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DAMP PROOFING OF HERITAGE BUILDINGS LOCATED IN HISTORICAL TOWN CENTRES

BAJNO Dariusz[1], **BEDNARZ Łukasz**[2], **NOWAK Tomasz**[3]

[1] Polish Federation of Engineering Associations, ul. Katowicka 50, Opole
e-mail: bajno@iq.pl

[2] Wroclaw University of Technology, Wybrzeże St. Wyspiańskiego 27, Wroclaw
e-mail: lukasz.bednarz@pwr.edu.pl

[3] Wroclaw University of Technology, Wybrzeże St. Wyspiańskiego 27, Wroclaw
e-mail: tomasz.nowak@pwr.edu.pl

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Abstract. *Damp is one of the key factors influencing degradation of heritage buildings, especially timber, masonry and metal structures. The apparent good technical standing of a building can prove very misleading. Timely and correct assessment of a structure's condition can save and conserve the building for future generations. In most cases, substructures of heritage buildings had no damp-proofing approximating the technological solutions used today. Damp-proofing methods used in the past lose their efficiency over time and newly constructed buildings often change the ground water level and flow direction, resulting in gradual degradation of historical buildings. Not all modern methods used for protection against water or moisture are effective and appropriate for old buildings. Inappropriately selected and installed damp-proofing materials (installed in the wrong sequence) can accelerate degradation further, especially in parts of the building lying below ground level. The paper presents example solutions to damp-proofing problems which were successfully applied in several heritage buildings located in a historic centre of a Polish city. The application methods used are also described.*

1 INTRODUCTION

Moisture frequently accumulates inside walls and on wall surfaces. This can be observed in all types of buildings and is caused primarily by sorption (absorption and adsorption), i.e. the process by which porous material uptakes water vapour from the air and the result of moisture transferring through walls (diffusion) due to pressure differences on the two sides of a partition. These processes may result in temporary or permanent moisture condensation on the inside of the wall.

Capillary rise of water occurs in most types of building materials except in hydrophobic materials, and is another cause of damp in the elements of a building structure. The capillary processes result from absorption and rise of water in porous materials which have no protective layers resistant to high diffusion. The water may come from precipitation, unregulated water management around the building or a high ground water level.

The paper presents examples of moisture penetration in the subterranean parts of heritage buildings, which do not have damp and water protection systems resembling technological solutions used in the present day. The effectiveness of methods used to solve problems are also discussed. In the past, buildings were protected from damp by favourable topography and lie of the land, channelling surface and ground waters through drainage systems or the use of materials characterised by a low infiltration factor, such as clay, as cladding (proofing) layers. In the majority of cases such protection, if ever realised, has not survived to the present day.

2 TECHNICAL CONDITION OF BUILDINGS AFFECTED BY DAMP

Damp is one of the key factors influencing degradation of heritage buildings, especially timber, masonry and metal structures. The apparent good technical standing of a building can prove very misleading. Timely and correct assessment of a structure's condition can save and conserve the building for the future generations. In most cases, substructures of heritage buildings had no damp-proofing approximating the technological solutions used today. Where the primary moisture protection systems of the building (e.g. drainage systems) has not been damaged, moisture from outside does not pose a threat to the subterranean parts of the structure. However, rebuilding and modernisation in urbanised areas and numerous residences in rural areas mean that the installation of water, sewage, electricity and gas supply systems, along with construction of new build in the vicinity of older building directly or indirectly impact them through changes in the direction or intensity of water flow in the ground. This in turn leads to changes in the type and amount of moisture impact on masonry walls and floors in the lowest levels of the building.

Primary damp-proofing loses its efficiency over time and new buildings constructed in neighbouring areas often increased the impact of water to levels in ways which could not have been foreseen at the time of construction of historic building structures. Damage to a building element caused by damp does not necessarily mean that the whole damp-proofing protection has been destroyed, but even a small leak may with time lead to total destruction. This is why buildings subjected to uncontrolled moisture penetration undergo a degradation process that intensifies over time. Numerous heritage buildings require more effective systems of protection against destructive moisture penetration in their footing elements, floors, cellar and foundation walls. Not all modern methods used for protection against water or moisture are effective and appropriate in the case of old buildings. Inappropriately selected and installed damp-proofing materials (building materials installed in the wrong sequence) can further intensify degradation, especially in parts of the building below ground level. The paper discusses the challenges described with reference to selected heritage buildings located in a historic centre of one of Poland's southern cities.

