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True-to-life modelling of Auteur architecture of the 20th century. From BIM modelling to webGIS fruition

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Abstract

This study explores the concept behind the modelling and digital fruition of 20th-century auteur architecture, with a specific focus on the Santa María Micaela residential complex designed by Santiago Artal Ríos in Valencia (ES). The research uses BIM techniques to create a detailed digital representation of this architectural landmark, facilitating the integration of different historical data sources and providing a comprehensive understanding of the building's original design intent, construction methods and subsequent modifications.

The Santa María Micaela residential complex serves as a case study to explore the potential of H-BIM in architectural heritage conservation. The 3D model of the complex was created after an in-depth data collection study, which involved archival research and an accurate on-site survey.

In addition, the study extends the utility of BIM models by integrating them with webGIS. This integration enhances accessibility and interaction, allowing a wider audience to engage with the digital model. Allowing the users to navigate the model, retrieve detailed information about various elements, and analyse the architectural and historical context of the complex.

The results highlight the value of combining BIM with webGIS technologies in the preservation and dissemination of architectural heritage, helping to preserve the physical and intangible aspects of historic buildings but also facilitating access to heritage information.

This study aims to be a preliminary approach that explains how contemporary digital tools can breathe new life into 20th-century architecture, ensuring that its legacy will endure for future generations, contributing to the wider discourse on digital heritage conservation and advocating the adoption of advanced modelling and visualisation techniques in the conservation of modern architectural icons.

Keywords: *digital twin, BIM, webGIS, auteur architecture.*

1. Introduction

This study investigates the use of Building Information Modelling (BIM) and Geographic Information Systems (GIS) in the digital representation and preservation of 20th-century auteur architecture, with specific attention on the Modern architecture complex recognised in the DO.CO.MO.MO Ibérico catalogue in the register of *"La vivienda moderna"* (Figure 1) and specifically focuses attention on the Santa María Micaela residential complex designed by Santiago Artal Ríos in 1958 and constructed in 1961 in Valencia, Spain. This complex exemplifies how these architectural styles aimed not only at building new flats but also at creating communal spaces without compromising on design and aesthetics. The design approach is a masterful combination of Vitruvian principles, i.e. *firmitas* (strength), *utilitas* (utility), and *venustas* (beauty), which are now widely recognised and appreciated globally.

