UDC 621

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ANALYSIS OF DEMAND, LOSS AND PROFITS OF ENERGY IN PASSIVE BUILDING WITH THERMAL IMAGING TECHNOLOGY

Passive construction standards were developed in 1996 in Darmstadt, Germany, and are in force today. The key to obtain a high thermal comfort with low energy consumption is to provide building energy efficiency. A significant reduction in demand for energy, in particular for heating, provides a very good thermal insulation of the overall heat transfer coefficient
U≤0,15 W/m²K, with a maximum elimination of thermal bridges.

Passive building should be characterized by extremely low demand for thermal energy ratio, maximum 15 kWh/m²/year. Obtaining such a low result may not be at the expense of growth in energy use for other purposes - preparation of hot tap water, electricity in household, lighting - total may not exceed 120 kWh/m²/year.

The total heat gains in heating zone are the sum of the monthly heat gains from solar radiation through windows, doors or glazed surfaces and monthly internal heat gains. Also take into account obtaining of renewable energy sources for lighting rooms.

To meet the requirements of passive houses, these buildings must have: compact lump, very good thermal insulation, energy efficient windows and doors, passive preheating of fresh air, efficient heat recovery from exhaust air and be equipment in energy-efficient household appliances.

Passive buildings are an alternative to energy-intensive buildings posed in traditional technology, simultaneously providing a very high comfort.

Keywords: thermal imaging, passive buildings, heat losses, heat gains.

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АНАЛІЗ ПОПИТУ, ВТРАТИ І ПРИБУТКУ ЕНЕРГІЇ В БУДІВЛІ З ВИКОРИСТАННЯМ ТЕХНОЛОГІЇ ПАСИВНОГО ТЕПЛОБАЧЕННЯ

Пасивні будівельні стандарти були розроблені в 1996 році в Дармштадті, Німеччина, і застосовуються до сьогодні для того, щоб отримати високий тепловий комфорт з низьким споживанням енергії, щоб забезпечити так звану енергоефективність будівель. Значне зниження попиту на енергоносії, зокрема, для опалення, забезпечує дуже хорошу ізоляцію коефіцієнта теплопередачі U≤0,15 Вт / м²К, з максимальним усуненням теплових мостів.

Пасивна будівля повинна характеризуватися вкрай низьким попитом на теплове відношення енергії максимум 15 кВт·год/м2/рік. Отримання такого низького результату не може бути за рахунок зростання споживання енергії для інших цілей – приготування гарячої водопровідної води, електрики, домашнє господарство, освітлення – загальне число не може перевищувати 120 кВт·год/м2/рік. Загальний приріст теплової енергії в зоні нагріву – сума щомісячних доходів тепла від сонячної радіації через вікна, двері або засклені поверхні і щомісячних внутрішніх теплопритоків. Також беруть до уваги використання поновлюваних джерел енергії для освітлення приміщень.

Для того, щоб відповідати вимогам пасивних будинків, ці будівлі повинні бути в основному компактними, мати дуже хорошу теплоізоляцію, енергозберігаючі вікна та двері, пасивний підігрів свіжого повітря, ефективної рекуперації тепла з відпрацьованого повітря і обладнання в енергоефективних побутових приладів. Пасивні будинки є альтернативою енергоємних будівель, поставлених в традиційній технології, забезпечуючи при цьому дуже високий рівень комфорту.

Ключові слова: технологія теплобачення, пасивні будинки, теплові втрати, приріст тепла.

Introduction. Passive construction standards were developed in 1996 in Darmstadt, Germany and are in force today. Passive building should be characterized by extremely low demand for thermal energy, the maximum ratio 15 kWh/m^2/year. Obtaining such a low result may not be at the expense of growth in energy use for other purposes - preparation of hot tap water, electricity in household, lighting - total may not exceed 120 kWh/m^2/year [1].