3 DAMAGE TO MASONRY STRUCTURES AFFECTED BY DAMP

Not one of the 200 year old buildings analysed in the urban area had primary damp-proofing or evidence of later (unjustified) water-tight protection layers on the vertical external surfaces below ground, as has been the case in numerous other buildings. The buildings analysed are located close to each other and have been built with similar technologies.

A comprehensive analysis of building structures found out that they were built on foundations and substructures of older buildings. The evidence for this relates to the use of different materials, different cross-sections and structural systems. (fig. 1) [1].

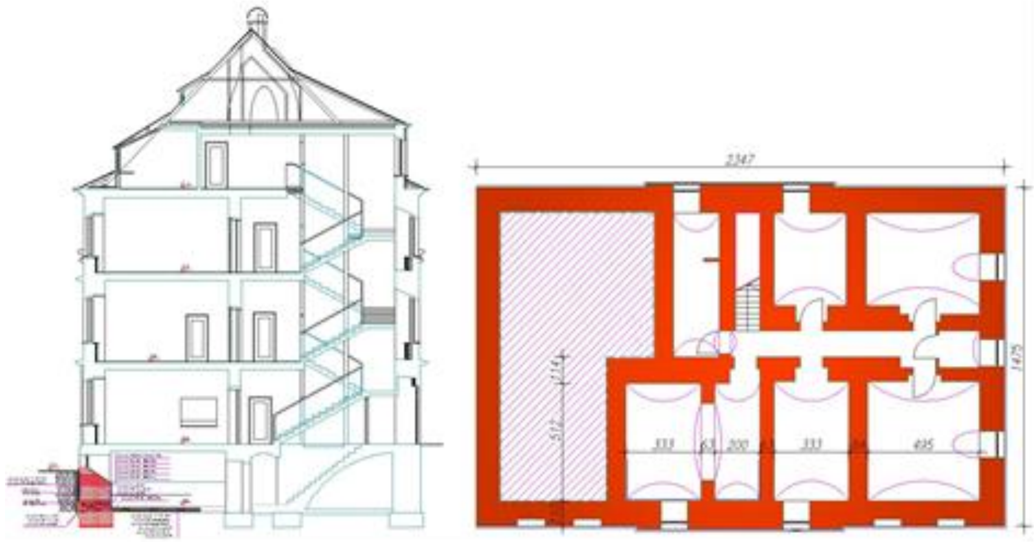

Figure 1: Cross-section of a building and floor-plan of its cellars (parts with and without cellar marked).

Even though the subterranean parts of the buildings had not been subjected to ground water impact, the cellar walls were found to be in very bad condition. The reason for this is inappropriate water management on the adjacent land areas, where part of an embankment causes surface water to reach the cellar level of the buildings.

Figure 2: Views of the façade of one of the buildings analysed.

External and internal walls of the buildings were built with full bricks and lime mortar. The arrangement of load bearing walls is mixed (longitudinal and transversal). Cellar walls were found to be very damp. Numerous salt precipitation concentrations were visible. In places, the dampness of external cellar walls has reached full absorbability (22%) extending to the top of the wall. The moisture in the fragments of walls shown in fig. 2 and 3 is not the result of long-term capillary rise of water from ground level. The damage was caused by precipitation water from adjacent land areas and in part by choked and leaky rainwater drainage systems.

Figure 3: Internal walls of the building.

4 RESTORATION/ REPAIR WORK AND MONITORING OF TECHNICAL CONDITION

As the buildings are located in a densely built up and serviced area, the decision was made to introduce complete and systematic damp-proofing protection with renovation plasters on most internal surfaces of cellar walls. Renovation plasters allow unrestrained evaporation of moisture contained inside the wall and gradual elimination of salts. After three years, the technical condition of walls was deemed to be satisfactory which demonstrates the effectiveness of the method adopted.

Analysis of walls and plaster prior to initiation of restoration work indicated high levels of chlorides and nitrates. Sulphates levels were medium and low (tab. 1, 2). A few years after the conservation intervention, all salinity levels had been reduced to low values.

Tab. 1. Classification of salinity levels for different types of salts in masonry structures [2], [3].

