

Inspections and Maintenance Programmes for the Conservation of Historic Architecture - Some Critical Issues Related to Degradation and Durability

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ABSTRACT

The durability of architectural technical solutions and materials, especially regarding historical buildings and monuments, is directly dependent on the frequency and mode of maintenance.

The contribution covers the definition of an operational methodology that is based on preventive activities aimed at a programmed maintenance, developed on an outstanding case study: the central archaeological area in Rome.

The reasons that suggest facilitating inspection and maintenance-type processes have long been known but have not yet been found the availability of effective contributions of an applicative nature.

Ensuring the extension of the life cycle of materials and components, in fact, is a specific objective of the conservation of historic remains and is considered a priority to structure maintenance processes aimed at control and "cure" rather than entrust the outcome to a more invasive restoration, sometimes carried out with products and techniques that are deemed to be effective, but which are often unreliable.

A further and equally important objective is to promote the opportunity of limiting the use of individual actions unrelated in time and to promote an idea of maintenance as a process. This is a radically new way of thinking and acting, which promotes strategies (prevention and treatment) rather than tactics (restoration as a solution to all problems), and the pursuit of long-term effectiveness rather than the pursuit of pure efficiency and immediate benefit.

KEYWORDS

Planned conservation, Cultural heritage, Inspection, Durability, Archaeological sites.

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1 INTRODUCTION

The durability of technical solutions and materials in architecture, especially regarding historical buildings and monuments, is directly dependent on the frequency and mode of maintenance. Addressing the issue of prevention and maintenance of historic buildings, however, requires careful rethinking of some questions related to the concepts of the *life cycle*, *durability*, *degradation*, *pathology* and *obsolescence* of materials and components, starting from the fact that these words take on significantly different meanings when applied to historic architecture rather than to newer residential buildings.

The statement that frequent maintenance is able to contain the progress of deterioration in historic buildings is quite obvious yet rarely followed.

If the adage that "prevention is better than cure" is commonly agreed due to common sense, in the area of construction activities - including Cultural Heritage work - the ideal of regular care with a very low technological content most of the time remains merely a ritual enunciation that is hardly ever put into practice. Indeed, the topic of scheduled maintenance, evoked for decades in conferences and seminars, has not yet found the availability of effective contributions in terms of application to define its contents and delimit its areas of intervention.

It is believed that the cultural and practical difficulties inherent in this type of procedure cannot be overcome except by deploying an effective organization that is able to control the entire process, including the management of feedback arising from the outcomes of the activities, thereby building up knowledge.

The reflections produced here were made following the important experience gained by the working group from Politecnico di Milano (scientific manager Prof. Paolo Gasparoli) which was appointed by the Commissioner Delegated by the Italian prime minister³, defined an operational methodology for implementing prevention and maintenance processes starting from the case study of the archaeological area in Rome [Cecchi 2009, Cecchi 2010, Cecchi & Gasparoli, 2010].

Enforcement procedures, work instructions and registration forms were chosen for this work with the intention of giving substance and structure to the "good intentions" and made the preventative action operational by means of a defined methodology. An equally important purpose of this study was also to promote a change of perspective proposed in order to limit recourse to individual actions that are disconnected over time, such as those tending to favour extraordinary restoration events, in order to promote the idea of maintenance as a *process*.

It is therefore useful, within the framework that has been briefly outlined, to reiterate the different theoretical and operational meanings that the "maintenance" project and process assumes in the cultural and methodological areas proper to Cultural Heritage conservation, as compared to those of industrial maintenance, which, as is known, primarily involve maintenance strategies, procedures and methods aimed at more recently constructed property assets.

The themes of prevention, and therefore loving, attentive and thorough "care", assume particular importance in the context of Cultural Heritage buildings, starting from Ruskin's (now hackneyed) heartfelt appeal [1981] for maintenance consisting of simple and repetitive activity.

Moreover, the "culture of maintenance", which would require, at least conceptually, the use of traditional practices established over centuries, involves the realization that past maintenance activities were consistent and frequent, aimed at carrying out repairs as soon as possible in order to save on materials, which were notoriously expensive compared to labour costs.

