Article

Interior Insulation of Masonry Walls—Selected Problems in the Design

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Received: 24 September 2019; Accepted: 14 October 2019; Published: 15 October 2019

Abstract: This article addresses the important problem of improving the energy efficiency of historic buildings, where due to the architectural value of the facade, thermal insulation should be placed from the inside. As a part of this publication, the author, on the basis of their own experience and research, presents and discusses selected problems to which special attention should be paid when designing this type of insulation. These are among other things: disturbances in the distribution of the temperature field on the partition; defects related to partial thermal insulation of partitions; the lack of detailed analysis of wall systems in terms of construction and their technical condition; wood decay; the selection of inadequate calculation methods, e.g., the simple method of Fokin–Glaser and many others. The author, on the basis of measurements and computational analysis, presents the methodology of a correct solution of such problems. This significantly simplifies currently applied methods.

Keywords: energy efficiency; thermal insulation from the inside; historical buildings; thermal bridges; hygrothermal analysis

1. Introduction

Current energy policy enforces solutions that reduce the consumption of energy and natural resources [1,2]. Activities are directed to newly designed buildings, and also to existing ones.

The application of thermal insulation of building walls is one of the methods aiming to raise energetic standards [3,4]. In new buildings, external walls are commonly insulated in the ETICS system (external thermal insulation composite system) with the use of Styrofoam, mineral wool or phenolic foam. According to estimates, the application of thermal insulation in the building envelope can bring about the reduction of carbon dioxide emission by 780 million tons a year [5]. For existing buildings which are legally protected, registered as historic monuments, or have the facade of acknowledged architectural value, standard insulation methods are not applicable.

Alternatively, walls can be insulated from the inside. In the literature, we can find many works describing the design methodology of such insulations [6–8]. Many publications have a mostly practical character and can be successfully applied in engineering practice [9–11]. We can find there, graphical solutions of design details and general information on the selection of thermal insulation type, its thickness as well as general guidelines involving its installation. Some of the proposed solutions were developed by the author in their in-situ research studies [12,13] and others were produced in laboratory tests on a smaller scale [14,15].

The works [16–18] present the designing procedure of internal insulation applied for historical buildings. Temperature and humidity were monitored in the envelope to optimize the selection of material for existing microclimate conditions and hygrothermal performance of the envelope.

The application of thermal insulation from the inside entails the risk of interstitial or surface condensation, especially in the local climate, where the temperatures can be significantly lower in
autumn and winter seasons. One of the main problems involving the structure of old buildings is the presence of wooden elements embedded in or connected with the external wall, which due to water increment effected by condensation are very susceptible to wood decay [19,20].

In the work of [21], the author make use of probabilistic analyses of the Monte Carlo type, which were applied to select the type and thickness of insulation to avoid condensation risk.

In practical applications [16], the solutions with vapor-tight barriers are suggested to avoid the risk of mold growth or surface condensation, and when wooden elements are present in the wall, appropriate ventilation is recommended as well as the application of high-diffusivity materials. In other cases, the application of an air gap can be an alternative [19].

The analyses of the recommendations and guidelines involving the design process of internal insulations indicate that it is a very complex process and the designer is required to have extensive knowledge and experience. It should be emphasized that the methods presented in literature are often inconsistent as to the application necessity of diffusive barriers, which notably hampers right decision making expected from the designer.

The aim of this publication is to indicate the most common errors and problems associated with the design of insulation from the inside. According to the author, the most common issues (discussed in this work) include:

- Disturbances in the distribution of the temperature field on the partition, often referred to as thermal anomalies or thermal bridges. They are not only an area of an increased heat loss, but also a zone of an increased risk of mold growth. For selected nodes in the building, the values of the linear thermal transmittance coefficient were analyzed and the risk of mold development was estimated using the value of the $f_{\text{Rel}}$ factor.

- Defects related to a fragmentary thermal insulation of partitions. On the basis of a thermovision photo of the wall insulated from the inside and the numerical model made for it, the distribution of the temperature field on the partition was depicted. The author payed attention to the so called edge bridges (the name proposed by the author), which cause significant disturbances in the temperature distribution, and are caused by a partial insulation that is the result of, for example, the lack of access or existing buildings and installations.