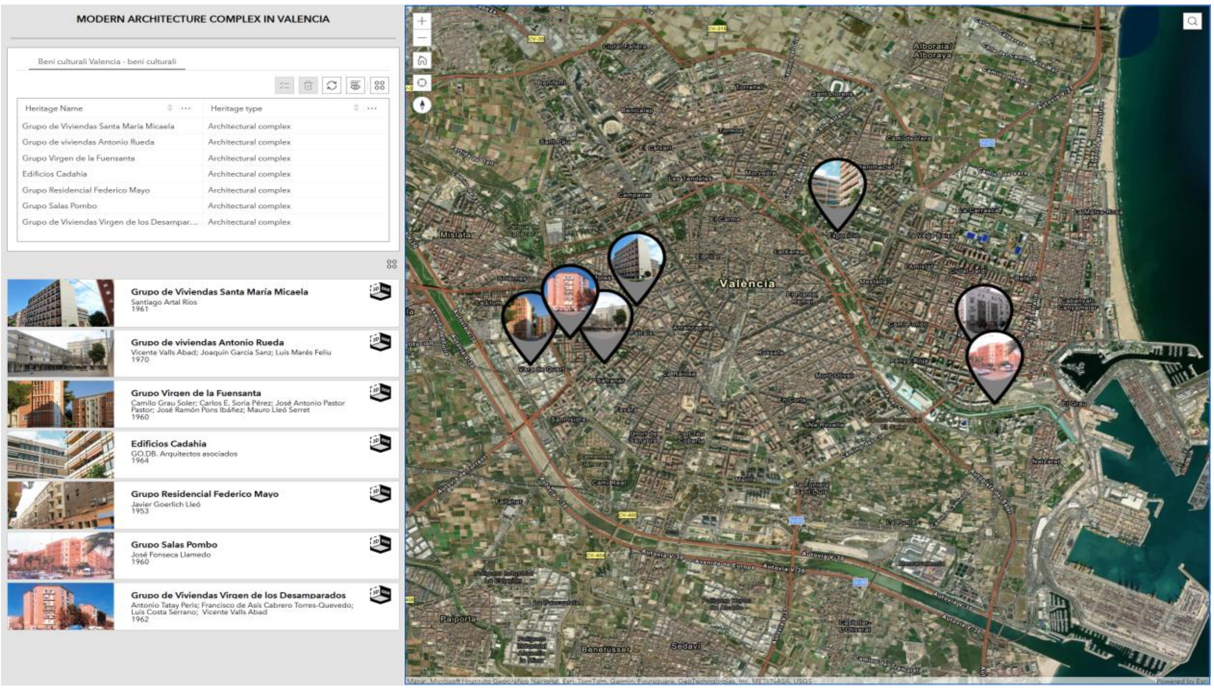

Figure 1. First web interface - identification and presentation of architectural complexes. Source: Angileri (2024)

These buildings were all constructed in the period between the 1950s until the end of the 1960s. Modern proposals are the result of rational approaches determined by the functionality of the space, the solar cycle, concerns about ventilation, hygiene and comfort, and the minimisation of technical elements in new buildings. At that time, however, there were no current calculation tools and aids, only certain approximations obtained through basic calculations, which, based on certain constants such as orientations, provided data on which elements to use and how to use them. Small diagrams were drawn on the then-famous graph paper, leading to coherent proposals with a certain design and construction logic.

The building that is the case study of this work takes part in the *"Plan de Mutualidades Laborales"* developed during the Franco regime; their magnitude and very short execution time were already boasted in the regime's own propaganda and is currently recognised, which exhibits the best architecture of the Spanish modern movement usually characterised for their sensitive attention to collective needs, a programmatic methodology, a technical efficiency and a critical assimilation of modernity. The case of collective housing is where this architectural style was most applied, modifying the style that had been established up to that time and opting for it in the creation of new buildings. In this way, they opted for the modulation of the façade, the liberation of the ground floor to create spaces for social recreation with vegetation and the use of materials such as reinforced concrete, which give it an exemplary character in Valencian architecture.

The Santa María Micaela building is the first project in Valencia Santiago Ríos (Pozo, 2004). The complex is located on the corner of Pérez Galdós and Santa María Micaela streets, where is also located the main access in a site that belongs to the extension of the Valencia General Plan of 1946 with a buildable depth of 46 metres. It is organised in three buildings with 138 dwellings. The architect offered a solution for widening a closed block, in which he introduced a coherent alternative of occupation based on the grouping of three blocks around a free area for the use of the community and carefully treated in all its details, with ponds and walkways. As a critique of the traditional planning of the city, the fragmentation of buildings is perfectly articulated to favour orientations and views, centralisation of common services and housing density with non-speculative use of the land.

The strict compositional geometry is subtly challenged by the diverse nature of the materials and by a chromatic animation with neoplastic roots: red panels under the windows, yellow brick closures and blue tiles for the terraces.

The use of BIM in the conservation and restoration of heritage buildings offers several important advantages for architects and heritage conservators (Dore & Murphy, 2022). First, accurate documentation of the building's structure and architectural details allows for a better understanding of its history and evolution, which in turn allows for more informed decisions to be made about the conservation and restoration of the building. The digitalisation techniques combine various historical data sources into a detailed digital model, enabling a comprehensive understanding of a building's original design, construction methods, and subsequent modifications (Fregonese et al., 2021).

This integration of historical data and advanced modelling techniques is crucial for the effective preservation of architectural heritage, ensuring that these cultural landmarks are accurately represented and sustainably maintained for future generations.

