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PASSIVE BUILDING – VERIFICATION OF ACHIEVED EFFECTS

BUDYNEK PASYWNY – WERYFIKACJA UZYSKANYCH EFEKTÓW

Abstract

The article presents a passive building to be used for office purposes that is under construction in Podlaskie region. The building has been designed to meet the characteristics of a passive building – i.e. compact shape, mechanical ventilation with heat recovery, ground heat exchanger, tight external partitions with an indicator U < 0.15 W/(m^2·K), heat pump, solar collectors. Calculation indicator of useable energy demand for heating purposes is <15 kWh/m^2·a. In order to verify the achieved effects the building was subjected to tightness test and infrared camera tests are also planned. The building is constructed by the Podlaskie Passive Building Center as part of a project funded by the European Regional Development Fund.

Keywords: passive building, project guidelines, verification, envelope tightness

Streszczenie

W artykule przedstawiono realizowany w województwie podlaskim budynek pasywny z przeznaczeniem na cele biurowe. Budynek został tak zaprojektowany, aby spełniał cechy budynku pasywnego – zwarta bryła, wentylacja mechaniczna z odzyskiem ciepła, gruntowy wymiennik ciepła, przegrody zewnętrzne szczelne o współczynniku U < 0,15 W/(m^2·K), pompa ciepła, kolektory słoneczne. Obliczeniowy wskaźnik zapotrzebowania na energię użytkową na cele grzewcze wynosi <15 kWh/m^2·a. W celu weryfikacji uzyskanych efektów budynek poddany został próbie szczelności, planowane są również badania kamerą termowizyjną. Budynek jest realizowany przez Podlaskie Centrum Budownictwa Pasywnego w ramach projektu finansowanego z Europejskiego Funduszu Rozwoju Regionalnego.

Słowa kluczowe: budynek pasywny, założenia projektowe, weryfikacja, szczelność obudowy

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1. Introduction

Passive house as defined by Wolfgang Feist cit. „is a building with very low energy consumption for heating the interior 15 kWh/(m^2·year), where the thermal comfort is provided by passive heat sources (residents, electrical appliances, solar heat, heat recovered from the ventilation), the building does not need a separate active heating system. Heating demand is met through heat recovery and reheating the air ventilating the building". The concept of a passive building was developed 20 years ago by W. Feist and his colleagues at the Institute of Housing and the Environment in Darmstadt, Germany. The first passive building with energy consumption of 10 kWh/(m^2·year) was built in Darmstadt-Kranichstein in Germany in 1991. Over the subsequent years more residential areas with passive buildings were developed. In 1998, the idea of passive houses was supported by the European Union through the project CEPHEUS (part of the THERMIE program). In Germany, Austria, Sweden and France 250 flats were built in 14 passive buildings. In 2003 in Germany, Austria and Switzerland there were more than 3,000 residential housing units in passive house standard, while in 2014 there were over tens of thousands and the number is increasing very fast [1, 2].

1.1. The criteria for passive building

The basic criteria to be met by a passive building are presented in Table 1.

Table 1

The basic criteria for a passive building

	Specification	Requirements
1	The energy necessary to heat the area of 1 sqm	< 15 kWh/(m2·year)
2	U-value the heat transfer factor for external partitions	< 0.15 W/(m2·K)
3	Tightness of a building – air exchange rate not (n50)	< 0,6 h-1
4	The maximum reduction of thermal bridges	Ψ ≅ 0
5	Windows of the heat transfer factor U-value	< 0.8 W/(m2·K)
	Total solar energy transmittance for glazing	*g* = 50%
6	Efficiency of recuperator for recovery of heat from ventilation	>70%
7	Reduction of heat loss in the process of hot water preparation and supply	
9	Efficient use of electric energy	

2. Project guidelines for the passive building completed by the Podlaskie Passive Building Centre (PCBP)

2.1. Technical description of the completed passive building

The building is located in the 4th climatic zone, it has two stories and no basement. The block consists of 2 parts: office (passive), made in the standard of passive building and the adjacent on the north side industrial hall made in the low-energy building standard. The total usable area of the building (office + hall) is 2400.86 sqm. Basic data for the office part:

- area (heated) A_f = 605.33 m^2,
- cubature 1765.65 m^3,
- building area of 368 m^2,
- building height 7.2 m,
- length 30.17 m,
- width 11.64 m.

