Architecture Anthology I

Architectural Construction, Materials and Building Technologies

Edited by

Jamal M. Khatib

Athens Institute for Education and Research

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Jamal M. Khatib
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Preface

Stavros Alifragkis and Nicholas Patricios

The papers contained in the series *Architecture Anthology I* are selected from those presented at the Conferences in Architecture, Urban Studies & Planning, Construction and Civil Engineering organized by the Athens Institute for Education and Research (ATINER) held in Athens. The chosen papers have been divided into categories and published in five separate volumes: 1 - Architectural & Urban History & Historiography; 2 - Architectural and Urban Theory; 3 - Architectural Construction, Materials & Building Technologies; 4 - Architectural Education, Research & Practice; and 5 - Sustainable Design. Further series will be published from papers presented at future ATINER Architecture Conferences. The selected papers are those that have been peer reviewed and approved for publication by referees, editors of each volume, and the general editors. It is hoped that the series will be both of interest and of value to academics, scholars, researchers, and practitioners.

The work of the referees and editors is much appreciated for without their volunteer efforts and time expended on reviewing papers and the re-writes by authors the *Architecture Anthology I* series would not be possible. S thank you to the editors of Volume 1: Arthur Chen & Stavros Alifr Volume 2: Nicholas Patricios; Volume 3: Jamal Khatib; Volume 4: Urbano; and Volume 5: Fatih Rifki.

Thank you also to the referees for Volume I: Stylianos Giamarelos, Mark Breeze, Simone Shu-Yeng Chung; Volume 2: Bahga Surinder, Amanjeet Kaur, Aarti Grover, Pankaj Chhabra; Volume 3: Marta Molina Huelva, Hugo Rodrigues, Elisabetta Carattin, Ksenia Piatkowska, Antonella Violano; Volume 4: Sergiu Petrea; Volume 5: Adrian Moleavin, Nirmita Mehrotra, Elham Madadi Kandjani, Christian Kersten Hofbauer.

The process of producing the volumes could not have been undertaken without the valuable assistance of Olga Gkounta, Research Assistant at ATINER.

General Editors
Stavros Alifragkis
Nicholas Patricios

Architectural and Urban History and Historiography: An Introduction

Jamal M Khatib

This book on *Architectural Construction, Materials and Building Technologies* is Volume III in the Architecture Anthology series published by the Athens Institute for Education and Research (ATINER). It contains selected papers presented at the 3rd Annual ATINER Conference on Architecture held in Athens on the 10th to the 13th June, 2013. In total, there are 20 selected papers which have been divided into two categories: *Architectural Technology* and *Building Materials and Construction*. Due to the nature of this volume, overlap between the various categories could not be avoided.

The *Architectural Technology* category includes papers on varied topics - the architecture of tall buildings; ancient materials; enhancing the historical heritage; architecture and wireless communication; effect of incorporation of reinforced concrete in archaeological areas; efficiency of solar shading devices in buildings; lighting design and visual comfort; responsiveness of interior design to external façade; design of contemporary masonry shell; and seismic vulnerability of building heritage. There is one paper on Construction Management which is concerned with variability analysis and risks associated with construction materials acceptance.

The *Building Materials and Construction* category includes papers on the following topics: rheology of polyethylene-modified asphalt binder; thermal characterization of ethylene TetraFluroEthylene ETFE foil; characteristics of waste fillers for solvent free and water-based industrial polymer floors; present serviceability index models for urban highway flexible pavements in Jordan; deflection of pre-stressed reinforced concrete beams with CFRP tendons externally; acceleration response of seismically isolated buildings; and the use of wood-waste and inorganic binder for the development of building materials.

Thanks go to the reviewers of this volume; Marta Molina Huelva, Hugo Rodrigues, Elisabetta Carattin, Ksenia Piatkowska, Antonella Violano.

This volume could not be produced without the assistance and the hard work of Olga Gkounta, Research Assistant at ATINER.

