Integrated survey techniques for the study and the restoration of the archeological heritage

INTEGRATED SURVEY TECHNIQUES FOR THE STUDY AND THE RESTORATION OF THE ARCHEOLOGICAL HERITAGE

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ABSTRACT

The safeguard and the valorization of the archeological heritage are, especially in Italy, a privileged field given the richness of the classic and late-ancient sites. This interest implies always new and advanced instruments aimed at their knowledge, restoration ad valorization.This paper presents some works where an integrated survey approach has been used to analyze and to plan the conservation of an archaeological site in Piedmont. The characteristic complexity of the archeological sites involves both instrumental and direct survey techniques. An example of particular interest is here illustrated: the theatre of Libarna. The synergetic use of traditional and innovative techniques allowed:
- in the acquisition step, a more accurate survey from the metric point of view
- in the restoration step, a more punctual analysis of the state of preservation (materials and pathologies)
- in the valorization step, a more immediate reading and communication of the obtained results and of the proposals for intervention (re-functionalization, image communication, virtual reconstructions....).

1. INTRODUCTION AND METHODOLOGY

During the centuries, the rich architectural heritage datable in the classical age and found in Piemonte area has been object of much different phenomena, leading it either to an absolute neglect or to a continuous use, either to a constant transformation or to a partial loss of integrity. In particular, as a result of destroying events or at least because of the lack of use, we inherited some structures as ruin, with no meaning manipulation. Famous archaeological areas such as Augusta Bagiennorum, Libarna, Industria, etc. are actual evidence of this degrading process (1).
That's the reason because, during the last two centuries, such extra-urban assets have been often object of archaeological diggings arranged and finalized to bring again to the light monumental finds.
Likewise during the passing of the time, numerous classical structures have undergone transformations, conversions to new uses, repairs, restoration or consolidations, adaptations to new style canons.
On one side all these processes have made it difficult to recognise classical features in the current architectures, on the other side thanks to their continuous integration in the urban functions, these structures just survived. Some evidence of this kind of process are still recognizable in the nowadays cities, such as Pollenzo, Torino, Ivrea and Susa (2), but mostly they can be red just through an accurate analysis of the architect restorer, demanding specific competences such as direct reading, surveying archival, metric and thematic survey, study of the eventual archaeological evidences, morphologic and typological analysis of the buildings and the urban centres, graphical representation. Cities of this kind are Aqui Terme, Alba, Tortona, Vercelli, Novara (3).
The detection of classical evidences followed in the single architecture is more difficult. Sometimes this identification is feasible just by the aid of particular cognitive and diagnostic evaluations, all above assessment focused to clearly distinguish ancient parts by the successive stratifications.
The study of these transformations and the safeguard of their traces are a cultural requirement, just because they often represent the only instrument allowing the *material* and documentary conservation of architectonic elements, urban contexts and territorial systems. That's true particularly for those cases in which the degradation and the conditions in which the buildings are, make it difficult to recognize architectonic elements, not allowing the starting of valorisation processes.
The phenomenon of the building material reuse such as marmoreal blocks, pieces of columns, capitals, tombstones and decorations emerging from following architectonic structures, is equally diffused (4). As a matter of fact, in this case just a careful investigations can characterize and put in evidence such traces, allowing to preserve and value them. Since the Middle Ages these *fragmenta*, taken away from classical buildings no more used, have been re-used in the new buildings, either for an easier supplying of the material, or with a declared symbolic and commemorative goal (5). Therefore, thanks to their transformations and reconfigurations, the ancient *monumenta* have crossed the centuries, renewing and consolidating the interrelations with urban context and land history. Nowadays, they represent accumulation points for centuries remembrance, for historical events, for economic and social changes.
In Archaeological Restoration works and practices held during the course of Restoration held at the Faculty of Architecture II of the Polytechnic of Turin, the scientific contributions deriving from different disciplines such as restoration, survey and representation have been integrated. Such experiences have suggested some remarks on the steadiness of the Piemonte archaeological heritage and on its current status of preservation. Furthermore they underlined the necessity of more advanced techniques and new instruments in order to improve investigations and diffusion of acquired knowledge.
Today, classical age elements can still be found in many cities of Piemonte: they constitute for this region a not much studied and often not available heritage difficult to read, but at the same time they represent a potential culture resource.
In fact until today it has been preferred to promote the valorisation of the structures existing in the archaeological areas which, having undergone no reuses, has preserved, even if as a ruin, an authentic "classical" appearance. Moreover the same cultural conditions have often suggested restoration actions on roman system buildings in order to remove the stratification, thus recovering the original image of the monument and therefore decreeing the irreversible loss of the precious evidences of stratification that the history left.

