

DIGITAL DOCUMENTATION AND MONITORING HUB IN CLIMATE-SENSITIVE TERRITORIES: THE ALBENGA CASE STUDY (SAN CLEMENTE SITE)

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ABSTRACT:

This paper will go into further detail on pressures and policies faced by the archaeological site of San Clemente's caretakers, that affect the sites preservation. Including the protection of the riverbed along the fragile coast line represented by the masonry portion of the thermal bath's foundation which is directly in contact with the water. Being the destiny of the site to be gradually eroded by flooding, digital documentation can play a significant role in documenting the sites changes over time allowing for easy analysis of newly revealed elements. As in the case of the documentation of the viewable openings through the thermal masonry-pipeline during the last surveying campaign this paper will discuss the experimentation of data management through Virtual Hub. Through which past sequences of data can be made accessible to anyone who must operate on the site, and to document the state of affairs of the archaeological complex over the last few years.

1. INTRODUCTION

Cultural and built heritage is recognized as a value not only as a symbol of community identity, traditions, and sense of place but also as an important economic resource. However, nowadays many cultural heritage sites are subject to continuously growing threats due to wars, climate change, etc. In many cases, the vulnerability of such sites is connected to their specific location and cannot be easily mitigated, like a site located in volcanic area. For such situations, digital documentation is a primary resource that can be exploited to preserve the significance of a site. This paper presents one such site, the former church of San Clemente in Albenga (Italy).

A series of archaeological sites are found within the city centre of Albenga, Italy, and throughout its surrounding landscape. One of the most interesting archaeological areas is located to the south of the cities roman centre and encompasses the former church of San Clemente. Nowadays the Centa river runs through this site, though this was not always the case. The Centa river originally ran to the north of the roman imperial city of Albingaunum until in the XIII century the river deviated to its current position. In Roman times this area would have been located between the cities roman harbour, to the east, and the roman Iulia Augusta Road, to the west. A complex of thermal baths, and later the church of San Clemente, characterized the southern Albingaunum suburb corresponding to the current historical site. The archaeological site of San Clemente in Albenga has the added peculiarity of being in the Centa riverbed, partially on the south embankment and partially underwater (Figure 1). The relevance of this archaeological area was well known to the archaeologists before the area was rediscovered in 2001 during excavations to widen the Centa riverbed. The purpose of these excavation was to mitigate the impact of chronic flooding of the Centa river on its surroundings and the city of Albenga (Massabò 2002a, 2002b,

2004, 2007). Earlier excavation work, also to mitigate the impact of flooding, in 1910, originally uncovered the archaeological site, and excavated a larger area than is accessible today, though little documentation, other than a plan dated to 1911, exists of this work (Lamboglia, 1934).

The remainder of the paper is organized as follows: section 2 introduce the San Clemente site and highlights its peculiarity; section 3 describes the strategy used for the digital documentation of the site and the tools developed to disseminate the results; section 4 concludes the works and highlights future developments.

2. SAN CLEMENTE IN ALBENGA: A CULTURAL MULTI-LAYERED SITE

San Clemente in Albenga is a multi-layered archaeological site important not only for reconstructing the ancient stratified history of the city, but also for the framing and placement of historical events, topography, building features and character of the entire 'Ponente Ligure' (this term indicates the western Liguria Region as a common cultural area) throughout the centuries.

The place where the complex is nowadays located is part of a landscape that in antiquity was quite different. It was placed in the southern peri-urban area of the Roman town of Albingaunum, in close proximity to the sea and the port, gravitating along a route of significant importance, the Iulia Augusta, that connected the centre of the Po Valley to the South of France. For these reasons, the site has been chosen over time as a place of aggregation for large social buildings. In the first century an extended large thermal complex was established on the site. During the late antiquity (V century) the thermal baths fell into disuse and the site was used until the eighteenth century as religious center, characterized by multiple

expansions, extensions and changes referable to distinct phases in its history. Among them, the most recognizable today is the triapsidal church erected in the XIII century, directly on the foundations and stone-masonry walls of the thermal bath complex, it was the seat of the Cavalieri Gerosolomitani and dedicated to San Clemente (Conventi et al., 2018; Lamboglia, 1934; Massabò 2002a, 2002b, 2004, 2007).