5

Cultural Content of Lighting for the Discovery of Archaeological Heritage

Santina Di Salvo

Archaeological sites, built landscapes of the past, represent the identity heritage for future generations. The aim of this article is to investigate and demonstrate the importance of the cultural identity reinforcement, which can be achieved by enhancing the historical heritage through the use of artificial lighting. The charm of an archaeological site or a monument comes from the perception of its whole environmental context, both for the functional lighting and the enhancement of the artistic and monumental. Light can turn into concrete matter both in interiors, in archaeological and urban spaces: combining innovative technologies, artificial light can be used to change the world, to shape cities, as well as architecture and space in general. The emphasis must be on what should be the most effective lighting system for the archaeological sites, one respecting the ruins and the authenticity of the landscape, while at the same time bringing out their architectural, historical and symbolic significance: the light, which is emotion, suggestion, evocation can support the experience of every single visitor. There is the possibility to obtain a recovery of memory and identity of a city, in order to achieve efficiency and effectiveness of the results. The choice of sites presented in this paper is derived from the author's doctoral research, through own direct study and experience, specifically dedicated to indoor and outdoor archaeological sites, according to an experimental view of strategic projects that aim to recover the ancient built environment.

Introduction and Research Aims

The present study is focused on the cultural value in lighting design that represents a very important aspect, particularly for the enhancement of the archaeological sites.

Lighting should be the responsibility of people interested in dealing with the issue of enhancing the public experience during their visit to an archaeological site. Recently, archaeological sites have experienced a gradual opening and a better projection to the outside world, to the point where archaeological ruins are now defined as sites of memory (Ruggieri Tricoli,

2005). This change involves two main groups: the people responsible for the preservation of cultural heritage and the visitors. This transformation has also been confirmed by the increasing number of visitors to archaeological sites. Evidently, there is a greater interest in disseminating the knowledge derived from cultural heritage and transmitting these values to a non-specialist audience.

Therefore, we need a tool to help us construing our cultural heritage and the adoption of a common language can set a dialogue between cultural heritage and visitors, citizens and tourists, all community. The issue is not just illuminate, "make light" to see something in a more or less way artistic, but also that of communicating the ancient fragment because every single piece of stone represents an evidence of our identity.

The advent of artificial light is of the twentieth century. This discipline has been for years been the exclusive interest and occupation of technicians and the companies that built the lighting devices. In Italy, the Association of Lighting designers, AIDI, was founded in 1959. Until that date, artificial light was not regarded part of architectural design[1]. The cultural aspect has been overlooked in the 1990s and since then the focus has moved to transmission of meanings and on how to convey historical data, artifacts, and documenting past life through light. We have demonstrated that light has got specific roles. This investigation has not been limited to some passive considerations, but it focuses on evaluating the current situation through the analysis of national and international case studies in Europe because in this area cultural tourism is also one of the fastest growing sectors (De Carli, 2003).

The most important aspects of an efficient artificial lighting design include:

- Recovery of the historical memory of the ruins.
- Perception of the archaeological fragment.
- Indication of the hierarchy of paths and creation of guidance and teaching routes.
- Enhancement of the archaeological heritage, in compliance with the ruins and their context.
- Providing a more accessible reading of archaeology.
- Establishing areas for walking, contemplation and conversation

An archaeological context includes the soil, the site type, the layer the artifacts came from, what else was in that layer. A site, properly valued and conveyed to public, tells us about the people who lived there, what they ate, what they believed, how they organized their society. The whole of our human past is tied up in the archaeological remnants, and it is only by considering the

[1]AIDI, the Italian Association of Lighting system, is the leading non-profit association in the lighting field in Italy. Active since 1959, based in Milan, it is present throughout the country with territorial sections. Since its foundation, the Association carries out an effective and constant action of scientific, technical and cultural centre for the dissemination of knowledge of the problems related to the issues of lighting.

entire package of an archaeological site that we can even begin to understand what our ancestors were about. Definitely, the use of innovative technologies helps highlighting the value of the archaeological heritage and their containers to enable communicating the significance at the visitors.

This analysis has been based on an interdisciplinary approach since in different contexts and environments the role of the light is quite different (Thomson, 1986). From the technical and technological point of view, "designing the light" is a demanding task for the professionals who intend to be involved in the enrichment of the historical contexts, because particular lighting sources can create damages to the original materials, if created and used without control (Feller, 1968). In the design, for example, the correct lighting in an indoor location, as a crypt, or any other indoor location, is important to pay particular attention on the non-visible lighting spectrum (Balocco & Calzolari, 2008). Hence, the ultraviolet rays emitted by halogen lights can cause the discolouration of pigments, the detachment of possible pictorial layers, the crumbling of paints; whilst the infrared rays could bring an increased temperature, humidity and create movements of air within the environment. Therefore, for each lighting project, thought ad hoc for each category of intervention, an interdisciplinary team needs to activate and reunite the competences of light designers, engineers, architects, experts in restoration and other professionals, to proceed following a methodological approach (Di Salvo, 2012).

