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Narrating Serranos Bridge Evolution in Valencia (1500–2022) Using Historic Building Information Modelling and Historical Data

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Abstract: The city of Valencia (Spain) is famous for its Gothic bridges, built in the 16th century. Today, the bridges no longer cross over the Turia River but have become walkways over one of the most extensive gardens in Europe. One of these bridges is the Serranos Bridge, the oldest bridge in the city and for centuries, it was the only one that existed. This research narrates the evolution of the historical changes related to this bridge, using Historic Building Information Modelling (HBIM) technology. The Serranos Bridge (and related Serranos Towers) were recorded with the help of terrestrial laser scanning, and parametric 3D modelling was followed after scan-to-HBIM. By referring to historical documents and traces from the past, the height of the historic wall of the city was obtained and used to recreate the urban footprint of the area. In addition, the details of the historical bridge components and the subsequent volumetric changes were reconstructed through HBIM. This investigation shows that there is a common symbol in the historical bridges of Valencia, called Casilicium, of which no traces can be identified in the present bridge. The effective integration of historical data, geomatics and HBIM can be used to understand the past and its complex transformation over six centuries with unprecedented expectations.

Keywords: historical bridges; historical documents; paintings; maps; 3D reconstruction; HBIM

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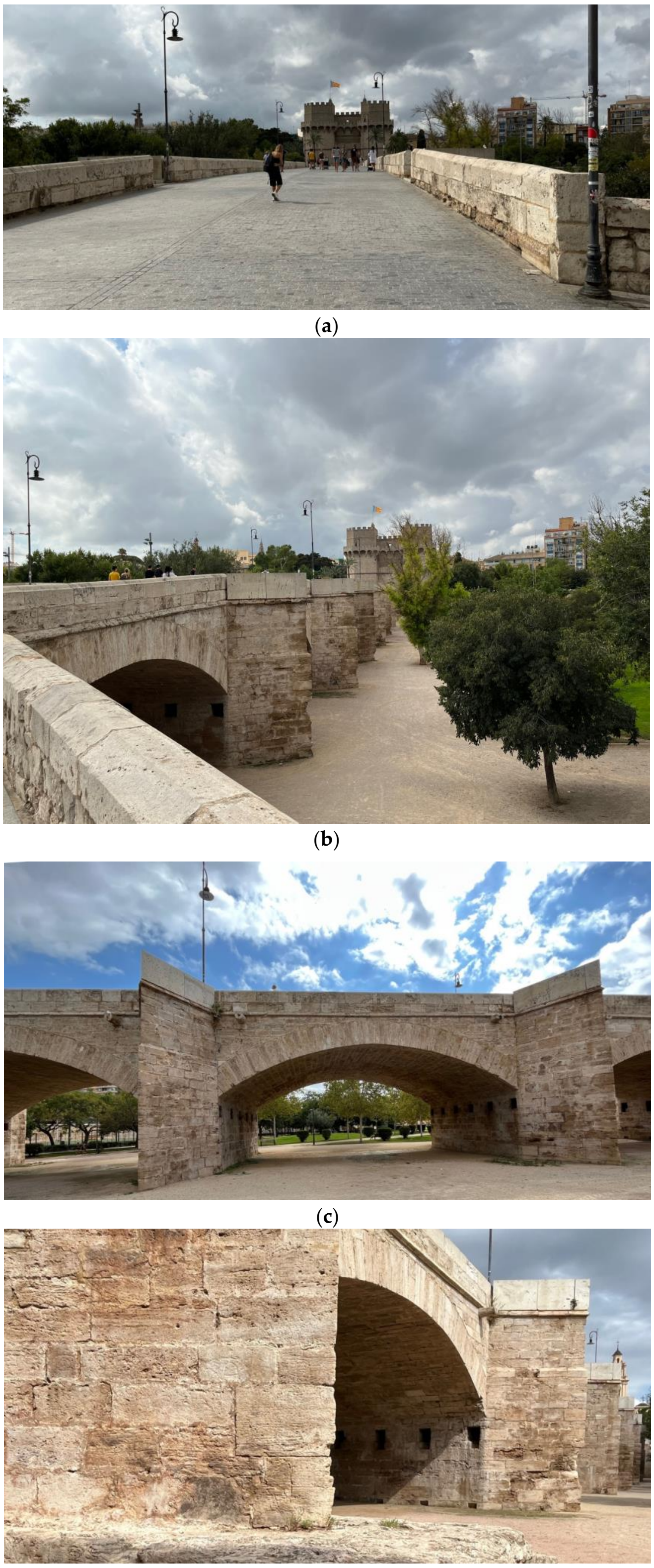
1. Introduction

Valencia (Spain) is located south of the historically mighty Turia River. Today its bed (now without water) has become one of the largest parks in Europe. Since its origins, the city of Valencia has periodically suffered from the overflow of the Turia River, causing great and irreparable damage, at least 10 times from 1088 before the largest flooding in 1957. “The mild Mediterranean climate is characterized by hot summers and mild winters. But its enviable temperatures are periodically interrupted by violent storms, where in a few hours hundreds of litres by m^2 are discharged causing large floods” [1]. Due to these periodic floods, the bridges built over the river, since the city’s foundation, have been destroyed and therefore reinforced or replaced by others. Even though the water no longer runs through the channel, the historical bridges have been maintained as they are essential elements to unite both sides of the city [2]. In addition to their usefulness, these bridges over the old riverbed are considered one of the best architectural pieces in the city.

Out of the five large historical bridges existing in Valencia, the subject of this article is the Serranos Bridge (Figure 1). This bridge is included in the Historical Complex of Valencia and in the protection environment of Asset of Cultural Interest by Decree 57/1993, of 3 May (DOGV of 10/5/1993). Also, it has been declared as an Asset of Local Relevance individualised by article 46 of Law 4/1998 of 11 June, of the *Generalitat Valenciana* [3].



(**a**) (**b**) (**c**) (**d**)

Figure 1. Serranos Bridge today 2023: (**a**) sidewalk south view with in the background, the Serranos Towers; (**b**) sidewalk northwest view; (**c**) river ground-view arch and cutwaters from the west; (**d**) river ground-level side view from the southeast.

All the bridges over the Turia are orthogonal to its banks, except the Serranos Bridge, which is oblique. "The layout of the bridge is not intentionally arranged obliquely over the river, but as an extension of the axis of the Towers and Serranos street, assuming its role as an urban element, in the definition of the public space in the city" [4].

