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INTEGRATED SURVEY METHODOLOGIES FOR THE MULTI-SCALE KNOWLEDGE OF ARCHAEOLOGY OF ARCHITECTURE: THE SURVEY OF THE AMPHITHEATRE IN DURRËS

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Abstract

In 2005 the MIUR co-financed an internationalization project coordinated by prof. Paolo Giandebiaggi and entitled *Survey of the amphitheatre in Durrës: understanding a monument for the enhancement of world cultural heritage*. The collaboration between several Italian and Albanian partners made it possible to continue the work initiated in 2004 till 2015. The mission carried out several archaeological, architectural and urban surveys using different integrated survey methodologies as the first important step to acquire knowledge in order to diagnose and draft restoration and refunctionalisation project for the amphitheatre.

Keywords

Survey, Multiscale knowledge, Archaeology of architecture

1. *The amphitheatre in Durrës*

The amphitheatre in Durrës is one of the biggest in the Balkans and, as far we know, the only one in Albania. It is located in the west sector of the old city next to Byzantine walls. While part of the amphitheatre nestles against the hillside, the rest is built on concamerated substructures.

Discovered in 1966 by Vangjel Toçi, the father of archaeology in Durrës, approximately two thirds of the site was immediately excavated by Albanese archaeologists[1]. The *arena* (a small part of which was brought to light) was surrounded by a *podium*; the *cavea* was divided into *maenianum*, *primum* and *secundum* separated by a small *praecinctio*, while a bigger one separated them from a possible *summa cavea*[2], of which, however, no traces remain. The building was constructed in *opus coementicium* clad with *opus mixtum*, brick bands, and stone *incertum*; the tiered limestone seats have been completely removed, but partial impressions are left on the *opus coementicium* structure.

According to Vangjel Toçi, the amphitheatre was built under Trajan (98-117 A.D.), when a library was also built in the city; these works were part of an Imperial urban master plan which on the one hand catered to the entertainment needs of the populace and, on the other, enhanced the cultural status of the city[3]. The amphitheatre was apparently abandoned in the second half of the fourth century A.D. due to a ban on gladiator sports, but perhaps the damage caused by the earthquake in 346 A.D. is a more plausible reason[4]; the attempts at restoration constitute one of the objectives of this research programme.

It is unclear whether after the ban the amphitheatre became a defensive element as part of the Byzantine walls (built between the late fifth and early sixth century A.D.[5]) running alongside its outer perimeter. Once the arena and galleries were no longer used for entertainment purposes they became a necropolis (at least from the seventh

[1] Toçi, V., 1971.
[2] Golvin, J.C., 1988.
[3] This theory, also supported by Golvin, is based on material found mainly in the excavation area, on yhe building technique, and on inductive reasoning regarding the inscription CIL III, 607 referring to *munus gladiatorium*, now lost and without a reliable transcription.
[4] Regarding earthquakes in Durrës: Guidoboni E., Comastri A., Traina G. et al., 1994; Santoro S., Hoti A., Monti A., Shehi E., 2003.
[5] Gutteridge A., Hoti A., Hurst A.R., 2001.

Fig. 1: Aerial view of the amphitheatre and urban fabric from the Ottoman period

century onwards[6]) and perhaps also a residential area: whatever the case, they became a place of Christian worship. Between the sixth and tenth century, a small crape decorated with paintings and mosaics was built in one of the inner chamber along the minor axis; although these embellishments are very interesting, their interpretation and dating remains very controversial. Another chapel, on the opposite side, was completely frescoed with paintings dating to the tenth to fourteenth century; unfortunately these frescoes are now completely indecipherable. Like the second crape, a small third chapel (a tiny rectangular apsed area) opens onto the anular service corridor (the lowest) probably at the level of the arena, at present this crape has no cladding.

The amphitheatre was well known, and perhaps also partly visible, as far back as 1508: Barletius mentions it in his biography of Scanderberg[7]. After which it disappeared, buried under the hillside. Then under the Turks and again in the twentieth century, houses were built on it scope and over what little was still visible; however, the roads in the neighbourhood circled the oval amphitheatre. After a rather fortuitous discovery, the excavations by V. Toçi in 1966 brought to light part of the cavea, the arena and the galleries. The structures were then fully restored using an integrative approach; this included modification on the internal pathways due to complete collapse of some of the galleries.

