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Original Research Article

THE PROBLEM OF MOISTURE CONTENT IN HISTORICAL BUILDINGS BASED ON A CLASSICIST TENEMENT HOUSE AT 14A, ŚLĄSKA STREET IN GUBIN

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Abstract

Diagnostics and mitigation of excessive moisture effects are some of the most frequent problems in historical buildings. In this article, an attempt was made to measure the moisture content of construction elements in the historical tenement house in Gubin. It is the largest town in the Krosno Poviat, in the area of the Lubuskie Voivodeship. The town suffered from military actions during World War II whereby approximately 90% of its urban development was destroyed. The tenement house at 14A, Śląska Street is one of the more well-preserved buildings, made in the classicist style with characteristic historical features. The whole history of the building is unknown but there are freemasonry symbols on the elevation, and probably the Military Police had its headquarters there after 1945.

Keywords: moisture content, drying, capillary action, Gubin, building diagnostics

1. INTRODUCTION

Gubin is a town located on the western border of Poland. It is one of the oldest Sorbian settlements along a significant trade route from Pomerania to Czech and from Sorbia to Greater Poland. Since the town suffered extensive damage during World War II, relatively few structures are preserved. The most

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impressive structures now include the parish church, a ruin at present, the town hall hosting
the Town Library and the Cultural Center, and fragments of defensive walls and a gate that formed a powerful fortification system. However, many individual buildings have remained in the town, mainly residential buildings such as tenement houses, detached buildings, or villas. One of the places with the highest density of such structures is the Gubin promenade running along Śląska Street (formerly Pförtner Straße), one of the main streets of the town center. The part of the street where the promenade runs has been excluded from vehicle traffic for 20 years.

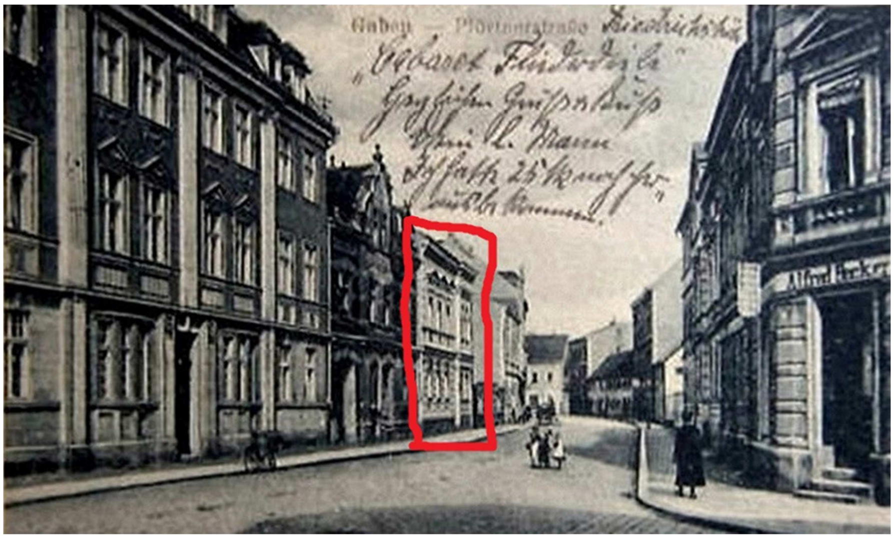

Fig. 1. View of Śląska Street (Pförtner Straße) at the beginning of the 20th century with tenement house numbered 14A marked in red (dolny-slask.org.pl, Ziemlicki, T.)

In most tenement houses in this part of town there were stores, restaurants, craft workshops, and bookstores on the ground floor, and the upper part was mostly intended for residential purposes. Today a café, beauty parlor, and fashion stores are located in this place. The tenement house numbered 14A is one of the more interesting buildings in this street; it was built in 1876 in the classicist style, evidenced by high windows which allow light to flood into the interiors, or by simplistic ornamentation, in this case limited to reliefs showing angels, roses, or lion heads. Additionally, the use of columns, pilasters, and straight-line facades enriches the structure's classical style, modeled on ancient Greek and Roman buildings.

An interesting curiosity of the front wall is a relief showing a square and compasses, symbols of a secret social movement – the freemasons. This suggests the involvement of former building owners in the activities of this unique association. No files, documents, or maps have been preserved to confirm its history, and the building itself is not included in the list of monuments. After 1945, the tenement house was probably the headquarters of military police operating within the framework of the garrison based in the town, possibly evidenced by three cells in the basement (the metal doors of one of which have been preserved). It is also known that at the end of the 20th century, offices of the Social Insurance Office (Zakład Ubezpieczeń Społecznych – ZUS) were located in the building.