³ L'architetto Roberto Cecchi è Commissario delegato per la realizzazione degli interventi urgenti nelle aree archeologiche di Roma e Ostia Antica (OPCM 28 maggio 2009, n. 3774)

The research work on the central area in Rome was therefore started from the development of structured inspections that subsequently led to the definition of Scheduled Maintenance Plans. Methodological ideas were gained from these experiences that were applicable to different types of Cultural Heritage buildings.

2 INSPECTION ACTIVITY

The Inspections consist of structured monitoring activities on the construction heritage.

Monitoring activities are mainly characterised by inspections, which are necessary for the periodic assessment of the buildings' state of conservation, for the identification of more evident critical aspects and for accessibility, inspection and maintenance checks.

These may already be scheduled as part of a maintenance plan or they can be organised independently, but to ensure their effectiveness, they must always be planned and carried out with pre-established timeframes. Minor maintenance activities can also be performed together with the inspections, if necessary.

All information pertaining to the buildings, their components and respective state of conservation is collected and recorded during the inspections.

The results of the inspections are described and articulated in the Final Report, which gives information in regard to:

- defects/degradation observed on the building;
- problems relating to critical points and individual technological elements;
- expected degradation and areas at risk;
- interactions between individual elements and the structure;
- reviews on the accessibility of the building system and the possibility of inspecting the elements that constitute it.

3 PLANNED MAINTENANCE ACTIVITIES

The objective of the Maintenance Plan⁴ is to monitor and re-establish a satisfactory relationship between the state of operation of a system and its functional units and the quality standard used as a reference. With specific regard to Cultural Heritage, this consists firstly in the provision of all the maintenance activities required for the preservation of the building, through maximization of the permanence of its materials and components, for which the frequency, cost indications and medium and long-term implementation strategies are estimated in relation to the state of conservation and functional efficiency of the building itself.

Within the maintenance plan can be found different levels of maintenance activities, operating at different intensities, which contribute to the preservation of the building:

- Prevention activities: these are indirect activities. This category includes both management activities (such as regulations of use) and maintenance activities aimed to controlling or containing situations of risk to which the asset is subject due to the surrounding conditions (such as the cutting of surrounding vegetation, the correction of counterslopes, etc.)
- Preventively effective activities carried out on the building: these are activities that, while directly involving the building, in view of minimal invasiveness on the asset and conservation objectives, can be considered as preventive activities due to their remarkable effectiveness in controlling

⁴ UNI 10874:2000.

degrading actions (they include, for example, cleaning gutters, dusting decorative displays, eliminating biodeteriogens, temporary surveillance and safety provision measures, etc.)

- Protection activities: these are direct activities aimed at providing additional resources for the building and its components, such as structural reinforcements, protective surface layers, or that include the addition of new technological elements. Such activities may include: applying protective top layers (provisional coverings, casing, metal covers, covering plaster), application of protective fluids (reaggregates, waterproofing, etc.) maintenance activities : these are activities that directly involve the material of the building and are considered essential in order to slow or contain the progression of damage. They are designed and implemented with the aim of redressing situations of damage, by removing the causes wherever possible.

The maintenance activities included in the plan and scheduled in the maintenance program are normally simple, repetitive activities, often preventive in nature (such as cleaning gutters, dusting decorative displays, using covers, eliminating biodeteriogens and temporary surveillance and safety provision measures, etc.) In any case, the decisions made once the Plan's documents and schedules have been drawn up can be continually adjusted to deal with unforeseen events, which often occur with historic buildings and archaeological structures.

The executive works, scheduled in the programme, are guided by operational instructions.

They define, in a logical sequence of actions, the methods, criteria and recommendations for implementing and controlling all specific executive activities.

The problems that emerged in the development of the above-mentioned research led to reflection on the special features of maintenance activities regarding Cultural Heritage and to the gaining of some awareness that allowed essential principles to be established regarding criteria for choosing maintenance strategies and executive interventions. As already mentioned, these concern the concepts of life cycle, degradation, disease, durability and reliability.