However the criteria adopted ensured that this modern restoration was visible, a fact reported in several documents. Very few excavations and restoration projects were carried out after that. Unfortunately there are no surviving documents and information about these later projects is entrusted only to the memory of those who worked there, undoubtedly in very difficult conditions. The size[8] and the internal and external layout of the amphitheatre were unclear not only due to the incomplete excavation which had brought to light only a very small part of the perimeter of the arena, but also because this unusual construction nestled against the hillside; a third of the internal pathways (the best preserved) was created by digging galleries, while all the others run along the concentric concamerated underground rings, with asymmetrical stairs and *vomitoria*. It is unclear what the large north gallery leading into the hillside was used for (blind alley or passage); likewise, the function of a possible south gallery is also a mistery. As a result, we cannot accurately establish the exact size of the amphitheatre, its layout, vaults and arches, nor its plan and internal design. Accordingly, the reconstruction of its geometry and the study of its internal layout design was one of our most important research issues. A survey, restitution and architectural/geometric study was performer by the team from the Faculties of Architecture and Engineeing in Parma (Sceintific coordinator prof. Paolo Giandebiaggi) during the new archaeological excavations carried out within the framework of the "Durrës project", an International Cooperation Agreement for the safeguard of the archaeological heritage of Durrës signed between the University of Parma, UNOPS, the Durrës Archaeological Museum, the Institute of Archaeology of the Academy of Sciences, the Municipality of Durrës and the Institute of Cultural Monuments of the Ministry of Sports and Youth of the Republic of Albania. The project was executed by the archaeologists of the University of Parma and Chieti-Pescara, coordinated and directed by prof. Sara Santoro.

2. *The first survey campaigns*

Before we could draft an initial containment project, we urgently needed to carry out a

[6] Toçi v., Op. cit.
[7] Barleti, 2012.

[8] In literature its major axis is presumed to be 136 m long with a seating capacity of 15-20.000 spectators; Golvin J.C., op. cit. p. 203.

topographic survey not only of the physical limits of the amphitheatre and neighbouring properties, but also the geometry of its excavated parts. There were several reasons for this: the lack of accurate information about the stability of the amphitheatre and adjacent building (so that they could be used for other purpose and not just as a museum), as well as the rather unreliable and fragmentary graphic documentation.

The superimposition and seamless continuity between the remains of the old amphitheatre and the urban fabric of the Ottoman city inside the very recognisable fortified enclosure (to some extent still standing) meant that we had to start with a topographic survey of the remains of the ancient amphitheatre and its urban surroundings.

The survey was divided into two parts: an urban survey to place the architectural object in the context by establishing and redrawing the boundaries of the oldest nucleus of the Ottoman city, as well as the identification, measurement and analysis of the city blocks based on an accurate photographic survey and cataloguing of the building types. This was followed by an indirect survey of the amphitheatre and its contextualisation. The planimetric data were acquired and used to establish the basic structure of the footprint of the amphitheatre and the elements contributing to its profile.

For logistical and organisational reasons the topographic and urban surveys were carried out at the same time. A total station was used to perform the indirect survey; a total of 5/6 operators were part of two teams involved in the field campaign. Starting with the closed traverse with nine vertices outside the amphitheatre, more stations were located inside the arena and further points were added using the "free station" concept; these points were limited by the compensation made during the calculation of the main traverse to which they were linked. These points, which could be defined as the vertices of a second order open traverse, were considered crucial in order to be able to use the narrow openings to access the galleries, fornices and ambulatories excavated in the Sixties and also to carry out a direct survey of the details in the future. Overall, we surveyed the topographic position of more than 1.000 points (1.031).