It is not a new issue as is easily seen, but certainly an issue that, in its own right, should be the responsibility of anyone who is interested in the enhancement of archaeological landscape since nowadays we live a time of explicit crisis because many expectations have not yielded the expected results and there are objective economic difficulties facing the management of cultural heritage. These difficulties are much more pronounced, even aside from the serious crisis when, as in Italy, people believe that archaeological sites should be fully borne by the government, when they believe that the basic decisions should be totally handled by a single controlling entity, the Superintendence; when they address the design choices from a conservative point of view, without considering other factors of interest, the community and economic professionals who operate in it; when they have a confused perception of the public, without any assessment of the differences (local community, scholars, students, tourists, children, old people, etc..); where groups (stakeholders) are scarcely involved and, finally, when the cultural heritage to be enhanced and preserved constitutes an unmanageable commitment.

Lighting is an essential tool to transform the landscape of our city when the sun is down: it is well known that tourism can be "night owl" and the nocturnal cityscapes are as important as the daytime view, for example in the Italian archaeological sites, where people see a mixture of interests - bathing, food, entertainment - and the enjoyment of our historical centres and archaeological sites is at night (Altarelli, 2006).

Case Studies

Light used to Create Emotional Responses and Dramatic Effects

Today, artificial lighting is one of the most important design elements and serves primarily to show but also to reveal hidden meanings, to communicate functions or dating, to dramatize fragmented structures of ancient building and reconfigure them in a non-invasive method (Ravizza, 2006).

Referring to the philosophy of perception, the Gestalt theory, it is possible to better explain the idea of light as a tool. Through the Gestalt principles - similarity, continuity, meaningfulness - it is possible reconstruct a fragment, going back to the whole shape, having a clear perception of the entire structure. The architecture is also made up of visual perception, texture and material volume, quality of light that rests gently or forcefully on exposed surfaces and gives them colour, texture and palpable quality. In this sense, light has the same characteristics of a real building material.

For example, in the case of London's Roman Amphitheatre, in *Londinium*, the intervention strategy offered the possibility to conserve and properly show the original Roman artifacts, including even a few of the original wooden fragments (Fig. 1). The intervention was conducted in 2004 by the London based firm Branson Coates Architecture. The work was concentrated on creating perspective effects, providing a remarkable charm for the visitor and recalling the dramatic and tragic atmosphere of gladiatorial games. The aim of the project was to study and reveal several aspects of Roman practices and traditions. This enabled a material and immaterial rebuilding of the environment, through the use of green wireframe projections on the restored wall, with particular attention to the preservation of the original artifacts[2]. The shapes of gladiators, the stairs of the arena and the background of a cheering crowd recreate the magnitude of the amphitheatre. In this project it was demonstrated that lights and sounds don't distract the visitor, who is involved by the show emotionally (Bateman, Coates & Wroe-Brown, 2008).

[2] Bateman, N. & Coates, B., (1997). 'The London amphitheatre excavations'. *Britannia* (28), London: 51-57.

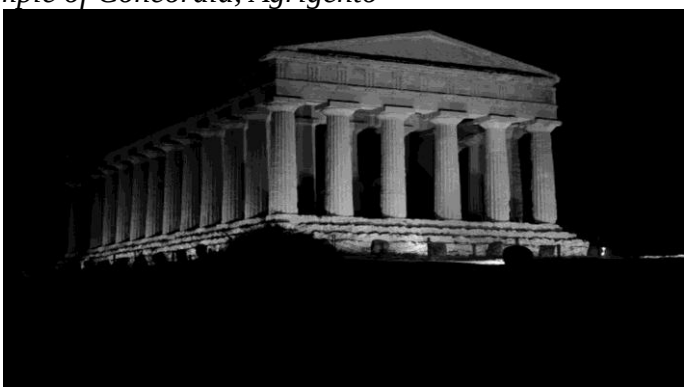
Figure 1. *Roman Amphitheatre of London*

Light on Valley of the Temples of Agrigento, Sicily

Outdoor lighting is an essential part of every town planning or architectural project that wishes to become a readily identifiable reference point. Monuments and other symbols of the history of a town/city, with adequate outdoor lighting become an essential part of the night landscape.

