METHODOLOGY FOR THE DIGITAL DOCUMENTATION OF MODERN ARCHITECTURE: APPLIED RESEARCH ON ÁLVARO SIZA'S WORKS FOR THE WORLD HERITAGE LIST

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ABSTRACT:
Digital Revolution is strongly impacting the safeguarding and enhancement of Cultural Heritage through the techniques and tools available for its documentation and communication. Specifically, modern heritage is a potentially fertile laboratory of work in this field because of the availability of the documental, physical, and oral sources required for its critical study and interpretation. This article aims to present an integrated methodology supported by combined techniques for the comprehensive digital documentation of modern architecture implemented on 18 buildings of Álvaro Siza included in the World Heritage Tentative List since 2017 supported on combined techniques: i) photogrammetry; ii) virtual tours through 360º photos; iii) didactic models in BIM iv) other digital tools, such as virtual reality. This holistic and integrated multi-methods approach provides better documentation and communication of the attributes of the Outstanding Universal Value (OUV), as well as of Alvaro Siza's design principles as a guiding framework for the future management of change.

1. INTRODUCTION

Digital Heritage is becoming a valuable resource as a field of knowledge that has been framing new ways of accessing and managing information about the Cultural Heritage (Forte, 2014). As the London Charter states (Denard, 2006, 2009), digital tools, when scientifically used, can enhance built heritage, increasing the perception of communities, engaging their experience, and providing new ways to see the attributes of cultural sites. Also, the Porto Santo Charter, introduced new digital territories as an extension for participation and cultural production. It recognized the digital realm as a unique means with its own possibilities and a facilitating tool for collaboration between institutions and citizens, considering all parties as collaborators (Council of Europe, 2021). In this context, several organizations claim for new documentation approaches and methodologies, namely the DOCOMOMO or ICOMOS-ISC20C and ICOMOS-CIPA, among others, while also providing critical reviews, publications and debates.

Specifically, modern heritage is a potentially fertile laboratory of work in this field because of the availability of the documental, physical, and oral sources required for its critical study and interpretation. Also, modern architectures are 'total artworks' following the tradition of the 'Gesamtkunstwerk' where the design process includes all features and scales (from the setting to furniture, artworks and details (Tostões 2022) which require combined and integrated methods and techniques for its documentation.

However, modern architecture is a heritage at risk because of its vulnerability in terms of the construction technologies and materials (often experimental or traditional solutions used in an innovative perspective) which tend to age faster (Boriani, 2003) and require accurate conservation and maintenance routines (Ferreira, 2014). This condition demands a careful methodology for documentation (digital databases, 3D surveys and modelling, BIM) as an important source for future conservation planning and maintenance over time.

Besides the increase of digital documentation applied to cultural heritage, there is still a tendency for digital representations of heritage buildings to be prone to serve more as entertainment than heritage dissemination or even a means to foster participatory approaches. On the other hand, the field is also dangerously attracted to the discussion of technology (emergent machines and software), rather than on its cognitive function to support heritage and provide innovative features to combine information from different media remains undermined (Forte, 2014).

Also, there are still few digital documentation experiences applied to modern heritage, namely with integrated methodologies allowing for a comprehensive documentation of its attributes and design principles (from setting/context to detail) which is the main contribution of the present paper.

How can a combination of methodologies be used to achieve a comprehensive digital documentation of modern heritage, including the context, exterior, interior, and details? Which methods and techniques are the most effective for accurately capturing and creating detailed digital models of modern heritage? In addition, how can the cultural significance, authenticity and integrity, as well as conservation and maintenance of modern heritage be considered and incorporated into the digital documentation process?

This article aims to present methods and tools used for the digital documentation of 18 buildings of Álvaro Siza included in the World Heritage Tentative List since 2017. This paper is framed within two research projects 'Siza ATLAS: Filling the gaps for World Heritage' (funded by the Portuguese Foundation for Science and Technology, 2021-2024) and the 'Keeping It Modern (KIM): Ocean Swimming Pool' (funded by the Getty Foundation, 2020-2023) both within the UNESCO Chair 'Heritage, Cities and Landscapes. Sustainable Management, Conservation, Planning and Design' hosted by the Faculty of Architecture of the University of Porto (FAUP).

