

MOISTURE – THE MAIN CAUSE OF THE DEGRADATION OF HISTORIC BUILDINGS

BY

DIANA-ANDREEA CLIM*, LIVIU GROLL AND LIVIA-INGRID DIACONU

“Gheorghe Asachi” Technical University of Iași
Faculty of Civil Engineering and Building Services

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Abstract. Considering the importance of preserving historic buildings, investigating the causes underlying the occurrence of degradation and establishing the degradation mechanisms is a priority. In this regard, the paper synthesizes the causes, the effects, and the degradation occurrence mechanisms commonly encountered in ancient buildings. Also, in order to highlight the effects of moisture in building elements, the main degradations of a historic building monument, located in the center of the city, the Kieser House, are described.

Keywords: moisture; moisture sources; physical degradation; chemical degradation; biological degradation.

1. Introduction

Preservation and restoration of historic buildings represent, worldwide, serious concerns within the cultural community. Many valuable buildings are degrading because of the climatic changes, of the intensive urban development or because of the aggressive factors from the environment.

The idea of preserving a building is to keep undamaged the characteristics of building elements and materials, by taking measures aimed at

*Corresponding author: *e-mail*: dianaclim@yahoo.com

protecting the building against the action of aggressive factors. The restoration concept is based on three fundamental principles: authenticity, minimal intervention, and reversibility (Carta de la Verneția 1964). The restoration norms require compliance with these principles, by using historically recreated materials, compatible with the genuine ones, by adopting non-invasive investigation and restoration technology and solutions and by ensuring the reversibility of any taken restoration measures.

Romania's architectural heritage comprises an impressive variety of buildings. Whether we refer to fortified churches, monasteries, citadels, boyar mansions, hermitages, royal palaces or simple peasant houses (Ichim, www.monumentul.ro), they all have an important contribution in describing the evolution of a society.

The degradation of the built heritage occurs mainly because of the presence of moisture in the building elements (Franzoni, 2014). This phenomenon, of a significant importance, is rendered even in the literary works of the nineteenth century, where the literary critic G. Călinescu described a building in Bucharest: "the brickwork was cracked and parched (...)" and "the moisture (...) peeled the lime" (Călinescu, 1961).

The degradation phenomena, caused by moisture, produced on ancient buildings, have manifested over time, mostly in Europe (especially in France and Italy), because of the use of porous building materials, such as burnt clay bricks, bound with lime and sand mortar, or calcareous stones. The aspects related to the occurrence of the degradation mechanisms, although apparently easy to understand, proved to be a challenge for the scientists (Franzoni, 2014). The partial understanding of these phenomena leads to the inability to establish a diagnosis and to adopt reliable intervention measures on the restoration of historic buildings.

2. Moisture Sources

Several causes may be held responsible for the presence of humidity in the construction elements of old buildings:

a) Defective collection of rainwater and the lack of an effective vertical systematization (Fig. 1);



Fig. 1 – *a* – Lack of vertical systematization; *b* – damage to the collecting rainwater elements.

b) Infiltration of groundwaters, because of the capillary rise and of the forces of electro-osmosis (Fig. 2);



Fig. 2 – Moisture coming from the capillary rise of water in the building elements (Zaharea, 2011).

c) Condensation of water vapors from the air and from the pores of the building materials (Fig. 3);

d) Accidental actions, such as installation system failure or clogged drains (Fig. 4);



Fig. 3 – Moisture from condensation (Zaharea, 2011).



Fig. 4 – Flooding of a basement because of accidental causes (<http://www.hidroizolatii-constructii.eu/category/lucrari/page/3/>).

e) Presence of water resulting from wet consolidation processes.

In the construction elements of historic buildings, moisture can come from both the raising of the hydrostatic groundwater level and its penetration through the capillaries, from the condensation of the water vapor from the air, and from the infiltration of rainwater (Massari, 1971) (Fig. 5).

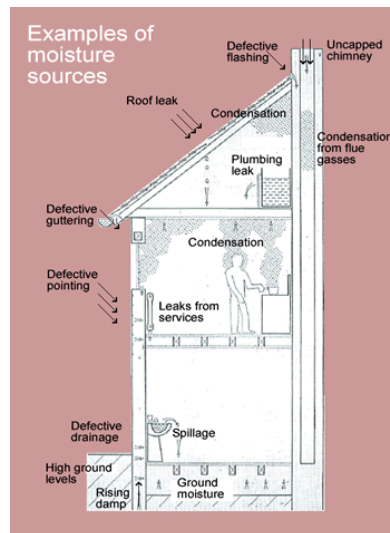


Fig. 5 – Humidity sources (Hutton, www.buildingconservation.com).