On the contrary, the presence of complex elements arising from successive stratifications, present in the urban centres and in all the land of interest, has not still undergone a recognition process. This happened because of the lack of instruments useful to spread the acknowledgment about the secular processes causing stratification (6).
Therefore, the necessity to improve the acknowledgment instruments, finalized to the valorisation of this heritage, raised from the increasing interest for the conservation of the cultural assets in Europe and in other Countries and from the initiatives undertaken in the field of conservation and of valorisation of archaeological assets.
Thus, once identified the assets present in the land and once analysed all the transformations they have undergone, it is necessary testing instruments for the reading of the classical evidences in the architectures, in the urban centre and in the landscape, by the aid proper strategies promotion.
Actually, in the last years, some Italian areas have been object of analogous studies, that has been often used as a starting point to plane the valorisation of the heritage places in Italy. Therefore the objective is the one of inserting all the regions, such as Piemonte, inside of a national panorama already consolidated. In Piemonte applied instruments of acquaintance and valorisation are too much berthed to the traditional systems of assessment and the current graphical representation is no more suitable to evidence those aspects able to emphasize such immense and interesting heritage (7).
Therefore the acquaintance of this complex heritage is the result of a process of surveying that can be summarized as follows:
- Location on the territory of the roman urban and architectonic heritage, through topographical maps, pointing out the subsequently stratified complexes.
- Control of the normative state and of the protection ties regulating the safeguard of the archaeological goods and particularly the elements of successive stratification.
- Control of the existing graphical documentation and execution of new surveys with more sophisticated technologies.
- Reading of the classical permanence in the urban and territorial tracings.
- Historical chronological list of the buildings with the identification of the transformations deriving from the functional fittings.
- Identification of the incongruous elements more recently added.
- Study of the building elements and the technological solutions found in the following fittings and control of their state of efficiency.
- Identification of the reuse elements (marmoreal blocks, pieces of columns, capitals, tombstones...) recognizable in the stratifications of the own structures and in the surrounding urban context.
- The analysis of the current use destination and of the environmental background in order to study compatibility between the conservation of manufactures and their current function.
- Realization of thematic tables dealing with the state of conservation of the preserved buildings.
- Recognition of eventual archaeological finds preserved in museums and bound to the examined buildings and urban structures, in order to facilitate the understanding of the same ones.

Moreover, aiming at conservation and valorisation, it is necessary to write up a Paper of the methodological guidelines in order to define a reference instrument containing the typologies, the requirements and the priorities among the acknowledgment actions and the conservation and valorisation of the heritage.
This paper will supply the following indications:
- Planes of conservation providing for actions of restoration, consolidation and planned maintenance.
- Urban and environmental recover plans.
- Compatible reuse proposals.

Such a document, in reference to the directions contained in the most recent Papers of the Restoration, will put the attention on: the recognition of the cultural value of the heritage; the modalities of intervention on materials and building elements; the permanence of the distributive and functional features; the relations with the urban and territorial context; the relationship with the economic and social status.
At last, in terms of valorisation and promotion, the more expected outcome could be a series of instruments allowing a guided reading (scientifically correct and easy to understand) of the heritage stratified in Piemonte. In particular:
- The planning of thematic routes to regional and sub-regional level for the reading of the architectonic-environmental evidences.
- The publication of maps, historical data, virtual reconstructions of the architectures and of the various transformations, and the abacus of the reuse elements found in the own structures or in the urban context.
- The creation of a GIS connecting the various spheres of study, making it accessible for various information scales .