- The lack of a detailed analysis of wall systems in terms of their construction and technical condition; knowledge of the wall system construction is necessary in the correct analysis and numerical modelling of hygrothermal phenomena. Due to the historical character of most buildings as well as the material and structural solutions used in the partitions, it is necessary to make a diagnosis based on open pitches and basic examination (described in the text).

- Wood decay; the author pays special attention to wood decay, e.g., wooden beams in ceilings. Wood degradation can be caused by fungi, bacteria and insects. Wood may be attacked by bacteria when very low oxygen levels occur. But it may take even over 100 years for wood to decompose in anaerobic conditions. Fungus is the most common cause of wood decay because it can break down cellulose and lignin, while bacteria can not destroy lignin. The decay of wood occurs at a mass moisture content above 20% and at a temperature of 0 °C to 45 °C. Mycelium growth does not necessarily have to be in the same place as a moist area, for example $Serpula lacrymans$ can grow out of moisture in the basement, but destroy wood on the second floor.

- The selection of inappropriate calculation methods; in engineering applications, the Glaser method (norm EN ISO 13788:2013) is most commonly used. However, it does not capture a number of phenomena. For this reason, author use the WUFI 2D program for modelling. It works on the basis of a system of non-linear partial differential equations describing non-stationary coupled transport of heat and moisture in building materials. In addition, modelling results have been compared with in-situ measurement results to indicate possible differences and their causes.

Applying the principle of Primum non nocerne to historical buildings—first, do no harm; the author wants to pay special attention to the problems that may arise in this type of thermo-modernization
work. The absolute compliance with energy regulations and determination to improve energy quality may prove dangerous for historical buildings. The article comprehensively presents short thermal and humidity diagnostics of external walls, which at the design stage will eliminate the risk of condensation, biological (and other) corrosion and will allow us to choose the right insulation technology (e.g., thickness, and type of material).

Remember that monuments connect the past with the future, and we are only their temporary guards.

2. Materials and Methods

2.1. Methodology of Insulation Design from the Inside

Recommended calculation methods were designed to match a typical envelope structure, and they did not define precisely the conditions in which the calculations should be carried out to be able to assess hygrothermal performance of the envelope when we were faced with an untypical structural solution, such as internal insulation of the existing envelope.

The author suggested the following methodology for estimating the applicability of internal insulation in terms of humidity risk or mold growth [22, 23]:

- Identifying the material structure of the envelope, including opencast works, measuring the thickness of existing layers (Figure 2).
- Measurement of surface moisture, using non-invasive methods, and in the case of ceramic walls of the thickness above 51 cm—measuring water content by sampling the opencast (Figure 3).
- Determining capillary absorption of the masonry wall (which allows us to determine the effect of rain on the outer shell of the wall) (Figure 4):
  - For substrates characterized by low capillary activity, for which: 
    \[ w = 0.5 \text{ (kg/m}^2\text{h}^{0.5}) \]
    can be insulated with a material that allows it to achieve thermal resistance at the level of 
    \[ \Delta R = 2 \text{[(m}^2\text{K)/W]} \]
    with \( s_d \) equal to 4 m. Partitions with capillary activity above 
    \[ 1.0 \text{ (kg/m}^2\text{h}^{0.5}) \]
    can be insulated with material allowing to obtain thermal resistance 
    \[ \Delta R = 2.5 \text{ [(m}^2\text{K)/W]} \].
- Defining the material type of wall layers and selecting most suitable physical properties with the use of available data.
- Inventory of sensitive places—linear thermal bridges (Figures 8–14).
- Selection of material and insulation technology in line with the following principles:
  - It is essential to carry out calculations in the 2D simulation programs, allowing for real parameters of local climate and indoor environment (relative humidity, temperature, Figure 5). The calculations must demonstrate that there is no water increment in the insulated wall and in the adjacent junctions of wooden structural elements.
  - It is recommended to calculate the temperature at the contact place between the layers:
    Existing wall—thermal insulation material, allowing for two-dimensional heat flow (Figures 7 and 8).
  - It is recommended for walls erected from ceramic bricks—without distinction as to the type of brick wall—as well as for concrete walls to select the thickness of the insulation material to ensure that after the insulation works the value of thermal resistance is within the range of 
    \[ 0.5–3.0 \text{ [(m}^2\text{K)/W]} \]
    (depending on the obtained earlier results of in-situ studies—see point 3.1),
  - The following values are recommended for the newly designed insulation layers, depending on the relative humidity of air in the room: 
    \[ s_d > 1500 \text{ m for the rooms having raised humidity RH} > 0.65; s_d < 0.5 \text{ m for the rooms having the humidity RH} < 0.65 \text{ [24].} \]
2.2. Test Stand