Fig. 2. Tenement house at 14A, Śląska Street – present view (author photo)

2. MOISTURE CONTENT IN THE BUILDINGS

2.1. Sources of moisture content in the building

Water, being the source of moisture, can penetrate various zones of a building in many ways. Therefore, buildings must be protected against the access of water in a complex manner [3, 6, 8].

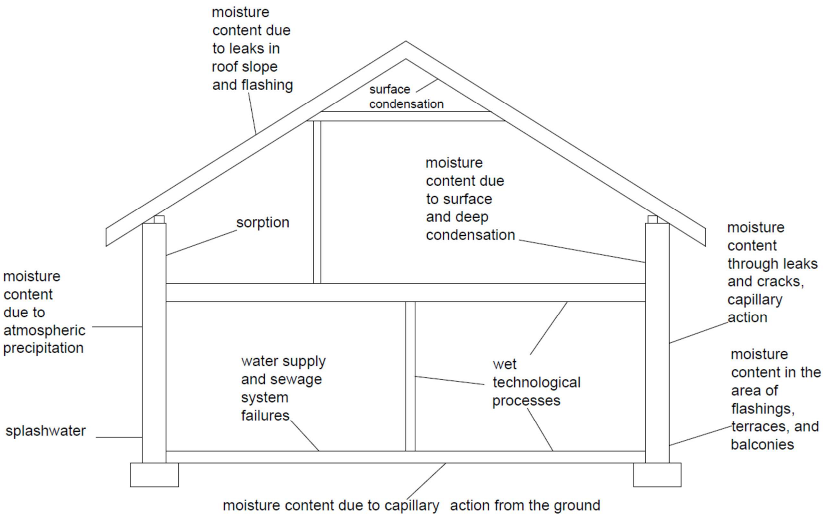

Fig. 3. Sources of building penetration by moisture

- Capillary action from the ground. Foundation and ground floor walls in any building are exposed to direct contact with moisture present in the ground, and with groundwater if it appears at shallow depth. This, however, does not mean that only a direct contact with humid environment constitutes a threat. Due to the phenomenon of capillary action, being the transport of water inside the pores in the building material and soaking of undamped areas, the exposure to moisture covers parts of the walls over a distance of several meters from the water source.
- Atmospheric precipitation. Atmospheric precipitation is the largest contributor to the quantity of water which causes most unwanted impact on the building. Precipitation water directly impacts each external surface of the building. The greatest danger is the threat to roof surfaces, which should remain waterproof and all rainwaters should be discharged from them into the rainwater drainage system through drainpipes. External walls are exposed to direct contact from rainwater, and indirect contact through increased quantities of water in the ground surrounding the building (capillary action), and due to so-called splashwater, i.e. water bouncing of the surface towards the lower parts of the walls.
- Technological processes. The traditional technology of erecting buildings requires tremendous quantities of water resulting from the necessity to use it in most processes related to the setting of concrete and the application of mortars and plasters. The moisture introduced into the building in this manner remains in building materials until its natural evaporation.

- Condensation of water vapor. The phenomena of condensation and liquefaction result from the regular use of the building, especially of the so-called wet zones, i.e. bathrooms, kitchens, laundry rooms, etc. Water vapor also comes from the people who stay inside the building.
- Sorption. Sorption consists of absorbing moisture contained in the building surroundings, for instance, by external walls.
- Installation failures. Sporadic failures of water supply and sewage installations can also be sources of moisture content in the building due to the flooding of a part of the building with significant quantities of water in a very short period of time.

2.2. Moisture content measurement methods

In Poland, several measurement methods are applied, both destructive and nondestructive (Table 1).

Table 1. Measurement methods of wall moisture content in buildings [5]

Group of methods	Name of method	Measured parameter
Chemical methods	Indicative method	Change in the indicator paper color under the influence of moisture
	Calcium Carbide Method	Pressure of acetylene (resulting from the reaction of carbide with water) in an airtight container
Physical methods	Dry oven method	Comparison of material sample mass with the mass of dried material
	Electrical resistivity method	Change in electrical resistivity of the material due to changes in moisture content
	Dielectric method	Change in the dielectric constant of the material due to changes in moisture content
	Microwave method	Attenuation of microwaves passing through dampened material
	Neutron method	Number of neutrons slowed down as a result of impacts with atoms of hydrogen
	Gamma-ray scattering method	Change in gamma radiation intensity after passing through tested material

