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KORNELIA CABAŁA, SEBASTIAN ZAWORSKI, JOLANTA GINTOWT*

THE INFLUENCE OF FITTING OF A WINDOW ON A HEAT TRANSFER COEFFICIENT AND AN ENERGY BALANCE OF A BUILDING

WPŁYW MONTAŻU OKIEN NA STRUMIEŃ CIEPŁA I BILANS ENERGETYCZNY BUDYNKU

A b s t r a c t

The project concerns windows and their properties. Four windows were considered to provide computations. Two of them were common windows and the other two – passive windows. The analysis focuses on a role of a fitting in heat losses, explains important aspects of choosing a window and shows main types of methods of mounting a window. The paper proves how big the influence of fitting a window is on a heat transfer coefficient value and shows what the losses steming from inproper fitting are. The project submits that fitting factor should be considered while calculating the heat transfer coefficient value and that windows ought to be mounted in an insulation to minimize heat losses.

Keywords: heat transfer, passive building, thermal bridges, montage, heat balance, window

S t r e s z c z e n i e

Analiza dotyczy montażu okien. Obliczenia przeprowadzono dla czterech typów okien: dwóch powszechnie stosowanych i dwóch pasywnych. Projekt koncentruje się na roli montażu w stratach ciepła, wyjaśnia, co jest ważne przy wyborze okna i określa, jakie są główne konsekwencje. Analiza podnosi że zagadnienie montażu okna powinno być brane pod uwagę na etapie obliczeń współczynnika przenikania ciepła okna, a nie dopiero przy obliczaniu wartości współczynnika przenoszenia ciepła.

Słowa kluczowe: przepływ ciepła, budynek pasywny, mostek termiczny, montaż, bilans energetyczny, okno

* Kornelia Cabała, Sebastian Zaworski, M.Sc. Eng. Jolanta Gintowt, Institute of Materials and Building Structures, Faculty of Civil Engineering, Cracow University of Technology.

Designations

A_g – surface glazing [m^2]
A_f – surface frame [m^2]
U – the heat transfer coefficient [W/m^{2}K]
U_f – the heat transfer coefficient for a frame [W/m^{2}K]
A_f – *the* area of a frame [m^2]
Ψ_g – the linear heat transfer coefficient (frame bonding) [W/mK]
S_g – the length of linear heat transfer coefficient (frame bonding) [m],
S_f – the length of a thermal bridge along window frame – wall bonding [m]
Y_f – the linear heat transfer coefficient of a thermal (wall bonding) [W/m K]
l_f – the length of linear heat transfer coefficient (wall bonding) [m]
g – coefficient of a solar radiation permeability (here: $g = 1$)
z – shading coefficient (here: $z = 1$)
ΔT – the temperature difference between inside and outside the building (here: $\Delta T = 35$ K)
t – number of hours in a month (here: $t = 720$ h)

1. Introduction

1.1. Topic of the project

The topic of the project is the influence of fitting a window on a heat transfer coefficient and an energy balance of a building. It is essential for each house to choose the best type of a window and to fit it in a proper way. It is not enough to choose windows with high insulation properties and great energy balance – but the surrounding of a window and its fitting are also important. They should be mounted in such a way that eliminates thermal bridges [1, 12, 13] and that makes fitting connections impermeable [1–6].

Criteria of assessing the window: impermeability, fitting, heat transfer coefficient U [W/m^{2}K], coefficient of a solar radiation permeability g, shading coefficient z, heat loss Q [kWh]. The analysis is connected with two factors mentioned above: fitting and heat loss.

