DIAGNOSTIC MONITORING FOR HISTORIC URBAN LANDSCAPE CASE STUDY: BUILDING IN VIA CARACCIOLO NAPOLI

Claudia Ciocia, PhD
Università degli Studi di Napoli "Federico II"
Teresa Napolitano, PhD
Serena Viola, PhD, Researcher
Dipartimento di Architettura,
Università degli Studi di Napoli "Federico II", Italy

Abstract

Anticipating the rise and degenerate of the degradation processes for urban landscape, is an area of research that requires the deployment of analysis and forecasting, informed to the impacts induced by climatic and environmental pressures on settlements. Taking into account historic areas, the study focuses upon the need to set up a practice-based research, rethinking the processes of condition's relief, by integrating deterioration data with the prediction of the impact-induced by microclimate processes.

The paper introduces as a case study, a nineteenth-century neighborhood in Naples, completed in 1869-80, with the reorganisation of the waterfront, filling the beach and constructing new buildings. The degradation reliefs, on sight and instrumental, carried out with the support of the infrared camera in three different moments of the building life cycle (2002, 2011, 2013), constitutes the knowledge base to relate degenerative phenomena with the constructive, morphological and dimensional characteristics and contextual conditions.

The infrared remote sensing, long used through the two-dimensional display of the measurement of irradiation in order to evaluate the performance of the building (to detect insulation defects, thermal bridges, the heat loss through the windows, the humidity) is adopted to bind information about the phenomena taking place in location factors, climatic and environmental conditions. The observation of the related iterated and superimposed effects of decay allows the scheduling of control actions, with the intent to prevent an overrun of critical performance thresholds. A recursive approach characterizes the investigation procedure, based on forecast and verifiability.

Keywords: Monitoring, plan, urban landscape, management

Introduction

The Unesco Recommendation on the Historic Urban Landscape is the first proposal in which policies and conservation practices are integrated in a broader view for built environment development. Significant impact in protection strategies assumes the change of perspective, introducing an enlarged notion of context and the use of procedures for documentation and mapping of cultural and natural characteristics with the aim of planning developments. An integrated vision of urban heritage, connotes the commitment of the Laboratory LRRM established within the University Federico II[1].

Since 2002, the Lab expressed particular attention to the impact of environmental loads towards urban landscape; in recent years, the scientific effort has gone aligning with the indications of the Unesco Recommendtion on HUL. In this direction, the Lab has been working on methods and procedures for controlling multi scale temporal processes investing HUL, engaging in delineating continuous passages from the impact analysis for individual buildings, towards the urban landscape dimension (Amaratunga, D., Baldry, D., Sarshar, M. 2000). Several experiences have been launched with the common aim to broaden the scope of investigation to the challenges imposed on the built, by natural hazards, environmental pollution and destruction of nature, climate change, traffic congestion and accident, motorization. Linking the issues of monitoring to those of maintenance, the LRRM undertook campaigns to acquire real-time environmental data and physical parameters to describe the degenerative processes of materials and technical elements, with the aid of portable instrumentation, for the prediction of vulnerability (Bloom, B. N. 2006). Specific attention has been devoted to decline the latter, as the loss of function of technical elements, in reference to the construction processes and the environmental pressures.

The concept of vulnerability for the maintenance plan, resumes visions already shaped in hazard studies in the geophysical sciences, human ecology, political economy and ecology[2]. Referring to the historic urban

[1] The laboratory has been running since 2002 for the development of inspection procedures and in situ measurement of significant variables in the Plan of Maintenance. In recent years, the laboratory has focused its observation on new pressures to which the built environment is exposed.