Salinity level	chlorides [%]	sulphates [%]	nitrates [%]
low	< 0,03	< 0,10	< 0,05
medium	0,03 ÷ 0,10	0,10 ÷ 0,25	0,05 ÷ 0,15
high	> 0,10	> 0,25	> 0,15

Tab. 2. Salt levels in brick samples

Sample number	chlorides [%]	sulphates [%]	nitrates [%]
1	0,70	0,11	0,55
2	0,65	0,09	0,50

The effectiveness of the comprehensive damp-proofing method introduced was analysed by comparing the original condition of the building to its condition after seven years (2007 – 2014). The condition of the walls was assessed using a thermographic camera. The effectiveness of restoration work is evidenced also by the visual appearance of walls as presented in fig. 4.

Figure 4: Internal surfaces of cellar walls – during the introduction of damp-proofing in 2007 (above) and after seven years in 2014 (below).

No methods available today can unequivocally detect defects hidden in architectural structures or individual building elements. Testing for salt level content or mass moisture in masonry elements is restricted only to selected point locations. But the process of searching for defects influencing the building as a whole must involve analysis of complete surfaces in diagnosing and solving problems. Thermography offers such possibilities as there is no need for full contact or penetration of each damaged building element. The application of the method is still in its initial stages and requires additional work but it may prove in coming years to be a very effective tool for diagnosing architectural structures.

Thermography is one of several non-destructive testing methods, which is used more and more often along with tomography [4], sonography and other methods to analyse the condition of buildings. Thermography is a process in which infrared (wave length between 0,9 μm and 14 μm) imaging is used to analyse the behaviour of solid objects and gases. Infrared is electromagnetic radiation with a wave length between the visible light and radio waves. This includes wave lengths ranging from 780 nm to 1 mm. Every object with a temperature above nominal zero emits heat radiation. Objects with a higher temperature emit more radiation with a shorter wave length, thus making them easy to detect. This means heat radiation emitted by solid objects can be detected in temperature ranges occurring in everyday conditions without the need for illumination with external light sources. Moreover, a precise measurement of wall temperature can be obtained.

Thermography is the only totally passive, non-contact method enabling imaging of the heat emitted by building surface at any given moment. This is why measurement using this method does not require looking inside walls by testing or intervening physically into structure or material.

Thermographic analysis in architecture and construction is used to check the quality and tightness of building insulation by detecting the occurrence of so called thermal bridges or damp zones resulting from leaky damp-proofing or freezing of walls.

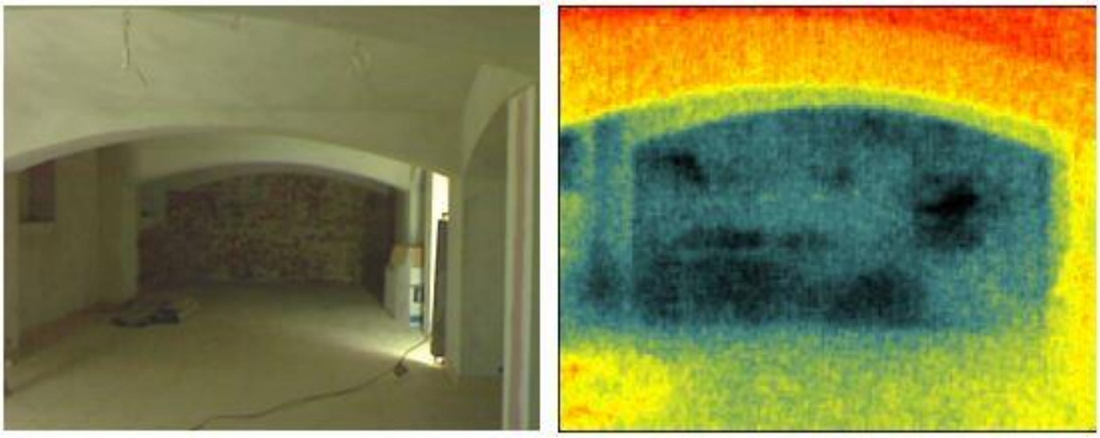

Figure 5: Internal surface of the end wall of the cellar in 2010 (on the left), thermographic image of the wall showing areas of high moisture (on the right).

