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Original Research Article

IMPACT OF BUILDING WALLS OF HISTORIC OBJECTS FROM HALF-TIMBERED WALL IN THEIR STATE OF THERMAL PROTECTION

Agnieszka SZYMANOWSKA-GWIŻDŻ[1], Tomasz STEIDL[2]
The Silesian University of Technology; Gliwice, Poland

Abstract

The paper presents the problems connected with preserved examples of buildings in Upper Silesia that contain the elements of half-timbered walls. This type of construction currently characterizes houses of various utility functions. Often, their formation was related to the construction of patron settlements, accompanied by the development of industrial plants. Today, there is a problem of insufficient thermal insulation of barriers in half-timbered houses and numerous attempts to improve their thermal parameters are observed. In this type of projects, the correct determination of the existing state in terms of construction of the barrier and thermal protection seems to be important, as the starting points for further analysis. The study determines the insulation of frame walls with ceramic fill, with a variety of material and construction solutions. Literature examples and in situ measurements results were used for the research.

Keywords: half-timbered wall, thermal insularity, thermal protection

1. INTRODUCTION

Upper Silesia is one of the Polish regions where there are concentrations of buildings, made of half-timbered technology. This type of construction is

[1] Corresponding author: The Silesian University of Technology, Department of Buildings and Buildings Physics, Faculty of Civil Engineering, Akademicka st 5, 44-100 Gliwice, Poland, e-mail: agnieszka.szymanowska-gwizdz@polsl.pl, tel. +480322372303

[2] Corresponding author: The Silesian University of Technology, Department of Buildings and Buildings Physics, Faculty of Civil Engineering, Akademicka st 5, 44-100 Gliwice, Poland, e-mail: tomasz.steidl@polsl.pl, tel. +480322372303

characterized now by houses of various useful functions. They come mainly from the late nineteenth and early twentieth century, and their origin is connected mainly with the industry development in this region.
Today there is a problem of insufficient thermal insulation of barriers in the half-timbered houses and one can observe their numerous attempts to improve the thermal parameters. With such projects important seems to be the correct definition of the existing situation in terms of barrier design and the conservation thermal status, as the output for further analysis.
The study identified the skeletal wall insulation filled with ceramic of a various material and structure solutions. Literature was used in the research and examples of the measurements in situ.

2. ANALYSED EXAMPLES AND RESEARCH METHOD

Skeletal structure filled with ceramic bricks appeared in Silesia as an independent in all buildings or characterized only parts of buildings. Wall floors were made of it and also-barriers of unheated spaces such as stairwells or attic. Buildings of this design are now present in large numbers in Upper Silesia, inter alia, in the settlements of Bytom, Ruda Śląska, Zabrze or Pyskowice. They constitute a unique landscape of housing estates primarily intended for labourers, along with whole teams of buildings and social facilities and houses of a better standard for officials. One of these is the Zabrze estate of Zandka erected during operation of the smelter Donnersmarck, or working colony in Zabrze Rokitnica, related to the coal mine "Castellengo" belonged to Count Ballestrem.
In Pyskowice, the construction of settlements with elements of timbered houses was accompanied with launching the railway line from Opole to Gliwice through Pyskowice. In 1910, there were already 12-family railman's houses, and after World War I, opened new buildings for railway workers but also for miners and steelworkers, working outside Pyskowice [1]. In the housing estate next to apartment buildings there are also single-family detached houses and terraced houses. A frame construction in multi-family buildings has been applied in the upper parts of buildings, particularly wasted attics but also in stairwells.
Gliwice’s "pearl" of timbered houses is a building of the current State Music School, dating from the early twentieth century. The skeleton construction is found in the walls of the second floor, the ground floor is made entirely of a brick. Floor rooms are a library and music rooms for exercise.

Fig. 1. Residential buildings in the settlement of Zandka in Zabrze

Fig. 2. Residential buildings in the railwaymen settlement in Pyskowice (left) and Zandka in Zabrze (right)

These objects were created during the periods of different, from todays, regulations on thermal insulation or lack of them. Their current state of the

thermal protection varies greatly, especially since the barriers of the same form in detached houses are already extremely rare.

Fig. 3. Building of State Music School in Gliwice.

