ENVIRONMENTAL TECHNOLOGIES IN THE FIELD OF SCIENTIFIC CONSERVATION OF CULTURAL HERITAGE. NEW PERSPECTIVES AND DIRECTIONS OF RESEARCH

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Abstract. This paper presents the modern strategies of research in the field of cultural heritage, taking into account aspects related to integrated conservation, new materials and technologies of intervention onto art objects and also co-assisting inter- and transdisciplinary methods of new, noninvasive techniques of scientific investigation.

Introduction

At present, to preserve a good cultural heritage has become a science of high interdisciplinarity, situated at the border between the science and engineering of materials, environmental science and engineering, architecture and construction engineering, theory and history of art, archaeology, anthropology, sociology, etc.

Since it covers several phases with specific activities, beginning with the discovery / acquisition / transfer / laying, up to displaying / valorization / hoarding, in the practice area it is defined by the concept of ***scientific preservation***, because between the two phases we can find: protection, ranking and classification; scientific investigation through a series of specific surveys and analyses; passive and preventive preservation - climatization, prophylactic or active preservation - restoration and treatments, involving aspects of related areas of science and technology [1, 2].

The concept of conservation has the broader meaning of *preservation* of cultural heritage. It refers to a particular state of conservation, at a certain moment in time. As science, it includes a series of subjects with specific activities, grouped in the above phases, considered as lucrative or operational steps.

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Nowadays, when we talk about the last two actions taken before the display, that of preservation and restoration, we use a new concept, that of ***integrated conservation***, by creating optimal conditions for the storage and for taking ecological measures for the conservation of the elements of the preservation environment and of protection of the visitors and other people in the neighborhood.

In this context, a detailed documentation is necessary, both regarding the issues related to the integrated scientific conservation, modern systems of scientific investigation, new materials and current processes of active preservation and restoration, and interactive knowledge through exchange of experiences and ideas in European schools with tradition in this field and also acquaintance with current trends in the field. We mention here the interdisciplinary and interuniversitary projects LabSTECH, I-ARTEC, EPISCON etc. that, in addition to contributions made to the substantiation and harmonization of the field's nomenclature, have also laid the foundations of the consolidation of the integrated conservation field as an interdisciplinary science.

1. Definition and classification of cultural heritage assets

According to the Recommendations of the UNESCO General Conference in Paris (16.11.1961), reprinted in Geneva in 1985 [3], the cultural patrimony or cultural heritage represents the preserved spiritual or cultural assets that belong to a people, ethnicity or collectivity [4]. It consists of the tangible and intangible cultural heritage and property. Within the intangible cultural heritage, we can distinguish a special group of assets: ***vernacular heritage***, which is represented by the *rural architectural heritage*, often less researched, exploited or valorized.

Regarding the definition and classification of historical monuments and tangible and intangible heritage assets, we have a series of national bibliographical sources as laws [5] and monographs [6 - 9].

As we know, national cultural heritage includes

a. intangible assets, consisting of historical sites and monuments (buildings, works of architecture, works of monumental sculpture and painting, including inscriptions in the caves, tangible structures or residual components - remains, topographical areas, buildings and land with archaeological, historical, ethnological, anthropological, scientific or artistic value), co-assisted or not by natural monuments or creations (ranging from defined, cultural, evolutionary or associative landscape to natural reservations) and

b. tangible assets (objects of great or exceptional historical, archaeological, documentary, ethnographic, artistic, scientific and technical, literary, cinematographic, numismatic, philatelic, armory, bibliophilic, epigraphic and cartographic value, in form of material testimony). Furthermore, there is another classification method of cultural heritage assets, according to the five groups - historical and documentary - archaeological assets (archaeological terrestrial and subaqucous discoveries etc.), assets of artistic significance (plastic art works, decorative and applied art works, objects of worship), ethnographic assets (clothing and costume pieces, ensembles of ethnographic objects etc.), assets of scientific importance (rare specimens and mineralogical, anatomical, zoological, botanical collections, hunting trophies, etc.) and assets of technical utility (unique technical creations, prototypes of devices, devices, machinery etc.).

2. Factors that influence the state of conservation of cultural heritage and preventive measures

Generally, monuments include in their structure materials of different strength, some having a longer, others a shorter life, but all suffering in time from damage and degradation. In the first case the physical state of construction and/or functional elements is affected, and in the second case the chemical nature of component materials [7, 8, 10, 11].