2. A CASE STUDY: THE ROMAN THEATRE OF LIBARNA

To propose the above mentioned methodology, the study case of the roman theatre in Libarna is here illustrated (8).
The roman theatre of Libarna is part of a larger archeological site along the main road n. 35 “dei Giovi” to Genova, this area is located between the two towns of Serravalle Scrivia and Arquata Scrivia. The roman theatre was builted in the first century A.D. by Attilius Bradua, as remembered by an inscription found near the builder, during the first excavation.
From the architectonic point of view, the structure and the plan arrangement are according to the typical roman theatre plan although it presents some changes due to distributive and constructive requirements. An accurate hypothesis of reconstruction was formulated by Silvana Finocchi.
The plan of the theatre is today quite understandable; there are still preserved traces of the *vomitoria* and part of the scene, part of the bases of the pillars once supporting the semicircular corridor, part of the semicircular wall, marked by still well visible pilasters, propping the *cavea*.
Generally the masonries show an advanced state of decay. According to the methodological formulations before established we proceeded, after the historical, bibliographical, cartographic and archival studies, with the analysis of environmental, geometric-dimensional, technical-constructive, of matters and of the damage assessment.

2.1 The excavation steps

Thanks to the photographic documentation, kept at the archive of the Piedmont archaeological Office, it was possible to reconstruct the main steps of excavation and restoration executed in the period between 1911 and 1965. We can trace three important steps in the excavation works, carried out in first decade of the 900, in the forties and in the sixties.
The plotting obtained with this survey were useful to represent the situation of the structures emerged in that excavation steps with a three dimensional model.

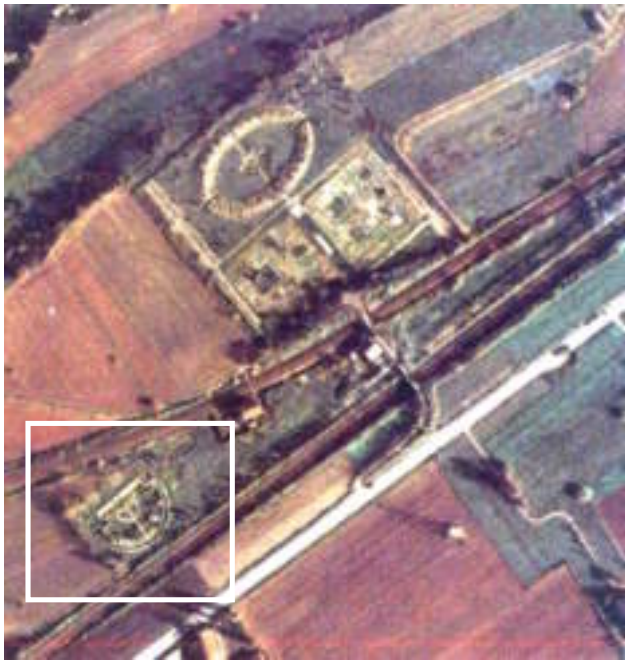

Figure 1. Libarna: aerial view of the whole archeological site

2.1.1 1911: After the early finds (1823) regarding the external semicircular ambulatory, in the 1911 began new excavation works, under the direction of G. Moretti.
From the excavations came to the surface: the walls of the radial substructions of the *cavea*, the masonries of support of the central *parodos* and the two semicircular *exhedrae*. At the end it was possible to see completely the *cavea* but there was no trace of the scene and the orchestra.

2.1.2 The forties: Findings of the orchestra and of the walls of the scene. The works started in 1937 under the direction of C. Carducci; (9) discovered the hydraulic works (waterworks feeding of the scene; channel in correspondence of the central *parodos*; *euripo*, that is the underground channel with a barrel vault, under the *cavea* and the scene at service of the adjacent thermal system). These findings enabled the study and the understanding of the draining waters system of Libarna.
Particularly interesting was the recovery of the holes in which were placed the pillars of the stage. The excavation of the area between the scene and the orchestra dug out the stony columns which supported the beams of the stage. The stony columns were replaced in the original position.