A factor that significantly favors water ingress and stagnation in the construction elements is the hygroscopicity of materials. According to the literature, the main cause of the presence of moisture in the masonry of historic buildings is the capillary rise, a phenomenon influenced by the internal structure of the materials through which it passes. The degradations are more severe as the amount of soluble salts transported by water is greater. The salts can come from the building materials, from the soil or from the air, and are driven upwards by moisture, which generates the appearance of efflorescences, because of the crystallization phenomenon (Frattari *et al.*, 2005). In the case of churches, whose walls contain murals, moisture irreversibly damages these works of art (Fig. 6).



Fig. 6 – Effects of humidity in the case of interior mural paintings (Zaharea, 2011).

According to the architect responsible for monitoring the “Churches of Moldova” site, on behalf of UNESCO, the main factors contributing to the degradation of monuments are “the poor collection of rainwater and the presence of capillary humidity in the walls, which affects both the interior and the exterior painting” (Filip, 2015) (Fig. 7).



Fig. 7 – Effects of moisture in case of exterior mural paintings (Frattari *et al.*, 2005).

The rising damp affects most Romanian churches with brickwork walls, and, in some cases, moisture can reach values of 75% (Soveja & Budescu, 2015).

3. Building Element Degradations, Caused by Moisture

Most degradations occur in historic buildings because of the presence of moisture in the structure of building materials, associated with various physical, chemical and biological actions (Frattari *et al.*, 2005).

3.1. Physical Degradations

The following are included in the category of damages caused by physical actions:

- a) exfoliations or expulsions of the exterior coatings, because of the inefficiency of the rainwater control and collection systems (Fig. 8 *a*);
- b) erosions caused by wind action, which carries solid micro-particles that grind the surface of the exposed elements (Frattari *et al.*, 2005) (Fig. 8 *b*);
- c) the staining of the exterior coatings or paintings, caused by the precipitation water intrusion (Fig. 9 *a*);
- d) exterior coating expulsions, freeze-thaw products (Fig. 9 *b, c*);
- e) swellings of the paintings, as a result of low vapor permeability;
- f) grindings and expulsions of the exterior layers of the masonry elements, because of water stagnation in the construction elements (Fig. 10).

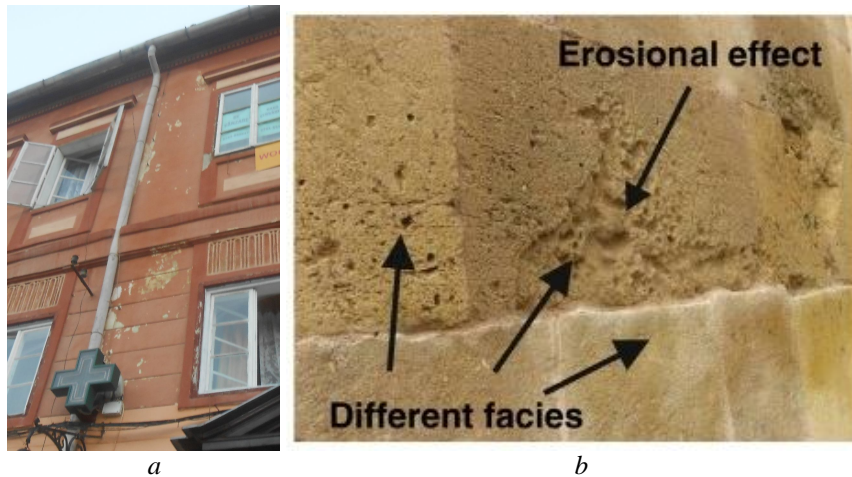


Fig. 8 – *a* – Coating peeling; *b* – erosions caused by wind action (Korkane, 2013).

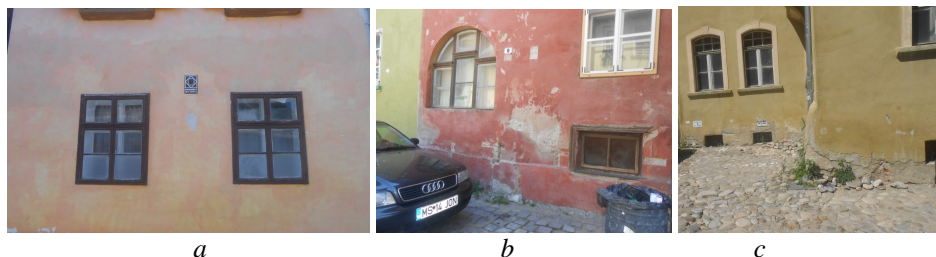


Fig. 9 – *a* – Stained coating; *b, c* – Expulsions of exterior coating



Fig. 10 – Grinding of the building elements.