Fig. 1. Office building under construction as part of the EU project (PCBP)

Fig. 2. Heating installations 4 heat pumps brine-water used for heating, ventilation and air-water heat pump for domestic hot water needs

Table 2

Thermal characteristics of partitions

	Specification	U [W/(m²·K)]
1	The floor on the ground – the foundation slab …+ Styrodur 24 cm	0.108
2	The external walls of lime-sand hollow blocks 25 cm thick 30 cm styrofoam (expanded polystyrene)	0.105
3	Flat roof – channell pllates + extruded styrofoam from 30 to 62 cm (average value)	0.062
4	Triple-glazed windows, low-E glass g(G) = 0.8 (Uw = 0.8, Ug = 0.5)	0.76*
5	Aluminium door joinery	0.7
4	Maximum reduction of thermal bridges	

* including "assembly" thermal bridges

2.1.1. Sources of heat

The source of heat for the needs of central heating, ventilation and hot water are 4 brine-water heat pumps and air-water heat pump for domestic hot water.

The source of cooling (passive) are two following sources of heat pumps:
- vertical well (ground probes),
- horizontal collector.

The additional source of cooling are heat pumps (active cooling).

2.2. Reduction of demand for heat as a result of increased thermal parameters of external partitions

The reduction of demand for heat in the analyzed building in comparison to such a building in which all the external partitions (including windows) are made in accordance with the WT 2013 was calculated on the basis of formulas stipulated in the Regulation of the Minister of Economy [3] and is given in Table 3.

Table 3

Compilation of designed and constructed thermal insulation partitions, the achieved effects in comparison to the requirements of the standard

External partitions				Resulting effect	
Specification	area [m²]	heat transfer coefficient U [W/(m² · K)]		reduction ΔQ	
		acc. to WT 2015	constructed	[GJ/year]	toe
External walls	319.6	0.25	0.105	11.26	0.27
Windows	65.2	1.3	0.76	101.74	2.42
Flat roof	351.18	0.2	0.062	14.56	0.35
Floor on the ground	351.18	0.3	0.108	7.58	0.18
			ΣΔQ =	135.14	3.22

The resulting energy efficiency in form of heat demand reduction is 135.14 GJ/year, which is 3.22 toe (tons of equivalent oil). The greatest thermal effect was achieved when using windows with improved thermal performance.

3. Verification – Tightness test

The measurements were carried out by a professional company which: made a tightness test of the building – Blower Door Test, set the air exchange rate n_{50}, located the spots of uncontrolled leaks.

Fig. 3. Tightness test in the office part of the building

As a result of the measurements carried out, an uncontrolled air leakage was found in a few places only. These were mainly the contact points of door frame with the door leaf around the door handle (lock) and contact point of door frame with the fire exit door leaf. After the removal of minor faults the building should meet the required value $n_{50} \leq 0.6^{-1}$.

4. Analysis of the achieved effects – the compliance with passive building characteristics

The building is under construction, completion date of construction work, commissioning of heating installations and then putting the building into operation is expected in 2015 (the date of the project realization is from 2013 to 2015). Only after a year of operation, a thorough analysis of the achieved energy effects will be possible and after three years the energy marking for the building will be obtainable with measurement method. Table 4 contains the designed and carried out works in regard to the criteria to be met by a passive building.

Table 4

Compilation of designed works in regard to the criteria to be met by a passive building

Specification	Values	Effect	Criteria met
Energy demand for heating 1 sqm	≤15 kWh/m2·year	Minimum air pollution	Yes *
Thermal insulation of partitions, windows + doors	0.062÷0.105	Σ ΔQ = 3.22 toe	Yes
Compact, not segmented block A/V =	0.31	Less heat loss by transfer	Yes
Most windows located on the south orientation	87%	Beneficial (positive) thermal balance, passive gains cover min. 40% of the heat demand	Yes
Windows – cooling in summer	Shutters, green	Minimization of overheating in summer	**
Achieved tightness test	n50 =0.62-1		No
Elimination of thermal bridges (infrared camera test)	~0 (assumption)	Tests to confirm the design objectives have not been made yet	***

* Verification by direct measurement of energy consumption after 3 heating seasons
** Verification during the operation of the building in summer 2016
*** Verification will be carried out using the infrared camera (winter)

5. Summary and conclusions

This article presents the building designed as a passive building which is under construction in Podlaskie region by Podlaskie Passive Building Centre (PCBP).

On the basis of the analysis of the building design documentation, calculations and participation in tightness test of the building it was found that the building meets the characteristics of a passive building, except for tightness test with slightly exceeded limit values. It is therefore necessary to seal the uncontrolled leaks.

It has been estimated that despite very good thermal insulation of the external partitions the reduction of energy demand in comparison to a standard building will be 3.22 toe only. Thus, the main factor to meet the characteristics of a passive building was achieved through limiting the heat loss through air ventilation heat recovery (recuperator, ground heat exchanger). Ventilation losses are estimated at ~9% of total demand for heat for heating the building.

All the calculation values of U factor, heat demand reduction ΔQ and the need for heat for heating purposes, presented in Tables 2, 3 and 4, were made by the authors of this article.

R e f e r e n c e s

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