[2] Vulnerability is applied as a core concept in disaster risk (Burton et al. 1978, Hewitt 1983, 1997, Blaikie et al. 1994, Oliver-Smith 1996, Wisner et al. 2004), in the study of livelihoods and poverty (Chambers 1989, Chambers and Conway 1992, Prowse 2003), food security (Sen 1981, Watts 1983, Watts and Bohle 1993, Bohle et al. 1994), and climate change (Klein and Nicholls 1999, Kelly and Adger 2000, Barnett 2001, 2003, Downing et al. 2001).

landscape the design of procedures for diagnostic monitoring was assumed as a specific commitment in the Lab activities, in order to extend the field of application for maintenance to the city dimension (Wood, B. 2003, a).. Pursuing this idea, the Laboratory conducted several research experiences, especially with the aim to understand the range of variability, when managing the impact of environmental loads on built textures.

The paper proposes procedures and tools developed by the scientific team, taking as a case study an experience of diagnostic monitoring conducted in Naples, on a nineteenth-century neighborhood overlooking the sea, along the busy Via Caracciolo (Viola, S., Diano, D., Napolitano, T. 2008). The examination of the actual state of research related to the understanding of degradation processes affecting built heritage highlights the need to address in an innovative way, preservation studies, giving a central role to the chorality of urban landscape. Despite the scientific effort for the determination of a cause - effect relationship between weathering and degenerative dynamics, the most scientifically reliable approach seems to be monitoring, aimed at the analysis of the progressive change of status in physical conditions (Wood, B. 2003, b). Monitoring is declined in the laboratory experience as an action that takes into account simultaneously the whole settlement system, by focusing on environmental factors in relation to constructive elements.

According to the Unesco Recommendations, monitoring is assumed as a necessary and sufficient condition for programming, obtaining through direct observations, useful information to predict, and then to decide in advance. A sense of urgency in starting the procedures for monitoring, informs the action on urban textures: the research has been carried out with great urgency, both in terms of time within which to intervene, both in terms of costs that could be incurred, with the aim to avoid the risk of loss or damage. This need is taken as a necessity in relation to progressing phenomena of urban vulnerability, due to the lack of financial means available for preservation and the need to make the best use of resources.

The monitoring plan:

Assuming cultural and regulatory changes recorded over the last decade in Europe[3], the LRRM Lab introduced the idea of developing a

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Key concepts of exposure, sensitivity, coping, and adaptive capacity, underpinning the theoretical approaches of Adger (2006), Gallopín (2006), and Kasperson et al. (2005).

3 The UNI 10604: 1997 defined that the goal of maintaining a property is to ensure the use, and preserve the asset value and the initial performance within acceptable limits for the useful life and promoting the legal and technical adjustment to the initial or new technical performance chosen by the manager or required by law. Throughout the life of the building, the use affects the acceptability of maintenance. The UNI EN 13306: 2003 introduced the

management supporting tool at the urban scale, based on the scientific organization of technical and administrative actions, intended to keep under control and to anticipate the set of actions that could affect performances in use and degradation processes. Such definition beyond resuming the concept of maintenance, exceeded the common praxis, and stressed the character of service, signed by an organizational and procedural order, attributing a central role to monitoring procedures, as opportunities to warn, advice, inform, control buildings' life cycles.

The research effort aimed at proceduralisating the cognitive approaches, according to a strategy that moving from qualities' recognition, tended to the identity preservation. Monitoring, derived from the latin monitor-oris, means to warn, advice, inform; the term "monitoring" has its origin in industrial environments, indicating the continuous control over a machine in operation, using special instruments that measure the characteristic parameters (speed, consumption, production, etc...).The literature identifies the monitoring procedures for systematic collection of variations of a specific characteristic (physical, chemical, dimensional, morphological, geometric,). ...). A maintenance approach based on monitoring introduces the vision of historic urban landscape as a set of interconnected nodes distributed to the systematic detection of changes in status indicators. Modifications in these parameters, are a prerequisite for the activation of procedures aimed at countering the rise of deteriorations. This approach reflects the cultural, organizational and procedural changes that are emerging in the urban management sector due to the transition from a concept of maintenance as a set of activities and technical procedures to a complex of services devoted to anticipation and prediction. According to the reliability theory, buildings and space's management can be can be pursued through a decomposition into unitary elements, predicting the failure kinetics for each of them. In order to create a maintenance approach based on reliability, it is necessary to complete the mere acquisition of data with a critical capacity for interpretation and forecasting through the foreshadowing of monitoring plans.