2. CONTEXT

Following the ICOMOS study "The World Heritage List: filling the gaps – an action plan for the future" and the Global Strategy of the UNESCO World Heritage Committee (WHC) encouraging State Parties to submit nominations on the 20th century Heritage, ICOMOS-Portugal presented an Ensemble of works of Álvaro Siza for the World Heritage (WH) Tentative List, in 2017.

Despite the international recognition of Alvaro Siza's architecture, there is not yet a complete and systematic inventory of his built works. The information on his work is scattered, partial or incomplete. The existent literature focuses more on compositional issues of the design, and less on the constructive and technical dimension of his works, on the state of conservation of the buildings, or on possible threats affecting them.

In this framework, the scope of SizaATLAS research project is to address a comprehensive i) inventory of all of Siza's built works, and to develop a detailed ii) documentation and analysis of the 18 buildings selected for the WH List. This research and the comparison with the body of work of other architects will result in a better understanding of the unique value of Siza's architecture, in a national and international context. This will be key to establishing the justification of the Outstanding Universal Value (OUV) of his work, its national protection, and an effective management system to support the instruction of Siza's works nomination for the WH List.

The "Operational Guidelines for the Implementation of the World Heritage Convention" (UNESCO, 2021) and the "UNESCO World Heritage: Serial Properties and Nominations" (UNESCO, 2010) emphasize the need to view component properties both individually and as a whole and were taken into account during the application process. Each component property of the serial nomination should demonstrate cultural, social, or functional links over time, and contribute to the overall OUV of the whole.

In this framework, "Álvaro Siza's architectural works in Portugal" serial nomination, being prepared by FAUP, sustains the OUV pillars based on i) criteria, ii) authenticity and integrity; iii) protection and management (UNESCO, 2021).As regards to pillar i), Siza's nomination meets both criteria ii) and iv) (UNESCO, 2021), being expressed through the following attributes:

1. Architecture responsive to a physical, social and historical context
2. Integration of international and local references
3. Sculptural volumetric expression
4. Oriented spatial experiences
5. Total work of art within details, furniture and artworks

Also, digital documentation allows to document the other OUV pillars such as ii) authenticity and integrity and iii) protection and management. Moreover, this also provides information for the 'state of conservation and factors affecting the properties. and other items as defined by the Operational Guidelines (UNESCO 2021).

3. METHODOLOGY

3.1. Selection criteria

As above mentioned, this paper is framed within two research projects (*Siza ATLAS* and *KIM: Ocean Swimming Pool*). The methods and tools selected are deeply connected with the research objectives, namely the contribution for "Alvaro Siza's Architecture Works in Portugal" serial nomination for the World Heritage List.
The criteria for the selection of the Ocean Swimming Pool by Alvaro Siza (1960-66) are sustained on the possibility of comprehensive documentation under the KIM Grant, including recent conservation and extension (2018-2021).

3.2. Methods and Tools

The project employs a cross-methodology approach that combines different methods and tools for the documentation of the 18 buildings:

i) Archival and bibliographic research
ii) Digital surveys
iii) GIS mapping
iv) Virtual tours
v) Didactic models
vi) Other (animations, virtual reality, etc).

i)Archival and bibliographic research
Archival research was sustained in several archives where Siza's work is conserved, namely the Serralves Foundation, the Calouste Gulbenkian Foundation, the Canadian Centre for Architecture, and Drawing Matter, as well as municipal and private archives. The literature review was performed in digital databases and physical libraries, including monographs and book chapters, journal articles, master dissertations, and doctoral thesis, among others. Archival and bibliographic research was complemented by on-site observation and confrontation.

ii) Digital surveys
Digital survey of buildings is supported on laser scanner or in most cases photogrammetry (in some cases both). Laser Scanner and Photogrammetry allow for the 3D reconstitution of Siza's works, showing their relations with the surrounding context, references and volumetry (Attribute 1, 2 and 3 of the OUV) as well as physically surveying the construction as built.

To develop the Photogrammetry models, drone photography campaigns were conducted for all buildings using two different drones: DGI Air 2 and DGI Mavick Pro, with the support of Map Pilot Pro software. By capturing the volumetry from various angles and heights, the photographs provide a comprehensive understanding of how the buildings interact with the landscape, both in terms of their physical presence and their visual impact. It was possible to capture their volumetrics and contextual relationships with the surroundings (pre-existences, natural elements, topography). The aerial photographs were complemented with terrestrial photogrammetry, which contributed to the accuracy and correction of the models.