2.1 San Clemente site peculiarities

The element that most distinguishes the archaeological area and that differentiates it from the topographical situation of the past centuries is the current presence of the Centa river, a watercourse that until the thirteenth century ran to the north of the city (Arobba et al., 2006, Petracco Siccardi 1997-98, Zucchi, 1938). Its gradual shift, due to anthropic and natural causes, has caused disruption, equilibrium, and upheaval. Today the river is the feature of great debate and stands at the center of important safeguarding activities for stratified archaeological emergencies. The archaeology site is therefore intricately linked to the Centa river: which has marked its most recent history, led to its re-discovery, as well as its partial loss. A watercourse that hides the sites remains, making critical any intervention not only of investigation, but also of conservation. It is a site that opens a difficult debate between archaeological protection and public safety.



Figure 1. Church of San Clemente, Albenga, Italy

2.2 A challenging site among preservation and public safety objectives

The extent of the Centa is comparable to that of the Arno, which makes it a particularly dangerous river, and in the last thirty years it has devastated the city of Albenga with three major floods: in 1994, 2000 and 2016. The first two floods that occurred in 1994 and 2000 revealed the city's main deficiencies managing flooding. First, the construction of a new cable-stayed bridge, without pylons that obstruct the outflow of water, was necessary. This combined with works aimed at widening the riverbed would aid in mitigating damages during flooding events. These interventions led to the sites rediscover and highlighted the risks faced by the entire archaeological complex, already partially investigated at the beginning of the twentieth century for the same reasons.

It was at the beginning of the nineteen nineties that the debate, nowadays still fundamental and critical, between the protection of cultural heritage and the protection of public safety arose.

Should an archaeological site, with recognizable architectural remains and a particularly notable history, be completely sacrificed in place of interventions for the hydrogeological safety of the area or should all possible forms of protection be implemented in order to deliver it to posterity within the constraints of public safety? The flooding of November 2016, which caused severe damage to the archaeological complex, gave a new impetus not only to cognitive research, but also reignited the attention of the necessary monitoring works and the planning of interventions to support its conservation.

It seems clear that the location of the site in the current Centa river bed poses major problems for its protection. The area, in fact, falls within the boundaries of the so-called "river basin plans," a regulatory and technical instrument to manage the actions and regulations of use in areas susceptible to hydrogeological instability. The long-term objective of these plans is to allow the outflow of the river to the sea without flooding, thus ensuring public safety. Generally, the run-off during times of higher water levels is managed by the so-called flooding areas adjacent to the rivers where it is not possible to build or conduct industrial or productive activities. However, these are not present near the archaeological complex due to the presence of dense urban districts facing directly on the river Centa, at this location.

Most of the projects that could protect the site clash against the works eligible according to the river basin plans. In order to guarantee the outflow of the water it is not possible to create embankments that could protect the vertical walls of the archaeological complex adjacent to the river that during floods would not be completely covered by the water run-off; and it is not possible to rebury the site because it would reduce the width of the riverbed near the mouth of the river. San Clemente is therefore destined to suffer the consequences of the phenomena - sometimes very violent - of an environmental context that was not originally inherent to it site.

To mitigate partially the threat of the Centa river on the San Clemente site a set of structural interventions must be planned. Indeed, such interventions without reducing the hydraulic cross-section of the river can significantly reduce the effect of the day-by-day scour of the church basement and reduce consequences of a medium level flooding. It is unfortunate that the instrument that is going to be implemented is not a definitive solution but will perhaps only postpone the loss of an asset that seems inevitable since, protection to severe flooding of the site conflicts with the safety of citizens. So, being the destiny of the site to be gradually eroded by flooding digital documentation can play an important role for documenting the sites changes over time and allowing easy analysis of newly revealed elements

Concerning structural interventions, keeping in mind the priority of public safety, since December 2016, immediately after the last great flood, a program of investigation, documentation and safeguarding of the site has been initiated. In addition to three excavation campaigns carried out in 2017-2018. There is currently another project is underway, thanks to financing provided by MiBAC. It involves the construction of 'Berlin micropiles' that will be installed sub-riverbed along the perimeter of the archaeological structures in order to prevent the river's current from eroding their foundations and causing the partial collapse of the structures. To prevent the loss of

precious archaeological features that were situated on the water riverbed line. As happened during the last flood, where large pieces of the masonry progressively cracked and detached from the structure.