A systemic approach connotes the monitoring, based on a theoretical decomposition of the constructive system, into units and elements and the description of properties through the enucleation of performance levels. Multiscalatity connotes the monitoring strategies, balancing the possibility of

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concept of maintenance management of all activities that set objectives, strategies and responsibilities for their implementation using tools such as planning systems, control and supervision of maintenance, the improvement of organizational methods, including economic.

a shift from environmental systems to buildings, making it liable to the continual deepening from standard templates accepted by the scientific world. The monitoring is rooted in the scientific reliability of assessments, through the specific organization of acquisition methods, data analysis and return, always reproducible. The data survey, changes' registration, comparative analyses are the main stages of the monitoring process. It consists of both, the examination of data from direct measurements in situ, or in the comparison between surrogate parameters and compensation evaluation. It is based upon repeated observations and measurements with appropriate frequency, in accordance with procedures established and documented. The completeness and incisiveness of monitoring activities are related with:

- sources of knowledge taken into account;
- frequency of data acquisition and analysis;
- parties involved for the various monitoring activities.

Referring the observation to an urban scale, the objective of monitoring is to testify the transformation of built, identifying and describing processes that can lead to hazardous conditions, disease, degradation, discomfort, obsolescence at the time of the occurrence, reporting the resulting consequences in terms of comfort, security, safety, durability.

To monitor at an urban scale, means therefore:

- define the performance of each built element in which the urban landscape can be decomposed,
- define the system of sensitive endogenous and exogenous indicators that can affect performance,
- keep under constant observation these indicators to assess trends over time and to systematically collect data on them,
- develop, interpret and expose the data in order to trace the changes in the indicators to changes in performance.

To draw a monitoring plan is possible starting from an articulation and ordering of knowledge to allow continuous passages from the particular to the general and vice versa. The theoretical assumption behind the definition of control procedures and registers is due to the binding of each direct action with a deep understanding of evolutionary dynamics for endogenous and exogenous variables that affect urban landscape. Stroking a priority system allows the city to schedule inspections and controls on all the various components of the urban system, helping to reduce the unpredictability and randomness environmental loads.

The register of at sight controls:

Maintenance’s technical standards emphasize the importance of rational organization for information, based on the specific drafting documents, manuals, designed to guide the interventions and controls[4]. The present section illustrates the iteration of the inspection activities carried out for the southeastern facade of the nineteenth-century neighborhood, located in Naples at the via Caracciolo, that is an arterial coast road with high-traffic density (Image 1). The research focused on external surfaces of perimeter walls through an "at sight" analysis. The front of the building is covered in smooth painted plaster for 18% of total solid surface - mq.37 on mq.210 for full surface -; it presents a rich stylistic array composed of:

- a basement in piperno slabs,
- string courses and crown, cantonal and surface of the first floor with covering in ashlars-work, pilasters with variable height, jutting out balconies with protective elements in marble and iron,
- at the fourth level, a veranda with iron and glass fixture.

Image 1. Case study: nineteenth-century neighborhood

The outcomes of these analyses have been mapped with the help of proper graphical representation. Degradations are declined in location, size and morphology with the support of photographic scientific reference to the Normal Recommendation – 1/88[5], relating to the lexicon of the macroscopic alterations of stone materials[6]. In order to localize the decays and to relate the positional factor of specific areas or elements to the different degenerative actions, the study adopted a graphic partitioning system of the

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[4] UNI 10874:2000, *Manutenzione dei patrimoni immobiliari. Criteri di stesura dei manuali d'uso e di manutenzione.*

[5] Cf. CNR-ICR, Raccomandazioni Normal 1/88. *Alterazioni macroscopiche dei materiali lapidei: lessico,* Roma, 1990.