The processing was carried out using the Agisoft Metashape software, which allowed for the georeferencing of the model based on geographic coordinates collected on-site.

iii) GIS mapping
The definition of property limits and Buffer Zones is define both in the Operational Guidelines (UNESCO, 2021) and in Article 11 of the "Conclusions of the International Expert Meeting on World Heritage and Buffer Zones held in Davos, Switzerland, from 11 to 14 March 2008" (Matin and Piatti, 2009), was essential. This document outlines six key features to

sustain and protect the OUV of the component properties. Aerial photos and the photogrammetric models were essential to verify and detail the geographic coordinates in the maps and textual descriptions required by UNESCO (2021).

With the support of various digital tools, including cartography and Geographic Information Systems (GIS) processed in Esri software (ArcGis and ArcMap) buffer zones can be accurately defined and strategies can be developed for their management. GIS also enables the integration of diverse data, such as topography and land use, to develop a comprehensive understanding of the area and its potential threats.

iv) *Virtual Tours*
The Virtual tours are essential for providing a comprehensive narrative of all the attributes OUV and Siza's design principles. This is also a valuable tool to outreach and communication, as well as for monitoring the conservation status of component properties.

The development of virtual tours follows a rigorous protocol in the selection of points for capturing 360-degree photographs. Special consideration was given to demonstrating all the attributes of the OUV. Additionally, the design principles of each work were carefully taken into account, exploring features such as visual axis and openings by translating them through the 360-degree photos. The aim is to establish an effective parallel with a physical visit to the sites, organizing the captures according to a promenade capable of simulating a virtual visit to the buildings and their most significant places, providing a complete and effective reading of them. This exercise did not aim for exhaustive documentation of all the spaces of the property component, but rather to provide an adequate storytelling/narrative of the property's OUV and design principles.

To capture the photos, a Ricoh Theta camera was used, with timed captures using a timer. Considering the objective of the photos, the choice of the day for the captures was essential to obtain the best quality, and weather conditions were a decisive element. Moreover, the ideal time of day was selected while avoiding exposure at dawn, noon, or sunset. Virtual tours were processed and enabled through Pano 2VR software.

iv)Didatic Models
The Didactic Models allow to explore the tectonics of Siza's namely the material components and constructive systems, such as the structural system, coverings, frames, details, etc. 3D constructive sections and details are selected because its representative in terms of the constructive and material options framed within the overall design (Attribute 5).

Conceived simultaneously in section and perspective didactic models were inspired on the pioneering study by Edward Ford, "The Details of Modern Architecture," (Ford, 2003), opting for a simple and clear language to transmit knowledge effectively and to disseminate it to a vast audience, including students. The development of didactic models required a permanent confrontation with written and drawn documentation, the photogrammetric models, virtual visits, and the built work.

v)Other (animations, virtual reality, etc.)
The use of virtual reality and its tools has enabled virtual visits to buildings that have either been digitally duplicated or have not yet been built. On the one hand, it allows access to places that may be physically inaccessible for various reasons, while on the other, it can be a powerful instrument for the conservation and enhancement of the component properties. Virtual reality is not only a useful tool for understanding and preserving modern heritage but also for testing non-invasive and completely reversible solutions and new proposals in architecture, thereby preserving the integrity and authenticity of the component properties.

In addition to its practical uses, there is also a potential for leisure and educational applications of virtual reality. As a complement to 360-degree visits, it allows for the exploration of spaces that can be digitally duplicated or subject to proposed alterations such as the expansion or construction of new volumes, or even improving the arrangement of exterior spaces. Hence, virtual reality can simulate situations that allow users to experience different sensations and perspectives in an immersive way (Forte, 2014).

3.3. Integrated multi-method approach

Combined methods and tools were essential for holistic and comprehensive documentation of the OUV pillars - i) criteria/attributes; ii) authenticity/integrity; iii) protection and management - as well as other complementary information required by UNESCO's Operational Guidelines, such as the state of conservation and the factors affecting the property, among other (UNESCO, 2021). The systematic methodology also provides a means for comparing and contrasting the various component properties (see Table 1).