The Valley of the Temples in Agrigento is one of the most important archaeological sites in the world, which is an exceptional concentration of sacral buildings built between the sixth and fourth centuries BC. The new lighting project of the archaeological site, entrusted to the Disano Group in 1999, involved the lighting of the Temples of *Concordia*, of *Giunone* and *Ercole*, which are the most significant archeological findings. The main objectives of the intervention were: ensuring basic lighting to buildings that would make them readable by default places to medium and long distances and outline the set; achieving illumination of detail to highlight the individual columns (Fig. 2). In addition, all the light fixtures were hidden in niches in blocks of tuff. Floodlights are perfect instruments for these projects. The lighting fixture are compact, powerful and reliable, in order to ensure the desired lighting effect without any unpleasant interference with the architecture and the environments where they are installed.

Figure 2. *Temple of Concordia, Agrigento*



Although this kind of intervention has benefits in terms of technological

features, it could be wrong in terms of didactic or communicative purposes. In fact, the lighting project attempted to identify the ruins not considering the landscape and the Temples, at night, seem almost float in the dark, suspended in space above all things. It seems that there is nothing else around. Definitely, the project has not contributed to the enhancement of the valley, making it not readable monuments both upstream and downstream of the hill and not allowing the visitor a comprehensive vision of the entire archaeological site. The Temples stand out among the ruins and fragments seem to lose legitimacy.

As a result, the spiritual and symbolic meaning of the archaeological site cannot be perceived. The final outcome is a real distraction from the landscape, leading to a misperception of the cultural content of the monuments.

The Functions of Artificial Lighting: Baden-Baden, Roman Bath in Germany

Starting from an archaeological fragment, through the use of light is possible to recall times, historical layers, locations and functions embedded in the collective imagination. The recent museum exhibit of the ruins of the Roman baths of Baden-Baden, the so-called Soldatenbäder in 2003, is an example of the expressive power of good practice that aims to give voice to the matter, which minimizes the mediating action of the traditional exhibition (Fig. 3). The use of modern methods served to "wake up" the ruins from an ancient sleep, as claimed by Petra Mayer-Reppert and Britta Rabold of Archäologischer Denkmalpflege (Ruggieri Tricoli, 2007).

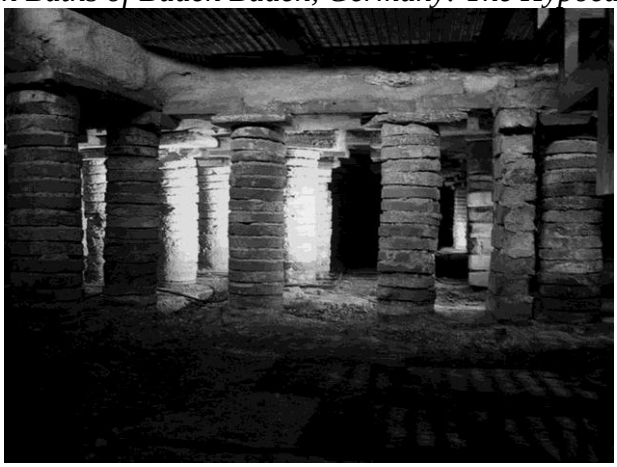
Figure 3. *Roman Baths of Baden Baden, Germany*

The emphasis of the intervention focuses on the technological system, which enhances its functionality. The remains of the Roman baths in Baden-Baden are, after two thousand years, among the best preserved baths of Baden-Wurttemberg. Among the more visible portions of the high walls that enclosed the baths, it is possible to see the cavity under the floors and walls where air circulated that warmed the various rooms. A correct interpretation it is possible through the use of coloured light, differentiated according to the functions of the rooms.

The fires of the *praefurnium* seem to be burning and the heat of flaming

red creeps into the *hypocaustum*, ranging from the warm orange colour of *tepidarium* (Fig. 4). A yellow light highlights the presence of a *sudatorium*, becoming a blue decidedly chilly in the locker room of the *frigidarium*. The light allows recognition of the remains of settlements, creating atmosphere through different colours, making emotional impressions on the visitors who are fascinated and enchanted. Materials capable of capturing the attention of the visitor were used, capable at the same time of describing different periods, functions or activities of the ruins in the past, without any damage. This goal was achieved through strategies in which the characteristics of different materials, different colours and other elements of communication were evaluated. The case of this intervention strategy is very representative and engaging in its clear and effective communicability.