We established the geometry and exact position of the remains of the old structure of the amphitheatre and adjacent buildings, which were to some extent located inside the area already

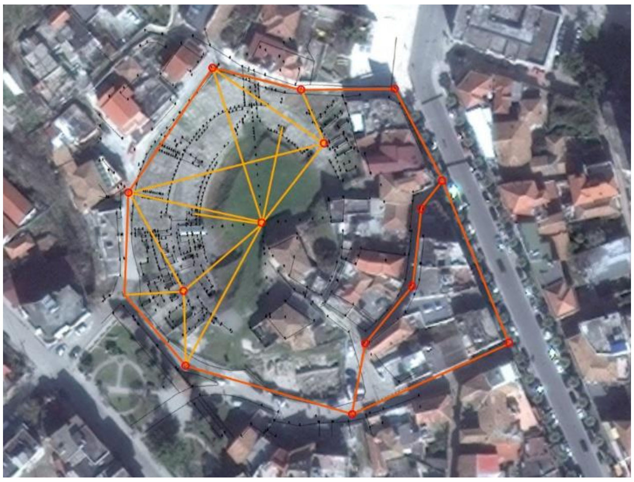

Fig. 2: Planimetric representation based on the photogrammetry of the topographic traverse and points

occupied by arena and its tiered steps. The entire work focused on the excavated area, the visible walls of the archaeological remains, the position of the enclosure and buildings bordering the excavated parts, and the ones above the unexcavated area; in other words roughly half the arena and a third of the cavea (south-east part).

The initial survey campaign was followed by direct surveys of smaller areas; this allowed us to elaborate the forms of the tiered seats which had already been brought to light, the visible portions of the wall of the podium around the larger excavated area of the arena, the internal galleries we knew and could actually access, and also the layout of the radial walls in the north-east area with entrances to inaccessible underground galleries for private use. We focused in particular on the survey of the north gallery, along the major axis of the oval, and were able to establish and verify the minor axis which appears to coincide with the axis of the chapel built in the west area.

An underground passage at the end of the north gallery allowed us to reach and survey the probably position of the outer perimeter. As in more famous amphitheatres, over the years several buildings have been constructed over the ruins of the amphitheatre. Despite the fact that the urban fabric reflects the underlying presence of a curved construction with radial walls, it completely covers all traces of the latter.

Many of the existing buildings constructed over the ruins of the amphitheatre have used the inaccessible galleries as cellars.

The plans drawn up after restitution also show that in many cases the walls of this ancient complex have been used as foundations or as the

Fig. 3: The first overall planivolumetric plan of the amphitheatre and its surroundings. Scale 1:200

walls of the lower floors on top of which the inhabitants built further floors. Although it's easy to imagine the scansion of some of these radial walls underneath the built-up area, it was not carried out during this initial stage because it's impossible to access these private areas.

Giver the complex current state and conservation of the walls, all the internal areas of the monument required careful attention and, as a result, a primarily direct survey; electronic instruments were used only to connect the measurements to several known points of the aforementioned topographic survey.

A total station was used to establish the external profile of the tiered seats of the amphitheatre, highlighting the gradual increase in the slope from the *ima cavea* to the *summa cavea* and establishing a section of the elevation of the amphitheatre for each of the underground passages accessible in the south-east area.

The radial sections were created by merging the direct measurements (mostly of the covered areas) with the points taken using the total station; these points were used to establish the haphazard structure of the outer part of the cavea where the tiered seats are no longer present (elements which would have required a much simpler direct survey); in fact, all the remains is the *opus coementicium*.

The twelve radial sections processed after this survey campaign provide extensive information about the entire area of the current entrance, often used during visits by the public or temporary exhibitions. The survey campaign provided comprehensive information about the remains of the amphitheatre. However, many issues still have