3.2. Chemical Degradations

The main factors contributing to the occurrence of chemical degradations are the presence of soluble salts in the building materials and the capillary rise of water through their pores. Equally, the pollution of the environment favors the degradation of historic buildings. The chemical compounds often responsible for changing the characteristics of the materials are: the chlorides, the sulfates, the nitrates and the carbonates (Frattari *et al.*, 2005).

a) The pollution of the urban environment contributes to the deterioration of ancient buildings, by the reactions produced between sulfates and carbonates. The effects of these chemical reactions are the volume variations of the coatings, because of the crystallization of the sulfates which, in time, get broken and allow the ingression of water from the exterior environment (Fig. 11);

b) Efflorescences are powdery deposits, which appear as spots or stripes visible on the surface of the building elements, because of the migration of the salts from their structure, under the influence of water dissolution, transport and evaporation phenomena (INCD URBAN- INCERC București) (Fig. 12). Efflorescences appear because of the upward humidity that carries magnesium sulfates, which are the most soluble in water, calcium or sodium sulfates (<http://www.hidroizolatii-constructii.eu/category/lucrari/page/3/>).



Fig. 11 – Coating degradations

b) Efflorescences are powdery deposits, which appear as spots or stripes visible on the surface of the building elements, because of the migration of the salts from their structure, under the influence of water dissolution, transport and evaporation phenomena (INCD URBAN- INCERC București) (Fig. 12). Efflorescences appear because of the upward humidity that carries magnesium sulfates, which are the most soluble in water, calcium or sodium sulfates (<http://www.hidroizolatii-constructii.eu/category/lucrari/page/3/>).

In addition to the unaesthetic appearance produced by the efflorescences on the paraments of old buildings, the soluble salts content has a negative influence on the mechanical performances of the construction elements. These changes occur after numerous salt hydration and dehydration cycles, when spots are no longer that obvious, changing their color from white in colors similar to those of the materials upon which they form (Fragata *et al.*, 2016);



Fig. 12 – *a* – Efflorescences (Korkane, 2013); *b* – Crystallized salts (Gentilini *et al.*, 2012).

c) The chlorides affect the historic buildings located in marine environment (Fig. 13), where the sodium chloride precipitates in a saturated

solution, which occupies a bigger volume in the pores of the material and, after several exposure cycles, the detachment of the coating or of the exposed material occurs (Frattari *et al.*, 2005);



Fig. 13 – Degraded building, located on the seashore.

d) Another cause of the degradation of ancient buildings is the carbonation of the building materials. This phenomenon occurs when calcium bicarbonate is decomposed into calcium carbonate and carbonic acid, the result of this chemical phenomenon being karst erosions (Niculiță & Groll, 2007);

e) Other types of corrosion are those caused by nitrates, when calcium nitrate crystallizes and causes damages in the building elements it encounters (Niculiță & Groll, 2007).

The degradation processes that are based on chemical actions affect both the aesthetic and the mechanical characteristics. Studies have shown that, when construction elements (ceramic elements bound with mortar) reach saturation moisture, mechanical resistances are reduced by approximately 50 % and the salt crystallization phenomena have a major impact on the structural performances of the construction elements (Gentilini *et al.*, 2012).

3.3. Biological Degradations

The presence of moisture in the walls of historic buildings has a significant role in their biological degradation, since it creates the ideal environment for the development of fungus and microorganisms.

a) The common manifestations of the biological attack are represented by the appearance of some black crusts on the side of the wall exposed to the outdoor environment. Research has shown that these pellicles appear because of the organic material content in aggregates or cement. This type of degradation is frequently encountered in old buildings, affecting both the aesthetic appearance of the paraments and the structural integrity of the building materials, by the deterioration and the detachment of their outer layers (Fig. 14);



Fig. 14 – *a* – Building exposed to biological attack; *b* – Masonry affected by the presence of microorganisms (Strzysewska *et al.*, 2015).

b) A rare type of degradation is the biological attack on lime mortar based coatings, called “Flos Tectorii” in the specialty literature (Fig. 15). Responsible for this type of degradation is an Actinobacteria, which is usually found in calcareous rocks, having a particular visual aspect, because of the bacteria colonies and of the presence of soluble salts (Randazzo *et al.*, 2015).