To meet the requirements of passive houses, buildings must be characterized by: compact lump, very good thermal insulation, southern orientation and taking into account the woodlots, energy efficient windows and doors, air tightness of the building envelope, passive preheating of fresh air, efficient heat recovery from exhaust air and be equipment in energy-efficient household appliances [2].

Due to the rigors of energy in passive construction envelope must meet high standards for heat transfer coefficient and tightness of convection air. It is very important that the various elements forming the outer shell of the building: roof, walls, foundations were selected and taken to the places of their connections are not produced leaks allowing air convection or thermal bridging. Divisions of external passive buildings should therefore ensure continuity of thermal insulation and coating ensures tightness.

The formation of thermal bridges is unacceptable in passive houses and their consequences are very serious: the greater heat loss, the threat of the formation of mold, the danger of water vapour surface condensation, risk of adverse health effects (eg. allergies), greater loss of heat energy, local cooling sensation. Thermal bridges can be avoided by using a basic principle: the continuity of the thermal insulation must be maintained. The most common method that allows for the analysis of heat loss in the building walls, is to perform research using the thermal imaging camera [3].

Table 1

Requirements for passive houses, developed by the Passive House Institute in Darmstat

Nr	Criterion	Range
1	The annual demand for thermal energy to heat the building	≤15 kWh/m^2·year
2	The tightness of the building for air infiltration n50	≤0,6 l/h
3	The annual consumption of primary energy to meet all the energy home requirement	≤120 kWh/ m^2·year
4	Heating load	≤10 W/m^2
5	The frequency of overheating of the surface in the summer	≤10%
6	The efficiency of mechanical ventilation intake-exhaust heat recovery	≥75%
7	The average heat transfer coefficient of walls	≤0,15 W/m^{2}K
8	The average heat transfer coefficient of windows	≤0,8 W/m^{2}K
9	The value of the total energy transmittance for glazing	≥55%
10	No thermal bridges	Ψ ≤ 0,01 W/mK

Characterization and analysis of heat loss in buildings. Thermal bridges can be generally characterized as locally limited areas in the building walls with high heat permeability, compared with adjacent surfaces. Increased thermal diffusion involves magnification energy loss from the building and, consequently, increase operating costs. Lowering the temperature on the inner surface of the walls is related with the risk of a fungal attack. In place of thermal bridges can also be observed the formation of condensation of water vapor and the related occurrence number of other destructive processes, damaging the walls, in particular layer of the coating and finishing.

Places where thermal bridge occurrence are mostly construction nodes and all the structural external connections, made of different materials. The most common are: contact floor on the ground with the foundation wall, slab with the outer wall, the rear seat windows and doors or roof connection with a knee wall. Also balcony slabs, joists protruding from the outer walls and other supporting structures, eg. places mounting location of the steel railings or supports satellite dishes [4].

The study was performed by thermal imaging camera Flir T440bx. The effects of errors in implementing the actual building walls are shown in the pictures below. Fig. 1 shows a situation where as a result of manufacturing defects, during warming building dormitory no. 4 Lublin University of Technology came to occurrence a number of thermal bridges in place of fastening anchors restraining polystyrene boards to the wall. This is a typical error during warming of the building. Point Sp1 has a temperature 6.6°C, while point Sp2 only 4.9°C. This situation is unacceptable in passive buildings. The continuity of thermal insulation, without thermal bridging point, can be provide by polyethylene pins for wool and polystyrene insulation, which penetrate into the thermal material. The resulting blind recess are matching by the wheel of the same material as the insulation layer [4]. At Fig. 1 it is clearly visible image on the thermal bridges, formed around the window. The temperature difference between the blue point (12.2°C) and a red triangle (3.8°C) is 8.4°C.