The Serranos Bridge is the oldest in the city and for centuries, it was the only one that existed. Being the oldest of the bridges in the city, it takes its place among the various bridges that have occupied that location. The first Serranos Bridge (wooden), was built at the Roman foundation of the city, and was located near a river port [5]. This initial bridge had already begun to be reinforced with masonry during the Roman era. The bridge was praised in the Islamic era as one of the most beautiful and solid in Al-Andalus. Muslim chronicles narrate how access to the city was through Bab al-Qantara [2], which meant "the gate of the bridge".

After a serious flood in 1517, the Serranos Bridge was the first bridge of the city to be built with stone ashlars, originating the series of beautiful Gothic bridges, although not medieval, with a careful stereotomy. Even though it benefited from important restoration work in 2011–2012, it is a bridge that has not been studied in depth, as has happened with the Trinidad Bridge, the Royal Bridge and others [6].

Either Heritage or Historic Building Information Modelling (HBIM) have long been used to model building constructions in heritage [7–9]. It is demonstrated as a feasible solution for complex architecture [10,11], despite the fact that BIM was not initially conceived for historical features. Furthermore, laser scanning in general either terrestrial or aerial and/or photogrammetric approaches are the preferred alternatives for documenting properly built heritage [8,9,12,13]. The final result of HBIM is a product consisting of 3D parametric models, including features according to the specified level of detail, level of development, or grades of generation (Banfi et al., 2022; Level of Development Specification Guide, 2017) [14,15], including construction materials, historical periods, decorations, costs, and providers, among others.

Historic bridges are relevant heritage features in both urban and rural areas; in Valencia city, they are considered architectural masterpieces [16]. However, little attention has been paid to documenting them using scan-to-BIM approaches. An exception can be found in the paper written by Previtali [17], which addresses a smooth workflow for bridge data sharing among different stakeholders for infrastructure management. Indeed, even for existing concrete bridges, there is no -optimized bridge inspection and maintenance information technology system available that might be extensively used for asset management and structural analysis [18].

In this article, remote sensing data, scan-to-HBIM workflows and parametric 3D modelling are combined with historical documents of the Serranos Bridge to examine its architectural evolution over time. The main periods are reconstructed using a scan-to-HBIM workflow and parametric 3D modelling. In order to reach the initial volume, old documents and pictures have been checked, in particular the View of Valencia by Anthoine van den Wijngaerde (1563), the woodcut from the book of Antonio Beuter (1583), Antonio Mancelli's Valencia plan (1608), Vicente Tosca's Valencia plan (1704), the Tosca Valencia plan engraved by J. Fortea (1738), and some views of Valencia from the 19th and 20th centuries. All the documents gathered, including the scan-to-BIM data set that records the latest existing state-of-conservation (acquired in 2022) are conveniently integrated into HBIM using Autodesk Revit software. Referring to historical documents and traces from the past, the height of the historic walls of the city have been obtained and used to recreate the urban footprint of the area. In addition, details of historical components and the subsequent volumetric changes are reconstructed within the HBIM project of the bridge.

2. Methodology

HBIM has been selected as the 3D modelling technology to introduce the evolution of historic features of the Serranos Bridge. Terrestrial laser scanning (TLS), digital images and historical archives with different layers of information, from the 15th century up to the last known restoration in 2012 have been gathered and used to introduce the methodology presented in Figure 2; the last data acquisition was obtained by the authors in 2022.

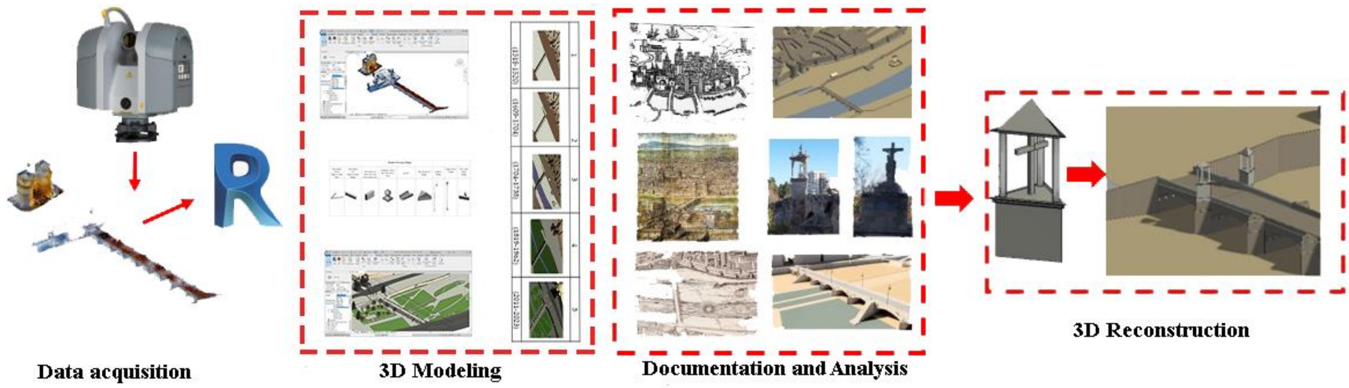


Figure 2. Data acquisition, HBIM and historic documentation workflow.

The methodology presented herein considers 4 stages (Figure 2): (1) Data acquisition with TLS and digital images; (2) parametric 3D modelling (HBIM); (3) historical documentation and analysis (including identification of lost details); and (4) HBIM reconstruction of former periods.