The integration of BIM in architectural heritage conservation is particularly relevant for structures of significant historical and cultural value, as it facilitates not only the preservation of physical attributes but also the intangible aspects, such as the socio-cultural context and design philosophy. The Santa María Micaela complex, renowned for its innovative mid-20th century design and socio-cultural significance, serves as an ideal case study to explore the capabilities and benefits of BIM in documenting and preserving such heritage. By leveraging archival research, on-site surveys, and advanced digital tools, this research aims to create a precise 3D model that can serve as both a preservation tool and an educational resource. This approach underscores the importance of incorporating modern technology in heritage conservation, providing new avenues for research and public engagement (Banfi et al., 2020).

GIS plays a crucial role in the documentation and inventory of heritage sites, providing spatially accurate databases that include detailed information about the location, condition, and historical significance of buildings and monuments. This capability is relevant for creating a thorough registry that informs preservation planning and decision-making. Furthermore, GIS facilitates condition assessments of heritage structures by enabling the visualisation and analysis of spatial data related to structural health, environmental conditions, and potential threats. This kind of spatial analysis helps to identify areas that require immediate intervention, ensuring timely and effective conservation efforts. The integration of GIS with BIM enhances data management by assisting the management of both spatial and building-specific data within a unified framework. This integration enables improved analysis and visualisation techniques, such as 3D GIS, which can visualise the spatial context of a heritage. Such combined capabilities support comprehensive analyses, including impact assessments, environmental simulations, and structural evaluations. Interdisciplinary collaboration is greatly facilitated by the combined use of GIS and BIM.

2. Aims and objective

The primary aim of this study is to demonstrate the effectiveness of contemporary digital tools, specifically BIM, in improving the preservation and understanding of 20th-century architectural heritage. By focusing on the Modern architecture complex recognised in the DO.CO.MO.MO Ibérico, the research seeks to achieve several interconnected objectives. Firstly, it aims to create a detailed and accurate digital model of the complex that integrates various historical data sources, including architectural plans, photographs, and archival documents. This model will serve as a comprehensive repository of information, documenting the original design, construction techniques, and subsequent modifications of the building. Secondly, the study aims to analyse this data to gain deeper insights into the architectural and historical context of the complex, highlighting its significance in the broader landscape of mid-20th-century architecture. Thirdly, the research extends the utility of the BIM model by integrating it with webGIS technologies, enhancing accessibility and interaction.

This integration allows a broader audience, including researchers, educators, and the public, to engage with the digital model, navigate through it, and retrieve detailed information about various elements. Additionally, users can analyse the architectural and historical context of the complex, making it a valuable tool for education and public outreach. Ultimately, the study aspires to contribute to the broader discourse on digital heritage conservation, advocating for the adoption of advanced modelling and visualisation techniques in preserving modern architectural icons. This approach ensures that the legacy of such structures is preserved for future generations, fostering a deeper appreciation and understanding of 20th-century architectural heritage (López et al., 2020; Bruno et al., 2021).

3. Methods and procedure

3.1. The approach to the digitisation process and the motivations behind the use of BIM/GIS software

GIS and BIM are two digital technologies that are widely used in the architecture, engineering and construction (AEC) sector but were originally designed to work in two different areas. GIS is a system for the creation, management, analysis and mapping of geospatial data, merging and combining spatial information with tabular data archives in a single system, widely used for the analysis of the geospatial characteristics of large areas and for the analysis of environmental data and natural hazards, while BIM is a system based on enriched 3D models for building management, combining many aspects related to building design, from architectural conception to the definition of installations.

The implementation of integrated BIM/GIS systems offers important perspectives for the management, conservation and valorisation of the cultural landscape and architectural heritage, as is widely recognised by the numerous academic studies on the subject and the important technological implementations by many software houses in the sector. It offers the possibility of integrating data from numerous sources, from instrumental to archival and beyond (Colucci et al., 2023; Misilmani et al. 2024)

The approach to the development of the materials described in this article is based on an in-depth study of state of the art and combines the most interesting insights gained from reading and studying other research in the field with a targeted approach by the entire research team that has led to the development of a web platform that aims to go beyond certain standards and features characteristic of the most widely used GIS platforms, aiming at a characterisation of information that can offer easy-to-read screens, reducing as much as possible the use of simple 'points' to denote elements and aiming at the realisation of a 3D environment.

