Integrated survey methodologies for the knowledge, restoration and valorization of modern architecture. The case study of the Archaeological Museum of Siracusa designed by Franco Minissi
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Introduction
The knowledge of an articulate architectural organism cannot disregard its critical observation: it is important to detect what it generously shows but especially what it jealously hides. This twofold recognition allows making the essential breakthrough for the planning of a conscious restoration project that will so find on it, a solid support on which to unfold and develop. This identification is a multi-faceted process that can today take advantage of digital technologies. These instruments - if properly selected and managed - can facilitate an in-depth investigation, stimulating new considerations and inspiring new fields to explore.

In this framework, this paper describes the path followed in the study of a modern building: the Regional Archaeological Museum “Paolo Orsi” in Syracuse, designed by Franco Minissi in the ‘60s and opened to the public almost 30 years later. This work, based on a careful “reading” of the edifice and its environment, made by integrating archival and documentary analysis and different survey methods, aims at suggesting the proper interventions to conserve and enhance the design process developed by the author. It, also, intends to contribute to the definition of a new approach to the museum visitor experiences through multimedia. Conceived as a vital center for research and cultural promotion, the museum, thanks to virtual reality technologies, can today found new capabilities, although keeping its original spirit.

1. The analysis of archival and documentary sources for the historical reconstruction of the Archaeological Museum of Syracuse architecture (1960-1988)
The examination of archival and documentary sources carried out at the Superintendence of BB.AA.CC. and at the State Archive of Siracusa, as well as at Central Archives of the State in Rome (Fondo Franco Minissi)¹, has allowed the reconstruction of the elaborate phases of planning, design and construction of the building. The first architect’s ideas (since the sketches drawn up for the project of the 1961) and the subsequent design variants (1962-1988), were then graphically compared with the work actually carried out. The current collection, the objects display principles and the modalities for museum access and visit, likened to the provisions of Minissi’s original project, helped in identifying aspects of great innovation and actuality, although designed in the ‘60s (fig.1).

The architectural plans and the interior design were studied by Minissi (in collaboration with Vincenzo Cabianca and on the basis of the inputs of Luigi Bernabò Brea, the Superintendent of Syracuse at that time), in order to ensu-
re the highest ductility. The intent of Minissi was to integrate the internal space of the museum with the external one through the insertion of patios. These elements will so provide natural lighting to the interior spaces, as well as a direct access to the outside. The patios will also interrupt the great extension of the roof surfaces, creating a sort of islands around which the architectural composition would be organized. The main idea was to create a “museum in movement”, a kind of “antimuseum” able to expand with the incrementing of the collections from excavations and the progress of scientific research. It was to obtain this “flexibility” - furthermore explicitly required to the designers - that a centrally based scheme was chosen. This would allow grouping the didactic sections together at the center, from which, spreading out like the petals of a daisy, the sections containing the exhibits could follow in a logical sequence. Moreover, the architectural plan was conceived on a modular principle following an equilateral triangular mesh, to which even the didactical equipment and the display cabinets adapted.

As required by the Ministero della Pubblica Istruzione in 1962, this would permit to eliminate all rigidity, allowing the visitors the choice of making either a complete and organized visit or a partial one during which they could freely go to any section of particular interest to them, without having to follow the general itinerary. The museum was set on three floors (including a basement) for a total area of 12,000 square meters, perfectly integrated with the surrounding natural space, showing the clear influences from Frank Lloyd Wright’s organic commandment. As required by the “client”, each section was composed by a historical-didactic section, an exhibition of what might be called “first selection” material, an exhibition of “second selection” material (i.e., works and references of particular interest to researchers), and a storeroom.

The Ministry approved the final design in 1967, with the arrival of the first funding provided by the Cassa del Mezzogiorno. On October 30, 1968, the Supreme Council of Antiquities and Fine Arts required a number of modifications, such as the unification of some patios and the suppression of the southeastern pavilion. In response to these claims, it was therefore necessary to amend the central part with a polygonal instead of a circular solution, with a consequent
increase of the circulation area around the central core, and so enhancing the function of movement and some “elasticity” in the museum visit. After several hitches, work interruptions due to the lack of funds, changes during the construction phase and maintenance interventions, the museum was opened to the public in 1988 (even if only the sections at the ground floor had been staged), benefitting from a wide internationally resonance. In May 2006, the pavilion D on the third floor of the museum was inaugurated in execution of a project delivered in 2001, while the set-up of E and F sectors is expected in the coming months. The area devoted to medals opened in 2010 and is located in the basement of the museum. The study undertaken has allowed clarifying the reasons underlying the present museum’s layout. It constitutes an essential step toward the comprehension of the successive phases of measurement and not only. Actually, the investigation and the successive clarification of creative and building processes are an important twofold planning component. On the one hand, they can drive and support building restoration choices and on the other, create an additional source of information to make available to museum visitors, which may so have the opportunity to both learn about archaeological remains exhibited and on the story of their precious “container”.