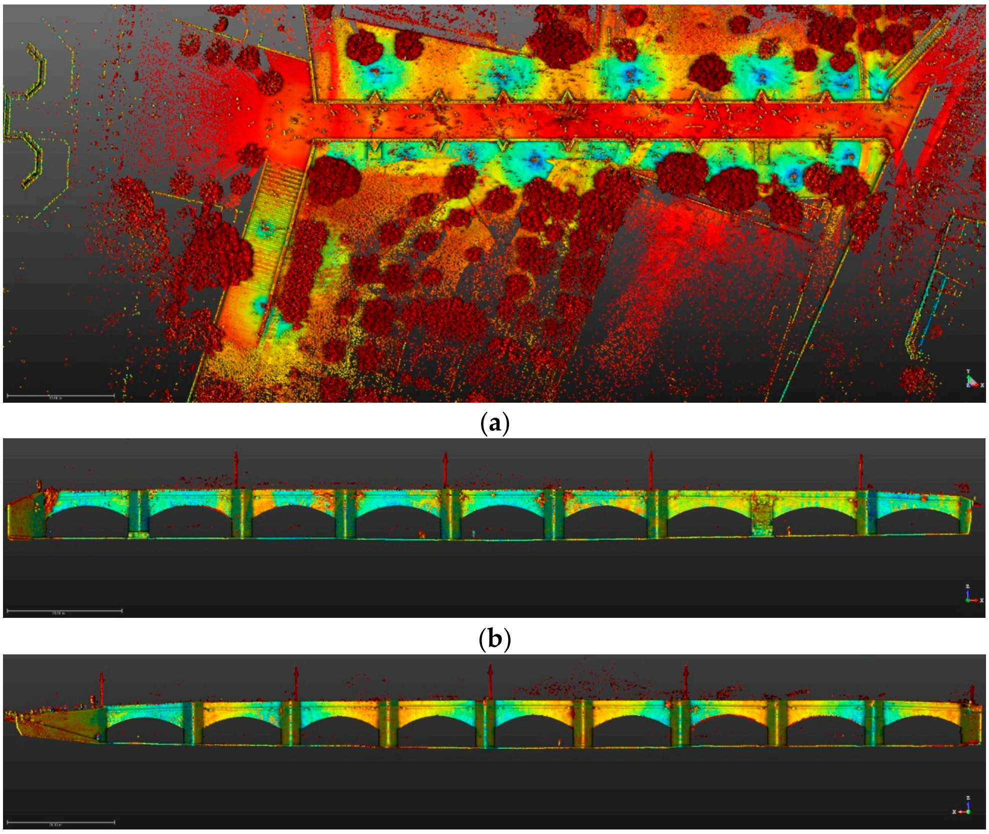
For the current state of conservation, a comprehensive TLS field survey, together with sketching and digital images was undertaken. After collecting field data and generating a dense unified (registered) point cloud, the process of HBIM started. The existing condition of the bridge was modelled with its structural components, and then changes over time were analysed with the help of historical documents.

Creating a Historic Building Information Modelling (HBIM) of the Serrano's Bridge evolution from point cloud data in Revit software involves several steps. Managing levels of detail (LODs) becomes crucial for representing as accurately as possible the historical development across five periods [19–23]. Next, an explanation of how LODs have managed in this study:

1. Importing Point Cloud Data: Supported Formats: point cloud data are turned into a compatible format (e.g., RCP, RCS).
2. Establishing Phases: Create Phases: To achieve this, different phases are set in Revit to represent each of the five historical periods.
3. Basic geometry and massing (LOD 100–200): Phase 1: Early Construction: In this step, the point cloud data are used to create the basic massing and geometry of the bridge for the earliest period (LOD 100).
4. Progressive detailing (LOD 200–300): Phases 2–4: The model is refined with more detailed elements, and LOD 200–300 is used to represent architectural features.
5. Historical accuracy (LOD 300–400): Phases 5–7: Specific Historical Eras: Details, materials, and textures based on historical research are added. LOD 300–400 is utilised to capture each period's specific characteristics.
6. Point cloud integration (LOD 400–500): Phases 8–10: Surveyed Periods: survey data are integrated from laser scans to achieve LOD 400–500. The point cloud data are used to capture precise measurements, ornamental features, and intricate elements.
7. Visualization and analysis (variable LOD): Phases 11–12: LOD is adjusted based on the purpose: higher LODs for detailed visualisations and lower LODs for analysis.
8. The 3D reconstruction was modelled based on historic maps, details, traces and features on the bridge, towers, and the old city centre. A total of five periods were identified and reconstructed. The summary of the workflow followed is presented in Figure 2 and described in the following sections.

2.1. Data Acquisition

The data acquisition was undertaken with a static terrestrial laser scanner and a high-resolution reflex camera. For the former, a Trimble TX8 laser scanning was selected due to its main features: fast data acquisition, accuracy, and range. In particular, 28 scan stations were required to record the overall bridge following several rings at a spatial resolution better than 5 mm from each single scan. In total, 437 million points were acquired. Several registration methods were tested, such as Target-based registration (with 50 black-and-white targets distributed across the area), and Auto-Register using Planes in Trimble RealWorks v. 11, with the last method being the selected one, reaching an overall registration error better than 3 mm. Figure 3 shows the main three views of the Serranos Bridge.



(**a**)

(**b**)

(**c**)

Figure 3. Serranos Bridge point cloud after registration: (**a**) top view; (**b**) east view; and (**c**) west view.

Regarding the complementary digital images, a considerable number of photographs were acquired with a Canon EOS-1Ds Mark III, using a wide-angle Canon EF 24 mm lens, at a resolution of 5616 × 3744 pixels, following the 3 × 3 rules for simple heritage documentation [19], just in case an additional photogrammetric survey was required. Nevertheless, only the TLS surveying data were used for subsequent stages.

2.2. HBIM State of the Serranos Bridge

Scanning to HBIM is a process that involves the use of advanced scanning technologies to capture detailed and accurate data of historical buildings, handle and enrich the data to create a digital twin using BIM software. This process is especially valuable for documenting, preserving, restoring, and reconstructing historical buildings [7,8,12–15].

The process of scan-to-HBIM involves two main methods: forward modelling and reverse modelling [20]. In forward modelling, historical documentation and reality-based data are combined to simulate parametric components of heritage structures, predicting their shape. These simulations are refined in a 3D space based on 3D point cloud data, with manual interpretation and shape recognition used to align them accurately [24]. Reverse modelling creates parametric primitives directly within the BIM platform using data from point clouds and other formats [25]. In this paper, two methods are employed. Initially, reverse modelling is utilised to create a 3D model of the existing structure. Subsequently, the forward modelling approach, informed by the study of historical documents, is used to predict the shape of the former building and features (Figure 4).

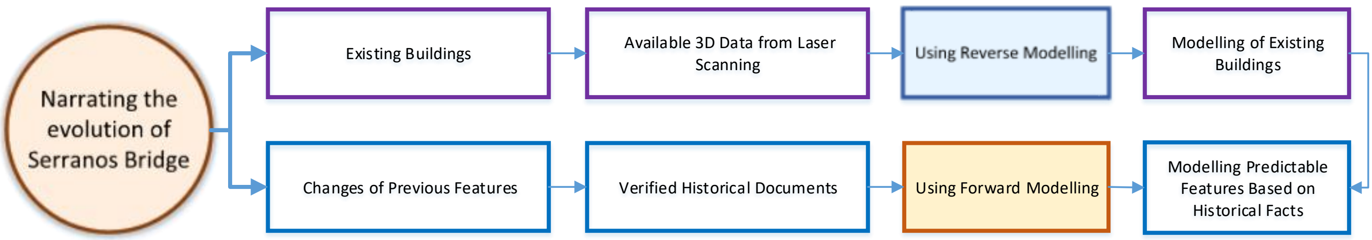


Figure 4. Narrating the evolution of Serranos Bridge HBIM creation process.