[6] In particular, the term *stone materials* includes both marbles, stones and stuccos, mortars, plasters and ceramic products.

prospectus. The grid locates vertically 4 spans - a, b, c, d - and horizontally divides the facade in zones coincident with the following elements: basement, facing of first level, string course of first/second level, facing of second level, string course of second/third level, facing of third level, crowning cornice of third/fourth level, facing of fourth level (Image 2).

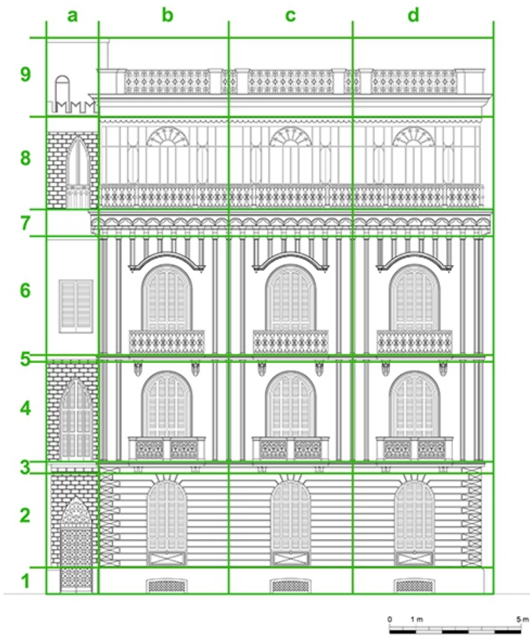


Image 2. The referential graphic grid

Faults mapping was carried out in 2002, 2011 and 2013; changes to the morphology and structure of the degraded areas have been highlighted thanks to a system of representation with monochrome graphics and numerical codification[7] (image 3). Based on the first analysis, the following results are synthetically deducible:

- chromatic alteration in the left frame of the facade;
- extended surface deposit in two lower levels;
- loss of plaster in fronts and below of balconies;
- efflorescence in basement large area;
- corrosion of metallic elements.

In 2002, the facade has gone through a partial rebuilding of the plaster in the areas deteriorated.

In 2011, the following degradation phenomena have been observed:

[7] The Recommendations indicate for each pathology a graphic symbol that univocally represents the phenomenon; differently, for this case, a numerical coding is adopted in order to specify observed phenomena.

- extended chromatic alteration due to washing out localized at the left of the facade, on the string courses and on basement;
- efflorescence on the left of the facade;
- surface deposit localized on the cantonal of the ground floor.

In the following years, the building has not been affected by maintenance actions. In 2013, the several phenomena have been observed, some of which attributable to an *incremental* evolution of the initial decay' conditions:

- expansion of areas with loss of plaster;
- chromatic alteration below of balconies;
- extended chromatic alteration on ashlars-work of first level.

Data acquired through surveys allow to formulate hypotheses about the causes of decay. According to consolidated practice, the validation of developed assumptions can be supported by results of an instrumental diagnosis project. In this case, the correlation between the observed symptoms, the characteristics of materials and contextual conditions allow to identify the main factors triggering and amplification of the degenerative processes of natural climatic factors, the morphology of the facade elements, air pollutants present and exposure to a marine atmosphere.

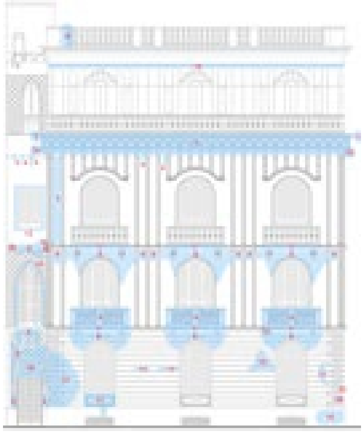
The erosive action of rain water is identified in areas that haven't been adequate elements of protection and draining, on the left of the façade; this decay is empowered by the shape of the compositional and stylistic elements - cornices and overhangs - that facilitate in part the water stagnation, like for the crowning cornice between the third and fourth level.

The proximity with the sea contributes toward the formation of saline deposits and efflorescence. The adjacency to an arterial road – via Caracciolo - exposes the coating materials to a constant polluting pressure; air pollution is an accelerator of degenerative processes, which may compromise the durability of materials, in the absence of maintenance operations.