Methods	**Tools**	**UNESCO guidelines (OUV / Other)**
Archival and bibliographic research	Literature review (digital databases) and physical consultation	-All attributes
Digital suveys	Photogrammetry -Mavic Air -Argisoft - Metashape	-Attribute 1,2 and 3 Authenticity/Integrity -State of Conservation
Virtual Tours	-RicohTeta -Pano 2VR	-All attributes Authenticity/Integrity -State of Conservation
Didactic Models	-Autocad Revit (BIM)	Attribute 5
Virtual Reality	- Autocad Revit -ReCap Pro -3DSTMAX -Engine Pro	All attributes
GIS Mapping	-GIS ArcMap	Protection and Management

Table 1. Synthesis Methods, Tools and UNESCO Operational Guidelines requirements.

4. CASE STUDY DEMONSTRATION: OCEAN SWIMMING POOL

The Ocean Swimming Pool was designed by the Portuguese architect Álvaro Siza (Pritzker Prize, 1992) between 1960 and 1966 for the coastal town of Leça da Palmeira, in the north Porto, Portugal. In this early work, Siza adopted an expressively modern technology and abstract neoplastic language reinforced concrete and wood, over the seaside rocks (Ferreira & Fernandes 2021).

The building is currently listed as a National Monument (since 2011) and is included in the Tentative List for World Heritage (2017) Also, the building has been in full use for almost sixty years, becoming a social and cultural landmark for the local communities, playing an essential role in its identity and collective memory (Ferreira, 2022a).

The Ocean Swimming Pool is a relevant example of how different methods and tools are essential for understanding and ensuring the protection and preservation of both the OUV and Siza's design principles, framed within a Conservation Management Plan developed under the KIM grant (Ferreira, 2022b).

i) Archival and bibliographic research

Archival documentation was supported on different archives such as Siza's archives conserved at the Canadian Centre of Architecture (Figure 1), the Municipal Council of Matosinhos, FAUP's Documentation Centre on Architecture and Urbanism, Espólio Fotográfico Português. Research is also supported on the consultation of over eighty publications in multiple languages (Portuguese, English, French, Spanish, German, Japanese, among others), including books, chapters, articles in journals and academic dissertations (Ferreira, 2022a).

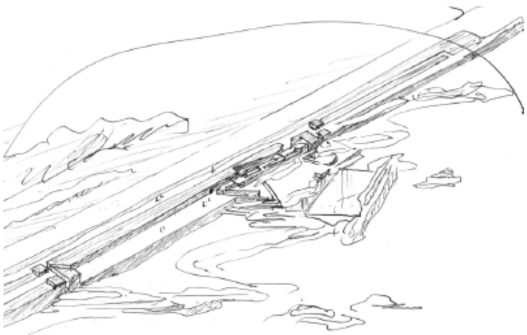

Figure 1. Alvaro Siza Sketch, 1973. Credits: Álvaro Siza (CCA).

ii) Digital surveys

Digital survey was combined using both laser Scanner (BLK 360 da Leica Geosystems) and photogrammetry (DJI Mavic Air). Processing was made through Agisoft Metashape (photogrammetry) and Autodesk ReCap Pro (laser scanning), also used for the integration of the two point clouds. The final model allowed for developing detailed BIM documentation of the building and the surrounding context (sea, rocks, topography, seaside avenue and buildings) (Figure 2 and 3). With data interoperability in mind, BIM model enabled the creation of the didactic models and other resources and tools (3D printing, animations, etc).

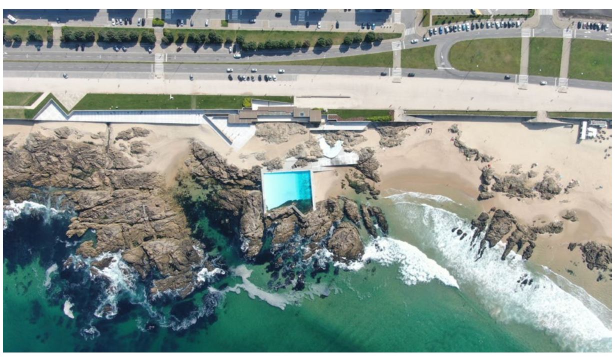

Figure 2. Aerial view, Ocean Swimming Pool. Credits: Pixel.