In particular, the chain of procedures that led to the production of the material shown in the following article (Figure 2) began with a study of the architectural assets and their significant characteristics through the collection of archival material and then, in the case of the Santa Micaela complex, the ability to associate original material produced during a series of inspections.

This material made it possible to create a BIM model for this structure, in which, in addition to the architectural characteristics, the performance characteristics were added, and for the other works, the GIS cataloguing process was carried out till the realisation of the webGIS environment.

The integration and enhancement of GIS and BIM not only optimise the management and conservation of historical and cultural sites but also pave the way for innovative applications in the AEC sector. These technologies set new standards for future technological implementations and demonstrate the significant benefits of merging geospatial and architectural data for comprehensive analysis and decision-making.

Figure 2. The phases of research and modelling, from knowledge to modelling to web use. Source: Angileri (2024)

3.2. The study of the architectures and the creation of a true-to-life BIM model

The knowledge phase of the project was based on Prof. Luis Manuel Palmero's experience of the sector of architecture and his knowledge in the city of Valencia, which allowed us to identify a series of works with similar characteristics, not only from the same construction period but also from a similar architectural style, which is now internationally recognised and referred to by the DO.CO.MO.MO. as modern social housing. These architectures are largely characterised by their simple materials, such as concrete and brick, which are often not covered with plaster or stucco but are left facing the work (Bernardo, 2023).

Numerous renowned architects - Carvajal, Sert, Coderch, Corrales y Molezún, Moreno Barberá – among others following the rationalist principles of the time gave life to new neighbourhoods or settlements of high compositional and formal quality. The single-family or farmhouse typology was flanked by the so-called ‘tower’ constructions with duplex housing in a cooperative regime. This building model, developed and perfected over time, solved the problem of housing demand and land consumption without neglecting aspects related to residents' comfort and well-being. In fact, following the dictates of the hygiene movement and new knowledge in the health field, the design also considered aspects aimed at improving comfort conditions, i.e. exposure, solar radiation of the rooms and natural ventilation (Barona, 2009; Bernabeu Mestre, 2009).

The BIM model was created using ACCA's Edificius software (Figure 3), which, unlike other products in the sector, has begun to include specific functionalities for the HBIM characterisation of the model among its commands. The model of Santa Micaela was created based on archival data found on the work, to which must be added some information found during a series of direct surveys of the work and one of the apartments in the complex. In particular, during these surveys, it was possible to carry out a series of analyses and to find high-resolution photographs of the characteristic surfaces of the work, especially the surface of the concrete, the facing bricks and the various mosaics that characterise both the external and internal elements of the building.

The use of this type of approach made it possible to conform a model as comparable as possible to the real architectural organism both from a geometric dimensional and technical point of view, obtaining a true-to-life model. The benefit of this approach, however, must always be weighed against the actual application, especially considering that the modelling and construction time of the model is largely influenced by the level of detail to be accomplished and the complexity of the building to be modelled.

Moreover, many of the features that make the model realistic are often not yet well exported to different platforms and therefore, the transition from BIM software to the GIS platform greatly impoverishes the quality of the implemented model.