A large part over the years has undergone different modifications, mainly associated with the attempt to improve thermal insulation. Determination for design purposes of the current state of the thermal protection inhibits the lack of project documentation and data concerning the construction and reconstruction of individual barriers. In determining their thermal insulation, helpful is a method of thermal imaging that allows to investigate the accuracy of temperature distribution and the occurrence of, so-called, thermal defects, i. e. for example unintentional changes in the material structure of the barrier. It also allows for imaging individual thermal differences associated with the complex structure of inhomogeneous barrier. Following this study, one obtains images of temperature differences on the tested surfaces of barriers. Analysis of the results is to extract places with different colours of the image, which corresponds to the variable thermal insulation of the barrier associated with e. g. its heterogeneous structure.

Knowing the structures of buildings, calculation of the thermal quality of the barriers is done in accordance with the standard requirements [3].

Thermal insulation can also be determined through the use of computer programs, based on the use of MES in the calculation of any two-dimensional model of the building element. They also allow for precise calculation of the heat transfer coefficient, taking into account all the elements of the barrier, thermal bridging and heat flow directions.

In the article one used three possible methods of determining the protection thermal state of the barrier. Standardization method was used, calculating the

insulation of walls, barrier total insulation through the THERM program, thermal differences of individual skeletal walls was shown using thermal imaging research.

For analysis were selected three commonly occurring types of outside barriers, which cover the spaces in homes with half-timbered wall in Silesia. They occur commonly in Zabrze settlements:

- Barrier (type A) having a thickness of two bricks (from the outside timber frame filled with ceramic brick from the inside-brick layer having a thickness of 12 cm); this type of wall also exists in the case of a building of the State Music School in Gliwice,
- Barrier (type B) with a width of 1 brick with insulation from the premises, from the suprema slabs with a thickness of 5 cm (timber frame filled with ceramic brick); this type of wall was mainly in detached houses,
- Barrier (type C) with a thickness of 1 brick, without thermal insulation (timber frame filled with ceramic brick, plastered on the inside), occurring in the case of originally unused attics and staircases.

Column spacing of wooden frame of half-timbered wall was determined by the shape of the building and the location of window and door openings. For the analysis one adopted spacing of 1m.

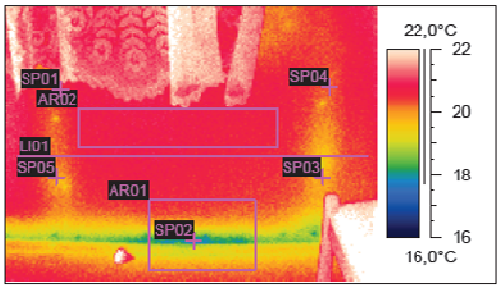
In the calculation one used standard size of wood, brick and cement-chip slabs thermal conductivity.

3. RESEARCH RESULTS

Thermographic survey was carried from the premises floors side, enclosed with frame construction, and from the facade of the building. As a result one obtained thermograms (Figure 4 and 5) showing the temperature at several selected points marked with a cross and the number (e. g. SP01, SP02) and areas (spaces) corresponding to the characteristic distributions of temperatures on tested barriers (e. g. AR01, AR02). For such marked areas, values of minimum and maximum temperatures were determined.

On the inner surfaces of the walls are visible differences in temperature between the fields of stone wall and elements of timber frame. It is worth noting that despite the improved insulation of wood, the temperature on the surface of the brick walls are about 1-3^{o}C higher. The reasons for this phenomenon may be sought in the occurrence of gaps between the frame and the adjacent brick elements and increased migration of heat and humidity in these places. They can result from natural processes of degradation of wood. This phenomenon describes Kozakiewicz [2], paying attention to the processes of aging and slow

loss of cross-sections of wooden elements, due to slow degradation of lignin, exposed to the UV radiation.



IR information	Value
Date of creation	2014-12-18
Object parameter	**Value**
Atmospheric	20,0°C
Label	**Value**
SP01	20,6°C
SP02	17,6°C
SP03	19,6°C
SP04	20,3°C
SP05	19,9°C