2.1.3 The sixties: The excavations of the sixties mainly involved the masonries of the scene that were still partially underground, while from the photographic documentation of the age seems it was not still dig out the portion of the *porticus post scenam* today partially covered by the railway line.

2.2 The survey

The metric survey of the Libarna theatre was the starting point of the subsequent analysis aimed at the conservation plan of the structures. On one hand, geometric-compositional and dimensional indication were acquired and, on the other hand, it was possible to recognize and study the building technologies, the walls texture and their actual state of conservation. Before proceeding to the survey a study and a critical interpretation of the existing graphical material were carried out; a survey of 1985 was the most updated graphic representation. Considered its incompleteness and the unsatisfactory metric reliability it was decided to proceed with a new survey. The survey was carried out by the integration of different methods: topography to define a reference system and to acquire 3d points describing the schema of the whole structure, digital rectification for thematic representations, digital photogrammetry and laser scanner for the documentation of the not flat parts. For each kind of analysis we establish the most appropriate scale drawing: 1:200 for the geometric study of the

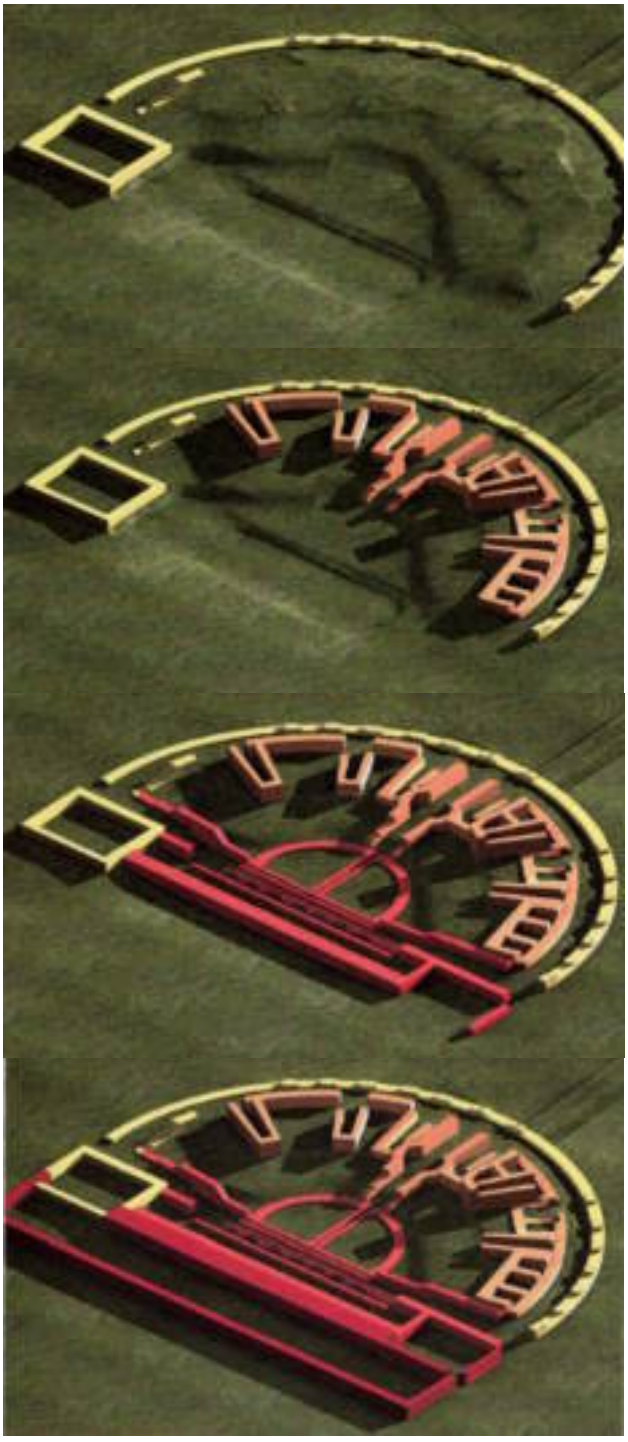

Figure 2. Libarna: 3D model
of the theatre main excavation steps

entire site, 1:50 and 1:20 for more detailed description of the materials, of the constructive techniques and of the state of conservation. The topographical survey was carried out with a total station 700 DTM Nikon. About 500 points were measured for the whole description of the structures.
The altimetry along the most meaningful sections was measured with an electronic level. The geometric description of the elevations was integrated with photographic rectifications in order to analyze and to understand textures, colours and decay and for drawing all the information useful to the conservation project. For the semicircular *exhedras* of the central *parodos* Cyclop system (a Menci Software product) was used: a revision of a stereometric cameras principle. It enables non experts to acquire stereoimages and to visualize a stereomodel without control points, the most demanding survey phase.
The acquisition system is an horizontal metal bar on a tripod, with a sledge run, on which it is possible to put any type of camera. To obtain stereoimages with known base and parallel optical axis, the sledge is fixed with a calibrated distance block. It is equipped with a specific software that allows the immediate plotting without orientation steps (10).