3. SAN CLEMENTE SITE: DIGITAL DOCUMENTATION

3.1 Surveying campaigns and documentation of lost remains

The sites location in the Centa riverbed is increasing its risk of damage due to heavy precipitation events and flooding, under the climate change pressures that have heated the Liguria Region over the last 10 years. A surveying campaign realized through a summer one-week workshop with the student of the SSBAP (Specialization Master after Master School on Architectural Heritage and Landscape of the Politecnico di Milano) documented the area, in 2015, under the supervision of the Soprintendenza (Soprintendenza Archeologia, Belle Arti e Paesaggio della Liguria). As previously expected the site was significantly damaged following the flooding event of November 23rd, 2016. In particular, the heavy discharge of the Centa scoured the portion of the structures directly facing the river. The main risks to the site connected to flooding events are: (i) scour and erosion of the riverbanks; (ii) deposition of debris over the site and (iii) removal of stones due to the strong current flooding event classified as water bomb rainfalls (Previtali et al., 2018).

This has led to the development of monitoring strategies to control the area and preserve the archaeological site by the Soprintendenza. Actions that must occur in a complex context where citizen safety is a priority and where solutions must balance this with safeguarding the natural environment, protecting the riverside, and protecting heritage assets requiring many difficult compromises. In this context the survey carried out in 2015 became the most up-to-date documentation and became indispensable after the November 16th, 2016, flooding for the Soprintendenza to check damages. A cost and time efficient surveying strategy was developed to document damages to the site after flooding events. This surveying strategy integrated photogrammetry, terrestrial laser scanner (TLS), and unmanned aerial vehicle (UAV) photography to document the site. Photogrammetry was used to capture the remains of the archaeological site and to create accurate orthophotos of the walls to realize a stratigraphic analysis. The UAV was useful in capturing the site and its surroundings allowing for a quick visual overview and to check the site for major damages caused by flooding. TLS was used to have a more detailed record of walls and vertical surfaces. In addition, comparison of point cloud at different epochs can be used to evaluate the removal of stones and small objects. While, onsite visits allowed for direct observation of the remains and a more accurate understanding of the real damages.



Figure 2: South-East Façade Photogrammetric Orthophoto

Surveying campaigns were carried out in 2015, 2016, and 2017. The comparison of datasets acquired during these surveying epochs allows for the comprehension of the entirety of the damages to the archaeological site. The main methods of monitoring the sites deterioration are comparison of various epochs photogrammetric site elevations (Figure 2), and aerial orthoimages (Figure 3).

The documentation work carried out by the Milan Polytechnic is an instrument of fundamental importance. The orthophotos realized during an educational exercise in 2015, were the only complete documentation available immediately after the November 2016 flood. They were essential for the registration of damages and for the request for special financing.



a.



b.



c.



d.

Figure 3. Orthophoto of the San Clemente site: before flooding - Survey Epoch 0 (a); close up of highlighted area that was highly damaged before (b) and after (c) the flooding; overlap of the two earlier orthophotos with epoch 0 in red (d).

3.2 3D object modelling to evidence the changes

To estimate and identify changes of the site in a quantitative manner the 3D information from the laser scanning surveys were used to perform the following analysis:

- Point Cloud comparison; and
- Cross-section comparison.

Point cloud analysis was performed comparing the point clouds acquired in the two epochs. This comparison is devoted to highlighting local losses, like stone removal and overturning of poorly connected structures or elements and identifying localized regions of accumulation/deposition of sediments transported during the flooding (Figure 4). Cloud comparison was performed by using the CloudCompare (Girardeau-Montaut, 2011) open source software. In this case the nearest neighbor distance between the reference scan (2015 scan) and the compared one (2017 scan). The nearest neighbor distance can be used in this case since the two point clouds present a similar density and the comparison is performed to highlight local losses that cannot easily recorded with the naked eyes. However, some miscalculations can be observed in the cases of the big holes caused by the overturning of the area close to the river. In such areas the calculated distance is only highlighting the changes but is not a proper estimation of the real metric.