In the adopted time intervals, an acceleration of the degenerative evolution characterizes the phenomena, helping to increase their complexity and unpredictability. This trend suggests the adoption of a dynamic and contextualized programming approach for the diagnostic monitoring. The aim is to prevent the excess of critical performance thresholds through planning and time tabling of inspection cycles.

The iterated observation of related and overlapping decays' effects suggests to graduate the inspecting action. Not considering the accidental events, experienced data support for the formulation of time scheduled controls. For example, with regards to plastered surfaces, it's appropriate to make a distinction between the coplanar areas of the front and the jutting out elements; on the base of time range defined by the scientific literature about building maintenance (Di Giulio R., 1999) specific contextualized controls and relative frequencies are assigned to technical elements (table 1). The graphic rendering through the grid allows to record the evolving phenomena and to point out areas with high criticality. Inspection activities can:

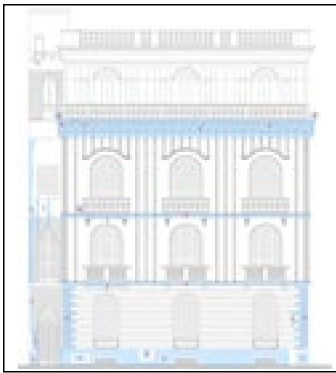
- produce a negative result, that adjourns the control to a later deadline, congruent or not from the expected frequency;
- suggest the need of instrumental control;
- outline a positive result, that directly activates the operational phase of the intervention.



Deterioration mapping, July 2002

Legend

1 - Fracture of marble, vegetation
2 - Loss of material and surface finish of bosses
3 - Chromatic alteration due to washing out
4 - Chromatic alteration, surface deposit
5 - Widespread chromatic alteration
6 - Surface deposit
7 - Loss of plaster in fronts of balconies
8 - Interruption of the continuity between low wall and railing
9 - Loss of first and second layer of plaster
10 - Loss of plaster
11 - Loss of finish of basement bosses
12 - Efflorescence of basement bosses topcoat
13 - Loss of plaster below of balconies
14 - Addition of cement for installation of exterior shutters
15 - Biological patina due to water stagnation
16 - Fracture of string course
Chromatic alteration of basement stone for drips of painting
18 - Corrosion of iron
19 - Stain due to acts of vandalism
20 - Loss of boss
21 - Fracture of bosses



Deterioration mapping, July 2002

Legend

1 - Loss of plaster or painting
2 - Chromatic alteration due to washing out
3 - Chromatic alteration below of balconies
4 - Surface deposit
5 - Efflorescence
6 - Delamination of basement slabs
7 - Stain due to acts of vandalism
8 - Vegetation

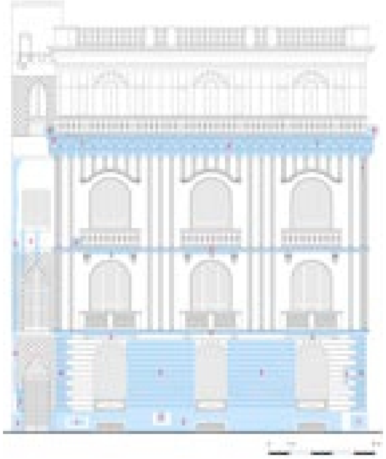


Image 3. The register of at sight controls

The register of instrumental controls:

The application of non-destructive tests in the field of construction allows to analyze the state of the surfaces and structures, without compromising the integrity of matter and functional building. The diagnostic instrument assumes, in this approach, the supporting role of the evolutionary dynamics of the built environment; non-destructive diagnostic techniques are of great interest, because they don't compromise the physical integrity of the building. Through this analysis it is possible to acquire information for the reconstruction of a unified framework of knowledge and detailed behavior of the built. Integrity, in particular, is usually assessed through the quantification of the change induced in some of its physical properties. Thermal parameters such as, heat and thermal diffusivity, have been shown to be affected by the deterioration processes, and their measurement provides a tool for monitoring the dynamics of degradation of materials.