In order to arrange a photographic support - geometrically corrected - also for the *exhedras*, a dense DTM was acquired with a laser scanner Riegl Lms-Z210. For each *exhedra* three range maps were acquired; each range map contain 5 reflecting targets, topographically measured, in order to refer the clouds of points to the same system used for all the structures of the theatre. After the elaboration of the acquired data, useful integrations - to complete the archaeological survey with the required details were carried out with direct measurement. By the results of the survey was possible to verify the amazing coincidence between the planimetrical framework of the theatre of Libarna and the very famous Vitruvio's schema for the geometric lay-out of the roman theatres (11).

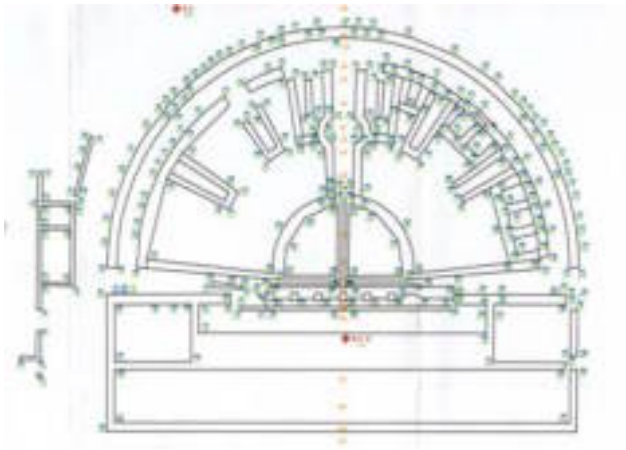

Figure 3. Topographic survey

2.3 Materials and constructive techniques

The materials of the theatre masonry, almost exclusively of local origin, are Monastero sandstones (platform, bases and pillars of the exterior), Serravalle sandstone, pebbles (finishing of the *cavea* radial substructures) and bricks. Opposite to what attested by the historians of the 19° century, nowadays the theatre does not have any marble coating, but it has only isolated marble fragments, which were reused inside the masonry and spread out on the ground. The constructive techniques are different in the sectors; the external walls of the *cavea* are mostly interesting: the finishing texture is *opus vittatum*, in which *sesquipedali* bricks are embedded any 60 cm, for the whole thickness. In the theatre, most part of the masonry has staggered joints, with variable thickness to compensate the different dimensions of the stone ashlars. Masonry of the scene is particularly interesting, which is conserved at the level of foundation, because it shows a wide employment of broken smoothed pebbles.
To understand the mortar composition of Libarna theatre, appropriate laboratory analyses were carried out (X-ray diffrattometry, mercury porosimetric analysis, spot tests, scansion electronic microscope) on a sample of mortar which was taken from the northern supporting masonry of the lateral *parodos*; the masonry remained un-repaired in previous interventions. The results of the diffrattometry show the calcium carbonate presence, as a component of the lime mortar, and quartz, component of the sand. The percentages is 2:1 for lime and sand. Porosity resulted 32,7%, with a uniform distribution of the pores diameter. The mortar porosity evaluation, if compared with the porosity of an integral samples, gives useful indications on its state of decay. Spots tests results permitted to determine the dosage of binder of the roman mortar; on the basis of findings and tests results, a mortar with a composition similar to the original one was produced to consolidate the most damaged structures.