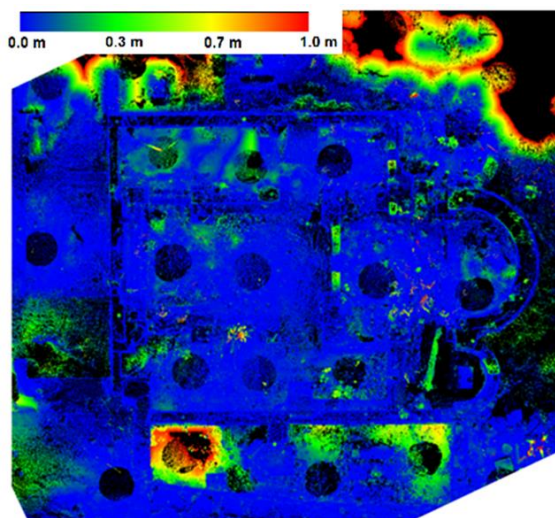


Figure 4: Cloud to cloud distance between point clouds acquired in 2015 and in 2017.

Cross section comparison was performed by manually tracing the point cloud. This allows the user to focus on specific areas and identifying local changes and allows for accurate definition of the lost areas. Figure 5 shows a comparison between the 2017 point cloud survey (dashed line) with the 2015 point cloud data (solid line). Area lost due to the flooding in November 2016 can be immediately highlighted and is concentrated around the scoured area close to the river.

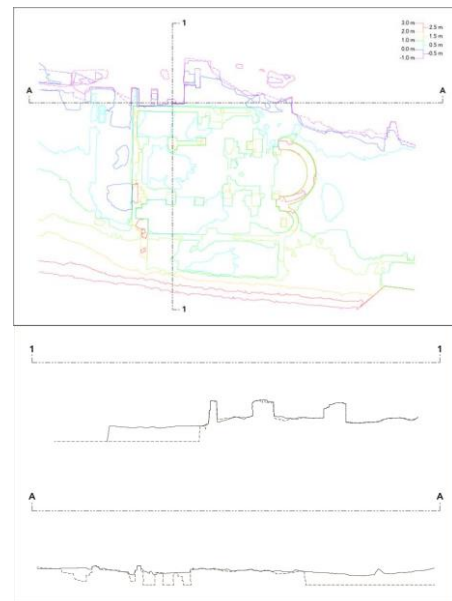


Figure 5: Stratified Plan of the San Clemente area in 2017 (top) and two cross sections (bottom).

3.3 Toward a virtual accessible platform

One of the main advantages of digital technologies is the possibility to disseminate the results of the surveying and analysis carried out to a larger audience (e.g., citizens, tourists, etc.) by using smart tools.

As a result of the previously listed analysis many products were generated, and further additional documentation is available both online and in other digital archives. The possibility to connect these pieces of information into a unique environment and use smart technology to disseminate those materials. Indeed, such information will determine not only a rise of consciousness of citizens, tourists, and public administration about the importance of the San Clemente site in the history of Albenga but will also increase the consciousness about its vulnerability.

Considering the volume of documentation, it would therefore be desirable to create a shared digital platform in which all the documentation produced was available. To make it accessible to anyone who must operate on the site, for the purpose of both protection and knowledge, and to document the state of affairs of the archaeological complex over the last few years. For this reason, a web-based solution was developed so that it can work as collector of information produced by different operators at differ epochs. In particular, the interactive 3D web application was developed to visualize 3D point cloud models online in a browser (Chrome, Firefox, Safari on desktop PCs and mobile devices) using the WebGL-based Potree viewer (Schütz, 2016). The Potree viewer allows for rendering of the 3D point cloud datasets as well as linking in other datasets to the model (e.g., photos, documents, drawings). An important aspect is that the user can select the information they are most interested in (e.g., historical data, photos, etc.) and can also perform simple operations like measurements of distance, area, and height profiles directly online. This allows for a tool that can be used by both professionals, involved in the management of the site,

and citizens or tourists more interested in informative contents. An important aspect to emphasise is the possibility to access multi-temporal data through the viewer. For example, the point cloud in Figure 6a was acquired in 2015 before the flooding that damaged the site. Figure 6b highlights the possibility to rapidly derive and compare cross sections acquired at different epochs. Figure 6c compares the point cloud acquired in 2015 (white) with the one acquired in 2017 (sand). A significant collapse of a wall can be immediately observed. This function is a fundamental aspect of the tool revealing the evolution of the site to both professional and tourists.

