed. Steady-state calculation was fulfilled to calculate the Ψ-value of heat losses through the floor construction and transient thermal bridge simulations were performed to estimate the effect of different seasons on heat transfer.

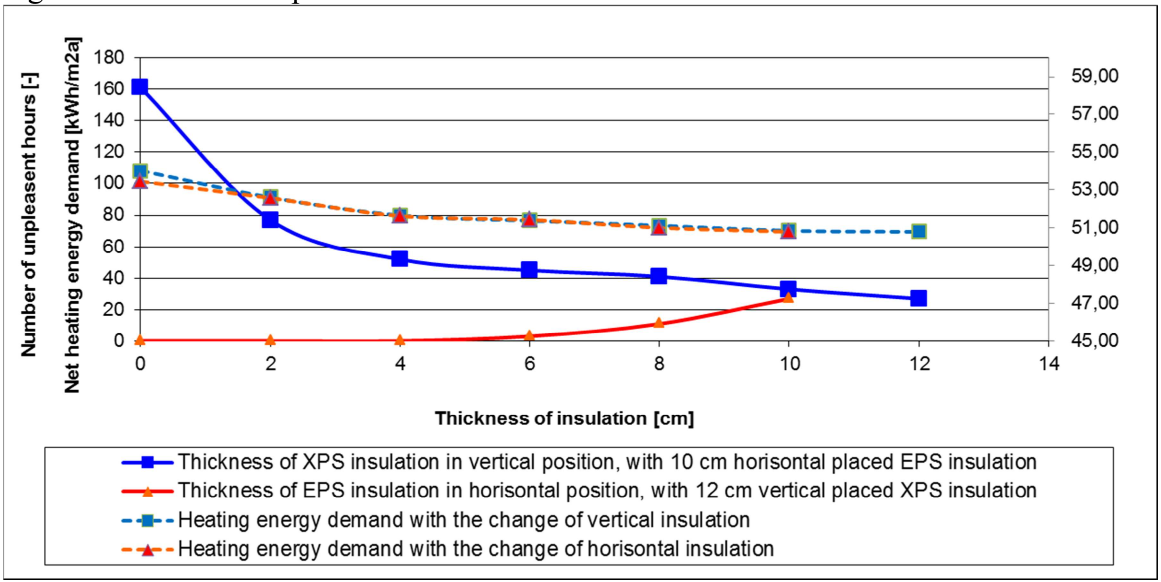

Fig. 3 *The number of unpleasant hours and the net energy demand of the whole building depending on the design of the floor at the first building.*

Steady-state simulations resulted that the Ψ-value is lower with 43 % in the horizontal insulated (a) situation, but the total heating energy demand is only with 15 % higher in the vertical insulated situation (b). Table 2 introduces the calculated linear thermal transmittance and energy consumption results.

Tab. 2 *Comparison of calculated energy consumption of a) horizontal and b) vertical insulated floor on the ground.*

	a) horizontal	**b) vertical**
Linear thermal transmittance: Ψ-value [W/mK]	0,5576	0,8048
Net heating energy demand [kWh/m^{2}a]	37,99	45,37
Primary heating energy demand [kWh/m^{2}a]	46,33	53,74
Primary energy demand of DHW [kWh/m^{2}a]	18,33	18,33
Primary energy demand of heating and DHW [kWh/m^{2}a]	64,65	72,06

The evidential advantage of the horizontal insulation of the floor on the ground, according to the experience of Tab. 2 is somewhat controversial. Firstly because of the measured fuel consumption is even lower as the calculated results with the horizontal insulated floor. Secondly because of the measured internal temperatures were at least 10 °C lower as the external temperatures in hot summer days without any mechanical cooling system, which could be a positive effect of the vertical insulation.