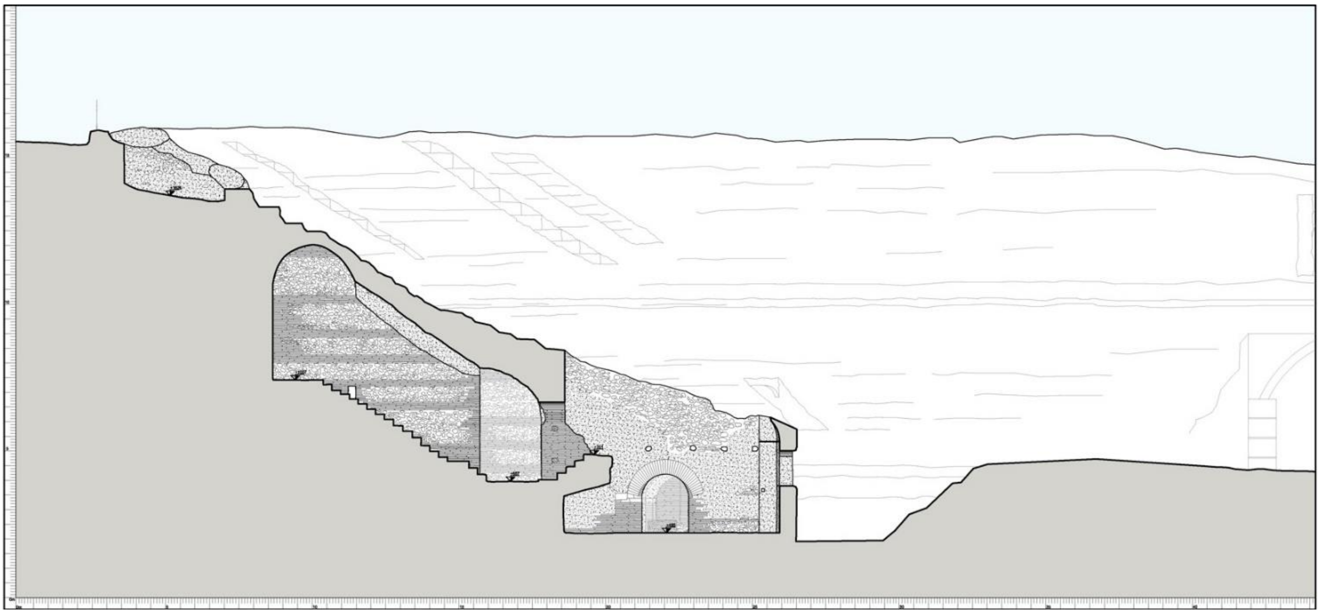

Fig. 4: Transversal semi-section of fornix 53. Scale 1:200

to be clarified and some problems solved. Since no structures of its façades emerged during the survey, we still don't know its exact position and therefore cannot determine its overall size. Neither were we able to establish how it was functionally organised since the parts we could survey were located in the area between the part built above ground and the part nestling against the hillside. Compared to the presumably regular scansion of the other parts of the amphitheatre, the irregular morphology of the terrain make these structures very unusual.

3. The laser scanner survey

Given the considerable geometric irregularities of all the old surfaces of the amphitheatre due to the centuries-old action of the weather, landslides, plunder and pillage, we can only create an abstract imaginary image of the original layout of the walls and shape of the amphitheatre at the time it was built. The slight geometric irregularities of the parts rebuilt after the amphitheatre was used for other purposes, and the reconstruction of the current state of the walls using direct survey (albeit based on topographic points) are not sufficiently accurate for us to be able to be establish whether the amphitheatre was an oval or an ellipse.

Only with a state-of-the art survey tool such as laser scanner it is possible to rapidly acquire millions of points from the whole surface of a monument and, in this case, allow the analysis carried out during restitution to provide an overall view of the amphitheatre backed up by more extensive alignments.

This is way two new survey campaigns[9] were performed in 2012 and 2015. Since we already had a very detailed survey of the whole area and neighbouring buildings thanks to the closed traverse mentioned earlier, we decided to focus the scansion stations on the area around the new excavations and vaulted spaces on the west (2012) and the east (2015) side. These stations were connected to form closed triangles and, in some cases, were in the same position as the station points still present from the old survey carried out in 2006.

The final result was based on the union of twenty-two points clouds from the scansions carried out in 2012 with the fourteen points clouds from the scansion carried out in 2015; it provided an overall three-dimensional vision of the entire monument and the immediate surroundings with very low margin of error, all less than one centimetre.

This final cloud shows all the structures of the amphitheatre: part of the wall around the arena, the podium, most of the cavea without its cladding,