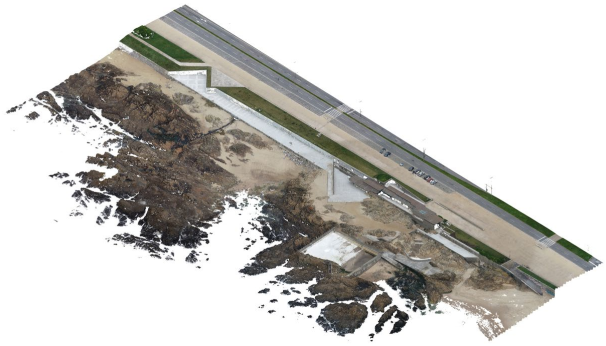

Figure 3. Photogrammetric model, Ocean Swimming Pool. Credits: The authors.

iii) GIS Mapping

GIS mapping allowed for accurate definition of the property limits and Buffer Zone (ArcMap Esri software integrating coordinates surveyed in situ with total station) defined in the listing decree by the General Directorate of Cultural Heritage (Decree No. 16/2011, 2011). The Buffer Zone (Ordinance No. 608/2012, 2012) is attentive to the specificities of the place and its visual relationships, as well as the conditions defined by the current management and planning tools. In this particular case, it aims to safeguard the property's landscape integration, namely the surrounding coastline and the dialogue with the Boa Nova Tea House and Restaurant, also designed by Álvaro Siza and included in the World Heritage Tentative List (Figure 4).

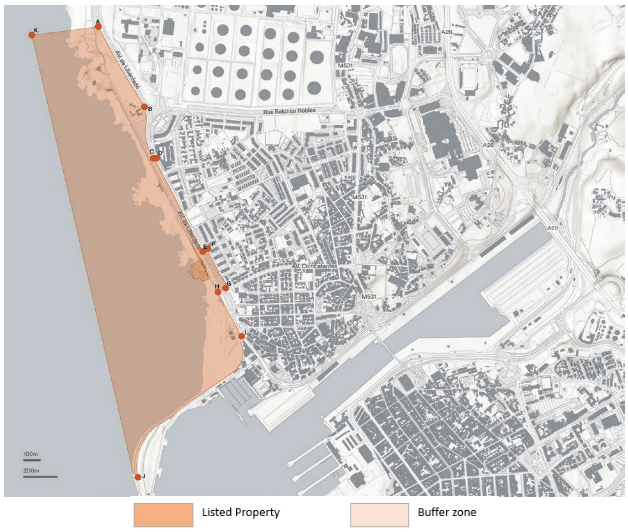

Figure 4. Buffer zone of the Ocean Swimming Pool. Credits: The authors.

iii) Virtual Tours

In the case of the Ocean Swimming Pool, capturing 360-degree photos illustrates the building in its current state, as well as a chronologic record of recent conservation and extension site over several months (2019-2021) . Hence, in a diachronic reading, they enable the exploration of buildings at different moments in time, following their evolution for monitoring conservation (Figure 5).

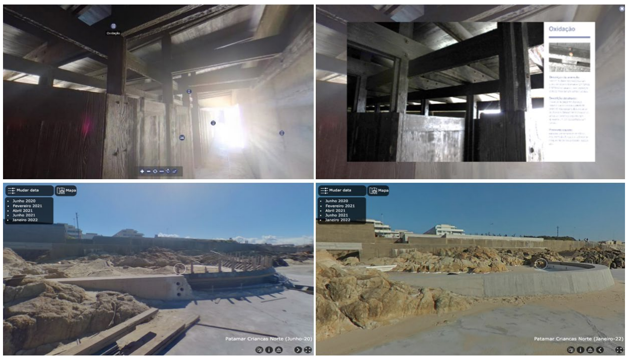

Figure 5. 360-degree photos and virtual tours of the Ocean Swimming Pool. Credits: The authors.

iv) Didactic Models

The Ocean Swimming Pool's tectonics is one of the most important features of the Ocean Swimming Pool, highlighted in the use of wood and concrete. Didactic models, allow to convey how this abstract and brutalist material expression is achieved while presenting accurate construction details with rigorous captions, supported by archival documentation (Figure 6 and 7).