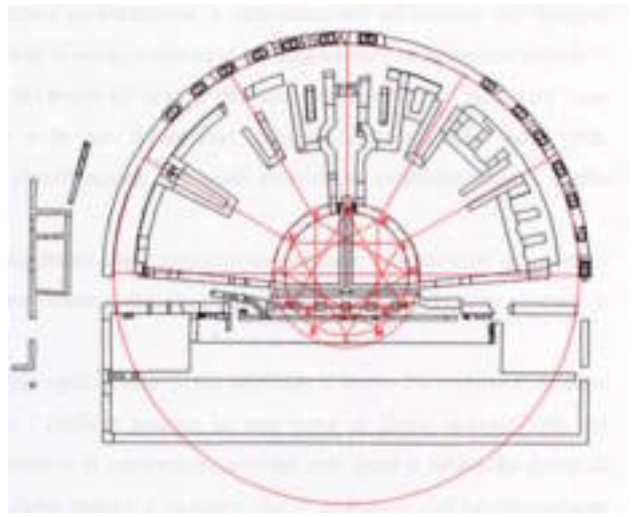

Figure 4. Application of Vitruvio's geometric construction

Figure 5. Elevation of the *cavea*

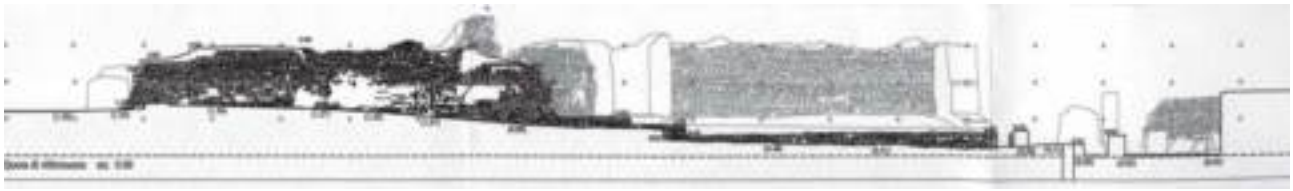

Figure 6. Cross section of the theatre

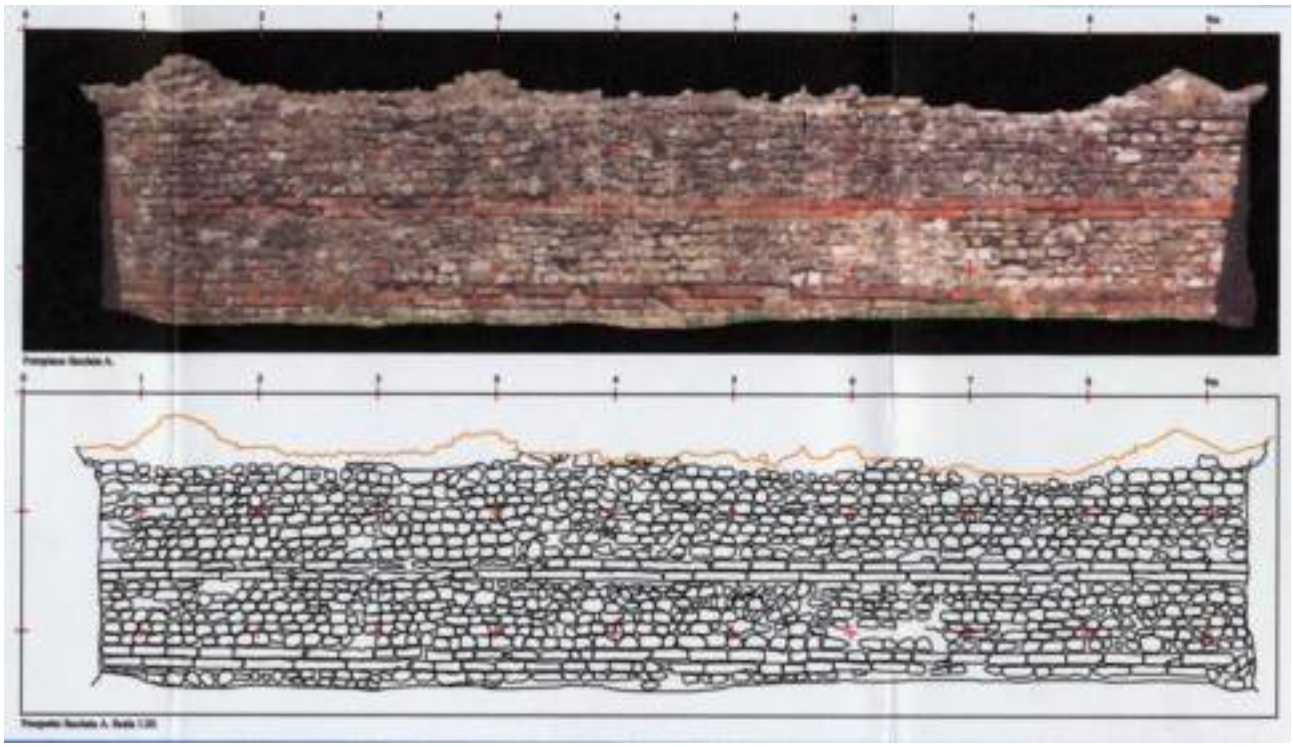

Figure 7. Digital rectification of a wall and its vectorial drawing

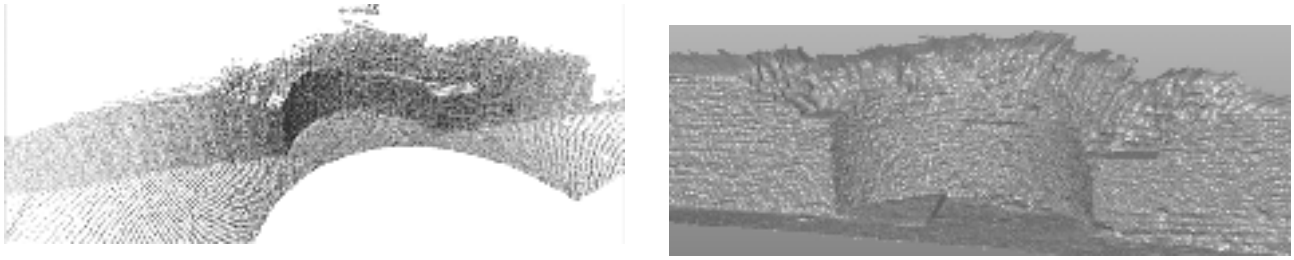

Figure 8. Cloud of points of an *exhedra* (left) and its mesh after the elaboration (right)

Finally, by optical scansion electronic microscope, it has been possible to compare a mortar sample taken from the masonry of the theatre with the seriously damaged one, which was taken from the arena of the amphitheatre. Operators noticed the formation of gypsum crystals, which generate fractures in the lime by crystalization between its grains. Consequently, gypsum crystals make more fragile the materials and exposed to the aggressive action of the atmospheric agents until, in extreme cases, the collapse of the masonry (as occurred in the amphitheatre).

2.4 Damage assessment

In order to integrate the documentation focused on the restoration plan, operators carried out the analysis of the state of conservation, by identifying the pathologies and analysing their causes: atmospheric agents, condensation or capillary humidity, temperature range, human actions and wrong restorations in the past. The direct visual analysis is always a fundamental starting point, although analysis addressed to an accurate diagnosis were performed. The state of conservation of structures and materials, as observed and verified by inspections, has been plotted on the rectified images and orthophotos. The results are thematic maps, which complete the graphical documentation supporting the restoration plan. The weather and environmental monitoring stations near to Serravalle Scrivia and Arquata Scrivia (Piedmont Region owner) provided data on climate and atmospheric pollution. These data allowed to recognize the main agents of the decay processes on masonry (exhaust gas and polluting emissions of the heating plants, naphtha combustion products of the regional trains, emissions of the cement industries on the outskirts of Arquata Scrivia) due to the unfavourable position of the archaeological site (it is close to state road, two railway lines and some industrial plants). Decay due to draining water, damp and superficial erosion phenomena were found on stones, bricks and