[9] In each survey campaigns, we used a laser scanner Leica Scanstation C10

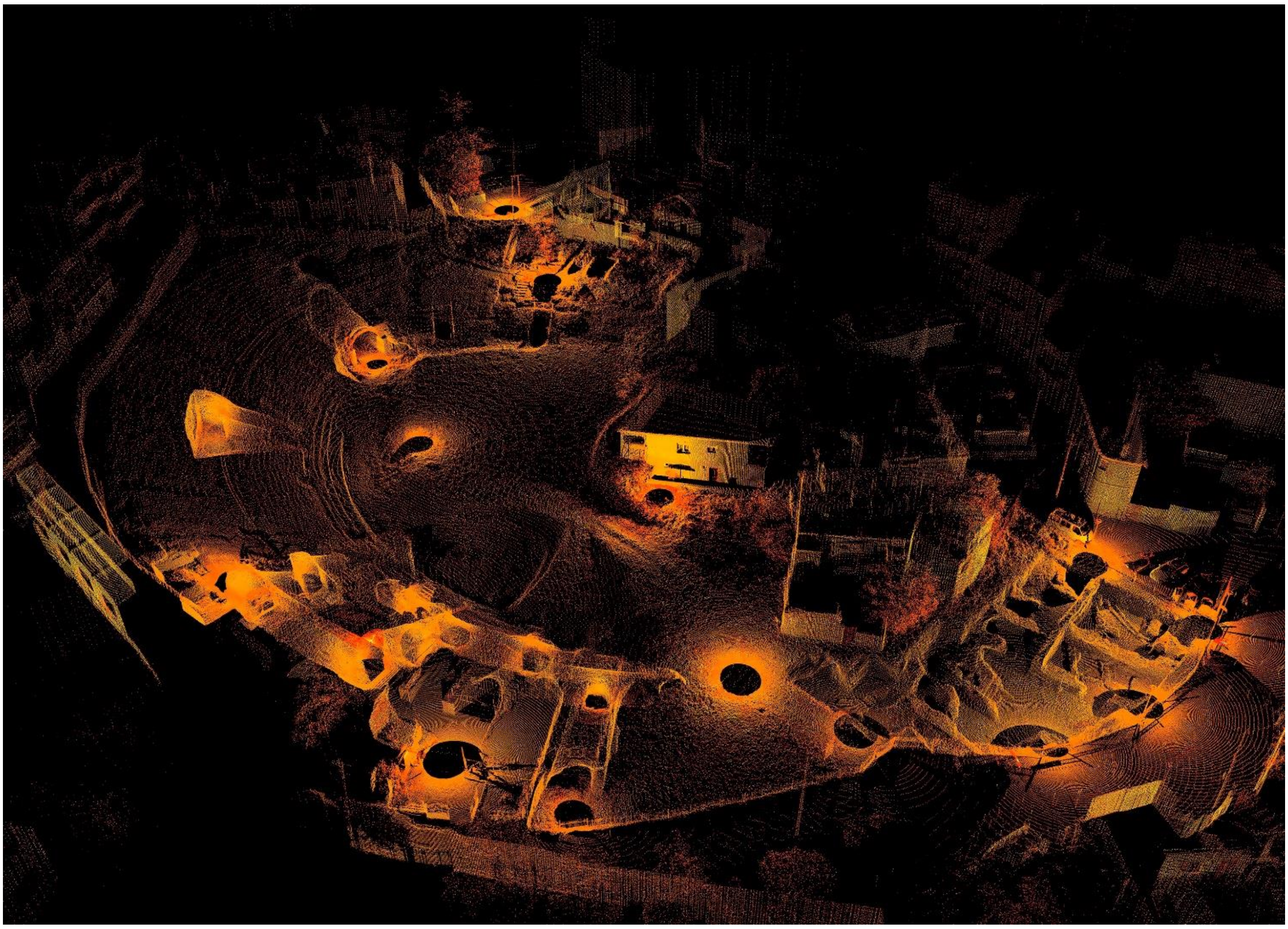

Fig. 5: The points cloud produced by the laser-scanner

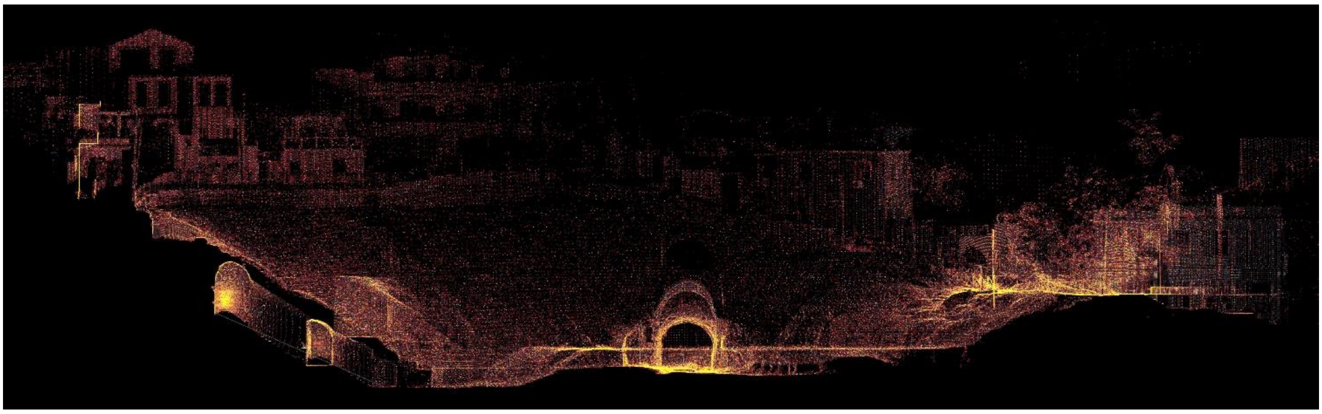

Fig 6: Transversal section of fornix 55 from laser scanner points cloud

the tiered seats probably made of marble and currently a continuous surface in *opus caementicium*[10], several of the radial walls around the fornices and all the anular galleries and ambulatories excavated (and also the not even excavated ones, on the east side) and freed from debris during the last century.

Another very useful element that helps us to interpret the geometry of the monument is the fact that all these elements can be interpreted together; it is a sort of X-ray of the built which makes the superficial structures semi-transparent and reveals the part underneath. In the surveyed area of the archaeological excavations it is possible

[10] Regarding the building techniques used in the amphitheatre: Adam J.P., 1988; Lugli G.,1957.

to see the two walls around the centre gallery, aligned and opposite to the large north gallery (still vaulted) which has been partially rebuilt; to the right, part of the steps and the first four fornices. South of the Byzantine chapel (date uncertain, ranging from the Sixth to the Tenth century[11]), ten walls around the ten fornices are recognisable on the perpendicular fornix of the central axis. The area between the west transversal axis and the south central axis seems to be the part of the monument which was reused and readapted first for military purposes, then a place of worship, and finally housing (up to the Thirteenth century[12]): then beginning in May 1966[13] it was excavated and reconstructed. Apart from the many irregularities caused by these alternations, it is possible to see the rows of fornices which, however, appear to be wider than the ones along the longitudinal axis.

The series of radial walls located in the north-east sector, present width also varied compared to the ones in other areas.