Figure 4. *Roman Baths of Baden Baden, Germany: The Hypocaustum*



Lighting to Sign a Path: The Roman Villa of Els Ametllers, Catalonia

In the case of the lighting project of the Roman villa of Els Ametllers, in Tossa del Mar, Catalonia, the intervention of the Aspecte Studio (2004) proposes itineraries by day and night and is developed with the need to make the Roman Villa accessible and perceptible to a non-specialist audience, after making systems of protection to safeguard the remnants of the 2nd century BC.[3]

The main theme of the project was to stage the path of the water from the *Nympheum* reconstructed to the swimming pool and to the canal, where the presence of water is simulated by the use of glass plates specially placed alternately in portions of blue glass. The treatment of the floor of the pool is remarkable due to a particular faceted texture made with fragments of blue polycarbonate (Figs. 5-6). A lighting system, consisting of corrugated pipes and suitably twisted, illuminates the water, which takes on the blue colour of the backdrop. The water seems to flow directly from the *Nympheum* but, in fact this effect is due to the light tubes to simulate a well-defined path to the canal, where the light intensity remains unchanged, giving the striking vision of the movement of the water. Lighting fixtures were used, with special shapes,

[3]News and information are available at http://www.disano.it/.

placed at strategic points, so as not to disturb visitors with contrasts of light and make the spaces recognizable.

Figure 5. *Roman Villa of Els Amettlers*

Figure 6. *Roman Villa of Els Amettlers: the Nympheum*

Innovative Lighting for Archeological Sites: Leds in Badalona, Spain

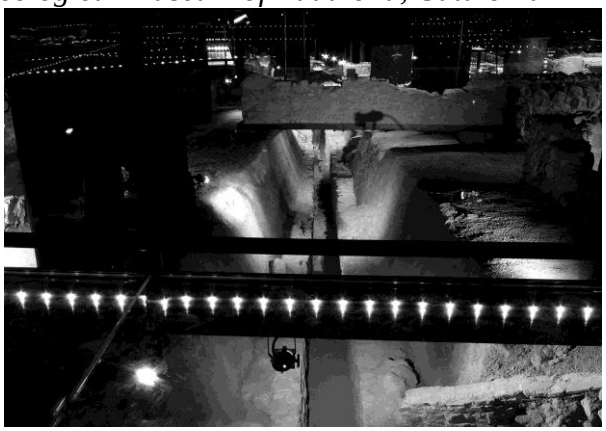
Light can serve to highlight the most significant evidence of the historical layers as in the case of the exhibition in the Municipal Museum of Badalona, where the ancient Roman baths are conserved and presented[4].

In an area of approximately 3.400 m^2 it is possible to discover the submersed city of ancient *Baetulo*, through a journey in time which begins visiting the Roman baths, where it is possible to distinguish all the places which form the installation: the *arena*, the *frigidarium*, the *tepidarium* and the *calidarium*. Along the itinerary the residential buildings remains and the small workshops on ground floor, are perfectly conceptualized following the direction of the secondary road, of which the sewers are preserved. Spots of focused lights signal the trace of the wide *decumanus maximus*, the main road

[4]Di Salvo, S., (2013) Luce per rivivere…Alla scoperta di Baetulo, Catalogna/Light to relive…Discovering Baetulo, Catalonia, 303(3), *Luce*, Milano: 32-39.

which joined the city from east to west, passing through a big commercial building until the intersection with the *cardo maximus*, which is even signaled with a punctual lighting (Fig. 7). There are also the remains of other buildings in the late-roman period, as a *mausoleum* and a tank of water.

Figure 7. *Archaeological Museum of Badalona, Catalonia*



All the area is illuminated with lights anchored on black pillars in the hall, maintaining contrast with effects scenically eye catching, and it is set up with elements useful to supply an identification of the spaces, with a precise historical contextualization. The installation includes also tactile aids for vision impaired people. The technological level for the presentation of the material exposed is of the most advanced and efficient, the location is amplified thanks to the auditory effects which emotionally drive transport and immerse the visitor in an educational journey of surprises, emotions, understanding the choice of joining the past with modern technology[5]. From the technological point of view, the intervention highlights the constant innovation of the lighting sector by using design devices of high quality, achieved with noble materials as aluminium, steel and glass, conveniently positioned to guarantee "visual comfort" and "comfort of the ruins". The lights delimitate the complicated remains, putting in evidence pathways, residences, workshops and plots of the *decumanus* and the *cardo*. The innovative LED system lighting in all runways allowed is at elevated levels of lighting, without entailing danger for the integrity of the archeological site[6]. LED lighting fixtures were installed at different strategic points with the aim of not disturbing visitors with unnecessary light contrasts and making the environments discernible. LED lamps give cold light, which is not harmful to the ruins and provide a way to help recognize the remains of settlements, to create various atmospheres through the use of different colours, and to help produce emotional impressions on the visitors: the red light is used to point out the presence of the *praefurnium*, a light of the warm colour orange is used for the hypocaust in the

[5]Commission Internationale de L'Eclairage CIE 157:2004 Control of damage to museum objects by optical radiationn, Wien 2004.