1.2. Means of mounting a window:

Although the first one is causing the greatest heat losses, it is the most popular way of mounting in Poland [7–9, 11, 12]. It is called "traditional fitting", where a window is located on internal edge of the wall. It is shown in Fig. 1a. The amount of heat loss through thermal bridges will be smaller in case of "flush fitting", where the window is located along the isolation, which is not covering the frame of the window as it is shown in Fig. 1b. Windows should be situated on the outside edge of the wall to stay in the insulating layer, which is additionally covering the frame of the window. This solution is recommended in passive buildings [1, 10, 12]. In this case windows should not be open able, as the suitable amount of air is provided by a special circulating system. Making the windows openable would also cause a problem of stability. That is why the solution comes with anchors which help the window stay in the insulation as shown in Fig. 1c.

a) b) c)

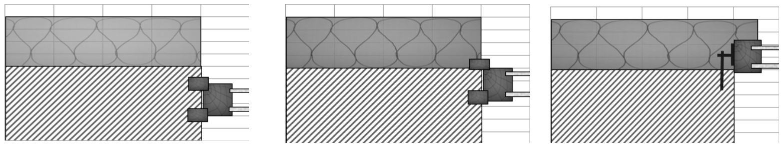

Fig. 1a) Traditional fitting, b) Flush fitting, c) Fitting in an insulation

2. Purpose of the project

The purpose of the project is to show the influence of fitting of a window on the value of heat transfer coefficient and to prove that a formula for calculating the heat transfer coefficient of the window which exists in Poland should include fitting and take into account consistent with [10] a method for determining the outside temperature.

3. Theses of the project

An inappropriate fitting of a window causes large amounts of heat losses and at the same time increases the cost of heating. Balancing gains and losses through windows for passive houses, nearly to zero-energy buildings, should be calculated according to the formula PHI [10].

4. Subject matter

The subject matter are four windows: two common windows (Aluplast IDEAL® 4000 [14] and Aluplast ENERGETO® 4000 [15]) and two passive windows (Internorm HF® 200 [16] and Oknoplast WINERGETIC PLUS® [17]).

5. Methods of analyses

The heat transfer coefficient calculations were done basing on the following formulas:

$$U_W = \frac{\sum A_g U_g + \sum A_f U_f + \sum l_g \Psi_g}{\sum A_g + \sum A_f} \tag{1}$$

In agreement with [12]

$$U = \frac{U_g \cdot A_g + U_f \cdot A_f + \psi_g \cdot s_g + \psi_f \cdot s_f}{A_g + A_f} \tag{2}$$

In agreement with [10]

Both formulas consider glazing, frame and bonding glazing – frame of a window. They differ from each other in a way that one of them does not consider the influence of fitting.

The formula for a heat loss calculation:

$$Q = \left[\left(U_w \cdot A_w \cdot g \cdot z \right) + \left(s_f \cdot \psi_f \right) \right] \cdot \Delta T \cdot t \cdot 10^{-3} \tag{3}$$

According to [12]

$$Q = U_W \cdot A_W \cdot g \cdot z \cdot \Delta T \cdot t \cdot 10^{-3} \tag{4}$$

According to [10]

The calculations of a heat loss for common windows were done basing on the first of the formulas. That is because in Poland fitting is considered in calculations only at this stage. In computation for passive windows the second formula was used. Additionally, to show significant influence of fitting on a heat loss it was assumed that common windows are mounted in a wall, as it is generally done in Poland. On the other hand it was assumed for passive windows that they are mounted in an insulation, according to rules for passive buildings.

For the purposes of comparison, the difference in calculation of a heat balance resulting from the different outside temperatures has been omitted (computational temperature is selected from: the coldest and warmest sunny/cloudy day) in [12] and [10].

6. Results

6.1. The value of a heat transfer coefficient

The chart below shows a value of a heat transfer coefficient of a window. It is divided according to a window model (first two of them are common windows and the other two are passive windows) and also according to a form of a calculation formula. The white color represents the formula which is in line with the Polish norm, which does not consider fitting. Light and dark blue colors represent the formula according to PHPP. "Proper fitting" should be understood as fitting which fulfills requirements of passive buildings. In turn an "improper fitting"is fitting failing to meet those requirements of passive buildings. In turn a bad montage is a montage which do not satisfy that demands.