The survey data allowed us to identify and draw a longitudinal section from the axis of the big north gallery to the centre of the two wallsdelimiting the south gallery discovered during the recent excavations. Correspondence and alignment are almost perfect. A perpendicular drawn from the middle of this axis will end precisely in the centre of the Byzantine chapel.

The axes of the walls delimiting the fornices to the south near the new archaeological excavations all point towards a small area located along the longitudinal axis of the amphitheatre.

The arena in the amphitheatre in Durrës is 59.70 m long and 40.74 m wide. The planimetric width of the *cavea* is 28.45 m, which brings the overall size of the amphitheatre to 116.60 m by 97.64 m.

The points cloud obtained through scansion allowed us to perform a detailed analysis of altimetric sections, above all the parts where the *cavea* is still intact because it rested against the hillside. It was therefore possible to verify whether the slope of the *cavea* remained constant, since this would confirm that its length also remained constant.

4. *The photogrammetric survey*

Although laser scanning techniques provide one of the most common and most powerful solution to address the hard and complex task of documenting big archaeological sites, where the irregularity and complexity of the object require a full 3D description, the devices usually lack of flexibility (in terms of range of precision, resolution and radiometric accuracy) and portability (e.g. the Leica C10 weights more than 25 kg and requires a stable topographical tripod). On the other hand, in the last decade, photogrammetric approaches have become more and more popular for several reasons: first of all the lengthy and technically complex photogrammetric pipeline has been greatly simplified by innovative algorithms which automated the image block orientation and 3D model reconstruction stages (Roncella, Re & Forlani, 2011); off-the-shelf digital cameras, thanks to an exponential growth of sensor resolution, provided a very cheap but still reliable solution for image acquisition. The capabilities offered by a photogrammetric survey usually span a broad range of possible products: orthophotos, 3D Digital Surface Models, etc.