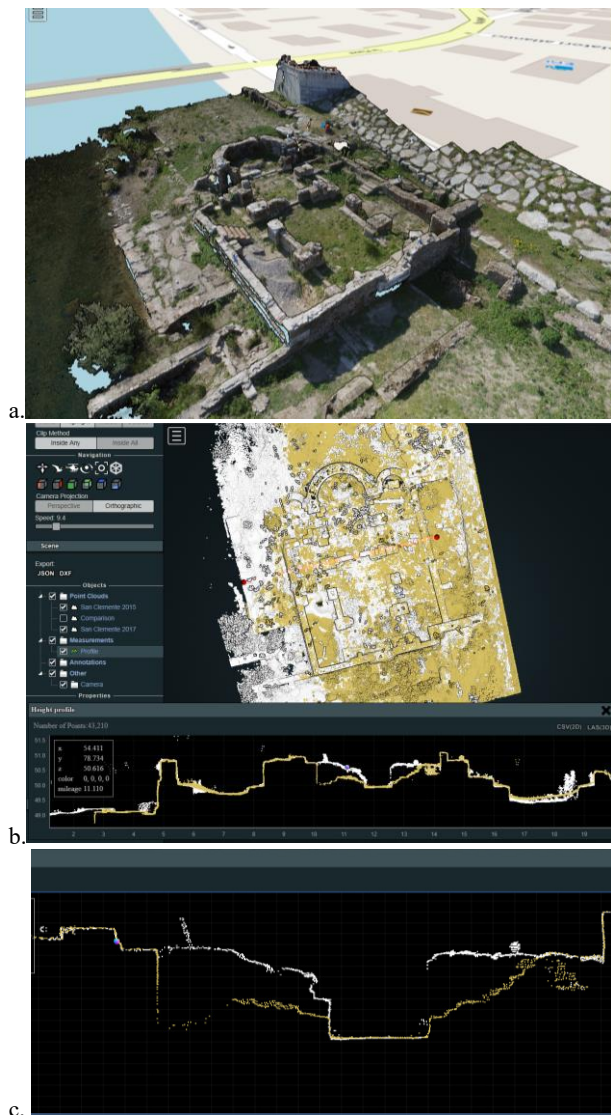


Figure 6. Web visualization of the San Clemente site: (a) survey carried out in 2015; (b) comparison of the point clouds acquired in 2015(white) and 2017 (sand); (c) detail of the cross-section comparison.

4. CONCLUSIONS

Cultural Heritage is facing challenges more demanding than ever. Global warming and climate changes, will increase the frequency of extreme weather events, leading to the need for

management strategies that will need more financial resources, but at the same time municipalities have a strict budget.

The fact that San Clemente is now uncovered is both an opportunity to study the site and a threat to the site itself – as long as it was covered by soil it was not exposed to erosion and natural calamities – and this is the real challenge of this place. It is not possible to realize superstructures to protect it because they would shrink the Centa riverbed near its mouth provoking more problems during floods. Having this in mind the development of a methodology to document and track damages caused by flooding events is of primary importance. In particular, in this paper, the combination of UAV image acquisition and TLS proved to be a useful strategy to gain a quick overview of the damages to the area after flooding. Documentation and monitoring through quick survey-based approaches and automated or semi-automated tools for site modelling can be used to prioritize threats and allocate budgets. Furthermore, the development of an online platform that collects information materials and allows for the interactive exploration of the San Clemente site can be used to increase consciousness about the importance of the site, the history of Albenga, and its vulnerability. In future works integration with remote sensing data will allow for quicker real time analysis of the damages. In addition, the chance to create a BIM based model of the site in the future will allow users to take advantage of informative content modelling as tools for data aggregation.

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