Infrared thermography is a measurement method that allows the display of the thermal energy emitted from an object, in the form of electromagnetic radiation, whose reading spectrum, conventionally divided into fields of wavelength, is infrared. In the building sector, it aims at identifying anomalies and defects in material-construction of building envelopes, and, in particular, the survey will measure and verify the surface temperature distribution in building components, the distribution of surface moisture, defects of plasters and coatings, water and air infiltration from the external vertical closures.

The tools that allow to visualize the energy radiated by an object in the infrared band of the electromagnetic spectrum, in an electronic video signal, are infrared cameras.

The cameras used for the investigations carried out are with uncooled microbolometer detector, the infrared spectrum from 7.5 to 13 microns. The first survey was carried out with the camera AVIO Series Thermo TVS - 500EX Z and the second with the FLIR B 335.

The inspection performed was conducted according to a specific methodology, closely related to type and subject of investigation.

Being the face of a building, it was considered appropriate to apply a "protocol" well-defined, articulated into two consecutive phases:

- the first phase, functional and preparatory to IRT, provides visual inspection, and graphic relief, stating the condition of the premises and the phenomena of degradation;
- the second phase covers the thermographic examination itself, developed and articulated on the basis of parameters that are dependent on the following factors : climatic and environmental conditions at the boundary, orientation of edges, direct and indirect irradiation of the surfaces.

The thermographic protocol provides a survey of the facade aimed to identify, with good margins of certainty, the causes of the observed phenomena. The protocol is divided into the following phases :

- determination of the temperature distribution on the surface of a part of the building envelope, obtained by measuring the distribution of apparent temperature of radiation;
- detection of anomalies in the distribution of temperature;
- estimate of the type and extent of the defects detected on the basis of recorded temperatures.

The diagnostic investigation focused on the external surfaces of the vertical perimeter walls of the building. It was performed in two different stages of the life cycle of the building in 2011 and 2013.

The thermographic survey together with an inspection performed in 2011 in sight, made it possible to trace and circumscribe the phenomena of degradation encountered, the types listed below, as can be seen in the thermograms shown below:

- chromatic alteration for leaching localized in correspondence of the frame and the crowning of the fixtures (Fig.1a, 2a);
- surface deposit located in the basement (Fig. 3a) .