Label	Value
LI01 : cursor	-
LI01 : max	21,0°C
LI01 : min	19,4°C
AR01 : max	20,7°C
AR01 : min	17,6°C
AR01: stdev	0,7°C
AR02 : max	21,1°C
AR02 : min	20,4°C
AR02: stdev	0,1°C

corridor of the **1st**

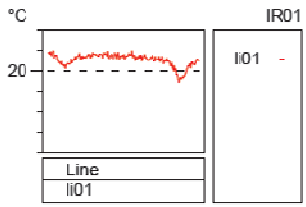
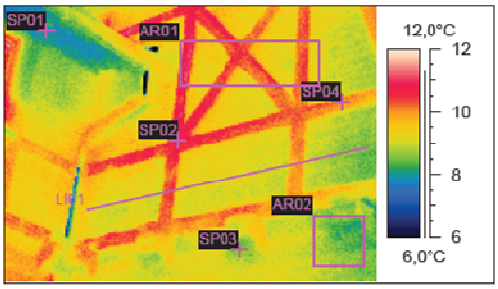
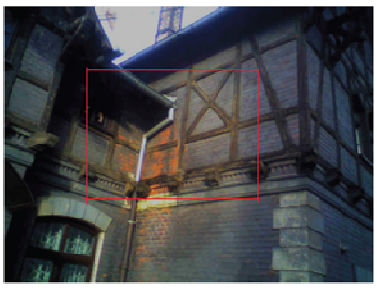


Fig. 4. Thermogram made on the room side of the building of State Music School in Gliwice





IR information	Value
Date of creation	2014-12-18
Object parameter	**Value**
Atmospheric	7,0°C
Label	**Value**
SP01	7,9°C
SP02	11,0°C
SP03	8,9°C
SP04	10,1°C

Label	Value
LI01 : cursor	-
LI01 : max	10,7°C
LI01 : min	8,5°C
AR01 : max	11,4°C
AR01 : min	8,9°C
AR01: stdev	0,5°C
AR02 : max	9,2°C
AR02 : min	7,9°C
AR02: stdev	0,2°C

ściana boczna
side wall

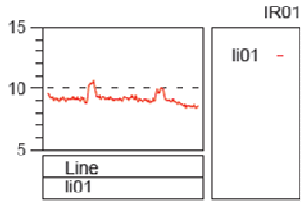


Fig. 5. Thermogram made on the outside of the building of State Music School in Gliwice

Calculations of thermal insulation of external walls of different construction, made for section of inhomogeneous barrier and carried out in the THERM program, showed differences in its values.

Table 1. Summary of heat transfer coefficients U for selected partitions

No.	Type of partition	Heat transfer coefficient U [W/m^{2}K]		
		Inhomogeneous partition section		Total U (THERM)
		Cross section through post	Cross section through brick	
1	Type A	1.34	2.06	1.08
2	Type B	0.798	2,65	1.41
3	Type C	0.97	3.17	2.65

Vocational practice shows that proper identification of the real thermal insulation is necessary for the design of thermal insulation, often associated with renovation or change of use of the building. Difficulties can make cases with built structure or the presence in its structure, e. g. air gaps or materials of unknown coefficients of thermal conductivity.

4. CONCLUSIONS

For proper determining of barrier thermal quality of existing buildings it is necessary to correctly recognize the barrier, and knowledge of the thermal characteristics of individual materials. For complex wall structure it is necessary to use advanced computational methods that allow for the execution of precise calculations of thermal resistance. Currently, in Poland, there is a lack of proper tools, in the form of computational programs in Polish, which, in an accessible manner would allow the designer to perform such calculations.

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WPŁYW BUDOWY ŚCIAN HISTORYCZNYCH BUDYNKÓW Z MURU PRUSKIEGO NA ICH STAN OCHRONY CIEPLNEJ

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

W artykule przedstawiono problematykę związaną z zachowanymi na Górnym Śląsku budynkami, zawierających elementy muru pruskiego. Ten typ konstrukcji charakteryzuje obecnie domy o różnych funkcjach użytkowych. Niejednokrotnie ich powstanie związane było z budową osiedli patronackich, towarzyszącą rozwojowi zakładów przemysłowych. Współcześnie istnieje problem niedostatecznej izolacyjności termicznej przegród w domach z muru pruskiego i obserwuje się liczne próby polepszania ich parametrów cieplnych. Przy tego typu przedsięwzięciach istotnym wydaje się być poprawne określenie stanu istniejącego pod względem konstrukcji przegrody i ochrony cieplej, jako wyjściowych do dalszych analiz.
W opracowaniu określono izolacyjność ścian szkieletowych z wypełnieniem ceramicznym, o różnorodnych rozwiązaniach materiałowo-konstrukcyjnych. Do badań wykorzystano przykłady literaturowe oraz wyniki pomiarów in situ.

Słowa kluczowe: mur pruski, izolacyjność termiczna, ochrona cieplna

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