ENVIRONMENTAL MONITORING FOR EVALUATION OF THE EFFECTIVENESS OF PROTECTION INTERVENTIONS WITH SYNTHETIC FILMS: the case study of a tower-building in Belvedere Marittimo (CS-Italy)

ALESSIA BIANCO¹, VITTORIO CERADINI², ELEONORA UCCELLINI³
PAU Department, Mediterranea University of Reggio Calabria

Key words: environmental monitoring, protective film, thermography, dataloggers

Topic: environment

Abstract
The paper reports the findings of experimental research aimed at evaluating the effectiveness of interventions to protect from rain for outer walls without plaster.
The application case refers to a tower-building, born as a military lookout and then localized in very exposed and windy position, and now destined to ordinary residence.
During a recent restoration has been removed a cement plaster, applied to exterior stone facades, and has been applied a protective film for a water repellent treatment.
To test the transpiration of this treatment, was performed a thermohygrometric and thermographic monitoring, which highlighted some critical aspects of that treatment, requiring a reflection on the limits of effectiveness of such products and interventions, in specific case studies.

1. Introduction

This paper reports the results of a diagnostic testing performed at a residential building, located in the historic town of Belvedere Marittimo (CS).
The diagnostic investigations carried out to investigate the cause of the serious material, arisen following the implementation of a restoration consisted in the elimination of a cement plaster, making visible the masonry.
The need was to create a protective barrier against aggression, induced by rain, but mainly by the wind, given the chief building allocation, which, being originally a watch tower, is located in a particularly prominent area and with a direct overlooking the sea.
The intervention consisted of a application of a synthetic film. From the first winter, after the restoration, however, the building has seen the emergence of a phenomenon of moisture, never occurred before the restoration; hence the plan of a diagnostic investigation, aimed at diagnostics detect if and what the intervention had previously been able to contribute to this phenomenon.
The diagnostic testing was conducted in two phases, in order to provide instrumental monitoring data, to determine qualitative and quantitative aimed at estimating and understanding the causes that led to the manifestation of serious, albeit timely, events of degradation.
The campaign consisted in conducting a diagnostic hygrothermal environmental monitoring, inside and outside, completed within a month and carried out according to UNI EN ISO 7730:199, related to a dense thermal campaign, carried out according to UNI 10824 - 1:2000, UNI 9252:1988, EN 13187:2010, and it is made for deteriorated portions and for non degraded parts, so as to investigate any environmental perturbation boundary conditions, which may have influenced the genesis of this complex type of degradation.

Fig. 1 - The building subject of the investigation
2. The thermographic investigation

2.a. The diagnostic plan

The diagnostic testing, although it had to go to investigate a well-defined and localized problem, had not a guideline of issues that could guide a targeted campaign; for this reason it was chosen to realize a priority thermographic test, such as, because it is an extended investigation, non invasive and highly expeditious.

The thermographic test consists in fact in an instrument capable of measuring the temperature of the bodies at a distance, without physical contact between the measuring equipment and the surface investigated, allowing the visualization of thermal images of the materials present in the element investigated, using the principle of their different natural thermal emission in the infrared spectral band.

The thermographic test is based on the principle that any material continuously emits energy in form of electromagnetic radiation in a manner proportional to its surface temperature and this is a function of the thermal conductivity and specific heat.

The moisture content of various materials, characterizing a product, differs due to different correspondences of thermal inertia, or the rate at which they cool under a heat stress.

It is necessary therefore to use the difference of temperature that occurs between the object to be investigated and the environment, according to the values of relative humidity.

The evening hours offer the best conditions, because it has the greatest heat release. For this reason, the thermographic investigations were carried out in two very different circumstances (Figs. 2 and 3):

A. after a long sunny day, in environmental situations characterized by dry weather and low temperatures, with poor ventilation from south;

B. during a cloudy, but not rainy, day with strong winds from north.

The comparison was able to not only provide information on problems encountered, but also on the relationship between the thermal response of the building, in different humidity conditions, hence the correlation with information obtained through the hygrothermal monitoring.

2.b. The instrumental results

The thermografic tests performed inside and outside the building, on May 6 and June 6 2010 (Fig. 3), it was carried out in order to highlight thermal anomalies caused by moisture conservation problems, for this reason were investigated both portions affected by severe event degraded (posting to paint and plaster, mold, stains) and portions not visually impaired. Also were investigated the areas that could give an indication of onset of moisture to external factors, namely:
1. portions close to water installations (to refute the hypothesis of moisture from leaks in the water installations, drain of white and black water, heating);
2. areas close to, both higher than in plant, bathrooms, kitchen and dining room, because these are places generally of production and accumulation of moisture (use of hot water, preparation of hot food, thermal delta induced by fireplace);
3. the covers, the top of walls and wall pieces next to gutters and descendants (to rule out the possibility of moisture from percolation problems, which are generally caused by poor regimentation of rainwater for inadequate roofing, malfunctioned gutters and descendants, poor maintaince of roofs);
4. areas close to windows (the presence of windows with high thermal stability may in fact lead to the onset of moisture from dew on thermal bridge, created in the absence of an adequate ventilation);
5. portions of walls in contact with fondation (often the historic buildings have small problems of moisture by capillarity).