3. RESEARCH OF MOISTURE CONTENT IN THE DISCUSSED BUILDING

The tenement house was designed on a rectangular plan with dimensions approx. 10.0 x 12.0 m with an added lateral part where the main entrance is situated. The 0.5 m thick walls were built using brick technology from ceramic bricks (stretcher-header and header bonds) and cement plaster. The building is approx. 11.0 m high and covered by a queen post truss with additional struts and brick dormer. The internal walls of the attic were constructed by the so-called Prussian wall technology. The ceiling over the basement was made according to the Klein ceiling technology, and on higher floors, wooden beam ceilings were used. Recently, the building's owners commenced renovation works. So far, the roof has been repaired to include thermal insulation using spray PUR foam. The construction elements of wooden roofing degraded by pests were repaired and secured. Window woodwork has also been replaced.

Fig. 4. Roof insulation with spray PUR foam and a fragment of Prussian wall structure (author photo)

Fig. 5. Repaired wooden beam degraded by bio-corrosion (author photo)

The measurements of wall moisture content were performed according to the dialectic method using a Voltcraft MF-100 moisture indicator. The dielectric method consists of measuring the electric capacity of the material at a moisture content change. Moisture content and material dielectric constant are interrelated [1, 5].

Fig. 6. Voltcraft MF-100 moisture indicator (author photo)

The instrument allowed for obtaining measurement results expressed as a percentage of the reference value and required calibration. During the process of calibration, the dependencies between instrument readings and the actual moisture content in the wall were assumed as indicated in the Table. Values were established based on the user manual for the Voltcraft instrument and calibration on dry material.

Table. 2. Dependencies between moisture indicator readings and moisture content in the walls

Instrument reading	Moisture content in the wall [%]
0-25	0-3
26-49	3-5
50-74	5-8
75-99	8-12
100	>12

Compliant with the manufacturer's instructions, measurements were made on surfaces that were as smooth as possible at a distance of at least 0.10 m from any metal elements such as the lightning installation or guttering. The spherical head of the instrument was clean and aligned perpendicularly to the measured surface. The partition penetration depth of the Voltcraft instrument amounts to approx. 0.05 m. All measurements were taken on 14.03.2020. The admissible moisture content in a wall made from brick was determined at the level of 3% and the wall can, therefore, be considered dry.

Table. 3. Levels of moisture content in brick walls [11, 12]

Level of moisture content	Moisture content [%]	Characteristics
I	0-3	Dry wall
II	3-5	Damp wall
III	5-8	Medium humid wall
IV	8-12	Highly humid wall
V	>12	Wet wall

Measurements in the basement and up to the height of the building base clearly indicated highly humid or wet walls. The building areas located above this height were moderately humid or damp, and both the brick and wooden elements of the roofing in the attic were dry. The high level of moisture content in the walls caused apparent damage to partitions, such as mold, salinity, swelling, and debonding of plaster over surfaces larger than 0.5 m^2.

Fig. 7. Debonding of plaster and wall salinity in the basement (author photo)

No foundation wall insulation was applied to the building. Recently, only vertical insulation on the north-western side has been performed. The lack of primary waterproof insulation, traces of salinity on the walls, degradation of partition surfaces, and the obtained measurements of moisture content explicitly indicate a significant presence of capillary action of groundwaters inside the porous ceramic material from which the building walls are constructed [2]. Also, the bricks in the Klein ceilings above the basement show medium and high humidity.

Fig. 8. Damaged external surface of Klein ceiling in the basement (author photo)

At present, the building is not in use and remains unheated, which additionally worsens its technical condition. The present condition of the structure, especially in the area of the ground floor, requires necessary repair works such as drying of the walls, application of new plaster coatings, and securing against the devastating influence of moisture (horizontal and vertical waterproof insulation) to avoid any future re-occurrence of the problem. Leaving the building without performing the necessary repairs will result in significant impairment of the thermal insulation properties of the partitions, reduction in mechanical resistance (e.g. to compression or damage resulting from regular freezing) of the ceramic brick and mortar used to erect the walls, and will lead to corrosion of the steel construction elements (Klein ceiling beams), destruction of plaster and elevations with valuable historical motifs. Excessive moisture content favors the development of bio-corrosion (moss, mold, lichens, pests), which, apart from degrading the building, has an adverse impact on the microclimate inside the spaces. The crystallization of mineral salts from groundwaters inside the pores of building materials is an uncommonly dangerous phenomenon for the technical condition of construction elements.

