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# Analysis of the influence of geometrical thermal bridges and their elimination by using a composite material based on secondary raw materials

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**Abstract.** This paper describes the problems of geometrical thermal bridges and discusses their relative influence on building heat loss. The paper also deals with the use of composite material based on secondary raw materials for elimination of thermal bridges in wall footing detail and flat roof parapet detail.

## Introduction

The term low-energy house is used as an internationally recognized standard for buildings with low energy consumption. Insulating the building envelope is the most important of all energy conservation measures because it has the greatest impact on energy expenditure. However, there is an emphasis on any individual surfaces of structures, but also to carry out construction details that are formed in connection to each of these structures. In these places significant thermal bridges are created increasing energy loss of the building. Assessment of their impact is presented in the paper. Another objective of this contribution is to apprise readers about new building composite material based on recycled materials that can be used as thermal insulation of structural details. The comparative method is used to evaluate new developments in mitigation of thermal bridges. To perform thermal engineering analysis was proposed theoretical model of low-energy building. Relative heat loss calculation was performed.

## Design and calculation of the temperature field of structure

**Definition of thermal technical variables used.** The criterion for the analysis of structure chosen suitable standard variables relating to the issue of thermal bridges and bonds were selected. Linear factor of thermal transmittance is defined by the ČSN EN ISO 14683 (730561) standard [1].

For a description of linear thermal bond, there are three values of $\psi$ ($\psi_e$ external, $\psi_i$ internal, $\psi_{oi}$ overall internal). The most important factor is $\psi_e$, which is determined from external dimensions of structures. For structural details that are affected exclusively by two limit temperatures, the linear thermal transmittance factor is determined from the following equation

$$\Psi_e = L - \Sigma U_j b_j \text{ [W/mK]} \quad (1)$$

where $L$ is the calculated thermal transmittance [W/mK], $U_j$ thermal transmittance of is $j$-th structure in [W/m$^2$K] and $b_j$ the width of the $j$-th structure [m].

**Theoretical model of low-energy building.** There are several fundamental principles that must be followed when designing low energy buildings. The most compact building would be in the shape of a cube and would have the least losses through the building envelope. Theoretical model has the shape of the block to be more realistic. The entire building envelope is highly insulated for low-energy standard. The external wall structure is made of ceramic hollow brick pieces Heluz THERMO STI 44. The flat roof structure is designed as a reinforced concrete ceiling slab with thermal insulating material made of EPS polystyrene. The roof is enclosed with a parapet wall around its perimeter.

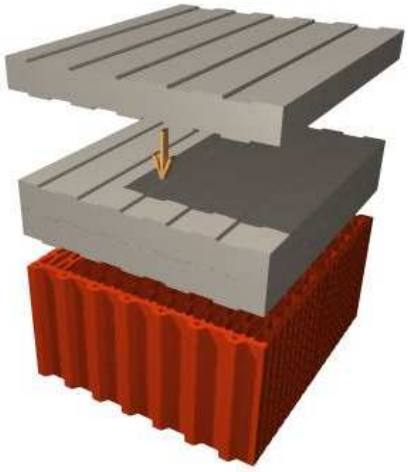

**Fig. 1 - Visualization of insulation blocks with ceramic hollow brick**

Calculation was performed with window and door system (typically the weakest elements of a structure), which has excellent thermal insulation properties.
Input parameters and definition of boundary conditions of calculation:

- $U_W = U_D = 0.800$ W/m$^2$K — thermal transmittance of a windows, doors;
- $U_{WALL} = 0.220$ W/m$^2$K — thermal transmittance of external wall;
- $U_{FR} = 0.130$ W/m$^2$K — thermal transmittance of flat roof;
- $\psi_{FRP,1} = 0.263$ W/mK — linear thermal transmittance factor for flat roof parapet detail without measures against thermal bridge
- $\psi_{FRP,2} = 0.059$ W/mK — linear thermal transmittance factor for flat roof parapet detail with measures against thermal bridge (using thermal insulation composite block)
- $\psi_{WF,1} = 0.146$ W/mK — linear thermal transmittance factor for wall footing detail without measures against thermal bridge
- $\psi_{WF,2} = 0.080$ W/mK — linear thermal transmittance factor for wall footing detail with measures against thermal bridge (using thermal insulation composite block)
- $T_i = 20.6$ °C, $T_e = -15$ °C — internal and external temperature (the entire floor area is heated)

