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Original article

When and how reducing moisture content for the conservation of historic building. A problem solving view or monitoring approach?

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ABSTRACT

The conservation of historic buildings requires to face the technical issue for preserving the historic building materials, as stated in the recent Code for protection of Cultural Heritage, in Italy (2004).

Rising damp is a recurrent cause of damage, and the climatic changes are going toward the increase of humidity in the historic masonry: at 40/50° latitudes, at continental/Mediterranean climatic conditions, the alternance of dry seasons and almost monsonic seasons dramatically affects the distribution of rising damp in porous materials, as well as the water content. The evaporation of rising damp from the wet surface due to occasional or seasonal change of air temperature, causes the major damage due to salts crystallization. The evaluation of the increase of water inside the masonry is a critical issue for preventing the damages, because the presence of the water can sharply, naturally decrease in the dry seasons, as well as rapidly increases one month or more after the beginning of heavy and constant rain.

The interventions against water intruding the masonry due to water table or rainfalls that are not properly taken away from the structure are totally different, although the damages caused by both these causes are the same.

Monitoring the presence and distribution of the water is useful to support the choice of the most appropriate intervention, reducing the risk to apply not effective and expensive products and preventing an oversize intervention.

1. Introduction

The conservation of historic buildings requires to gather a wide, always updating, data crossing knowledge of the building and its environment. The recent change of perspective from the intervention after the damages occurred, into the prevention of damage itself, required also to update the perspective of the diagnostics objective and the strategy for obtaining the required knowledge to decide any further step of maintenance or repair [1–3].

Although in the last decades procedures to a preliminary knowledge for restoration were defined, at present the requirement is to face the knowledge management, and to reorganize the verified testing techniques and innovative ones as well, according to effective and convenient procedures for monitoring in the field.

Information in the preliminary phase of the project is crucial to define a compatible reuse of the building and to improve the residual performance of the building. The limited cost and invasivity of tests allow to apply them on the widespread built environment, and to support all the planned conservation activities [4].

In such a way, diagnostics with increasing levels of accuracy and effectiveness are successfully applied in most of historic buildings non monumental too, where economic issue is a fundamental criterion for planning intervention and cares.

As a common cause of decay, rising damp is a recurrent cause of damage due to the exchange between water/porous materials; the climatic changes are going towards the increase of exchanges at 40–50° latitudes, at continental/Mediterranean climatic conditions, due to the alternance of prolonged dry seasons and heavy rainfalls and storms [5,6].

Therefore, only through monitoring water distribution is possible to explore causes and support the choice of the most appropriate intervention, reducing the risk to apply not effective and expensive products and preventing an oversize intervention, according with the "minimum" (least) intervention criterion [7].

The higher is the variability of the environmental change, the higher is the time of monitoring, that necessarily requires to record the data representative of the recurrent changes of the parameters under analysis during one or more years.

Without a midterm monitoring, before and after any intervention or application of devices, it is not possible to determine the effectiveness for reducing or eliminating the water intrusion in the structure.

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2. Climate has changed in the last six decades

As well known, in the last years [8,9] scientists have been recording a general increase of temperature (European Alps and higher mountain regions in the world), drought and extreme high temperature (Spain, Australia, etc.), extreme heavy rainfalls (hurricanes on the Atlantic ocean, summer monsoon in Asia, flood in New Zeeland, etc.). At the poles, melting of ice has local and global consequences, as well as the reduction of glaciers at any latitude, at a speed that never was recorded in the past. The increased rains at high elevation causes thicker ice layers; their melting causes risk of collapse for structures of dams and riverbeds due to the increased amount of melted ice. The database International Disaster shows an increase of prolonged and powerful floods and fires since the 1960s, as well as an increase of global warming [10].

The risk of hurricanes and big waves/flood will increase [11–15], menacing the large amount of the coastal population along the ocean sides for an extensive band towards inner region. In Italy, the climatic change will cause an increase of temperatures, intense rainfalls but a decrease of the amount (5–40% in the Alps region), the increase of the risk of desertification (decrease of the total amount 20% of the national territory) due to aridity and erosion risk. As a consequence of the risk for human/animal/vegetal beings, *Cultural Heritage*, especially the tangible and immovable items, are under risks for many factors.

2.1. The consequences of climatic changes on historic buildings

With respect to the European heritage "The Noah's Ark Project – Global Climate Change Impact on Built Heritage and Cultural Landscapes" produces a map of climate, the built heritage, its damages and risks and comparison of past conditions (1961–1990), next future (2010–2039) and far future (2070–2099). [10]

Among many changes affecting inorganic and organic materials/structures, the final table shows (Fig. 2) that in the European region the change of humidity will increase water content in soil.

The alternance of dry seasons (with high temperature and no rain for months) and almost monsonic seasons (at mild temperature with heavy and prolonged rains), dramatically affects the distribution of rising damp in porous materials of masonry, as well as the water content in time [13–16].

In addition, the evaporation of rising damp from the wet surface due to occasional or seasonal change of air temperature, causes the major damage due to salts crystallization and condensation [17–26].

The evaluation of the increase of water inside the masonry is a critical issue for preventing the damages, because the presence of the water can sharply, naturally decrease in the dry seasons, as well as rapidly increases one month or more after the beginning of heavy and constant rain.

In some cases, the draining nature of the soil prevents any swelling due to the foreseen variation of the water content and could prevent the damage of structures. The nature of soil can be different in close regions, at it happens in the Po Valley. In the southern part of Lombardy, the clay component is higher than in the northern part with a variability of the distribution that is influenced by the presence of past/preset riverbeds, the use of the soil (agriculture, animal stock, industry, urban life, etc.) and the stratification of the debris for natural geological cycles of rocks (Fig. 1).

Therefore, the amount of humidity could affect the same structure based building (same materials and building techniques) with different consequences according to the location. This introduces another parameter to observe for an adequate time before determine all the data for design the proper intervention.

The higher is the variability of the environment change the higher is the time of monitoring, that necessarily requires to record the data representative of the recurrent changes of the parameters under analysis during one or more years.

Fig. 1. Geological map of Lombardy: the different colors refer to different formations. The green color shows the debris component of soil, the white indicates the presence of clay.

The water content, its distribution, the temperature of the surface, of the air and air humidity are the commonly accepted variables under monitoring, together with their change outside the buildings.

These parameters are also the same those, after the application of the devices against rising damp, or the intervention on the masonry, can determine if the water inside the masonry is effectively reducing or not.

3. Methods for diagnostic moisture presence and distribution in the present scenario

The scenario of climate changing and its consequences on the built heritage constitutes a challenge for the current standard methods for humidity measurements. In fact, despite of the not destructiveness, the water content measurement is seldom an absolute quantity (other parameters resulting from the measurement), especially if the measures are related to the interior layers of masonry. For in depth measurements, techniques are dramatically reduced to a very few, most of them related to microwaves, radar and including the steady standard of gravimetric method, that implies the related drill and collection of samples from the masonry.

The need of monitoring for prolonged time (2–3 years and more) the humidity distribution, its spreading, the exchange toward the environment and the building interiors, the effects of any intervention, requires to adopt non destructive methods. In fact, the possibility to repeat the test without loss of material, or selecting the least waste of material (in the terms of a few grams) is extremely beneficial. The repetition of tests and their validation require to use fast, low cost, analysis to apply both extensively in the preliminary phase, for a preliminary localization of the anomalies, and in the second phase of the advanced diagnostic, on some specific area and time [27].

According to the perspective of planned conservation (PPC), in the last decades the development of diagnostics focused on the need of procedures for the preliminary analysis of the building

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