4 MAINTENANCE AND “LIFE-CYCLE”

All the maintenance definitions contained in the voluntary regulations refer to a "life cycle" of buildings and argue that the task of maintenance is to restore the service system to how it was when the building was completed. This implies that without adequate maintenance the "life cycle" of a building can be less than that which is expected. In the area of Cultural Heritage it must first be understood that the term "life cycle" cannot be used with the same criteria applicable to newly constructed plants or buildings. It is therefore necessary to distinguish between Cultural Heritage buildings that are in use and those that are defunctionalised or collapsed. For buildings in use the topic of the service response must be commensurate with:

- the system of requirements and with the compatibility of the functions installed or to be installed in relation to any functional obsolescence phenomena that may have occurred;
- the system of technological requirements related to the events of degradation or damage.

For buildings not in use or that have collapsed, the problem may be limited to the need to ensure at least the minimum technological requirements connected with the decline in performance due to events of degradation or damage. It should be repeated, however, that the "no-use" does not mean *no-usefulness*: in fact, without doubt Cultural Heritage has an irreplaceable cultural, documentary and informational function as well as providing a material witness.

In any event, the purpose of the maintenance work on the monuments cannot be that of restoring the subsystem or component to its initial level of service (which is, in any case, only theoretically possible), but to control the effects of deterioration agents through interventions of different intensity and frequency that allow the life of the asset to be prolonged and ensure the conservation of its authenticity and identity through the permanence of original materials and components.

It is possible, however, that within the maintenance process it may be necessary to "realign" some levels of performance, at least partially, before implementing a maintenance plan: as in the case of the plaster becoming partially detached, which need re-bonding to the support; of structural elements that require work to reinforce their static function; or of roofs that require a significant review of their water- and wind-proofing performance. In all of these and other similar cases, the works to realignment performance are designed to bring the level of functional quality not necessarily to the building's original levels, but to one which is consistent with its specific function.

In the area of building maintenance (individual buildings or real estate assets) the "life cycle", "useful life" or "life duration" is essentially connected to building's recognised capacity to still provide services, and is therefore calculated in assessments related to the possibilities and modes of use. At the end of the "life cycle", i.e. when there no more apparent possibility of use at affordable costs, the building would be decommissioned.

The "life cycle" of buildings, however, is never either linear or predictable, since it depends on widely different factors of a technical, social and economic nature that involve varying rates of deterioration and obsolescence.

The concept of "life cycle" in the above mentioned terms is therefore inapplicable to Cultural Heritage, bearing in mind the fact that, in general, the usefulness of a cultural asset cannot decay over time and the issue of decommissioning does not arise.

With regard to component parts, the "life cycle" is connected to possibilities of repairing them based on economic criteria. With industrial components, replacement is envisaged at the end of the "life cycle".

The replacement of component parts of historical buildings and monuments (plaster, stone elements, structural elements, etc...) is only permissible when their conditions of degradation or damage may jeopardize the existence of the asset itself. As already noted, punctual, diligent and constant maintenance are specifically intended to keep these components in operation, regardless of their chronic state of disrepair.

It is completely normal, however, that in certain cases, even in the area of Cultural Heritage, once the permanence of the object's identity and authenticity data has been safeguarded, *new added elements* with a protective function, as a "sacrificial layer", or one of enhancement (implants), can be maintained and periodically replaced. In all cases, as can be seen, the topic of the "life cycle" of materials and components is not foreign to the field of Cultural Heritage: one can, in fact, also speak in terms of a "life cycle" for new structures and protective elements (roofs, top covers over collapsed walls, etc..), safety measure systems and new technological systems implemented during preventive or maintenance activities.

5 MAINTENANCE “DETERIORATION AND BUILDING PATHOLOGY”

The concept of deterioration and the criteria for interpreting the events connected with its cause and progress do not differ substantially in the field of Cultural Heritage from that of recent building work. Deterioration is therefore an expected event, which can be viewed as the response of the materials and components of a building to the actions of weather and the anthropic aggression connected with its uses. There is natural deterioration when it occurs at a rate that corresponds to the expected life span of the technical solution. Pathological degradation occurs when there are situations of disturbance, normally caused by design or process errors, that accelerate the natural deterioration phenomena causing degenerative events in times that are greatly anticipated compared to normal natural aging dynamics ("lifetime" or "life cycle") [Croce 1994].