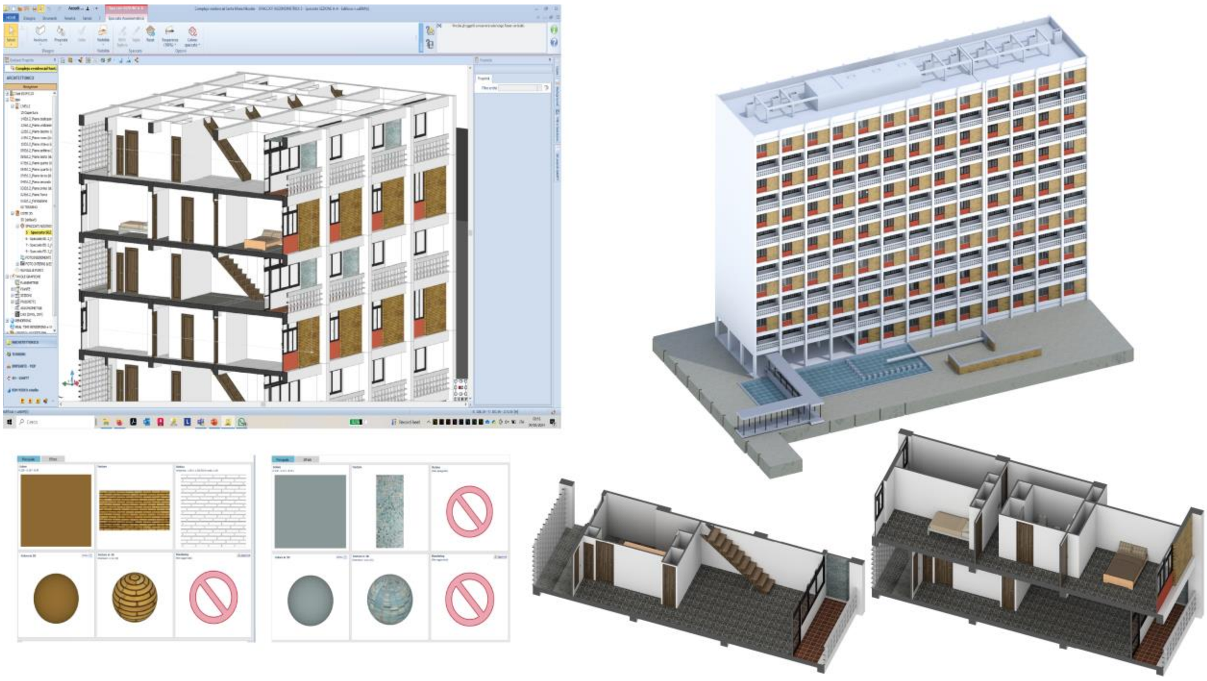

Figure 3. Edificius interface and examples of photorealistic exported views of the building. Source: Angileri (2024)

3.3. The export to webGIS-based platforms and the configuration of the 2D/3D digital experience of the projects

The first step in the implementation of the virtual fruition environment is the definition and configuration of the area of interest and the significant data of the GIS environment.

For this purpose, a data design process was initiated to define the significant information needed to characterise and identify the works. The areas identified were divided into the following six categories:

- Heritage Identification
- Historic identification
- Architectural information
- Extended information
- Heritage protection
- Attachment and External link

The software used to manage and implement the GIS environment is from the ArcGIS software house. This includes the on-premises PRO version for managing BIM models and pre-configuring fields and icons and the online version for managing and publishing to webGIS systems.

The BIM model, modelled and characterised as shown above, was exported in .ifc format, an open-access format that allows the file to be used within other software. Once the model has been loaded into the GIS platform, the first operation performed on the file is to georeference the file and position it correctly according to the geographic reference system.

After the georeferencing activity has been completed, it is necessary to carry out the process of creating and exporting a georeferenced 3D file used by ESRI software for sharing and use; the format is called Esri Scene Layer Package or ‘slpk’ and to create it is necessary to launch the create Building Scene Layer Content command.

To develop the web application or website, ArcGIS Online's Experience Builder was used. This ESRI product allows the creation of 2D and 3D web applications that integrate spatial data and 3D models. Once data is published in ArcGIS Online, it can be visualised online. To do this, it is first necessary to import the materials made on ArcGIS Pro and in particular:

The 2D elements identifying the building complexes are uploaded directly into the online system with a direct connection process, which leads to the generation of a 'Feature layer' containing both the graphic and the computational data of the works. With it in the realisation screen called Map Viewer, it is possible to configure what will become the actual base map. In this screen, it is also possible to define and characterise the pop-up screens that open when the icons identifying the complexes are touched.