Moreover, depending the accuracy and resolution of the survey only on the image scale (and imaging geometry), photogrammetry provides a very versatile technique if objects of different size must be documented. In other words, with the very same hardware (e.g. a consumer-grade reflex digital camera with some fixed focal length optics), both building-scale surveys (with accuracy in the range 5-20 mm and sub-centimetre resolution) and small details or archaeological artefacts surveys (with accuracy and resolution up to 0.05 mm) can be performed (Re, Robson, Roncella & Hess, 2011). Finally, although some attention to technical requirements (e.g. a correct camera calibration, a proper image block design, etc.) should always be provided, image acquisition can be performed often by not-skilled operators.

In this context the survey of the Durrës amphitheatre was considered an interesting case study from a methodological point of view: on one side the survey team has a lot of photographic material available, acquired in all the different stages of the work (sometimes documenting

[11] Toçi V., op. cit.
[12] Santoro S., 2003; Bowes-Hoti, 2003.
[13] Toçi V., op. cit.

Fig 7: 3D photogrammetric reconstruction of the cavea.

subsequent stages of the archaeological excavation); on the other, some smaller details (e.g. the beautiful mosaics of the sixth century AD located in the Byzantine chapel inside the amphitheatre) would require a much higher level of accuracy and resolution of the one obtainable by the C10 laser scanner.

For the former topic (3D reconstruction from photographic material) a test acquisition of the whole amphitheatre *cavea* (see fig. 7) was performed during the last survey campaign using a Nikon D3X (resolution 6000x4000 pixel) with 35 mm optics. The images sequence was captured moving the camera along an elliptical path following the edges of the internal *podium*, with almost constant baselengths between subsequent frames and maintaining the image plane vertical and approximately parallel to the steps section depicted in the image. The imaging geometry is not ideal for several reasons: first, since consecutive frames have divergent optical axis, the image overlap is usually low even with small baselengths, which requires a much higher number of photos and achieves lower precision than a traditional pseudo-nadiral or convergent photogrammetric block. At the same time, being the image plane vertical, and then inclined with respect to the object mean plane (i.e. the slope of the steps) the image scale is much different at the base and at the top of the steps. This leads to a notable variation of the level of accuracy and resolution of the final restitution (the precision deteriorates quadratically and the resolution linearly with the distance from the object) between the lower and upper parts of the amphitheatre. However, to provide a much better imaging geometry, different equipment should be implemented, for instance an Unmanned Aerial System (UAS) to acquire the images from above.

In this case, the easiness and rapidity of the acquisition operations were preferred since the main objective of the reconstruction was to provide a general overview of the amphitheatre. The final image sequence consisted of 49 images that were oriented automatically using Agisoft Photoscan. To define the reference system of the restitution and orient absolutely the image block, some ground control points from the laser scanner point cloud were extracted. At the end of the structure from motion procedure, with the same software package, the DSM of the amphitheatre was produced.

For the mosaic reconstruction, two rectilinear pseudo-nadiral sequences, approximately at 1.5 meters from the object, were acquired with the same 35 mm optics used in the previous example. The resulting Ground Sampling Distance was therefore very small (0.25 mm ca.), allowing a very high resolution and precision in the final restitution. To better connect the two sequences, rather than relying on the ground control point network provided by a high-resolution laser scan,

Fig 8: Textured DSM of the Byzantine chapel mosaic.

which were used exclusively to define the object scale, some images along a circular path and framing both the walls of the mosaic were acquired as well (see fig. 8).

The final DSM of the mosaic, obtained using the Agisoft Photoscan pipeline, consisted of more than 6.9 million of faces. From it, two high-resolution orthophoto (pixel size 0.5 mm) were produced.

5. Conclusions

The knowledge of a complex organism such as the Roman amphitheatre is something that can hardly be ended, as each sector study conducted on it in times and different ways, continues to increase the wealth of information that are layered over the centuries, clarifying or sometimes confusing interpretations that have been given over time to a well articulated monument, through our distribution in that using aspects that have followed.

The process of knowledge becomes operational tool, system of general rules and enforcement practices can target the work of those who institutionally is called upon to intervene to end the exploitation of the monument, facing the challenge to bring together the reasons for the protection of those with development.

The procedural aspects, the planning commitments and surveys are only the basic operations, the essential steps to follow to ensure the success and the quality of each targeted intervention, which has as its objective the preservation, protection and enhancement of a heritage of great historical value for cultural community.