As previously mentioned, following the acquisition of field data via laser scanning and additional visible digital imagery, subsequent processing was carried out. To streamline the modelling process using HBIM technology, the registered 3D point cloud file was imported into Autodesk Revit software 2021, thereby commencing the 3D modelling process.

One notable advantage of HBIM modeling lies in its ability to individually model components and details while consolidating them within an integrated database, defining distinct phases seamlessly. To create and manage these phases, navigate to the "Manage" tab and select "Phases". Initially, different phases are set up in Revit, representing each of the five historical periods of Serrano's Bridge (Figure 5). This capability proves especially valuable for discerning similarities and differences among features across time, particularly in the context of historical structures. Throughout the modeling process of Serrano's Bridge, specific distinctive details were meticulously crafted within designated categories, enhancing the precision of the 3D model and resulting in a comprehensive virtual representation (Table 1). Furthermore, the refinement of these models involved a thorough examination of historical texts and documents.

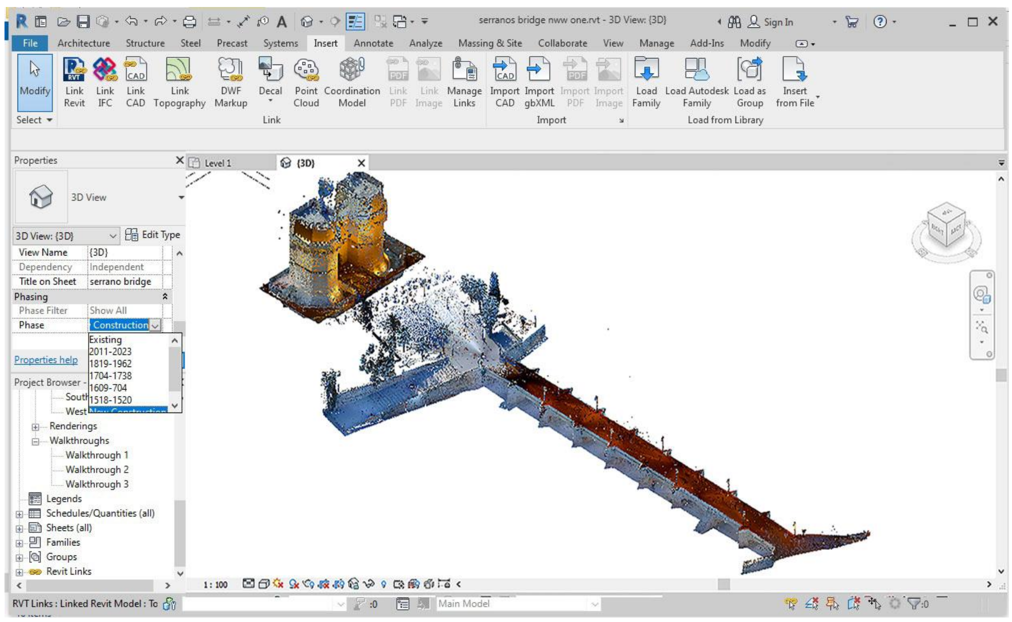


Figure 5. Created phases of different periods and importing of the point cloud into Autodesk Revit software 2021.

After completing the variety of 3D existing building features, the HBIM Serranos Bridge (and the corresponding Serranos Towers in the background) were rendered with their constituent materials for better visualisation (Figure 6).

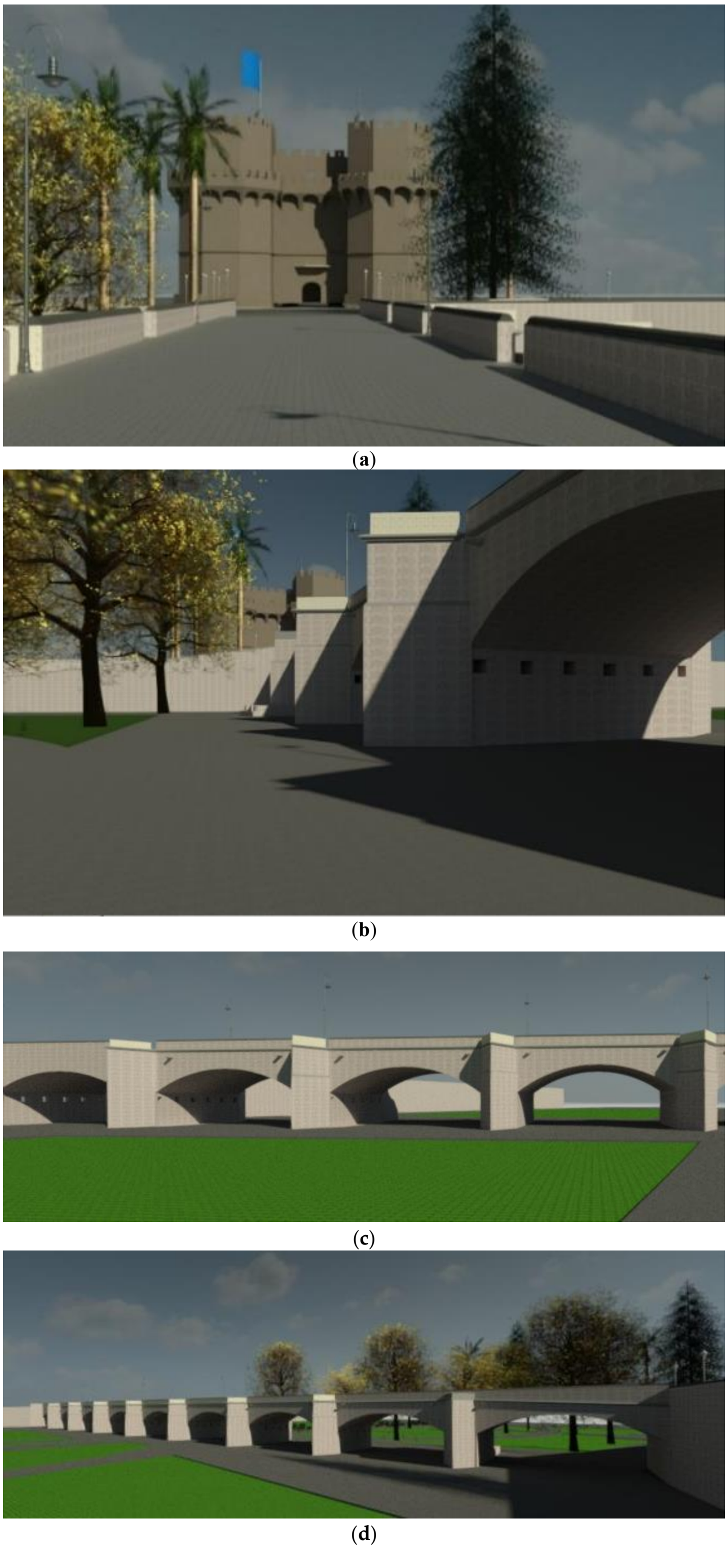
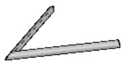
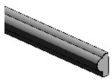
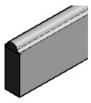
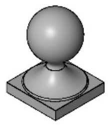
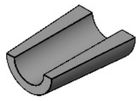
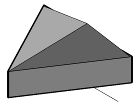
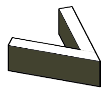