Fig. 1. Facade of the building after renovation, made by thermal imaging camera

At Fig. 2, there is thermal bridge in the house corner, which is the result of bad made the ceiling above the ground floor the wall system. Between points Sp1 and Sp2 temperature difference is 3°C, to the point t=13,6ºC Sp1 and Sp2 for t=16,6ºC. As a result of long-lasting moisture and a large temperature difference in the corners of the kitchen there is moisture, resulting in a black mold spot. Founded situation requires immediate intervention and absolute removal of both effect and causes mold. Molds are carcinogenic, allergenic and the increasing symptoms of upper respiratory tract [5].

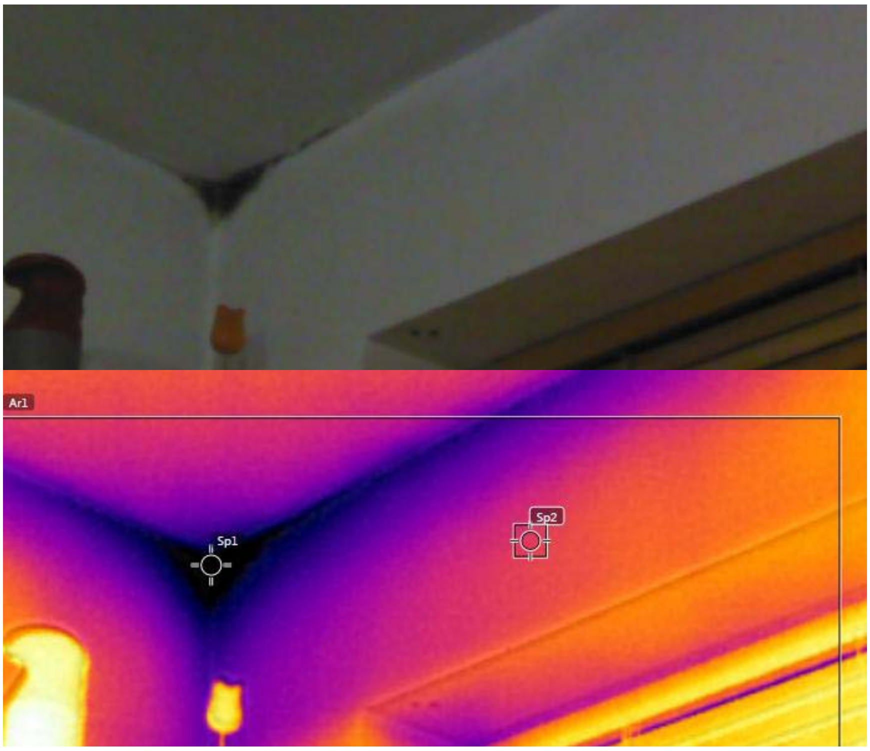

Fig. 2. Mould in the corner of the room

One of the common mistakes, as a result of which creates a thermal bridge is bad performance of the base of the building and lack of thermal insulation. Fig. 3 shows the temperature points Sp1, Sp2, Sp3 is sequentially equal 1.2ºC, -0.1ºC, -1.0ºC. The building is not built on basement but built on traditional foundations. Can be seen clearly the lack of thermal insulation and energy losses due to errors in design and implementation.

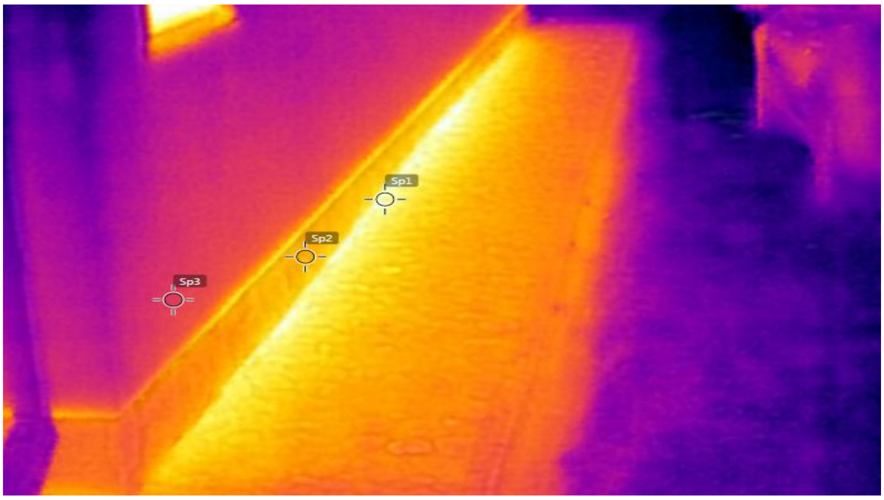

Fig. 3. Thermal bridge, which is the result of poorly made thermal insulation base