To understand the effect of different seasons on heat transfer transient thermal bridge simulations were performed. Nine consecutive seasons were simulated. As internal temperature in summer 24 °C, and in other seasons 20 °C was set. As external temperature the Hungarian average seasonal temperatures were set: in winter 0 °C, in spring 10,4 °C, in summer 19,7 °C, in autumn 9,9 °C. [6]

The transient thermal bridge simulation proved that the ground under the floor by the vertical insulated ground floor can work as large heat storage mass. The ground in that case became warmer than by the horizontal insulated ground floor, and it can help to balance the internal temperature fluctuations in the summer period and can reduce the heat losses in winter. (Fig.4, Fig. 5)

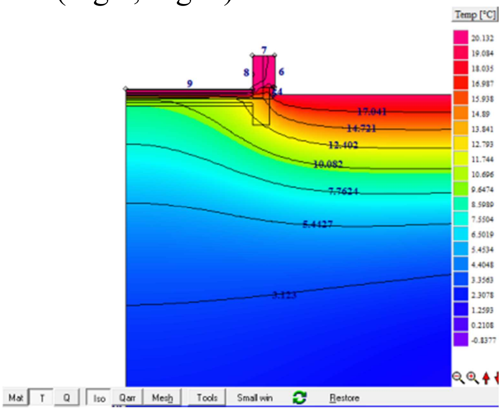

Fig. 4 *Isotherms of horizontal insulated floor in summer period.*

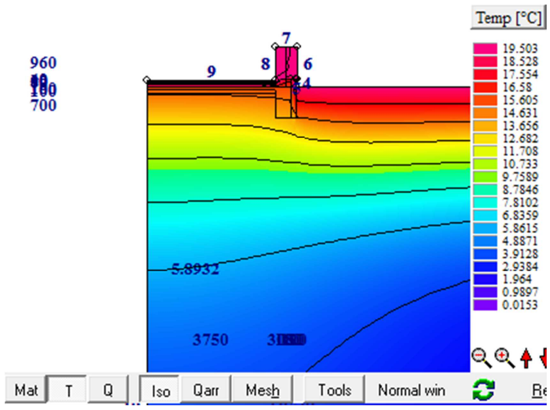

Fig. 5 *Isotherms of vertical insulated floor in summer period.*

3 Conclusion

By the case study buildings the calculated net heating energy consumptions were in both cases higher with 5-8 kWh/m^{2}a when the vertical insulation system was used on the ground floor instead of horizontal insulation system. But the measured energy consumptions were even lower than the calculated energy demands where the vertical insulation method was used. The primary energy consumption calculated from the measured fuel consumption of heating and DHW is 82 kWh/m^{2}a at the first building and 63,5 kWh/m^{2}a at the second building which are significantly lower values than the Hungarian near to zero energy requirement for residential houses (100 kWh/m^{2}a). In both cases, the internal temperature were at least 10 °C lower as the external temperature in hot summer days without any mechanical cooling system.

The vertical insulation of the ground floor is an effective solution to increase the thermal mass of single-storey buildings. Further research is necessary to understand the mechanism of vertical insulation, especially in the winter period.

References

[1] 7/2006 TNM Regulation: The definition of the energy characteristics of buildings 2006-2015.

[2] MEDGYASSZAY, P.: *Possibilities of optimum usage of adobe-building in Hungary, with special attention to the aspects of building-ecology and energy-conscious planning (Hungarian language)*, PhD dissertation, Budapest University of Technology and Economics, 2008, pp. 1-110.

[3] MEDGYASSZAY, P. *Success of an impossible to build house in Brussels (Hungarian language)* ÉPÍTÉSZFÓRUM 2010: Paper 10.15. (http://epiteszforum.hu/egy-megepithetetlen-haz-sikere-brusszelben) (2010)

[4] MEDGYASSZAY, P. *Compromise in the application of industrial and natural materials (Hungarian language)* Metszet 2013:(July-August) pp. 32-35. (2013)

[5] MSZ EN ISO 10211:2008 Thermal bridges in building construction. Heat flows and surface temperatures. Detailed calculations (ISO 10211:2007)

[6] Hungarian Meteorological Service (OMSZ): Change of yearly and seasonal temperature (Hungarian language) http://www.met.hu/eghajlat/eghajlatvaltozas/megfigyelt_valtozasok/Magyarorszag/