The research involved external brick walls of buildings located in Poland in the Upper Silesia Region. The main objective of the work was to assess the changes of humidity in the particular layers of the flat wall through the measurement of temperature and equilibrium moisture in the selected layers of the masonry wall. This publication presents selected measurement results for one of the analyzed buildings.

The building was built in the 1920s, using traditional technology. The external walls were made from 38 cm-thick bricks on lime mortar, with one-side cement-lime plaster finished from the inside with gypsum rendering coated with emulsion paint. Upper floors in the building were made as wooden beam structures.

The studies began in 2015. Opencasts were made in the selected places of the envelope to identify the structure of wall material and to sample small fragments of material for further studies (Figures 1 and 2). For the collected samples of material (solid brick), water content was determined basing on the measurement of mass losses in a weighting dryer (Figure 2). Depending on the sampling place of the material, it ranged from 1.5% in the central part of the wall to 3.0% in the basement parts. The recommended permissible water content of the masonry wall should have been around 3% [25]. With higher values, it was advisable to examine and eliminate the source of water ingress and to dry out the wall. The value of water content in the wall obtained from the studies was applied in numerical calculations which simulated the initial hygrothermal performance of the envelope.

![Diagram](https://via.placeholder.com/150)

**Figure 1.** Scheme of the test bench with description.
The measurement of surface moisture (Figure 3) was carried out with the use of the apparatus (TESTO 435-2). For the internal surface, with gypsum plastering coated with emulsion paint, it was at the level of 2.5%.

Figure 3. (a) Determining surface moisture of the masonry wall before insulation—research was carried out to determine the so-called moisture maps areas with different moisture; (b) measuring water content of brick samples (taken on the basis of developed moisture maps for the wall; thanks to the water content measurement, the actual water content for the wall was assumed in the numerical analysis).

The capillary absorption of the masonry wall was determined with the use of Karsten tube [26,27] (Figure 4). The measurement enabled us to find out the extent of water penetration into the brick wall. The study used between 4 and 10 samples. They were fixed and measured simultaneously on the wall. In order to be able to compile statistics, 10 correct measurements on the facade were obtained. The final result for the brick wall was 7.3 (kg/m²h⁰.⁵). In view of the recommendations provided in [18], we can state that for the obtained absorption of brick wall, an insulation material of s_d (equivalent air layer thickness) not higher than 1 m would be the best to accept [28–30].

In the course of the whole research cycle, the parameters of climate around the envelope were monitored, i.e., temperature and relative humidity (Figure 5). The measurement was carried out in the continuous mode with the time step of 1 h.
The selected planes of the insulated envelope were provided with measurement systems (Figure 6) which measured changes of temperature and relative humidity (sensors Pt-100, St 171 controlled by a multichannel recorder type MA56902M09TG3). Additionally, a measuring device was installed to monitor and register the changes of internal and external climate parameters (temperature and relative humidity). All the quantities were measured in the continuous mode with the time step of 1 h.
2.3. Numerical Modeling

The modeling tests were carried out on the basis of hygrothermal simulations for transient boundary conditions, using the software WUFI 2D [27]. From the described physical principles of heat and moisture transport, a closed differential equation system was developed with which the moisture behaviour of multi-layered building components were calculated under natural climatic boundary conditions. Since it was a non-linear equation system whose coefficients were greatly dependent on the potentials, an analytical solution was not possible. Described in detail below is the derivation of the coupled equation system and the numerical solution technique which forms the basis for the computer program called WUFI [27]. For non-stationary flows and conditions of two-dimensional heat transport and mass equations, they have the form:

- Heat transport:
  \[
  \frac{\partial H}{\partial \delta} \frac{\partial \vartheta}{\partial t} = \nabla \cdot (\lambda \nabla \vartheta) + h_v \nabla (\varphi \nabla (p_{sat})) \tag{1}
  \]

- Mass transport:
  \[
  \frac{\partial \varphi}{\partial \varphi} \frac{\partial \varphi}{\partial t} = \nabla (D_\varphi \nabla \varphi + \delta_p \nabla (\varphi p_{sat})) \tag{2}
  \]

where

- \(dH/d\delta\)—heat storage capacity of the moist building material [J/m³K],
- \(d\varphi/d\varphi\)—moisture storage capacity of the building material [kg/m³],
- \(\lambda\)—thermal conductivity of the moist building material [W/mK],
- \(D_\varphi\)—liquid conduction coefficient of the building material [kg/ms],
- \(\delta_p\)—water vapour permeability of the building material [kg/msPa],
- \(h_v\)—evaporation enthalpy of the water [J/kg],
- \(p_{sat}\)—water vapour saturation pressure [Pa],
- \(\vartheta\)—temperature [°C],
- \(\varphi\)—relative humidity [-].

The program had its own material database comprising basic types of building products. Some specific information involving physical features of the envelope components was supplemented basing on measurements (e.g., water content based on Figure 3a).
The parameters of the indoor climate and external climate conditions, i.e., temperature and relative humidity were assumed based on the measurement being carried out (Figure 4). Other factors such as rain (heavy rain) and sunlight were adopted on the basis of data for the nearest meteorological station Katowice—Figures 5 and 7. A three-year period of hygrothermal simulations was adopted.

### 3. Results and Discussion

**In Situ Research and Modelling**

As the first step, we presented the results of temperature and relative humidity measurement related to the results of modelling in the WUFI program. The test results were given with a one-hour time step for the measurement for the period from January 2015 to July 2015 (Figures 8 and 9).

![Figure 8](image-url)  
**Figure 8.** Temperature profile for the selected measurement places of the envelope. Collected results of the measurements and numerical modeling (description in the text).
The lowest temperature at the contact place according to the calculations was 12 °C, as observed in Figure 8. When analyzing the changes of relative humidity at the contact plane (Figure 9), we observed that the correlation index with the measurement results for relative humidity was 0.79, which means that moisture was being released, reaching ultimately the value of ~40% in the summer months. The dependence of thermal conductivity on humidity for that type of material had a linear character, and for the relative humidity of the surrounding air higher than 70%, the rise of thermal conductivity within the range of 60–70% took place [31].

Comparing the modeling results, where the correlation index with the measurement results for relative humidity was 0.79, we observed slight differences between the measurement and calculation values. Yet, a general trend involving the performance of the envelope within the time period of research studies was maintained.

Differences appearing between the results of numerical analysis and measurement (correlation coefficients of 0.77 and 0.79, respectively) were caused by the acceptance of material data for analysis.
(e.g., for brick, mortar, thermal conductivity, and the diffusion resistance coefficient) based on material bases (WUFI program, as in the literature).

One of the criteria ensuring effective designing of internal insulation involved suitable elimination of thermal bridges (Figures 10–12). For the needs of the analysis, three most common linear bridges were modeled: A—the outer corner of the external wall, B—the junction of the internal wall with the external one, C—the junction of the external wall with the wooden upper floor. The assumptions presented in Table 1 were accepted for the calculations. The modeling of the joints was executed in line with the guidelines specified in ISO 10211:2017 [32].

To develop a suitable solution of a thermal bridge detail which would satisfy the binding hygrothermal regulations, detailed calculations of the following physical parameters were carried out:

- Linear thermal coupling coefficient $L^{2D}$ [W/(mK)],
- Linear thermal transmittance, defining additional heat losses effected by the presence of linear thermal bridges [W/(mK)],

$$\psi = L^{2D} \sum_{j=1}^{N_j} U_j l_j$$  \hspace{1cm} (3)

where:

$L^{2D}$—thermal coupling coefficient obtained from the calculations involving two-dimensional heat flow of the component separating the two investigated environments [W/(mK)],
$U_j$—thermal transmittance of the one-dimensional $j$-th component separating the two investigated environments [W/(m$^2$K)],
$l_j$—length applicable for $U_j$ [m],
$N$—number of one-dimensional components.