[6]LED stands for Light Emitting Diode (light-emitting diode), the first LED was developed by Nick Holonyak Jr. (Illinois, 1928) in 1962. The LEDs are increasingly being used in lighting replacement of some traditional light sources.

calidarium, whilst a blue light used to indicate the *frigidarium*.

The use of LED lamps is an important new development for illumination of cultural heritage since the infrared radiation component is minimized and therefore they have important preservation implications. At the same time, LED lamps have a spectral power distribution that provide good colour rendering and better appreciation of details (Palladino, 2005). Exhibition materials capable of capturing the attention of the visitor were used. These materials provided a non-destructive way of presenting the information about the settlement including time periods and various past functions or activities. This goal was achieved by following strategies that focused on the characteristics of different materials such as their different colours and other inherent elements of communication[7].

As a matter of fact, LEDs reduce the thermal load on ancient stones, because they emit cold light which is not damaging for the remains, where the component of infrared radiations is reduced to the minimum, with important implications for what concerns the preservative issues. Additionally, these generate direct lighting, punctual, very precise and focused on the point which one wants to emphasize. In the same way the result is extremely ductile and they are able to create shadow games and lighting scenic effects, contributing, through effects of dynamic lighting, to recognize the remains of the settlements, creating different atmospheres through the use of different colours. LEDs are considered, by now, lighting of the future. Many are the reasons, one of which the energetic efficiency, give an extremely low environmental impact as they do not contain mercury, they last longer, produce less waste and are created with recyclable materials. At the same time, the sources LED have a strong distribution which supplies good colour rendering index and a greater appreciation to details. For all these reasons, in general LED lamps are highly recommended for the illumination and appreciation of archaeological sites[8].

Conclusion

Today visitors and the community, through the use of new technologies desire to be surprised, of getting a grip on emotion in ancient contexts. Often, architecture approaches fashion, and presents more its image that its function, the "container" is described much more than the "content" (Paesetti, 1999). Therefore, we believe in the need of considering the following important issues, which may constitute essential guidelines, for establishing criteria to enhance and appreciate the ancient contexts:

[7]Di Salvo, S., (2012). *Luce e colori sulle rovine: strategie museografiche per la comunicazione dell'archeologia*, Roma: Aracne.

[8]Di Salvo, S., (2013). 'Innovation in lighting for enhancing the appreciation and preservation of archaeological heritage.' *Journal of Cultural Heritage*, Elsevier. Available at http://www.sciencedirect.com/science/article/pii/S1296207413000800 [10 April 2013].

1. *Specificity* - The architect technologist must be able to understand the peculiarities of each site, in the place where he is going to design, considering the specific historical and geographical context.
2. *Cognitive process and uncertainty of the project* - We must remember that, in particular, the field of archaeological heritage is a complex area because the matter is submerged, unpredictable and quality and quantity change over time (Sposito, 1999). To be able to proceed with an application of innovative technologies having positive outcomes, we must have awareness that the project takes shape very often during the execution of works and can take on connotations different from those projected at the beginning. Therefore, each path of development comes from a cognitive process, understood as a sequence of moments, as a succession of ever-changing facts.
3. *Reliability of interventions* - The existence of the space-time factor is an essential component in every process of definition and enhancement of the archaeological places, where the basic prerequisite for the reliability of interventions is the flexibility of the project which can be reached through a cognitive process, understood as a succession of events in continuous transformation (Di Salvo, 2013).

Furthermore, through the creation of research groups made up of professionals of different disciplines, issues related to conservation and restoration of archaeological remains can be undertaken, but also issues related to technological aspects, always strongly considering important requirements, aiming to protect the *cultural heritage*: flexibility, a semantic thinness more accentuated than the pre-existence, reversibility, distinctness, ease of maintenance, energy efficiency and minimal environmental impact.

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