2. The need for an integrated survey
The wide and multifaceted geometry of the building and the park outside has required the use of several integrated survey methods. In particular, the traditional direct (made by straight rulers, measuring tapes, laser distance meters) and topographic (Global Positioning System and total station) acquisitions were combined with laser scanning and photogrammetric techniques. The need to employ a so varied instrumentation was dictated both by the diversity of the elements to measure - variables from small to large scale – and by the opportunity to simultaneously grasp aspects with a high level of detail, spatial elements, metric and colorimetric data, materials and shapes, structural and plant engineering systems. This has led to the understanding and accurate redrawing of the articulated geometry of the building, set in a dense mesh of hexagonal pillars arranged in a honeycomb pattern. As the museum is part of the XIXth century park of Villa Landolina and is situated in the area of a famous Greek latomia, the topographic survey has been an important step for the reconstruction of the intricate altimetry of external routes for which Minissi had requested the collaboration of the landscape architect Pietro Porcinai. The use of the total station and GPS enabled geo-referencing within Sicilian regional cartographic system, the coordinated of all points measured. To this end, two closed traverses (linked between them) were established: one external to the fenced area of the museum (in order to correctly identify the boundaries and relate them to the coordinates of known points of Italian GPS Reference Network (IGM) and the other along the inner perimeter of the museum and garden. Their vertices, measured by means of a total station Topcon GTS-105N and offset in order to minimize closure errors and evenly redistribute them on each station, have supported both the GPS and the laser scanning survey.
In particular, the measurements were performed by differential mode with two global navigation satellite system (GNSS) receivers Topcon GR-3 series, a fixed one placed at the vertices of the network intended to allow the best satellite signal reception and a mobile rover positioned from time to time in correspondence of points of interest to acquire. Besides, the “internal” traverse allowed to “beat” the coordinates of the centers of the checkerboard paper targets composing the local network necessary to the registration of scans made with the terrestrial laser scanner. The measurement of the absolute coordinates of the checkerboard paper targets has made it possible to relate the position of every single point cloud with respect to the unique system of reference adopted, while the measurement of the partial distances has allowed checking the accuracy of the targets network. In particular, the laser scanner technology has been used for the survey of the building in its entirety. 3D scans (more than 500) were entirely performed with the instrumentation Faro Focus 3D and aligned thanks to recording networks created by means of checkerboard paper targets and polycarbonate spheres. The small distance between each station - always less than 15 meters to ensure the optimal automatic detection of targets at the chosen laser scanner resolution - i.e. 1/4 of the maximum one and a quality of 4x - has resulted in a very dense final point cloud with limited occluded areas. During every scan, it were acquired approximately 43,000,000 of points in times slightly higher than 9 minutes (including color data).

Following the subsequent registration phase carried out by the FARO Scene 5.1 software, it has been possible to obtain textured 3D models. From them, high-resolution orthophotos (at the nominal tolerance for vectorial representations of 1:50), necessary for the rendering of top and plan views, elevations, longitudinal and transversal sections to describe the structure as a whole and all of its structural components, were extracted. The orthographic projections produced were subsequently “reworked” in accordance with established practices of 2D graphics in order to get images allowing a more clear and defined reading of degradation phenomena (and in general of the status quo of the building) while not altering the veracity of colors, materials and geometry (fig.2). Moreover, the integration of different instruments and survey methods aimed at acquiring three-dimensional data has made it easier the 3D modeling of the building. To the aim of making it more intuitive some stages of the design evolution of the museum, both the virtual model of the as-built work and the original planned version of 1961 have been created, the latter supported by the redraw of the original design charts discovered in the process of archival researches (fig.3). The CAD model, easily converted in the .stl format, was also used to support methodological processes of reverse engineering and rapid prototyping. Actually, the creation of 3D models was aimed not only at the virtual reconstruction (image rendering) but also at the realization of a polypropylene-like material prototype of the museum, on the size of about 23x19x3 cm and at 28-micron resolution. To this end, it was used the 3D printer Objet24, designed to jet head slides back and forth along the X-axis, similar to a line printer, so depositing a single super-thin layer (16μ) of photopolymer onto the build tray. Immediately after building each layer, UV bulbs alongside
Fig. 2 - The 3D laser scanning survey for the understanding and the representation of the morphology of the building: point clouds and orthographic projection

Fig. 3 - Three-dimensional virtual reconstruction of the museum based on the preliminary plan (left) and the survey of the status quo (right)

the jetting bridge emit UV light, immediately curing and hardening each layer, so eliminating the additional post curing required by other technologies. Two different photopolymer materials were employed: one for the real model and another gel-like material for support. Once the build was finished, a water jet easily removed the support material, leaving a smooth surface (fig. 4).