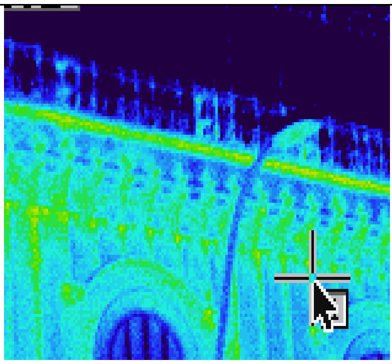


Image 4 a Chromatic alteration

Image 4b Chromatic alteration

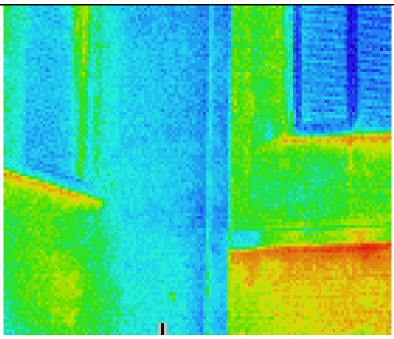


Image 5a Chromatic alteration

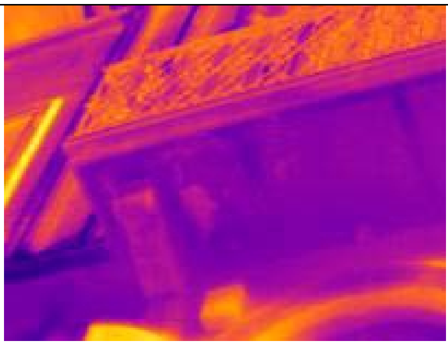


Image 5b Chromatic alteration

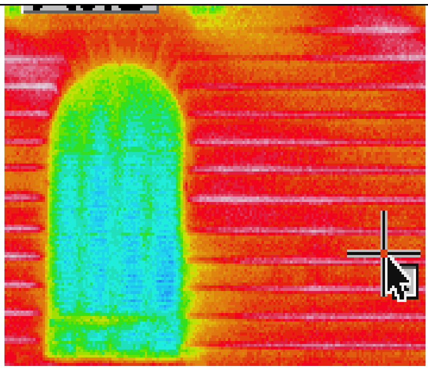


Image 6a Surface deposit

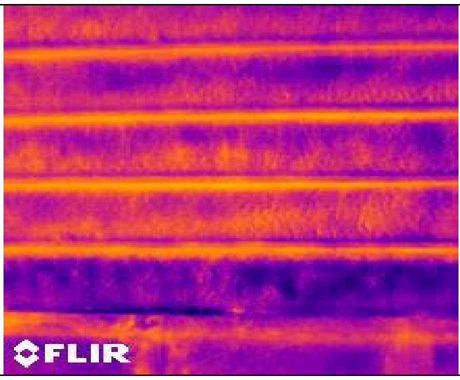


Image 6b Surface deposit

The thermographic survey carried out two years later, in 2013, highlights the phenomena already present, and notes the following factors:

- deposit on the surface of the bugnato on the basement ;
- chromatic alteration for leaching localized at the crowning cornice;
- chromatic alteration on underside of the balconies.

The results of diagnostic tests performed in 2011 showed widespread phenomena of chromatic alteration of the painting at the crown cornice as well as can be seen in Image 4; the thermogram shows the phenomenon of stormwater runoff in areas with strong differences in temperature (blue-green areas). The factors that cause deterioration of the disease, are attributable to the runoff of rainwater and the radiation constant. Another phenomenon observed is the deposit surface, very evident in the thermogram reported in figure 6; whole basement strip by a thermal response inhomogeneous, typical of this phenomenon.

The results of diagnostic tests performed in 2013 in addition to noting the evolution of the phenomena already present, as well as in the thermograms of Images 4 and 5, reveal the presence of spots under balconies, due to infiltrative phenomena . In Figure 6, shows the thermogram of balconies and show, in the vicinity of the support structure temperature differences (At), equal to 3 ° C between the coldest and the warmest area, clear symptom of leaks.

Conclusion

In the complex scenario of search for urban sustainability, a new technological thought referred to different opportunities of acquiring, managing and exchanging information is at the origin of the idea of innovating the monitoring processes related to historic urban landscape. The proposal moved from the needs of developing scientific knowledge in order to support urban and architectural heritage preventive conservation and future promotion with the creation of standardized procedures and of criteria for the development of structural appraisals, integration of a management approach and efficient operations. Applying the theorethical principles of heritage settlement as interconnected nodes distributed to the systematic detection of changes in status indicators, to the case study, the search resumed the *Recommendation on the Historic Urban Landscape* as an opportunity for new approaches, in line with the principles of built environment integrity and respect for authenticity. An integrated use of systems borrowed from the field of information technology and telematics, with advanced monitoring devices, introduces the major innovation on the stages of diagnosis, design and implementation. Hard and soft technologies are assumed as able of enabling urban landscape to perform new tasks.

Thanks to prolonged and repeated cycles of observation, this research has experienced the cognitive potential of data systematization. A new idea of maintenance site impressively emerges. The measurement of indicators returns a profound contrast between urban fabric, characterized very strongly on the level of idealization of shapes, distributions, and environmental impact. Reporting the priorities is the final output of the monitoring action in order to return to technicians responsible for historic urban landscape management, a hierarchy of information from direct surveys. A synthetic meta project approach, aimed at identifying at an early stage, unforeseen adverse effects of degradation, supports the practice based research for the adoption of appropriate corrective measures. Direct consequence of the monitoring is to define tolerance ranges and to detect in advance whether the impacting forces are reaching a threshold level.

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