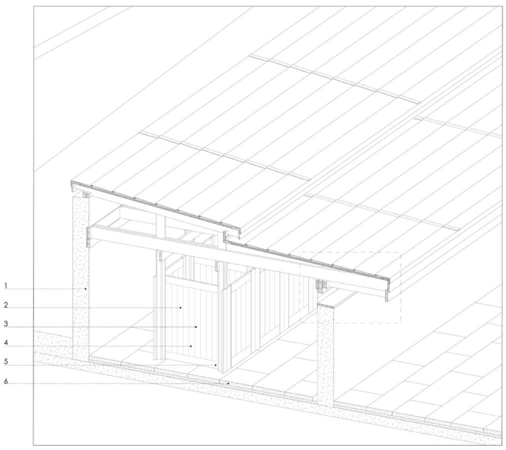

Figure 6. Didactic model of a section of the Ocean Swimming Pool. The authors. 1– Lightly reinforced concrete walls; 2 – Partition walls of dark Baltic pine treated with linseed oil and fixed with galvanized fittings; 3 – Roof's structure made out of dark baltic pine treated with linseed oil and fixed in place with galvanized fittings; 4 – Cover in copper over the insulation made out of a bituminous membrane and agglomerated cork of 1mm thick; 5 – Wooden structure ceiling made of 4cm thick wood slats; 6 – Precast reinforced white concrete slabs.

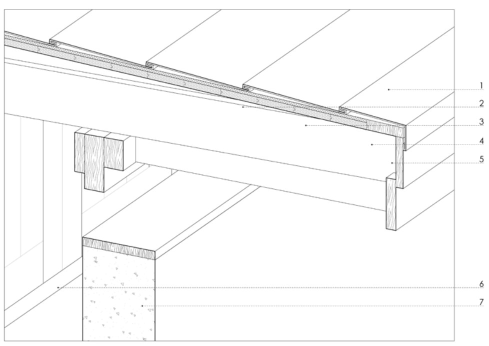

Figure 7. Didactic model of a detail of the Ocean Swimming Pool. Credits: The authors. 1– Bituminous membrane with copper coating; 2 – Waterproofing; 3 – Agglomerated cork, 1mm thick; 4- Wooden boards, 0.15 thick; 5 – Wooden structure; 6 – Concrete wall; 7 – Concrete slabs.

v) Other (3D prints, BIM facility management, virtual reality)

By developing 3D models of the entire complex and its various construction phases (including the restaurant, which was designed but remained unbuilt), each of the building phases was digitally printed and displayed to the public during the exhibition "No place is deserted. Álvaro Siza: Ocean Swimming Pool (1960-2021)" at the Faculty of Architecture of the University of Porto in 2022. The printing of these models provided an in-depth understanding of the building, which was never conceived in one single gesture but was the result of several commissions and additions (Figure 8 and 9).

Figure 8. Tridimensional model of a section of the Ocean Swimming Pool in the preparation for the 3D prints. Credits: The authors.

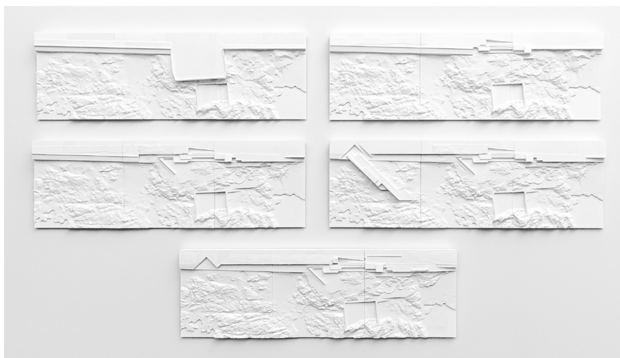

Figure 9. 3D prints of the different construction phases of the Ocean Swimming Pool, Credits: the authors

The 3Dl BIM model also allowed to develop a facility management strategy integrating the maintenance plan with the BIM model through a digital twin, currently in development in articulation with the Municipal Council of Matosinhos (Figure 10).