Discussio

Over the last few years and in connection with the dynamics that accompany development of the industry of building technologies, there is available on the market, more and more solutions that meet the criteria and requirements for passive buildings. Almost every major manufacturer of materials for building or warming walls provides solutions to achieve walls coefficients of external U≤0,15W/m^{2}K. Many manufacturers, including leading Polish company specializes in energy-efficient and low energy solutions.

As examples of solutions available on the market, thanks to the external partition can reach the required, low heat transfer coefficient U, are:

- ceramic hollow Porotherm 38 DRYFIX, and 15 cm styrofoam λ=0,04 [W/mK] or 12 cm styrofoam λ=0,03 [W/mK], factor U=0,15 [W/m^{2}K];
- slot block keramzite 24 cm heat mortar and 20 cm styrofoam EPS 80-036 (FS 15), factor U=0,1408

[W/m^{2}K];

- aerated concrete (800) 24 cm (adhesive or heat-insulating mortar) and 18 cm styrofoam TERMONIUM PLUS facade λ=0,03 [W/mK], factor U=0,1471 [W/m^{2}K];
- ceramic hollow Max 29 cm, styrofoam TERMONIUM PLUS facade λ=0,031 [W/mK] 18 cm, block of porous bricks 11,5 cm, factor U=0,1434 [W/m^{2}K].

However, the only system on the market, the use of which provides almost complete tightness of the construction, is produced by the Polish company IZODOM 2000. This system offers components fully compatible with each other: the wall elements, the foundation slab and panels for thermal insulation of roofs.

Bringing the walls in the system IZODOM Poland 2000 is based on the construction of concrete or reinforced concrete structures directly on site. Instead of the traditional prefabricated formwork boards or shuttering panels are used Neopor moulder, which has a very low coefficient of heat conduction ratio of 0,032W/mK. Formwork is arranged with fittings for all walls, taking into account the architecture of the building. The basic structural element of the wall is hollow Super King Blok MC 1/45. Walls are concreted to floor height and after setting the laid concrete formwork elements are not removed but remain in the wall and take on the role of thermal insulation.

Conclusions

To avoid heat losses at the intersection of vertical baffle the foundation of the building, which is shown in Fig. 3, one of the solutions used in the building may be a passive application of the foundation slab connected to the wall elements. The slab is used in passive construction instead of traditional walls and continuous footings. It is poured at the construction site concrete slab, reinforced reinforcement distributed or conventional steel bars. To implement it used are the basic elements of formwork produced by Izodom in order to obtain a variety of shapes consistent with the project object. The heat transfer coefficient of such a foundation can be up to 0,09W/m^{2}K. A thick layer of heat insulation under the building protects against the penetration of frost into the building, freezing and deformation of the surface. The advantages of this solution include: a significant reduction in construction time for 2-3 business foundation, perfect protection against moisture and heat, monolithic element provides stability, reducing the time of earthworks.

The analysis can be concluded that there are solutions which allows construction of a house with an extremely low demand for thermal energy. Both the choice of thermal insulation materials and technology of the partitions have a significant effect on heat loss in the building. Passive houses are an alternative to energy-intensive buildings posed in traditional technology, while providing a very high comfort.

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Рецензія/Peer review : 18.5.2016 р. Надрукована/Printed : 8.6.2016 р.
Рецензент: д.т.н., проф.. Параска Г.Б.