Figure 6. Rendering of the present state of the Serranos Bridge in Autodesk Revit: (**a**) side-walk south view with in the background, the Serranos Towers; (**b**) river ground-level side view from the northeast; (**c**) river ground-view arch and cutwaters from the west; (**d**) river ground-level side view from the southeast.

Table 1. Scan-to-HBIM: details of Serranos Bridge.

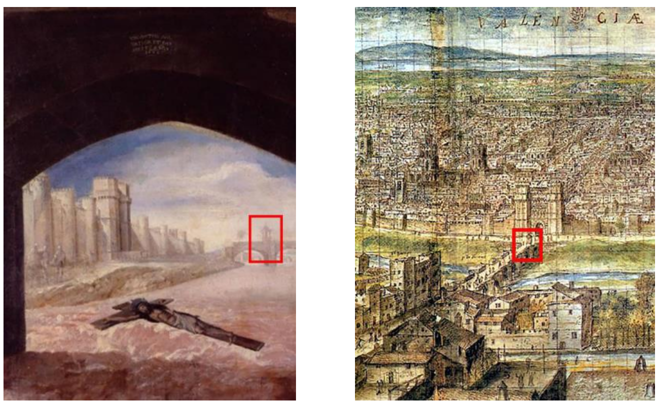
Details of Serranos Bridge (LOD 400–500)								
Decoration of top edge of each base	Decoration of edge in whole bridge	Decoration above the wall next to pass way	Sculpture above the wall next to the river	Gutter	The old part of the bridge	Light in bridge	Light next to the bridge	New stone added to the bridge
								

2.3. Historical Documentation and Analysis (Including Identification of Lost Details)

The Serranos Bridge was built in Christian times by the "Junta de Murs i Valls", which was in charge of the maintenance, repair and construction of the walls, towers, gates and bridges of the city (Figures 7 and 8), as well as the cleaning of the defensive moat (Melió, 1991) [26]; the rest of the wall can be seen in Figure 9b.

The plans for the current Serranos Bridge began in 1518, by order of the Duke of Segorbe and after the devastating flood of 1517, which destroyed the previous stone bridge, contemporary with the towers of the same name. According to the drawing by Anthoine van den Wijngaerde (Figure 7b) [27], very close in time to its construction (1563), the bridge had sidings or scrambles that coincided with the places and the triangular plan of its breakwaters.

The Juries of the city agreed (1538) on the construction of the Serranos Bridge, which was the first of these structures in the city, which although not in great detail, is included in the view of Valencia executed by Wijngaerde in 1563. A casilicium, a roofed element, was built on the bridge. This casilicium construction was called the Patriarchal Cross [28], and can be seen, although not in detail, in the painting "Coming to Valencia of Christ of the Savior" (1668) (Figure 7a). (These details build the basis for the virtual reconstruction of the 1518–1520 Serranos Bridge in HBIM shown in Figure 11a).



(**a**) (**b**)

Figure 7. Serranos Bridge: according to the old documents: (**a**) detail of the picture showing the casilicium with the red rectangle [29]; (**b**) the bridge with the casilicium, highlighted with the red rectangle and moved into the middle of the bridge (van den Wijngaerde, Anthonine, (1563), Valencia) [27].

In 1670 another casilicium was built, opposite the previous one, dedicated to Saint Peter Nolasco [2]. From the beginning, in the cutwater of pier 7 (downstream), "(. . .) there existed (. . .) a staircase whose walls are an extension of the pier, with no sign of construction differences, before, on the contrary, the stone material used, the cutting and rigging of the factory, and the stonework marks, are the same" [3].

As the hydric characteristics of the river have fostered the link between the city and its bed, through various uses of the channel, at the beginning of the 16th century ramps and stairs connecting the city-channel were arranged for this purpose [30]. The ramps eliminated the function of the old stairway, which was partially demolished, remaining as a stump. The ramparts are visualized in the HBIM for the period of 1609–1704 shown in Figure 11b.

After the flood of 1589, the City Council agreed to undertake the construction of large walls, and a descent of carriages was carried out (1609–1704 and 1704–1738), on both banks of the Turia (Figure 8). This work was commissioned by a new institution, dependent on the "Fàbrica de Murs i Valls", which was called "La Fàbrica Nova del Riu" [26]. On these walls, after the flood of 1731, some diamond-shaped stone pier abutments were built every 50 m to prevent the waters from breaking directly on them. Today there are still 28 of these pier abutments [1]. (The parapet walls are included in the HBIM for the period of 1704–1738 and visualized in Figure 11c).

(**a**) (**b**)

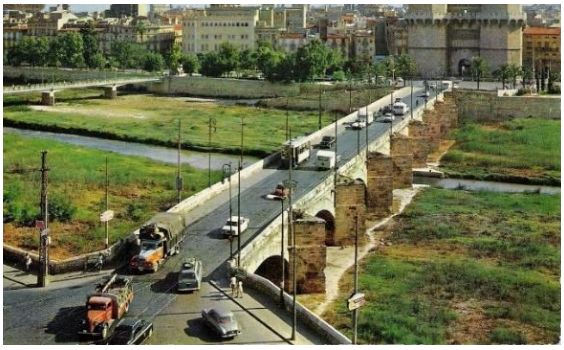
Figure 8. (**a**) Map Valentia edetanorum, vulgo del Cid (Kalendis Aprilis Anno a Reparationi Mundi 1704 ca. 1738) by Tosca, Tomás Vicente (Llopis and Perdigón, 2010) [31].; (**b**) zoom in (red rectangle (**a**)) on the area surrounding the Serranos Bridge.