In the case of Cultural Heritage buildings, it could also be added that deterioration, which is physiological in a building that is already old, should not to be understood in a negative sense and does not always require corrective interventions; it should be recognised, in any case, that it will never be entirely eliminated. Secondly, the deterioration which becomes evident with aging as time passes, leaves "signs" and "patinas" on the building that, rather than being removed, should be preserved in as much as they give to object the value of antiquity and characteristics of authenticity that makes it unique and unrepeatable. Maintenance work will therefore be aimed at managing the "chronicity" of the deterioration through "treatment" [Treccani 1996] that will be most effective when performed in a continuous and constant manner.

Assessments of the gravity of the damage and urgency of intervention are relevant from the operational point of view. Gravity involves an assessment of the phenomenon of deterioration observed, expressed in relation to its consistency, extent and impact on the state of conservation of the asset as a whole. Urgency, however, refers to an assessment of the greater or lesser need for rapid intervention, in relation to a greater or lesser propensity of the object to deteriorate at varying rates of acceleration (connected with the intensity of the agents, their interactions, the state of preservation, etc.) and depending on the risk of further loss of material. This means that a high degree of seriousness in ongoing deterioration does not automatically correspond to a high degree of urgency. Building pathology [Croce 1994] is the discipline that studies factors of disturbance (whether human, environmental, technical, technological, physical or chemical) and the mechanisms that lead, at an early date, to deterioration or damage related to physical alterations that may undermine the natural aging process. Since, as stated above, the deterioration of Cultural Heritage buildings in general can only be natural, i.e. due to continuous and long-term exposure to the elements, one of the most common causes of possible pathological damage to these buildings is incorrect maintenance. This may be due to an insufficiently detailed diagnostic analysis of the causes of deterioration, the use of incompatible materials or techniques, or the use of insufficiently trained personnel. Knowledge of the range of phenomena that have led to the unexpected deterioration of materials and components (which is also acquired through the development of inspection and monitoring activities, recording the results in an information system), or of maintenance activities that have had little long-term effect, enables the causes of the defects and process errors to be traced and more appropriate maintenance work to be developed.

To ensure efficient repair work, therefore, it is essential to preventively remedy any signs of trouble by correcting defects (faulty design, implementation or use) and designing interventions (e.g. "sacrificial" protection or layers, stabilising unsound elements) that are able to slow down or reduce the likely actions of agents of deterioration and situations of risk.

Within certain limits, and according to a certain point of view, even lack of maintenance may be a cause of "pathological" deterioration, in that failure to provide necessary repairs in a timely manner in cases of predictable, well-known or overt phenomena can greatly accelerate degenerative processes, partly due to the combination of the effects of various agents that progressively speed up the progress of the degenerative phenomena.

6 MAINTENANCE, "DURABILITY AND RELIABILITY"

The issue of durability in the field of Cultural Heritage buildings becomes critical when you start to think of the "limit state" beyond which the component or subsystem should be replaced. The argument once again involves the topic of the "useful lifetime." Granted that, for obvious reasons, the a priori substitution of elements, even in situations of degradation, is excluded, the need for intervention can be assessed in various ways, according to the development of the diagnostic phase.

It is evident, however, that the issue of durability is justified, even in the field of Cultural Heritage:

- firstly as an assessment of the reliability of the techniques or materials used in previous maintenance;

- secondarily, as an assessment of the "limit state", beyond which the component must necessarily be replaced. This evaluation requires consideration of the specific features of the element, its function and the relationship it has with the adjacent components; its actual state of deterioration in relation to the minimum functional requirements; and the level of residual performance in relation to that which is expected;
- lastly, as a criterion for choosing the most appropriate measures, which may be preventive or maintenance.

The topic of greater or lesser durability, therefore, together with that of reliability, will be a criterion for the choice of intervention techniques and will also determine the most appropriate criterion for the predicting and sequencing of the subsequent intervention.

7 MAINTENANCE AND "OBSCOLESCENCE"

Obsolescence is a phenomenon inherent to the passage of time, which necessarily refers the theme of the life cycle.

Even in the field of Cultural Heritage, the concept of obsolescence is connected, for buildings that are in use, to the loss of benefits that is evidenced by the loss of functional efficiency of an object, a plant or an environmental unit as a result of a change in the framework of needs, regulatory modifications, or in the case of plants, due of the implementation of technological improvements.