Factors that lead to deterioration and degradation can be grouped into:

- Exogenous (environmental), including environmental factors (the climate: temperature, humidity, pressure, light and cosmic radiation, air currents, curl and ascendant currents or wind, microbiological agents, pollution, with its various forms and, finally, animals and man or the anthropogenic factor, by use - normal wear and by vandalism) and risk factors, uncontrollable (random), which can lead to collapse and which are grouped under the term of calamity or natural disaster (earthquakes or seism, floods, hurricanes, hail, storm, drought, frost, lightning, fire, compaction and landslides etc.) and, respectively, of man-made disasters or catastrophes (accidental radiation or nuclear accidents, explosions, fires, wars etc.).

- Endogenous, which are linked to materials (quality, outage, warranty period or term etc.) to the construction technology (observance of the steps and phases of construction, of the parameters of work etc.) and to defects (original or native and from the construction works or acquired).

The last two induce minimal resistance points or active centers, where deterioration and degradation begin.

As we know, buildings, as all engineering buildings for that matter, monuments and works of art are subject to the action of multiple environmental factors of deterioration and degradation, most of the effects being caused by the lack of maintenance or intervention in due time.

In addition, an initially small damage or deterioration may worsen in time, leading to accidents and causing effects that are difficult and costly to remediate if not irreversible. Today, we speak more and more of the priority of the prevention measures, dealt with by the passive preservation.

The prevention of deficiencies can and should be made both by providing the appropriate conditions for the timely execution of works, of placement or the restoration processes and by strictly complying with all rules of construction and of involvement of compatible materials, provided for in the technical regulations in force.

All mistakes and negligence that cause degradations and deteriorations or various accidents and damages must be identified and corrected. This way, risk factors can be assessed and avoided in the future, in order to further optimize the constructive solutions and to improve the technology for carrying out the works, involving the most appropriate materials and equipment.

Timely organization and execution of a program of maintenance and repair of cultural heritage assets, well designed, involve both competence and high degree of ingenuity.

Issues regarding prevention of damages, casualties and continuous improvement of the quality of repair works also depend on the preparation of the certified technical staff and of the skilled workers. Without a well-trained staff that masters the science, the technology and art of carrying out the works (especially the restoration of historical monuments) it is not possible to make quality, safe works in the context of the requirements and of the progresses reached in all socio-economic areas. One of the primary goals of restorers is to know the mechanism of the alteration and destruction processes of various materials, in order to improve them.

4. Aspects of integrated conservation of cultural heritage

This concept was used for the first time with reference to architectural heritage (built) in Resolution (76) 28/1976 on the adaptation of laws and regulations to the requirements of integrated conservation of architectural heritage. As defined in this document, integrated conservation includes "all possible measures which aim at the perpetuation of cultural heritage, maintaining as part of the living environment (whether natural or created by humans) its use and adaptation to the needs of society."

The principles contained in the Resolution were then repeated and defined broadly in art. 10 of the Granada Convention [12].

To implement this concept, it is necessary that the policy of territory planning and that related to environment protection should also integrate the conservation of cultural heritage so as to produce a unified whole that meets the cultural, social and economic needs of human communities.

Integrated conservation has two main objectives:

a) Conservation of Heritage understood in a broad sense, as cultural environment, through

• Implementation of mechanisms of protection as efficient as possible;

• Taking measures to conserve or improve the physical state of the heritage elements;

• Initiation of as many processes of valorization as possible, but also exploitation of the economic potential of the cultural heritage;

b) integration of cultural heritage in contemporary society by:

• Implementation of local, regional and national development programs, including issues related to cultural heritage;

• Cooperation between the territory planning and development elements, at local and regional levels for the most effective use (recovery) of elements of cultural heritage;

The main novelty brought by the principle of integrated conservation is the focus on environmental issues, seen as crucial elements in ensuring the quality of life. One of the directions provided by La Valetta Convention is to increase the impact that the major investment works (especially construction) have on archaeological heritage. For this reason, La Valetta Convention requires the signatory states to establish measures (including mechanisms and methods of preventive digging) to protect archaeological sites, in case of implementation of the investment projects [13].

Article 5 of the European Convention (revised) for the protection of archaeological heritage (Valletta 1992) established the principle of integrated conservation. Such a policy of conservation of the archaeological heritage allows archeology to find its place in the overall policy planning and the environmental protection, establishing cultural, social and economic objectives.

The sustainable development desideratum cannot be achieved without the application of the integrated conservation principle, which ensures the connection between all those sectoral policies which concern, on the one hand, the economic development (with all its components) and, on the other hand, the protection of the environment (including cultural heritage).