4. BUILDING DRYING METHODS

4.1. The undercutting method

This is one of the oldest methods still in use. Formerly it consisted in undercutting of a wall fragment and performing a tar paper diaphragm. At present metal sheets driven into a horizontal wall joint by hydraulic or pneumatic machines and passing through the whole thickness of the joint are used for this purpose. The frequency of impacts necessary to drive metal sheets and reduce the risk of wall cracking is 1000-1500 impacts per minute. Metal sheets have various lengths and widths and are joined by seams. It is standard practice to use profiled or smooth sheets, made of chrome or chrome and nickel stainless steel. Such metal sheets are resistant to salts diluted in water. However, if the level of salinity is high, the application of steel with molybdenum addition is recommended. In case of wall thickness exceeding 0.50 m, metal sheets are driven from both sides [8].

4.2. The injection method

This method consists in providing a substance forming the diaphragm to a wall layer. The diaphragm cuts off capillary action and leads to a gradual drying of the partition above its level. We can identify several types of injection:

– gravitational injection: holes are drilled in the wall at a 30-45°C angle to provide a preparation that flows into the partition interior. This method, however, fails at a high level of moisture content and has been superseded by pressure injection. The applied preparations are based on silicates, acrylates, and silicones;

– injection damp proofing: a patented method based on mortar constituting a solution of Portland cement and silicate activator injected into a hole;

– electro-injection: combines the phenomenon of osmosis and traditional injections. This method consists of inducing an electrical potential difference with direct current, which causes movement of liquid in pores and capillaries, and finally leads to their emptying. Afterwards, a traditional injection is applied;

– thermal injection: the idea is to initially dry an injection belt up to approx. 7% humidity by providing heat, and then apply a classical pressure injection [10].

4.3. Artificial methods

There are several artificial methods, and their application is effective only with proper moistureproof insulation.

– hot air drying: one of the oldest and most popular methods of construction partition drying consisting of directing hot air towards the partition and ensuring proper ventilation for evaporating water;

– microwave drying: as the name indicates, the method is based on a principle close to the operating principle of microwave ovens. It consists of directing an electromagnetic field generator towards the wall. The activity of the field accelerates the movement of water particles inside the wall and, therefore, increases its temperature. After heating a section of the wall, the generator moves to another place. This method is very effective even for significant thicknesses of wall (over 1.0 m). However, incompetent performance of the task brings a risk of thermal loads in the wall that may lead to damage in extreme cases;
– absorption drying: the method consists in absorbing moisture from the wall by dried air. The air is dried by an absorbent, heated, and directed towards the partition. Since the air is highly hygroscopic, the moisture is collected from the wall and released outside the building;
– condensation: this method consists of using air dryers in the rooms to condense humidity contained in the air. Dryers are most effective in the temperature range from approx. 20 to 25°C. the method efficiency increases proportionally to the increase in moisture content [9].

According to the authors, the suggested method for use in the described building could be the injection method. It is a relatively simple method to be implemented in this type of facilities and the cost is acceptable. Additionally, insulation of buildings should be considered. This can be done using eco-friendly, easily accessible placement of materials [4].

5. CONCLUSION

The tenement house at 14A, Śląska Street is one of the more interesting buildings in the area of the Gubin promenade. It has an interesting straight façade characteristic of the classicist style. Ornaments showing angels, roses, and lion heads are preserved in an ideal condition. The history and symbols of freemasonry, as yet unconfirmed by documents, make the building even more fascinating and mysterious. Unfortunately, the building has been out of use for years and remains unheated. In-situ examination proves that the walls in the basement and ground floor (up to the window line) are highly humid or wet. The upper parts of the building are less damp. Construction elements (brick and wooden) in the attic are dry. The water and ground conditions have a significant impact on the technical condition of the building. In this case, the sources of moisture content include capillary action from the ground or sorption. Unfortunately, quite frequently the moisture content of buildings is accompanied by bio-corrosion occurring both inside and outside the buildings (e.g. degraded ceiling beams or delamination of external ornamental plaster). This may lead to thermal contractions and deformations of construction materials used in the building. In extreme cases, building defects caused by poor technical condition of the structural elements and unfavorable soil conditions can even lead to excessive vertical deviation [7]. It is necessary to implement protective and reparative actions to avoid any further advance of damage and to ensure ongoing durability of the building. Stopping further advances of adverse effects of moisture in the building is the sole remedy.

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