- Temperature factor, defined on the basis of the minimum temperature on the envelope surface at the place of thermal bridge $f_{Rsi}$ [29]:

$$f_{Rsi} = \frac{\theta_{si} - T_e}{T_i - T_e}$$  \hspace{1cm} (4)

where:

$\theta_{si}$—calculated temperature of the internal surface at the critical place,
$T_i$—temperature of indoor air,
$T_e$—temperature of outdoor air,

- The following qualities were accepted as boundary conditions: Temperature of outdoor air $t_e$: $-20$ °C, temperature of indoor air $t_i$: $+20$ °C, thermal surface coefficients $h_e = 25$ [W/(m$^2$ K)], $h_i = 7.69$ [W/(m$^2$ K)], for calculations $f_{Rsi} h_i = 4$ [W/m$^2$ K] was assumed.

We observed from the results (Table 2) that there was no risk of surface condensation or mold development for any of thermal bridge details [33]. The temperature factor on the internal surface $f_{Rsi}$ was for all variants higher than the critical value [34] applied in local climate conditions $f_{Rsimax} = 0.72$ (limit value for Polish conditions, according to the Polish regulation [30]).
Figure 10. Distribution of isotherms for variant A.

Figure 11. Distribution of isotherms for variant B.
Figure 12. Distribution of isotherms for variant C.

Table 2. Collected results.

| Variant | $\theta_i \ [^\circ C]$ | $f_{Rsi}$ [-] | $U_{1D} \ [W/\text{(m}^2\text{K})]$ | $L_{2D} \ [W/\text{mK}]$ | $\psi_i \ [W/\text{mK}]$ |
|---------|-----------------|---------------|-----------------|-----------------|-----------------|
| A       |                 |               |                 |                 |                 |
|         | $t_1$           | 15.6          | 12.9            | 0.82            | 0.58            | 0.060           |
|         | $t_2$           | 18.4          | 16.9            | 0.92            |                 |                 |
| B       |                 |               |                 |                 |                 |
|         | $t_1$           | 17.4          | 17.2            | 0.88            |                 |                 |
|         | $t_2$           | 19.5          | 18.9            | 0.97            | 0.29            | 0.010           |
|         | $t_3$           | 16.9          | 16.8            | 0.92            |                 |                 |
| C       |                 |               |                 |                 |                 |
|         | $t_1$           | 18.9          | 17.1            | 0.93            |                 |                 |
|         | $t_2$           | 14.9          | 13.9            | 0.85            | 0.22            | 0.011           |
|         | $t_3$           | 13.2          | 12.2            | 0.81            |                 |                 |

Apart from typical internal thermal bridges, the author knew of untypical forms of thermal anomalies which the author named edge bridges. This case is illustrated by the thermographic image in Figure 13. The measurements were made with the FLIR ThermaCAM—B-200 thermovision device.
The wall was insulated incompletely due to installation works carried out in the wall. The insulation was not applied in the area near the ceiling, and an air gap was left to avoid moisturizing the wooden upper floor. The air gap was applied as recommended in the guidelines. The results were also compared to the envelope model developed in the numerical program Therm 7.4.

The thermovision device enables the visualization of the temperature field on the tested surface in the form of a thermal image—a thermogram.

## Table 3. Momentary surface temperatures from the thermogram in Figure 11.

| T [°C] | SPO1 | SPO2 | SPO3 | SPO4 | SPO5 |
|--------|------|------|------|------|------|
| 22.0   | 22.7 | 22.1 | 16.7 | 18.1 |

Climatic conditions during measurements:

- During the tests, both the outside air temperature and the temperature inside the building were measured before and in the course of the tests.
- Measurement performed: December 19, 2016:
  - Outside ambient temperature, $t_e$: 5.5 °C–5.0 °C,
  - The temperature inside the building, $t_i$: 20.0 °C–22.0 °C,
- Thermovision measurements were made at a temperature difference, $\Delta t = 14.5$–17.0 °C.