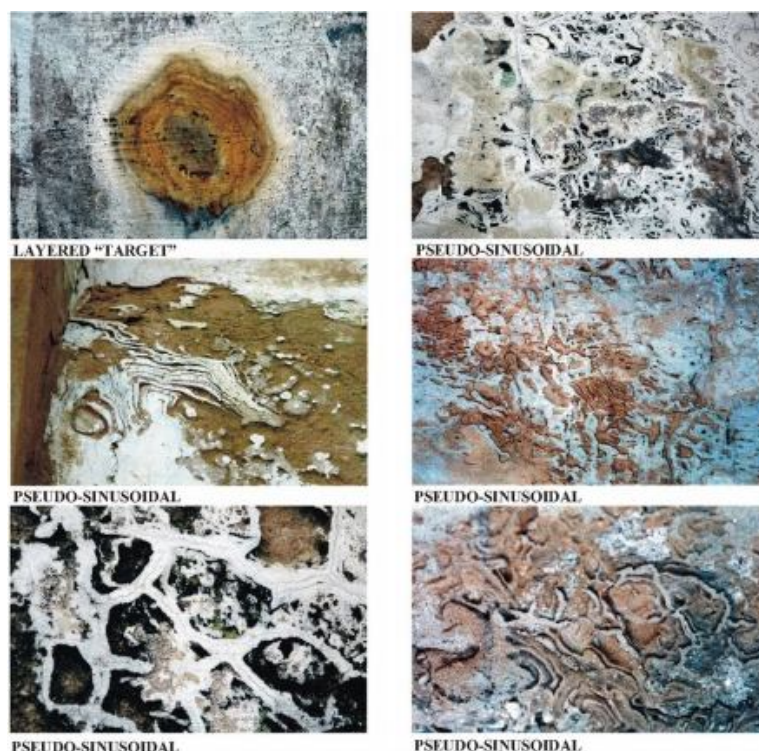


Fig. 15 – Buildings affected by Flos Tectorii.

4. Case Study – the Kieser House in Iași

In order to understand the degradation phenomena caused by moisture, the state of a historic building from Iași – the Kieser House (Fig. 16 *a*) has been investigated in-situ. This building was built in the early 1880s, by F.M. Kieser, and it is currently included in the Historic Monuments List of Iași county (Păunescu, 2016). According to the archives, the building has not suffered any structural or architectural interventions, the original style of the early nineteenth century being maintained.

The aesthetic aspect of the building is stark, because of the multiple degradations caused by humidity and the action of the aggressive factors. The outer coating shows signs of biological and chemical degradation (Fig. 16 *b*), being expelled in numerous places (Fig. 16 *c*), because of the great number of freeze-thaw cycles to which it has been subjected.

The rainwater collection elements are defective, allowing it to flow directly on the facades, fact which produces severe degradations (Fig. 17 *a*). The deterioration of the marginal sidewalks allows water intrusion and stagnation in the base area, favoring the appearance of mosses and lichens (Fig. 17 *b*).

Efflorescences can be seen at the soffit of the exterior slabs (Fig. 18 *a*) and on the exterior walls, in the lower third (Fig. 18 *b*).



Fig. 16 – *a* – Kieser Building; *b* – areas affected by biological attack; *c* – peeled coating.

Despite the degradation state of this historic building, the Kieser house has an impressive restoration potential due to the uniqueness of the nineteenth

century original style architectural elements and thanks to its location in the historic area of Iași.



Fig. 17 – *a* – Defective rainwater collection systems; *b* – base area affected by the presence of microorganisms.



Fig. 18 – *a* – Efflorescences at the soffit of the exterior slab; *b* – base area affected by the presence of efflorescences.

4. Conclusions

The preservation and restoration of historic buildings is a priority, aimed at maintaining the cultural identity of a society. In this respect, the scientific community must aim to investigate the degradation mechanisms and the causes of their occurrence, in order to identify some innovative solutions for the restoration of historic buildings.

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UMIDITATEA – PRINCIPALA CAUZĂ A DEGRADĂRII CLĂDIRILOR ISTORICE

(Rezumat)

Luând în considerare importanța conservării clădirilor istorice, reprezintă o prioritate, atât investigarea cauzelor ce stau la baza producerii degradărilor, cât și stabilirea mecanismelor de degradare. În acest sens, lucrarea sintetizează cauzele,

efectele și mecanismele de producere a degradării frecvent întâlnite la edificiile vechi. De asemenea, pentru a evidenția efectele umidității în elementele de construcție, sunt descrise principalele degradări ale unei clădiri monument istoric, amplasată în centrul Municipiului Iași: Casa Kieser.