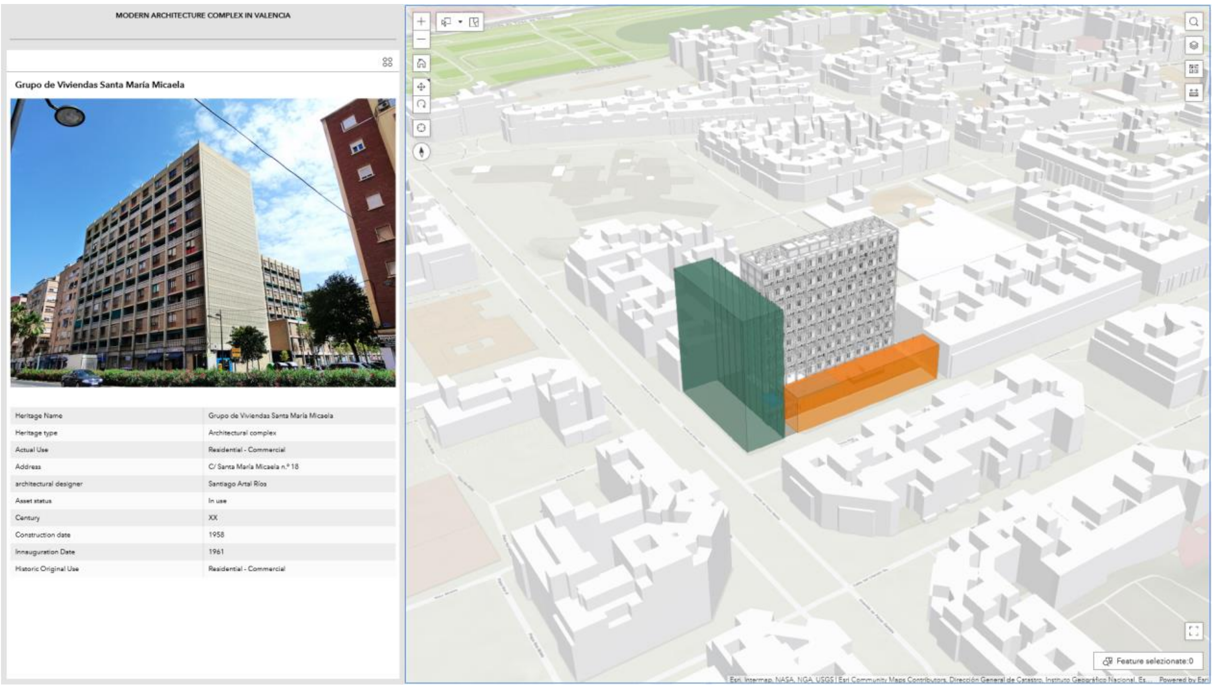

Figure 4. Second web interface -. 3D interface with content integration from BIM software. Source: Angileri (2024)

Regarding 3D content, the process is similar; the slpk file, once uploaded online, is uploaded into a Web Scene, which differs from the Web Map precisely because of the possibility of connecting inspectable and configurable three-dimensional data in addition to 2D data. In the Web Scene interface, it is possible to interact with the loaded BIM model and is also given the possibility of interacting with it by being able to filter the various levels that make up the structure or through vertical and horizontal section planes, thus giving the possibility of an exploratory tour of the work.

The last step of the work involved the creation of the WebGIS, and for doing this, the tool used was ArcGIS Experience Builder, which is a configurable solution for creating web apps without writing code. The tool gives the user the opportunity to choose an already prearranged template and create an immersive web experience for the audience by unifying web maps, apps, pages, interconnected widgets, and both 2D and 3D data through a flexible drag-and-drop interface.

Three types of interfaces were developed. The first (Figure 1) shows the area on which the works insist and gives the possibility both by selecting a field in the table and by selecting an element in the list to zoom in automatically, which allows a closer view of the area on which the selected good insists, clicking instead on the icon on the map will display the popup window, in which some of the significant data of the work have been reported.

To access the second type of screen (Figure 4), only it is needed to click on the 3D BIM icon next to each building on the list. This will take you to the 3D screen that contains not only the imported BIM model but also the reconstruction of the volumes of the buildings surrounding the building.

The last screen (Figure 5) is accessible after tapping the "Attachments" button located below the project card, which is present in the second interface. From there, it will be possible to view various elements divided into three categories: drawings, documents, and photos. These elements allow interaction with the documents used in the research and study phase, which were used as sources, particularly for the creation of the 3D model.