In the specific case of the archeology of architecture, the architectural survey, returned in the manner of representation, it assumes the role of delicate form on which basis to make any restoration and enhancement.

The problem is always to find, beyond the techniques and forms of representation used, the proper relationship between the content and the graphic language, both linked to the selected scale of representation, acts to restore the structural complexity of the object under investigation.

The continuous evolution especially of quantitative and qualitative techniques of analysis,

Fig. 9: Textured DSM of the Byzantine chapel mosaic.

allows us to acquire every time new information, to be integrated with those obtained in previous survey campaigns, thus forming a real database always updatable, which can be characterized as a knowledge open system on the object of study.

It is therefore even more clear that this requires an approach inherently cross between different skills: archaeologists, architects, engineers and specialists in the restoration, surveyors, but also sociologists, economists and administrators, those involved at all levels in the management of a product as delicate both in terms of material and immaterial.

Documentation and analysis of the so called Archaeology of Architecture (buildings where the architectural and archaeological values are actually inseparable) is always a very challenging: first, from a cultural point of view, for multidisciplinary skills that this activity involves; the other, from the technological point of view and procedural because the use of ever more advanced instruments makes it inevitable a continuous feed-back between operational capabilities and instrumental innovations.

Nevertheless, analyzing the most research developed in this area, the concrete application of this cooperative approach can definitely be considered a great strength.

In this type of multidisciplinary approach, documentation, analysis, interpretation and contextualization of an architectural-archaeological building continues to be the foundation of every first depth research.

For this, thanks to an integrated survey over the years has seen the use of methodologies and technologies (3D scanning, image matching, but also photogrammetry, topography and direct survey), together with the analysis of the visible structures, was possible to envisage the reconstruction of geometry and proportional scheme of the original project.

The cognitive approach used, which has seen the integration of the various instruments and methods of survey depending on the nature and length scales of the elements under investigation, was revealed as the only way to come to a knowledge of multi scale various aspects of the amphitheatre.

The topographic survey together with the three-dimensional scans allowed us to tie the readings on an urban scale to the architectural scale, supplemented by direct survey; as well as the photo-modelling has enabled the analysis of the monument as a whole but also focusing on aspects most minutes of the paintings or mosaics, impossible to catch with the other used instruments. More and more, in fact, in the reading of complex realities in their intrinsic configuration as well as in the relations with the context and the detailed aspects of the survey conducted by integrated tools, methods and different technologies is characterized as the only one methodology that can lead to a scientifically based knowledge and increasingly full of the investigated monument, especially if the object is an archaeological architecture characterized by discontinuity and missing parts, which make it difficult to interpret the object of investigation.

On the more strictly archaeological, stratigraphic reading of the monument was completed by the study of technical solutions used during construction and renovations have taken place through the direct recognition in the field and on the building itself, as well as in the excavations area, the elements that provide information about the organization of the constructive phases, the characteristics of the execution, etc. All these aspects have therefore permitted to include, in practice, the skills of the various researchers and framing better than in the past, a number of specific issues that were likely to remain hidden behind the general historical phenomenon.

Then, the conviction emerges that this specific class of problems, connected with the Architecture of Archaeology, should be considered more "cultural" than simply "technical", so that the scientific rigor of the acquisition phase set to a specific cultural sensitivity to guide the process of choice aimed at achieving a level of knowledge deeper and more structured of the studied element.

New technologies can play a very significant role in this scenery: 3D acquisition, modelling, acquisitions of frames, contribute to improve the level of general knowledge; but the use of different methodologies and instrumentation for the execution of the various types of survey has also led to identify a mode of graphic restitution that could be characterized as a synthesis of the various elaborations obtained, obviously very diversified depending on the used acquisition techniques. The three-dimensional model, more or less completed by the photographic image, while beneficial in view of this monument and in understanding of it, not replaces the more traditional type twodimensional drawings that with or without photos rectifications underlying, provided the basis on which is currently being examined a restoration project aimed at the conservation and safeguarding of the most degraded parts of the amphitheatre.

Survey, in the broadest sense possible, has once again shown itself to be the primary expression of the elaboration and perception of a text, in other words, of the signs connected by functional links and therefore a communication to know, understand, and enhance a project to preserve and safeguard heritage.

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