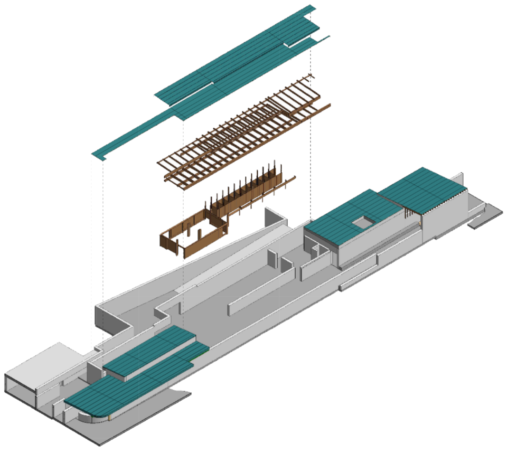

Figure 10. Didactic model of the Ocean Swimming Pool. Credits: The authors.

Furthermore, during the cross-reading of documents, a proposal for a virtual construction of the restaurant designed by Álvaro Siza (1965; 1995), which remained unbuilt. This proposal was developed as part of a master's dissertation in Architecture and utilized Virtual Reality technology (Autocad Revit, ReCap Pro, 3DSTMAX, Engine Pro) through to enable non-invasive and fully reversible visits to a non-built space (Barbosa, 2022).

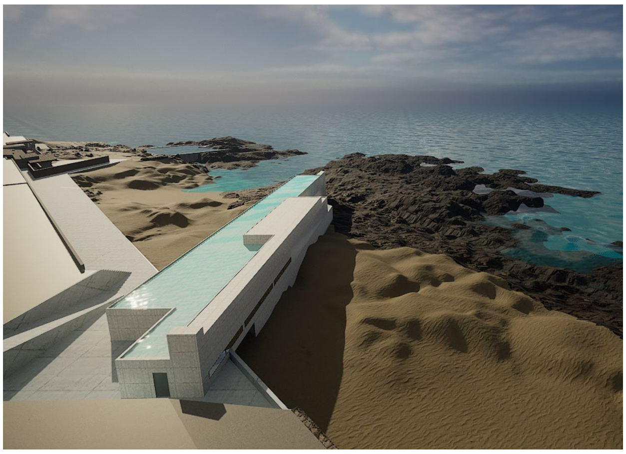

Figure 11. Virtual reality simulation of the unbuilt restaurant for the Ocean Swimming Pool. Credits: The authors.

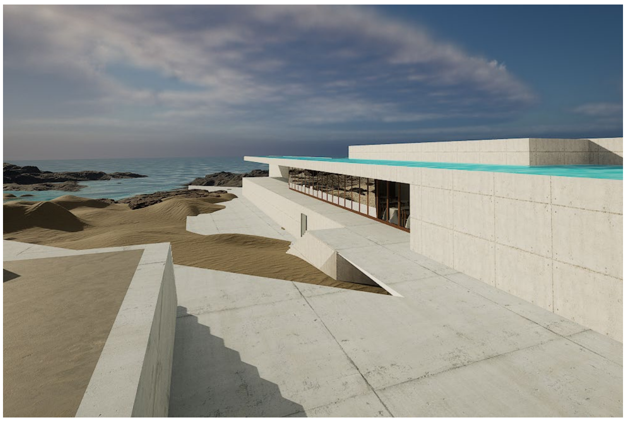

Figure 12. Virtual reality simulation of the unbuilt restaurant for the Ocean Swimming Pool. Credits: The authors.

5. CONCLUSIONS

Despite the exponential increase of digital tools applied to Cultural Heritage, there are still few documentation experiences applied to modern heritage. Moreover, there is a general lack of with integrated multi-method approaches allowing for a comprehensive documentation of built heritage, namely properties inscribed in the World Heritage List.

Methodology description and case-study implementation have demonstrated the potentiality of combined methods, techniques and tools in the documentation of cultural heritage. Modern architecture, such as the Ocean Swimming Pool has a great potentiality because of the high amount of sources available for its documentation.

Limitations of the work are related with time and resources to apply with the same detail all methods to the 18 works inscribed in the World Heritage List. However, future work previews the enhancement of the methodology and its extension to other works and techniques, further development of Facility Management in BIM, and enhancement of other communication supports such as augmented reality.

Early results show how digital drawing allows for the critical illustration and storytelling narrative of the OUV attributes and the buildings' design principles. Also, systematic and integrated methodology for the digital documentation of modern heritage – using different methods and tools - allows for new perspectives on Álvaro Siza's work while preserving his legacy for future generations.

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