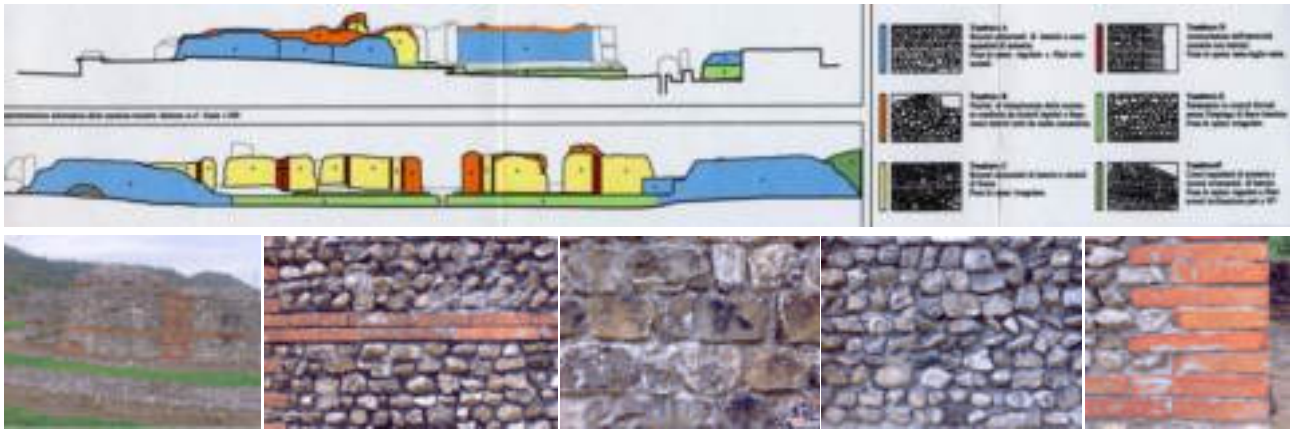

Figure 9. Materials and constructive techniques map

mortars of the theatre masonries, which are without protective structures, like covering or cantilever roofs: damage gets worse also because of the elevated sandstones porosity.
The erosion phenomenon is particularly apparent on the pillars of the external semicircular ambulatory and the columns close to the scene. The combination of wind and water actions magnifies phenomena of (surface erosion) and salt crystallization. Therefore, rain and wind are the main responsible for the "pattern" of the decay on the elevations of the structures.
Phenomena of spoiling chips, due to cryoclastism, are visible on the northern masonries. The high values of humidity, due to condensation, capillary, and the strong material hygroscopicity, trigger processes of chemical reaction. The process makes the attacks of vegetation easier than on sound materials. The biodegradation is attested, above all in the most wet zones, by the formation of algas, mosses and lichens and the increase of the infesting vegetation. Limited cracks, above all close to the corners of masonry, can be due to subsiding foundations or the modifications due to the land adjustment. Finally, the effect of the wrong past restorations is not negligible. In the recent past some parts of the masonry were filled and levelled with improper materials. The intervention produces rough patches. In particular, in the Sixties, operators consolidated the stone masonry of the scene by concrete: the contact between stone and cement caused the disintegration and the cracks of the stone, therefore facilitating the infiltration of meteoric waters inside the structures.

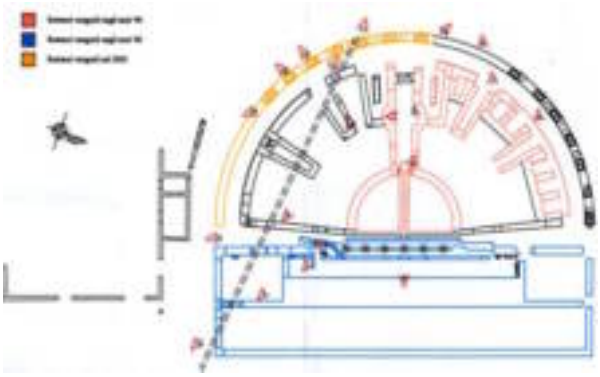

Figure 10. Thematic map of the previous restoration

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