During the French invasion, at the beginning of the year 1808, the Marquis de Caro, defender of the square, together with the jurors, made the decision to demolish the two casiliciums and the sidings, leaving a parapet in a straight line, so that they would not serve as a defense against attacking troops [3]. After this operation, all the sculptural and architectural elements existing on the bridge, including casiliciums, were thrown into the Turia riverbed.

The city repaired the bridge between 1813 and 1819, ignoring the sidings and leaving their surfaces outside the bridge space. In this state, the bridge reached the 21st century, supporting both pedestrian and road traffic. The wall of the Christian enclosure, which was demolished between 1865 and 1866, "(. . .) widening, ventilation and better hygienic conditions for the city, (. . .) making the corrosive and unhealthy emanations of the fence, which previously discovered the circuit, disappear" [4] (Figure 9a).

"Yes, well, throughout history, the Valencians have been adopting different measures in order to try to alleviate the damage caused by these large floods" [1]. In 1958, studies began to divert it to the south of the city, since the double flood of 1957 had caused great damage to the town centre and its surroundings [32]. This was achieved with a great hydraulic plan, which was called Plan Sur (1965–1969), which consisted of diverting the Turia River through land to the south of the city, with a much wider channel, thus avoiding the danger of flooding [33]. But in the 60s and 70s the river still flowed through the channel, until 1986, when the water definitively disappeared from the city.

(a)



(b)

Figure 9. (**a**) Traces of the demolished city wall, in the Serrano's Towers (photo of the authors). (**b**) The Serranos Bridge in the early 1960s, when the riverbed still contained water (photo by the authors).

After the old riverbed lost its natural function (1986), the Valencia City Council decided to turn it into a large green space almost 10 km long and of an average width of 160 m [34]. The general traces of the new garden were entrusted to Ricardo Bofill, who in turn coordinated with other architects, taking the space between each of the bridges as the scope of action for each team.

All these details are shown in the HBIM for the period of 1819–2010 and visualised in Figure 11d.

In 2011, the Valencia City Council made the decision to reorganize traffic in the Torres de Serranos area, considering pedestrianizing the bridge and recovering its old image with the sidings. The intervention was also aimed at repairing and reinforcing some areas of the bridge. The work was completed in 2012. The coordinator of the reform project and its subsequent execution was the architect Ignacio Bosch Reig. The dimensions of the bridge built by this team, with modern equipment, are identified in this text.

"The Serranos bridge is 159 m long, in an oblique layout to the axis of the river. It consists of 9 segmental arches with 1.20 m voussoirs, whose light ranges between 16 and 18.30 m wide. (. . .) It has 8 free-standing piers 3.50 m wide, with triangular breakwaters on both sides, topped with a pyramidal roof, except where remains of the original stairs leading down to the river are preserved. The deck has 11 m between eardrums and useful for the passage, 10 m. The parapet is 1-m-high and is finished off with beveled coping (. . .). Both bridges were built with rough Rocafort stone taken with lime mortar, using lime and pebble concrete as filler for piers and arches (. . .)". From the eighteenth century, for the replacements, and especially the parapets dismantled during the war of Independence, Godella limestone ashlars were used [30]. The bridge received a structural restoration program based on two main needs.

On the one hand, the restoration needed structural reinforcement at some points. The main areas to be reinforcedwere spans 8 and 9. These had to be joined with 12 internal anchors, to tie the two side elevations, crossing the 11-m width of the bridge. Secondly, the pedestrianization and the recovery of the sidings was proposed, which at that time had been separated from the bridge road by its parapet and could not be used. In addition, these sidings were a singular characteristic of the bridge that differentiated it from the others. The actual situation of the Serranos Bridge, after its restoration in presented in the HBIM for the period of 2011 until today, is shown in Figure 11e.

In the restoration neither the recovery of the stone seats that existed in the sidings nor the reconstruction of the casiliciums was considered. The sidings were not reproduced as they had once been, since their parapet section was reduced and they did not interlock with the rest of the bridge parapet. It was intended not to create a "false history" and that the restoration of the original be clearly noticed (see Figure 10). A reinforced concrete ramp was built upstream and next to the bridge, to increase the level of connection between the Turia garden and the city.

(a) (b)

Figure 10. (**a**) The new replacement sidings on the bridge); (**b**) the staircase has not regained its use and has remained as a stump.

Finally, although it was estimated that, as part of the original staircase had been mutilated, direct bridge-river communication had been interrupted, the staircase was not restored and the stump still exists, without function (Figure 10b).

3. Results

The process of virtual HBIM reconstruction for the Serranos Bridge and Towers commenced with the gathering of data from diverse sources, such as historical documents, photographs, architectural drawings, and physical measurements taken on-site. As previously mentioned, these data sources provided invaluable insights into the bridge's original design, materials, and any modifications made over time.

After collecting the data, they were digitally processed to create a virtual model. These models served as intricate representations of the historic bridge in its original and altered forms. The utilisation of software tools allowed for the meticulous recreation of every structural aspect, including arches, bridge foundations, parapets, gutters, and any features that had been either fixed or altered. By incorporating such detailed information into the 3D models, HBIM facilitated a comprehensive analysis of how structural changes had affected the bridge's integrity over time.

As previously explained in Section 2, five models were reconstructed integrating the HBIM and historic documentation workflow, which include:

1. First Serranos Bridge made with stone, and side staircase (1518–1520).
2. River bed with side ramps for carriages (1609–1704).
3. River bed with built parapet walls (1704–1738).
4. Bridge in the 20th century, before its restoration (1819–1962).
5. Bridge in the 21st century, after its restoration (2011–2023)

These models have been created and are depicted in Figures 11 and 12, and Table 2.