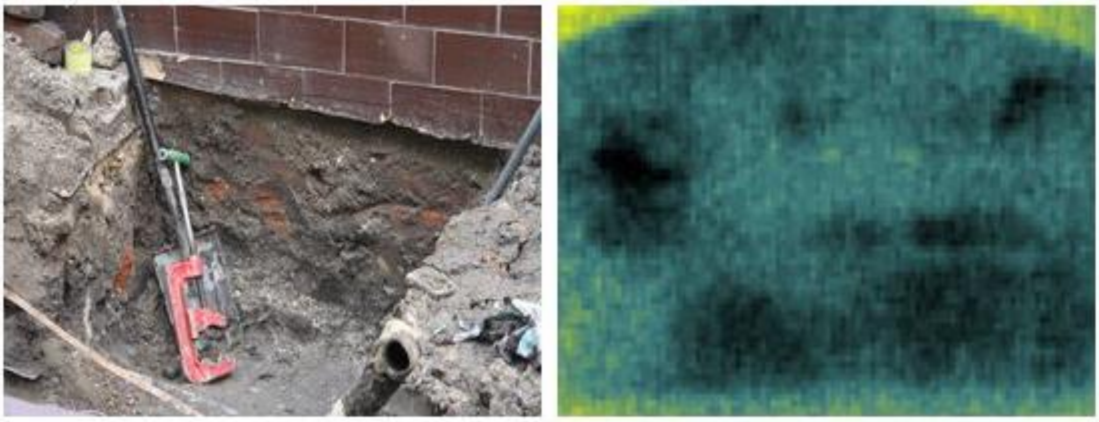

Figure 6: Internal surface of the end wall of the cellar shown in Fig. 5: the wall uncovered for installation of a draining system (on the left), thermographic image of damp (on the right).

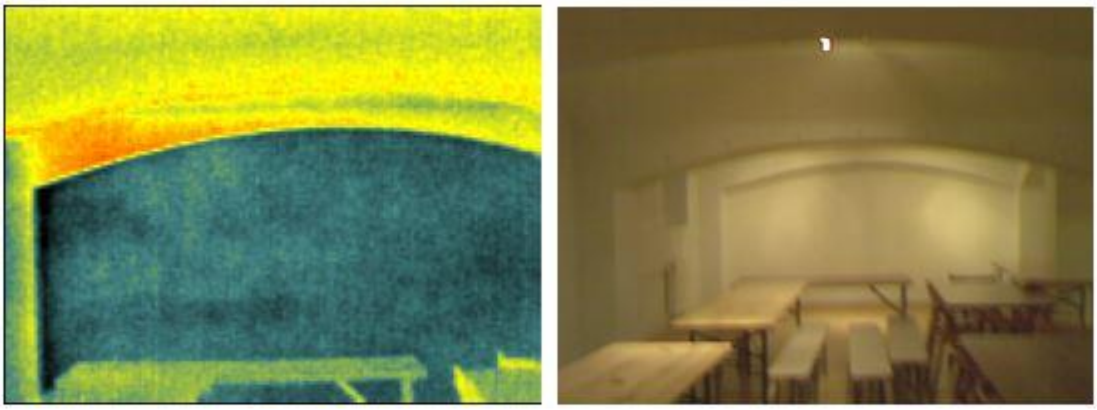

Figure 7: The building's cellar seven years after the damp-proofing work: thermographic image of the wall with no damp focal spots (on the left), view of the inside of the cellar with the end wall (on the right).

No damp-proofing was introduced in the case shown in figs. 5 – 7. The building remained in its original state. The only intervention involved digging out a channel along the end wall and installation of a draining system, which together with the channel collected rainwater from the roof with transfer to the municipal rainwater drainage system. The technical condition of the cellar has improved significantly. No modern methods of damp-proofing protection were introduced. So called chemical building materials did not have to be used because traditional methods were deemed to be sufficient on the basis of the analysis and observations carried out in the building, which ruled out the possibility of ground water penetrating its substructure.

5 CONCLUSIONS

The examples presented in this paper illustrate an important heritage conservation rule which states that the problem of damp in heritage structures or in their fragments should not be dealt with in an universal and routine way. Each case requires an individualised analysis and careful selection of a damp and water protection system that will ensure effective long-term use of the building. Modern methods will not always be the most appropriate, especially in heritage buildings, which were constructed with traditional methods and materials and are characterised by a high level of technical wear and tear. Thermographic monitoring of the condition of damp-proofing and the damp levels in building elements has the potential of becoming a very useful and significant method for preserving architectural heritage.

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