The set of thermographic investigations, together with a visual inspection, led to every possible problems listed above, the following conclusions:
1. there was no evidence of moisture by losses (all systems appear effective) ;
2. there was no evidence of moisture by stagnation (the service rooms appear dry and ventilated) ;
3. there was no evidence of moisture by percolation (the shell and the system of regimentation of meteoric water are adequate and efficient);
4. there was no evidence of moisture by dew (the windows were not replaced, are made of wood and they have come loose and spread apart);
5. there was no evidence of moisture by capillary (if not small portions on the ground floor, with insignificant amount and existing before the restoration).

It should be added that the provision of the severe degradative events (posting to paint and plaster, mold, staining), visually identified and confirmed in their severity by thermographic tests is very unusual (in fact, is not placed at the foot of the building, or near roof, or in the north-facing portions of the building).

Their layout seems almost random, chaotic.

3. The hygrothermal monitoring

3.a. The diagnostic plan

The hygrothermal monitoring consists of positioning in specifically selected points, inside and outside of buildings, a data logger system to measure temperature and relative humidity (°C - % RH). The instruments must be placed in the environments inside and outside of the building affected by noticeable degradation from moisture, both in areas not affected by this phenomenon, as highlighted below.

3.b. The instrumental results

The thermographic tests was accompanied by a hygrothermal monitoring of variation of temperature and humidity inside and outside. The graphs (Fig. 4) show that the value of the relative humidity reaches into all areas considered and with extreme frequency, the maximum limit value (green line) proposed by the UNI EN ISO 7730:1997 Moderate thermal environments, determination of PMV and PPD indexes and specific conditions of thermal comfort, to occur the condition of thermal comfort and to safeguard the health of occupants. The rule recommends in fact, that the relative humidity "has to be between 30% and 70%. These limits are set to reduce the risk of skin unpleasently wet or dry, irritated eyes, static electricity, development of microbes and respiratory diseases".

Exceeding this limit is particularly visible in the graphs since the second week until the third. In the same period the relative humidity values recorded outside were equally high.

The values also confirm the presence of moisture in the environments as shown also by the characteristic deterioration present on the inner walls (mold, paint chipping).

If you compare the results with those of foreign internal temperature and humidity at all ordinary, there is a significant anomaly in the hygrothermal regime within the building, which instead should be characterized by a certain thermal inertia, induced by the fact that this historic building has walls that have a thickness of over 1 m.
Fig. 4 - Hygrothermal diagrams
4. The diagnosis

The articulated diagnostic testing performed did not lead to determination of one or more found causes of direct kind; yet with reasonable certainty it has led to the exclusion of the major functional abnormalities and accidental from moisture; add to that the anomalous internal hygrothermal regime of building.

In the process of diagnosis should also include some informations given by the owners of the building:
- during the first winter after this recent restoration, which saw the elimination of the incompatible non-breathable outer plaster in cement mortar, the building did not show any manifestation degraded by moisture, the removal of plaster was in fact properly accompanied by a reorganization and a closing of mortar joints between the stones making up the external face;
- during the second summer after restoration, as a preventive and precautionary treatment, was carried out with a product aimed, as indicated in the data sheet, to improve the performance of waterproofing and breathability. From the first winter, after this intervention of protect, the building began to show signs of deterioration from moisture, with a significant burden during the following winter.

In a process for determining a diagnosis of certain cases where there are not clear causes, we can only proceed by elimination, hence the conclusion that:
- the most likely cause (not merely possible) of manifestation of this deterioration is attributable to the application of synthetic film, which prompted a change of regime anomalous hygrothermal interior-exterior of the building, carrying the result of water-repellent treatment, which would seem not have ensured adequate breathability.

Should state that in fact these general categories of synthetic chemicals are used on traditional historic masonry (then composed of natural materials) only if they can not apply traditional methods (whitewashing, grouting, lime, etc), that the long history of application of these natural products showed no harmful, even before effective. The synthetic chemicals may be used, in the second instance than the traditional natural methods, provided that you weigh carefully determined provisionally behavioral compliance with the required performance (water repellent course, but also transpiration) to the product, in view of its application on a specific substrate (masonry), which is characterized by material composition, thermal inertia, its breathability. It follows the need to do before choosing a product or treatment with the finding of a case and effectiveness of compatibility with the substrate, in memoranda now widespread and quite normal (and mineralogical-compositional investigations, testing the air-tight, passive and active thermography).

In this particular case, in fact, more than a visual inspection, a necessary but not sufficient, was not carried out any further investigative finding, which shows a certain lightness in choice of product and the application solution most appropriate to the properties of the walls in question.

Hence, in all probability, the occurrence of degradative events investigated.

Notes

(1) The diagnostic investigation was planned and realized by SIS (Section of structural analysis) and by SICS (Section for sustainable conservation) of Laboratori of experimental research M.A.Re. (Materials and Analysis for Restoration) of PAU Department of Mediterranea University of Reggio Calabria-Italy, directed by prof. arch. Simonetta Valtieri. The investigation was commissioned by arch. cons. Gilda Mistorni.

References