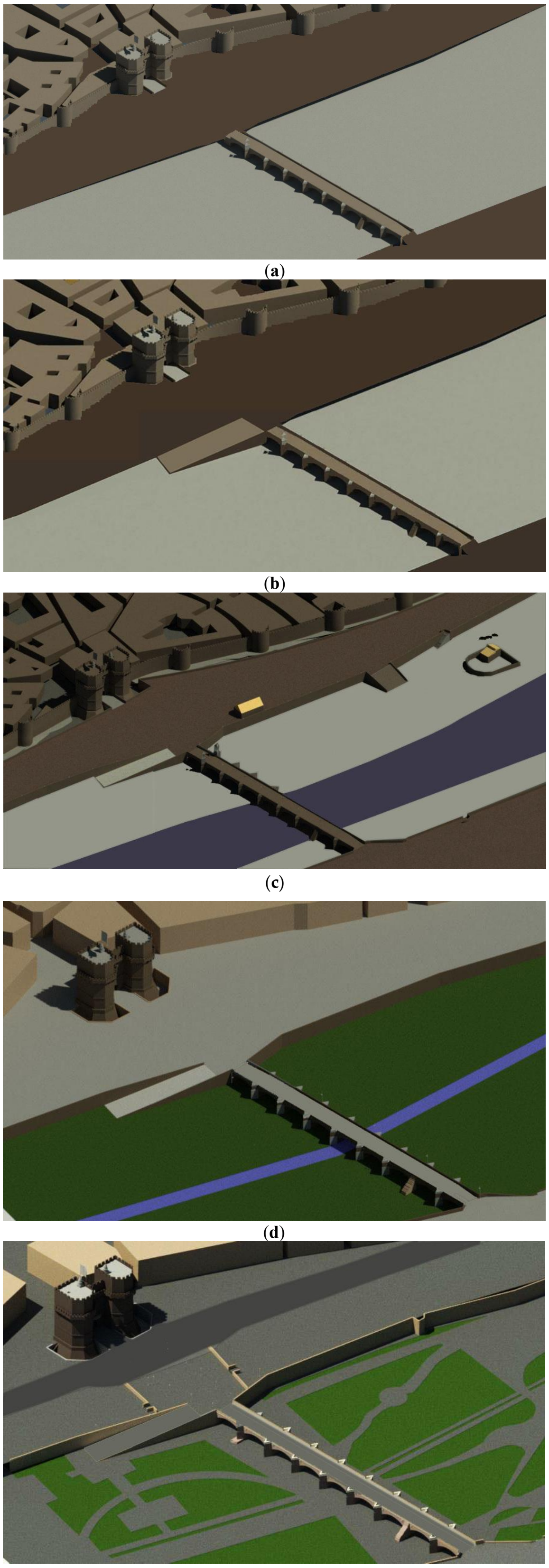


Figure 11. (**a**) Serranos Bridge made with stone, and side staircase, vid Figure 6d (1518–1520); (**b**) river bed with side ramps for carriages (1609–1704), since there is no historical plan that represents this phase, the authors have based the proposed reconstruction on written historical information.;

(**c**) river bed with built parapet walls (1704–1738) vid Figure 7b; (**d**) Bridge in the 20th century, before its restoration (1819–2010) vid Figure 8a; (**e**) Bridge in the 21st century, after its restoration (2011) vid Figure 1.

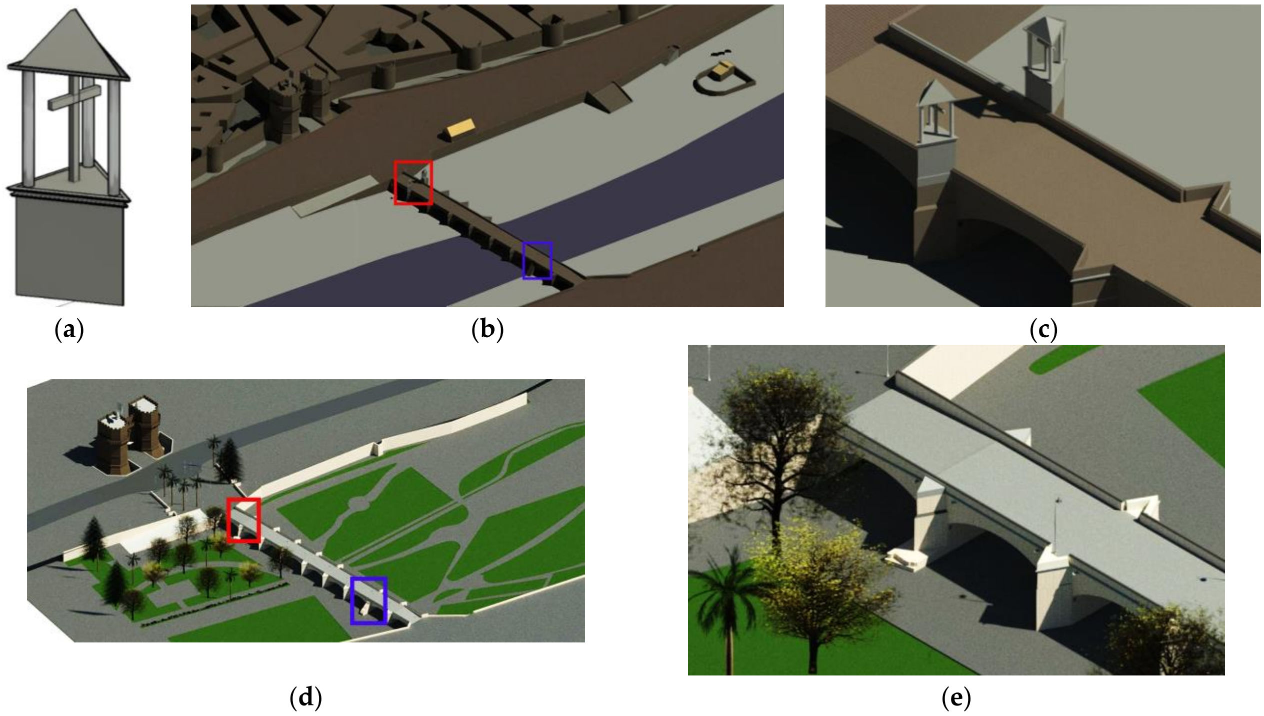
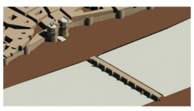
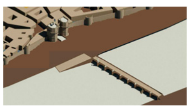
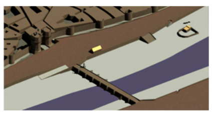
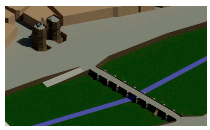
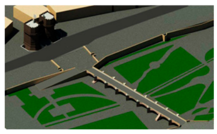


Figure 12. The 3D reconstruction of the Serranos's Bridge with casilicium: (**a**) recreational hypothesis of casilicium with Patriarchal Cross; (**b**) the 3D modelling of Serranos Bridge, in red rectangle the two casiliciums and in blue rectangle the original staircase; (**c**) the 3D modelling of the location and volume of two casiliciums; (**d**) the 3D modelling of bridge and the location of casiliciums and staircase 2022; (**e**) the 3D modelling detail of the location and volume of the casiliciums and the sidings in 2022.

Table 2. Serranos Bridge evolution over time.

1	2	3	4	5
				
(1518–1520)	(1609–1704)	(1704–1738)	(1819–1962)	(2011–2023)

When comparing the models from 1704–1738 and 2011–2023, it becomes evident that during the restoration process, neither the restoration of the stone seats located on the sidelines nor the reconstruction of the casiliciums, as illustrated in Figure 12, were considered.