The obtained temperature difference between external and internal air (about 15 °C) met the requirements of the EN 13187 standard—the minimum temperature difference at the level of $\Delta t_{\text{min}} > 10$ °C.

The appearance of the so-called edge bridges. (Figure 13. (a) Fragmentary external wall insulation from the inside (compare with Figure 1). The appearance of the so-called edge bridges. (b) Momentary distribution of temperature field on the wall surface insulated and non-insulated from the inside. The temperatures indicated on the thermogram are presented in Table 3.)
Analyzing the results of the thermographic studies (Figures 13 and 14), we observed big differences in the temperature field on the wall, reaching almost 6 °C. The maximum temperature on the insulated surface was 22.7 °C, with the indoor air temperature being 23.6 °C, and it oscillated within the range of 22.7 °C–22.0 °C. At the same time, the temperature on the surface of non-insulated wall was within the range of 16.3 °C–18.5 °C. We observed a local temperature drop on the wall surface at the distance of about 10 cm, i.e., the distance of one thickness of the thermal insulation material from the edge of this material. The envelope model developed in the numerical program with the preset boundary conditions obtained on the basis of thermographic studies demonstrated a similar tendency in the distribution of temperature field, as shown in Figure 15. The maximum difference in temperature values between the insulated and non-insulated surface was approximately 7 °C—on the insulated surface the temperature was within the range of 22.0 °C–22.3 °C (max) whereas on the non-insulated surface it was within the range of 14.5 °C–18 °C. Special attention was paid to the drop of temperature at the edge of the insulation. It was probably caused by a big difference in the density of the applied materials. The said effect was observed mostly with respect to old brick walls or stone walls, and this area was labeled as the material-edge thermal bridge.

![Temperature distribution along the line L 01.](image)

Due to temperature drop and higher heat flux, an intensive condensation of water vapor and the development of mold occurred in these places. An interesting method which might hopefully solve the problem mentioned above has been presented in the literature [35]. At the contact place between the insulation and the ground, gaps were made into which heating pipes were inserted together with control devices which trigger the heating mode when the temperature at the insulation edge dropped below the dew point. The heating pipes emitted thermal energy principally into the zones which were markedly cooled out, eliminating local conditions and encouraging the development of condensation on the surface.

Due to the fact that the junction detail of the wall with the wooden beam floor was regarded as a place posing higher risk of wood decay, numerical calculations defining the content of water in selected nodal places were carried out (Figure 16). In real conditions, the measurement and assessment of hygrothermal performance of wooden beams involved large intrusion into the structure of the
masonry wall and upper floor. In residential buildings such measures would be very difficult and expensive to undertake, and therefore, they are only applied for in-situ analysis in exceptional cases.

Figure 15. Distribution of isotherms (a) and the density of heat flux (b) in the cross-section of the envelope (only a fragment is presented in the picture) obtained from numerical calculations.
Due to high convergence between the measurement results and the numerical calculations, the author only used the results of numerical analysis to estimate water content in the selected places of junction details between the wall and upper floor. Physical parameters presented in Table 4 were applied for the calculations.

| No | Material/Layer                      | R.H. [-] | μ [-] | λ [W/mK] | ρ [kg/m³] |
|----|------------------------------------|----------|------|----------|-----------|
| 1  | Cement plaster                     | 0.8      | 25   | 1.2      | 2000      |
| 2  | Solid brick; historical            | 0.8      | 15   | 0.60     | 1800      |
| 4  | Gypsum fiberboard                  | 0.8      | 16   | 0.32     | 1153      |
| 5  | Lightweight concrete               | 0.8      | 4    | 0.04     | 115       |
| 6  | Wood                               | 0.8      | 200  | 0.13     | 650       |

As it follows from the above graph (Figure 17), water content in the cross-section of the wooden beam slightly surpassed 100 kg/m³, i.e., about 20% of the mass with respect to pinewood. It was assumed that to avoid biodegradation (wood rotting), the content of water in the structural wood should not exceed 18%–22% of the volumetric weight [24–26]. Slightly higher values were acceptable for the period of six months. In the investigated case, we observed a decreasing tendency—a drying-out process to the level of 80 kg/m³. It is worth noting that in the simulation, the initial content of water was assumed at the level of 20% and it did not increase significantly. In this type of analysis, special attention should be paid
to the increase in the water content of the facade layer due to sloping rain (a phenomenon taken into account in modelling). For this purpose, wall water absorption tests were carried out (Figures 1 and 4). The lack of a protective or hydrophobic layer on the external surface of the brick wall often caused the increase of water content and migration of rainwater into the wall.