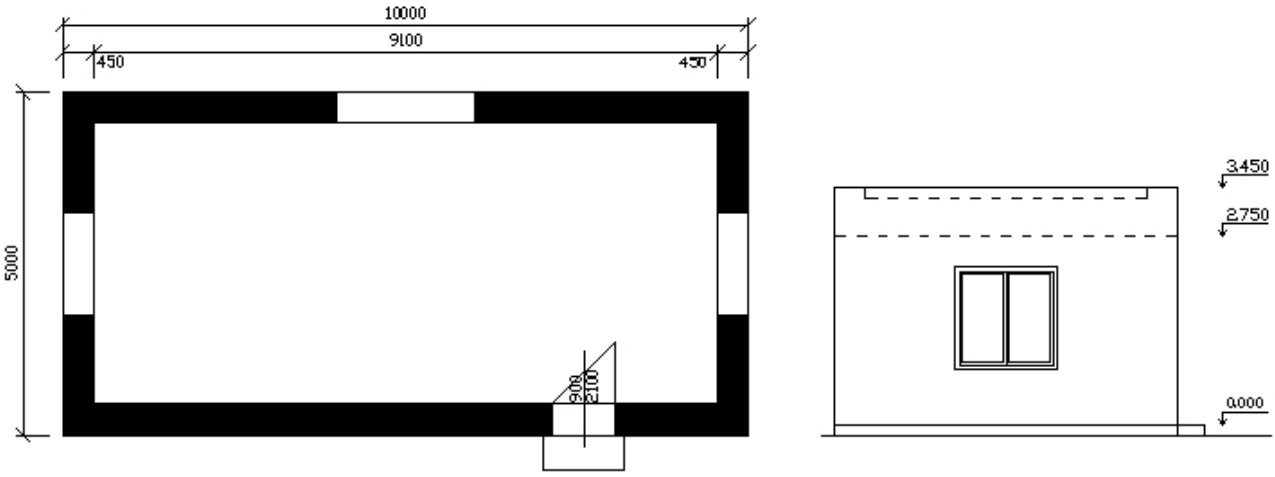


**Fig. 2 – The exact dimensions of theoretical model of low-energy building [units: mm, m]**

**Analysis model of examined variants.** The software ANSYS performing the analysis using finite element method, was used to model two variants of structural details. Variant V1 is a structure without a solution to eliminate thermal bridges and the variant V2 designs structural solution by application of thermal insulation block [EU patent, 2] on the basis of secondary raw materials, whose thermal conductivity coefficient is $\lambda = 0.09$ W/mK [CZ patent, 3].

**Table 1 - Comparative table of calculated heat losses**

| Heat loss survey | | Variant V1 | | Variant V2 | |
|---|---|---|---|---|---|
| | | The percentage heat loss | | | |
| Types of heat loss | Building structure | Separate | Total | Separate | Total |
| Surface heat losses | Wall | 36.9 | 76.5 | 42.7 | 88.5 |
| | Roof | 11.6 | | 13.4 | |
| | Floor | 14.6 | | 16.9 | |
| | Windows and door | 13.4 | | 15.5 | |
| Geometrical thermal bridges | Wall footing detail | 7.3 | 23.5 | 4.6 | 11.5 |
| | Flat roof parapet detail | 13.2 | | 3.4 | |
| | Wall corner | 3.0 | | 3.5 | |

In variant V1 geometrical thermal bridges account for 23.5% of the total heat loss. After application of thermal insulation blocks (variant V2) geometrical thermal bridges account only for 11.5% of the total heat loss, Table 1.

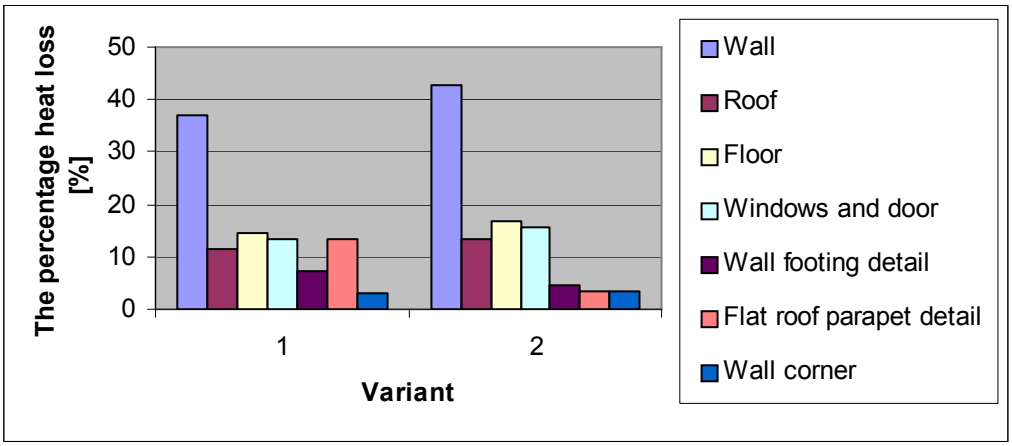


**Fig. 3 - The chart of percentage heat loss**

**Table 2 – Total heat loss for both variants (V1, V2)**

| | Variant V1 | Variant V2 | Difference between V1 and V2 | Reducing [%] |
|---|---|---|---|---|
| Heat losses [W] | 56.15 | 48.54 | 7.61 | 13.6 |

The heat losses were reduced by the application of thermal insulation blocks by up to 13.6%, Table 2. This is a significant amount of heat losses.

## Conclusion

It leads not only to economical use of the building, but also to extended life of building materials that could degrade due to negative influence of thermal effects on structures with insufficient thermal insulation measures. From the environmental point of view it is desirable that low amounts of energy is used to produce building materials. In this regard, the materials basis on secondary raw materials are less energy intensive than primary raw materials. Thermal insulation composite block is arguably one of the most singular products in the sustainable construction material field.

**References**

[1] ČSN EN ISO 14638 Tepelné mosty ve stavebních konstrukcích – Lineární činitel prostupu tepla (Thermal bridges in building construction – Linear thermal transittance). Prague, Czech Republic : ÚNM 2009.

[2] VUT v Brně, FAST, ÚPST. Dämblockelement zur Unterbrechung von Wärmebrücken im Fussbereich des Mauerwerks (Insulation block element for interrupting thermal bridges in the transition area between a wall and a foundation). Inventor: MATĚJKA, L., ŠINOGL, J., PĚNČÍK, J. European Patent Office – EPO. EP 1918471. 2009-08-05; (EU patent)

[3] VUT v Brně. Tepelně izolační kompozitní plast (Thermal insulation composite polymer). Originator of the copyright certificate: MATĚJKA, L., PĚNČÍK, J. Industrial Property Office, Czech Republic. P 302851. 2011-11-02; (CZ patent)