The services are constituted by behaviours that the various building components and objects (either individually or in relation to each other) are able to implement in response to the requirements connected with needs of use. In the case of the project on an existing building, unlike one for a new construction, it is necessary to consider that every existing building object is always able to deliver performance. Perhaps minimum performance, due to age, functional obsolescence or a precarious state of conservation, but these should be evaluated and, where possible, measured through the tool of performance analysis. This will tell us the quality and consistency of existing performances. The comparison between existing performance and design requirements will tell us, instead, what can be preserved and what needs to be transformed. Another key aspect of the concept of performance is given by variability over time. It is known that over time, some items may lose benefits due to obsolescence, wear and aging, to the point of no longer being suitable to perform the function for which they are intended, leading back to the issue of life cycle.

It is clear that performance analysis is mainly applicable to buildings in use. But also for abandoned buildings, especially for Cultural Heritage, new possibilities of use can and must be found, to give rise to a new "life cycle", starting precisely from an analysis of existing (or residual) benefits. This however requires the capacity of studying, with good sense and refined planning, which utilities we see that these buildings still capable of offering, to provide answers to our diversified needs. Furthermore, if they are carefully re-used and maintained, with the passage of time adds they are enhanced by new and hitherto unknown information, data and experiences.

8 MAINTENANCE PLANNING

One can therefore say in summary:

- outside of a maintenance plan (or where, within a maintenance plan, unforeseen events occur), maintenance activities are generally aimed at partially re-aligning existing performance, or parts thereof, in relation to the condition of walls, surfaces, components and systems, avoiding, as far as possible, invasive procedures or replacement. They nevertheless must always be properly managed by a project phase that defines their characteristics and limitations, each time re-evaluating their objectives more precisely. To coherently address the maintenance project on a historical building, certain levels of performance need to be more adequately considered, or

reconsidered, such as those of "durability" or "functional efficiency" and, more generally, those associated with issues of needs and performance, in respect to the assessment criteria for more recent buildings which, in this area, cannot be taken as absolute.

It will be necessary therefore to consider that different criteria may exist, for example, on historic surfaces with varied degrees of disintegration - which bear the marks of the passage of time and that, because of this, are able to convey essential documentary information - compared to the demands of "functional efficiency" for the facade of a new building: in other words ... if it is logical to think of the new because you are slowly growing older, it is absurd to think that aging is a priority issue for a building that is old " [Della Torre 1999], especially if it is defunctionalised, as is the case, for example, with Archaeological Heritage.

- If provided for as part of a maintenance plan, it will be a question of repetitive, normally low-tech activities, but always performed in a controlled manner, that are defined and programmed according to predetermined intervals and performance criteria laid down in codes of practice (Operational Instructions). Maintenance activities performed as part of a scheduled maintenance plan, moreover, should never affect the stratigraphic reading of the buildings, nor be conceptually identified as new phases of the long process of transformation of the asset over time. It can be reasonably argued, in fact, that the operations related to activities of caring for building structures (such as removing dust and small ruderal vegetation, cleaning gutters and downspouts, maintaining roofs, integrating small faults, restoring sacrificial layers, implementing temporary static safeguards for the securing of unsound parts etc..) can be procedured and defined a priori in their scale, intensity and extent. These works, therefore, structured as part of a more complex maintenance "service", would not require specific planning, but would be performed by maintenance experts, properly trained and supervised by specialised technicians. It is an observation shared by operators and maintenance technicians, in fact, that in practice, given the universe of possibilities, of the mutability and often amazing uniqueness of sites, significant similarities reappear in practice with a considerable frequency.

They provide a good approximation, based on experience, or even on the basis of a focused analytical assessment, to re-use techniques and methods of intervention that have already been used in previous similar experiences and, therefore allow in fact, by totally reusing procedures already in place (or some variant), to validate previous choices wherever positive result are observed.

9 CONCLUSIONS

An experience of planned maintenance process, guided by this principles, is, just now, being applied to some buildings of the central archaeological area of Rome where a few case studies have been selected. The planned maintenance strategy has to face the specificity of the archaeological heritage, made of ruined building with a particular behaviour. The first output of this process is surely a growing knowledge of the buildings and a increase of the operators consciousness. Planned maintenance indeed involves managing authority, conservation operator and also users in a partecipate process of conservation and enhancement of the cultural heritage.

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