**Water Content**

![Graph of Water Content](image)

Figure 17. Cont.
Figure 17. (a) Water content in selected places (B_1, B_2, J_1) of the detail (Figure 14). (b) Water content in selected places (C_1-C_4) of the detail (Figure 14).
4. Conclusions

In the process of designing insulation from the inside, a lot of attention has been given to detail, particularly when it involves historical buildings which render services. Great financial resources are being allocated for the execution of such projects, which can facilitate a detailed and comprehensive examination of the building and its envelopes. Such investment projects are often sponsored by state authorities, or other forms of support are used, e.g., structural funds, subsidies etc.

In the case of detached houses or even blocks of flats or terraced houses, where insulation from the inside is the only way to raise the energetic standard, investment costs are most commonly covered by the tenant or the owner of the house.

The aim of this work was to present comprehensive thermal-humidity diagnostics which cover the basic research and helps to avoid a number of errors, and as a consequence—adverse physical phenomena.

The author payed special attention to the selection of calculation methods, the choice of which was dictated only by good design practice and experience. The commonly used Fokin–Glaser method [33], in terms of condensation issues, is not the right approach—especially for existing buildings for which the state of moisture is of key importance in designing. It is absolutely necessary to perform examination of the layout and structure of the masonry elements by taking samples to determine the fundamental moisture parameters.

It must also be mentioned that the absolute determination to meet current energy requirements and the use of large insulation thicknesses, without taking into account the properties of the wall covering part (facade), can be negative. Facade properties and the direction of the partition have a direct impact on the absorption of cutting rain, the distribution of water in the partition, and finally on the kinetics of its drying out from rainwater.

Having said all this, there is still the issue of thermal bridges to discuss. Some of them occur as a result of improper insulation of the partition edge bridges (Figure 13). Although the term edge bridge is invented by the author, their presence is often the result of already existing infrastructure in the building (e.g., installations, etc.) as well as the unawareness of owners who insulate only parts of full walls, without the so-called additional margins (Figures 10–12).

An important problem that occurs in the case of historic buildings are wooden ceilings and the risk of their biological corrosion in the place of support on the wall. This risk increases when larger thicknesses of insulation material and high diffusion parameters are used. Each time this type of node (placing the ceiling on the wall) should be thoroughly analyzed due to the material used and
the conditions in which the barrier works. The previously mentioned IN method may be a solution. However, this method’s rather high cost of application means that it has limited use in the case of private buildings.

The author cites in her work the results of in situ research as well. Only these types of measurements give a clear picture of the efficiency (or its lack) of the thermomodernization activities of the partitions. It should be added that the presented in situ tests belong to long-term tests (measurement of changes in temperature and humidity) and destructive (making outcrops) and often in buildings for which this method of thermal insulation is directed—impossible to make (historic buildings, covered by conservation). Not only does the article aim to signal the problem related to the difficulty in conducting research (availability of this type of objects), but also to indicate elements which should be given special attention in the design of this type of insulation.

The author of the present work focused principally on the development of a technological and material solution involving internal insulation which would compromise the needs of residents and eliminate the adverse aspects such as wood decay or the condensation of water vapor in the envelope. The research and development work on producing such a material has been carried out for two years now and the main aim is to invent a new material for thermal insulation from the inside [23,36–38]. Due to specific geometry and structure, its application in historical buildings from the inside can eliminate unfavorable moisture impact in the envelope and in its nodes.

The author’s efforts to invent and produce a new insulation material agree well with the principles of the Clean Energy Program in Poland which encompasses all buildings, especially those from the 19th and 20th century. On account of the time period of a building erection, the issues of both thermal protection as well as the need to maintain the values of architectural and historical objects become truly important.

**Funding:** The publication is financed from funds 03/030 / BK19 / 0089.

**Conflicts of Interest:** The author declare no conflicts of interest.

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