Analyzing the chart, one should notice that an improperly-mounted passive window (Oknoplast Winergetic Plus®) has comparable value of a heat transfer coefficient as a well-mounted common window (Aluplast Energeto® 4000). One A big difference between a well- and badly-mounted window is also clear. In this case it equals 0.432 [W/m^2·K] (Internorm® HF 200). Both factors mentioned above show the significance of influence of fitting on a heat transfer coefficient of a window.

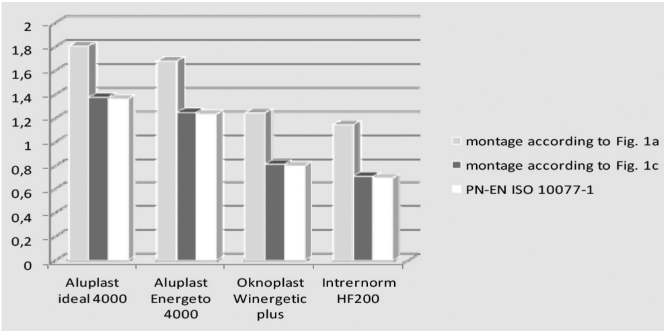

Fig. 2. Heat transfer coefficient U [w/m^{2}K]

Table 1

Window – *U* coefficient

Window	PN-EN ISO 10077-1	According to Fig. 1c	According to Fig 1a
Aluplast IDEAL® 4000	1.360	1.375	1.807
Aluplast ENERGETO® 4000	1.234	1.249	1.680
Oknoplast WINERGETIC PLUS®	0.800	0.815	1.246
Internorm HF® 200	0.699	0.714	1.146

6.2. Comparative analysis of the heat loss through windows

The chart shows a heat loss through an analyzed window in a period of one month. Time interval adopted for the purposes of this analysis seems to be sufficient. One should notice that the difference between a passive window mounted in insulation and a common window mounted in a wall is almost tripled and equals 91.11 [kWh]. It shows how great the losses created by a bad fitting are. It is shown in Fig. 3a. The difference resulting from the use of [10] and [12] for the calculation of the heat demand is approximately 25%. (An only loss associated with heat transfer through windows). This is a value that should not be ignored. This is shown in Fig. 3b.

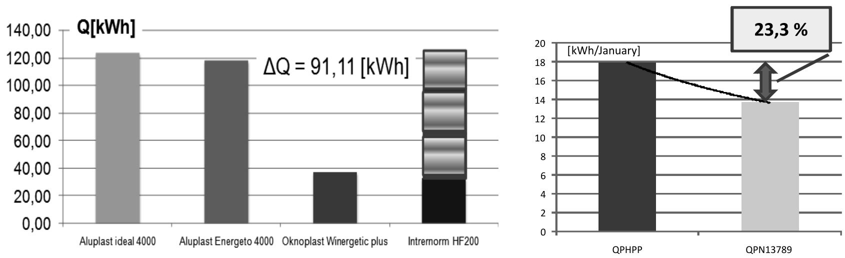

Fig. 3a) The heat demand for heating-window [kWh], b) PHPP and PN 13789 methods

7. Conclusions

To minimize heat losses and to eliminate thermal bridges windows should be mounted in an insulation. The fitting should be considered in a formula for a heat transfer coefficient because fitting considerably influences its value. It seems that the use of a formula for calculating the heat demand for passive houses, nearly-zero buildings, plus building, proposed by the Passive House Institute in Darmstadt, and entered in the PHPP, is justified.

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[7] Dz.U. 2013 poz. 45, Rozporządzenie Ministra Transportu, Budownictwa i Gospodarki Morskiej z dnia 3 stycznia 2013 r. zmieniające rozporządzenie w sprawie metodologii obliczania charakterystyki energetycznej budynku i lokalu mieszkalnego lub części budynku stanowiącej samodzielną całość techniczno-użytkową oraz sposobu sporządzania i wzorów świadectw ich charakterystyki energetycznej.

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