4. Discussion

HBIM technology stands at the forefront of documenting historical buildings, leveraging robust data obtained through advanced techniques such as laser scanning. This foundational information serves as the bedrock for drawing and modelling in software environments such as Revit, enhancing precision in document production and maintenance while facilitating efficient document management, plan presentation, supervision, and monitoring [7,8,10,12,13].

The effectiveness of HBIM extends to interventions, where it excels in providing exact documentation of impacts and enables the recall and display of changes in virtual form. In our research, we delve into the historical narrative using a combination of textual sources, maps, and existing images. The objective is to unveil the chronicle of transformations using HBIM technology, constructing a multi-layered virtual model that captures the various states of the Serrano Bridge.

The segmentation of the historical timeline into different layers within the virtual model empowers us to seamlessly study and implement details related to changes on an integrated platform. This approach facilitates the examination of each component's evolution over time, revealing intricacies and identifying missing elements. The ability to restore each historical period by defining it as a distinct layer, and subsequently adding or removing details within this integrated platform, emerges as a significant advantage of HBIM.

Before the adoption of this method, presenting such comprehensive data necessitated the use of multiple drawings, both in 2D and 3D formats, with different details dispersed across each drawing. The integration of the modelling environment in this monitoring process, spanning various historical periods, emerges as a pivotal aspect that underscores the efficacy of HBIM technology in narrating the evolutionary history of the Serrano Bridge. This method not only streamlines the workflow but also enhances the overall efficiency of studying and understanding the dynamic changes that have shaped this historical structure over time.

The kingdom of Valencia and its capital benefited from a period of economic and cultural splendor, mainly in the 15th and 16th centuries, that influenced its constructions [30]. In this period works were undertaken, especially civil ones, of great importance. Symbols of the city, from that period, are the magnificent Serranos Towers and the old great *Lonja de los Mercaderes*. Although these buildings are chronologically included in the Renaissance, in Valencia, as in the rest of Western Europe, the aesthetic reference was still Gothic [35]. It is precisely this late Gothic style, which has been called Mediterranean Gothic, that characterizes the works that, at that time, were built throughout all the kingdom of Aragon, peninsular and not peninsular (Naples, Sicily) [36].

When the task of building solid and "definitive" bridges to connect the city with the north was undertaken, the same aesthetic and quality criteria were followed.

The Serranos Bridge, analysed in the text, aligned with the great towers of the same name, represents this intention to show the high level that existed in the kingdom [32]. The place it currently occupies, since the Roman foundation of the city, has always been reserved for this purpose. Over the centuries, the bridge has changed its materials, until its current state came to fruition from 1518, following a large flood.

It is noteworthy that, despite being bridges from different periods, the city tried to give them a uniform image. The use of the stonework of the country, the location of the casiliciums in each one of them, even their position with respect to the shore, close to the city, seems to be an anticipation of the gates that existed at that time, aligned with each one of them.

Citizen interest in its bridges is demonstrated objectively, with the creation of an institution that should ensure their good condition and the walls. Since 1358 the Junta de Murs i Valls, dependent on the Valencia City Council, has been responsible for this task [1].

In 1589, after a large flood, the city council thought it appropriate to create another institution, which dealt exclusively with the architectural elements of the river. This is how the Fábrica Nova del Riu was created, dependent on the aforementioned Junta de Murs i Valls, which dealt exclusively with works and repairs that affected the riverbed [30].

Historically, the river bed had very easy access due to the orography of its banks, and with stair systems from the bridges themselves to the docks that existed in the river bed. The Serranos and Royal bridges had a single staircase, while the Trinity Bridge had two. When it was decided to build side parapets of the channel (from the 16th to 17th centuries) to prevent flooding in the city, natural access was considerably complicated. By creating this architectural obstacle, the city was forced to make new accesses to the river to facilitate its use and enjoyment [26]. This previous concept was applied to all three bridges. All of them were equipped with wide ramps for carriages. Currently, the old bed of the Turia river is equipped with 40 ramps and 27 access stairs. However, the bridges were not identical, differing both in the number of arches and in other details. Although the three bridges contained a couple of casiliciums with statues, only the Royal Bridge conserves these structures. The casiliciums were demolished on the Serranos and Trinity bridges.

They also differ in certain formal and functional aspects, as all the piers of the historic bridges were covered with stone pyramids, except that of Serranos, which has a siding. It also had stone benches located in each of these spaces, but they were demolished, along with the casiliciums, and were not recovered.

It is notable that, despite being bridges from different periods, the city tried to give a uniform image to these bridges, for example, the use of the stonework of the country, the location of the casiliciums in each one of them, even its position with respect to the shore near the city, which seems to be in anticipation of the gates that existed at that time, aligned with the bridge. The casiliciums with the atypical triangular shape and all of them covered by blue ceramic tile, were used distinctively, very frequently in the kingdom of Valencia. All the characters, housed in the casiliciums were religious and chosen from the Valencian saints, with these characters, the reason for all of the bridges was unified and referred to the city that was going to be accessed via the bridge. Actually, "these medieval bridges introduced three novelties: religious symbolism through the chapels or casiliciums; defensive approach with bastions at the access, which represented authentic fortresses" [3].

Based on the comparison and investigations mentioned, it seems that this symbol also existed on the historic Serranos bridge, which was initially placed at first base and later expanded to two numbers, with the sculptural elements thrown upstream and downstream of the bridge in 1808.

5. Conclusions

When the Serrano Bridge was restored in 2012, it was not subjected to an in-depth infographic study, as this article has provided.

For this reason, in this text, the existence of the historic bridge and the towers, which are inseparable elements, were precisely determined. For this operation, the integration of a state-of-the-art terrestrial laser scanner was used, together with the comprehensive study of old documents and photographs that have led to the completion of the findings related to the changes to the Serranos Bridge. These works have resulted in being able to represent the Serranos Bridge in each of its various historical phases, using the HBIM technology.

Applying HBIM technology to represent the different periods of Serranos Bridge based on historical documents and point clouds shows a useful method to put many layers in one place and add different details to it. Therefore, the graphic potential of HBIM 3D models is a great advantage to represent the constructive evolution of historic buildings.

Thanks to this method, the tumblers, removed from the surface of the bridge since its destruction during the Napoleonic siege, have been graphically reintegrated. Also following the historical, written, and graphic descriptions, the two casiliciums, which suffered the same fate, have been virtually reinstated.

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