As anticipated, the phases of geometric and material knowledge have not, however, only been focused on the architecture itself but went as far as to the small scale. This resulted in the digital surveying of one of the most important
pieces from the collection of the Museum, unfortunately, for reasons of space, inaccessible to the public: the marble head dating from the 2nd century - probably between 128 and 149 - representing a patrician woman “Clodia Falconilla” and measuring about 22x25x30 cm. The acquisition was performed by integrating the three-dimensional morphological data obtained by means of laser scans and those arising from color photographs of the exhibit taken by a Canon EOS 5D, equipped with a full-frame sensor of 21 megapixels and with a fixed focal length lens Canon 24mm/f1.4. The merge of the two types of data was possible after the operations of photomapping, by which images were projected on the monochromatic mesh model, so generating a high-resolution texture (fig.5).

The measurements of the artifact were carried out using the FaroArm® Edge based on the handheld laser scanner technology in which, the scanning system applies the triangulation calculation and includes a laser-stripe generator at the tip of the arm allowing movements with seven degrees of freedom. Maneuvered by hand on the free surface of the object to be detected at a distance of about 15-20 cm, this procedure allows obtaining the digital 3D model of the object, avoiding any physical contact with its surface, so respecting its integrity. For scanning, it has been necessary to place the instrument in two different handholds located opposite to the front and to the rear of the sculpture; a single station, in fact, did not offer the possibility of a rotation of 360° around the object. The data obtained, which were visible in real time during the scan in the monitor of the PC connected to the instrument, thus were made up of two clouds of about 3.000.000 points each. The Geomagic Studio 12® software allowed performing the post processing phases, so that: to record the two scans by exploiting the homologous points present in overlapping surfaces specifically detected; to obtain a single point cloud consisting of about 2.500.000 points; and to originate a continuous model mesh of about 1.500.000 triangles from which exporting orthophotos and dynamic .pdf files. The benefits assured by the methodology here employed can be found in the high precision of scanning data (± 35 micron) associated with photorealistic color information, in the speed of acquisition and in the possibility to conduct the survey in situ, so avoiding the transport of the object in a laboratory external to the museum. Even in this case, the obtained digital model was converted into a .stl file and then used for the realization of a resin prototype at 1:10 scale (fig.6).
Finally, for the perception and communication of spaces the technique of immersive 360° photography has been adopted. Following a preliminary, methodical and accurate photographic campaign, scenic tours based on navigable spherical images were created. They permit moving around inside the museum accessing, not physically but virtually all premises, including deposits. This kind of photographic survey, supported by techniques of photo sticking, proved to be a useful investigative tool too, through which obtaining information on the colorimetric characteristics of space, the exhibition itineraries, the display cabinet and the plant designs. At the same time, as well as being a useful working tool, it allows accessing in an indirect and virtual way to the museum premises. For the acquisition of these data, photographs were taken from different stations. They were mounted together in post-production to create a single path inside the halls of the museum and the surrounding park.

3. Conclusions
The case study here presented intends to show the first results of a pilot project launched by the Laboratory of Restoration of Architectural and Cultural Heritage of KORE University in collaboration with the University of Bergamo. The acquired data, subsequently integrated with other elements of detail, are an important database for the establishment of a multimedia platform at differentiated levels of accessibility, firstly useful to the museum’s administration to the appropriate need for control and maintenance but that could easily also be
opened to scholars and tourists, with a view to create an interactive or a virtual museum. The survey made by integrated methodologies (traditional, advanced and innovative), led to the creation of the fully navigable 3D digital model of the museum. Organized at various levels in order to make clear the form and the architectural structure, it has allowed the understanding of the entire building: a vast system based on a hexagonal geometry that found in the interaction between the environment and the constant change of heights, its most interesting spatial character. It could also offer the opportunity to “virtually” visit the museum and the park from outside, as well as the places currently inaccessible, such as the storages. Actually, digital technology can overcome problems dictated by the shortage of space and the presence of logistical constraints, restoring or enhancing the original spirit expressed by Minissi since the early projects, of an immersive and complete fruition of the archaeological heritage of the museum. Minissi fact was fully aware of the “alive” nature of the collections, even in progress. This objective, perhaps today difficult to achieve in a real way, could be attained with the help of virtual reality, allowing to realize new virtual paths and encouraging users to visit the museum after having obtained through the web an overview of what it can offer.

**Notes**

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**References**