The final webGIS designed is a simple tool that provides an overview of all the heritage architectures of interest, helping the user to locate and contextualise each element first in a 2D map of the city of Valencia. This map acts as a point of access to the elements, providing little information and basic search and inspection tools.

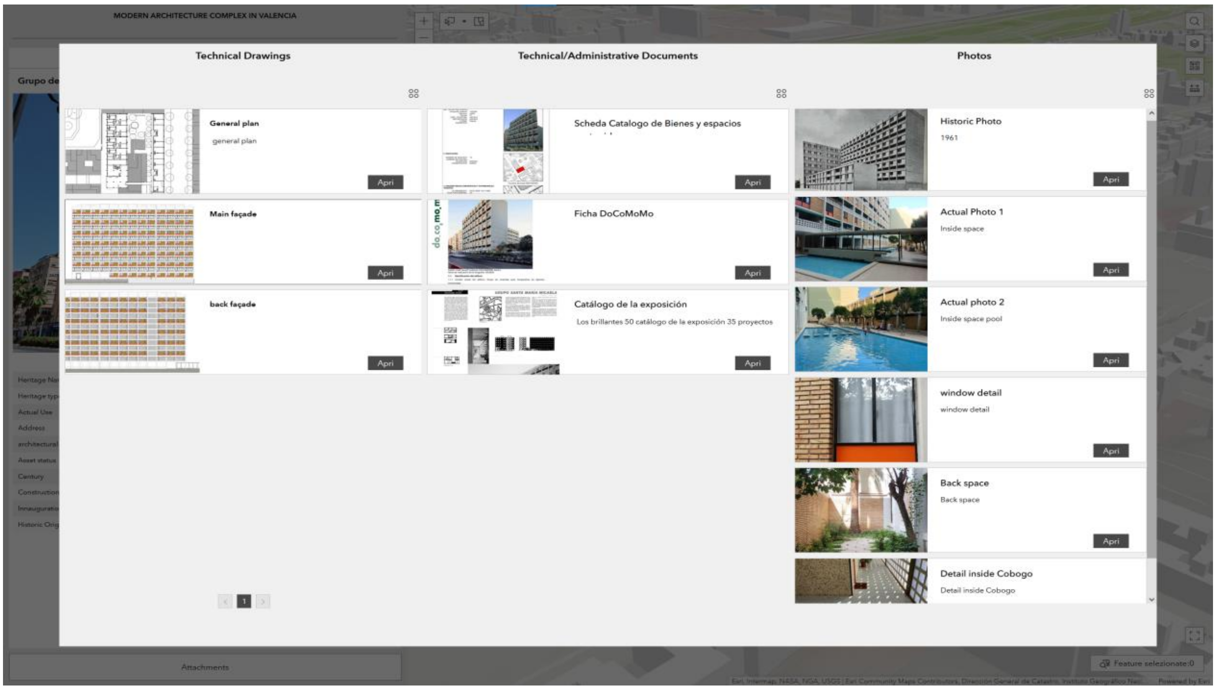

Figure 5. Third web interface - presentation of annexes by drawings, documents and photos. Source: Angileri (2024)

4. Conclusion

At present, the operational relationship between digital tools, in this case BIM and GIS/WebGIS, allows us to make a very significant advance in the management and knowledge of our buildings and our architectural heritage, as well as urban and landscape heritage. These tools, aided by complementary computer support, provide a series of parameters applied to the building itself, providing knowledge from a holistic point of view and application in various fields such as design, social or tourism.

A few years ago, the previous lack of software to be able to know the behavior of the building over time by rationalist architects was solved by a variety of software adapted to the building's comfort resources. At present, the HBIM as a more specific element for the phase of geometric knowledge and the history of the building, through the evaluation, the state of conservation of the materials, a tool that offers a three-dimensional catalogue oriented to the documentation and planning of maintenance tasks.

This previous one, with the incorporation of data from GIS, will allow a deeper knowledge of our building, enriching it with information that allows a more effective management and calculation of the impact in terms of mobility, environmental information, heritage as well as existing infrastructures.

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