That is why the issue of archaeological sites and historical monuments should be systematically addressed in studies of environmental impact, thereby providing the opportunity of correlating their protection with the other economic and social issues involved by the major works, publicly or privately funded.

The application of the principle of sustainable development encourages a more dynamic action both on territory and on cultural heritage, by:

- Major investment programs at national level, which should include numerous opportunities to maximize cultural heritage;

- Urban restoration programs (e.g. the historic centers of cities) and local rural development programs with the participation of local actors;
- Using cultural heritage to produce both cultural benefits and economic and social progress (eg. tourism);
- Valuing assets so as to further meet the current needs of society or of a broader public and not only those of a reduced number of specialists.

5. New materials and procedures of intervention

Researches conducted on obtaining new compatible materials and modern methods of intervention have continued to draw the attention of curators and restorers [11, 14, 15]. In time, this area has depended largely on the achievements of contemporary science and technology, which allowed improvement of materials and continuous optimization of processes.
The selection of specific materials for certain interventions takes into account the chemical nature and the physical condition of the structural element in the heritage asset composition, and also its state of conservation, age, climate agents and other exogenous factors as well as the storage conditions [16].

For an optimal intervention, processes and materials that have minimal action on the work of art, that provide high reliability in the display and allow the best highlighting of the elements and functions of the heritage should be involved in the operations of restoration and in the active preservation treatments. Furthermore, interventions must respect the general principles, widely accepted, of the integrated conservation science, introduced by a series of rules and codes of ethics [1, 11, 14].

To do an optimal intervention protocol, it is necessary to establish correlations between the conservation case status and the interventions nature, through the participation of all specialists professionally related to that work.

Usually, in selecting the materials for intervention, an analysis of the typical physical and chemical properties, correlated with their behavior in various operating systems, temporary or definitive, is carried out. The materials with multiple implications are the subject of study for several disciplines, with their respective methods and techniques. Thus, besides the chemical nature of the material, we are interested in its physical-structural, optical, mechanical, rheological properties (and other technical characteristics) related to the obtaining, handling, application and behavior in the operating system, in order to restore or create optimal parameters for implementation. Moreover, it is necessary to know the correlations between the physical characteristics of the application instruments or device and the physical-chemical properties of the material. Most materials used in the processes of preservation-restoration are firstly submitted to chemical, physical, microbiological and mechanical tests, of compatibility and reliability, to predict their behavior over time. A primary place in these studies is taken by the research of their structure and initial reactivity, also after the application in the operating system. Data on materials chemism in various operating systems, the optics and mechanics of structures affected by interventions and the influence of endogenous and exogenous factors on them are absolutely necessary in order to create a complete image for the compatibility and reliability studies.

6. Modern nondestructive methods

The main methods and modern techniques used in the investigation of heritage objects may be classified into two groups: nondestructive or direct methods and semidestructive or para-destructive but non-invasive methods.

We mention some methods of the first group, in the order of their frequency of use: visual analysis by the naked eye and with enlarging devices, micro and macro photogrametry, stereophotogrametry, UV reflectography, Vis and IR (assisted by photo or video techniques), reflectance colorimetry, emissiography, IR thermography, thermoluminiscence, microendoscopy, x-ray, X-ray fluorescence, together with direct measurements of weight and size. Most of these methods are digitally assisted for the retrieving, processing and rendition of analytical data, thus, becoming very expensive.

Of the second group, we mention the following methods, still in order of their frequency,: microstratigraphy assisted or not by microchemistry, optical and electronic microscopy, differential thermogravimetry and calorimetry, UV spectroscopy, Vis and IR röentgenography or X-ray diffraction, normal or pyrolysis gas chromatography (the last one with or without silylation, but assisted by mass spectrometry).

In the development and application of various analytical techniques, a key point is the use of reference standards, useful in the qualitative identification and quantitative determination of the components of a material or object. Using standards common to all institutions can be very useful when comparing the analytical results of different laboratories.

Particular attention is given to the development of new methods by coassisting systems and by conjunction between specific techniques, characteristic to the disciplines; as for example, coupling optical or electronic microscopy with other techniques like X-ray fluorescence, X-ray diffraction, tests of color, reflectance colorimetry and so on. In this direction, our team has perfected a number of methods, involved especially in authentication. They include microstratigraphy coupled with colorimetry and SEM-EDX or with mineralogical analysis and colorimetry.

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