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HBIM-Based Digital Surveying Challenges: The Larraín Palace Case

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Abstract

This research addresses the challenges of applying the Heritage Building Information Modeling (HBIM) methodology for the digital documentation of built heritage in the Chilean context. The case study focuses on the Larraín Mancheño Palace (LMP), an iconic structure of the 19th-century Belle Époque that blends Baroque and Art Nouveau elements. Its complex geometry represents a significant challenge for modeling in BIM platforms, specifically Revit.
The digital survey methodology involved the use of non-specialized drones and photographic cameras to generate a point cloud, which served as the basis for modeling its façade. A hybrid approach was adopted, employing Revit for standard geometric components and Rhinoceros for complex geometries. This interoperability was achieved through the Rhino.Inside.Revit plugin, facilitating the workflow between both environments. This study critically examines the limitations and advantages of HBIM in creating a centralized information model for conservation purposes.
The results highlight persistent limitations in HBIM workflows, such as the rigidity in representing complex ornamental elements, software interoperability issues, and the documentation of material deformations. The study emphasizes the need for investment in training and specialized technology to overcome these technical challenges, aiming to develop more efficient methods for the preservation and digital analysis of complex heritage structures in Chile.

1. HBIM and Built Heritage Conservation

The HBIM methodology has become a strategic tool for the documentation, analysis, and conservation of historic buildings, thanks to its ability to centralize and integrate geometric and non-geometric data into parametric digital models. These models become key instruments for decision-making in heritage interventions, enabling more informed and coordinated management of architectural elements. Building upon this potential, HBIM 3D modeling is complemented by 6D and 7D BIM, integrating sustainability and asset management throughout the building's lifecycle, which is essential for the long-term conservation of historical heritage" (Monteiro, 2024, p. 4; see Figure 1).

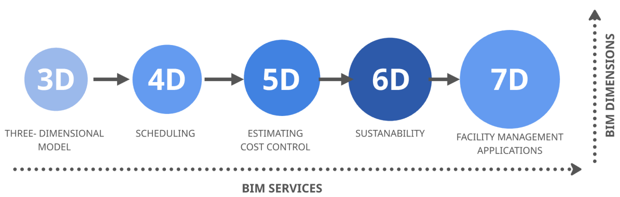


Figure 1. BIM Dimensions Diagram.

Although significant progress at the international level, various studies have demonstrated HBIM's potential to integrate laser scanning, photogrammetry, semantic classification, and structural analysis (Dore et al., 2015; Bruno & Roncella, 2019; Zarogianni et al., 2021). Nevertheless, its application still faces significant challenges, such as the rigidity of parametric objects available in BIM software, limited interoperability between platforms, the lack of specific standards for complex heritage structures, and the shortage of specialized professionals in the field (Volk et al., 2014; García-Valldecabres et al., 2016). Despite this, HBIM has been widely embraced internationally as a platform with great advantages for the development of historical conservation, as it "allows continuous monitoring of the building's condition, identifying structural, material, and environmental changes that may contribute to its degradation, thus enabling early detection of problems and preventive preservation strategies" (Monteiro, 2024, p. 4).

Even though significant progress has been made in European contexts, the adoption of HBIM in Chile—has developed gradually, presenting conditions and challenges that must be addressed based on local experiences.

2. HBIM in the Chilean Context

In Chile, the implementation of the BIM methodology has been promoted since 2016 by the State through the Planbim program (Digital Transformation Committee CDT of CORFO[1]), with the aim of improving the productivity of the public sector through the standardization of processes and the interoperability of information in projects funded with public resources. Although this policy has allowed progress in the digitalization of the construction sector, its focus has been primarily on new buildings, neglecting the specificities of historic structures.

As a response to this omission, academic initiatives have emerged that seek to adapt BIM standards applied in Chile to the specific requirements of heritage buildings through the

[1] Chilean Economic Development Agency.

HBIM methodology. Among them, the work of the School of Civil Engineering of the Pontifical Catholic University of Valparaíso (PUCV) stands out, aimed at creating digital repositories for cataloging and managing historic buildings. The first phase of this project was based on the survey of the Valparaíso Port Market, a building located within the heritage protection area of the city designated by UNESCO.

At the same time, researchers from the University of Valparaíso (UV) are developing an HBIM Platform for Built Heritage, as part of an ANID[2] project. This tool is designed to facilitate heritage intervention processes in public institutions by integrating documentation, 3D models, and conservation criteria in an environment compatible with the national BIM standard.

Additionally, emerging experiences have been developed, such as the surveying and modeling of heritage churches in Chiloé, specifically the thesis titled “Detif Church, Lemuy Island, Chiloé: Information Management through the HBIM Methodology for its Conservation and Maintenance.” This study has allowed the exploration of digital documentation methodologies in cases of high morphological and constructive complexity, nevertheless still in a partial or experimental manner.

Despite these advances, the Chilean BIM standard continues to address heritage from a generic perspective, without deeply considering the technical procedures required for surveying, modeling, and managing such buildings throughout their life cycle. In response to this context, the present research proposes applying the HBIM methodology to the case of the Larraín Mancheño Palace (see Figure 2), an emblematic early 20th-century building located in Santiago, notable for its geometric complexity and the coexistence of late French Baroque elements with features of Art Nouveau (Gazmuri, 2023). The main objective is to identify the tensions between the uniqueness of heritage and the standardization inherent to the BIM environment. Through the development of an experimental HBIM model, this study aims to contribute to the discussion on how to adapt this methodology to the real conditions of built heritage in Chile.

Figure 2. Larrain Mancheño Palace aerial view.

3. Methodology

The documentation of the Larraín Mancheño Palace (LMP) was developed through three complementary phases, each addressing a fundamental aspect of the HBIM process: data collection, digital processing and modeling, and the structuring of the HBIM model, as illustrated in Figure 3.

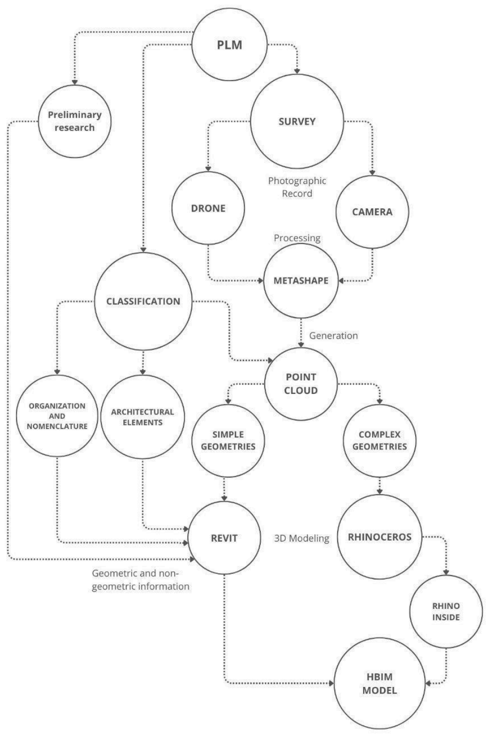


Figure 3. Methodological process diagram.

3.1 Data Collection

Initially, a collection and analysis of historical and architectural background information on the LMP was conducted (see Figure 4). This preliminary survey allowed the identification of its value as a heritage conservation property and helped to understand the morphological and stylistic particularities of the building. Documentary sources were studied alongside on-site visits to record its current state of conservation.

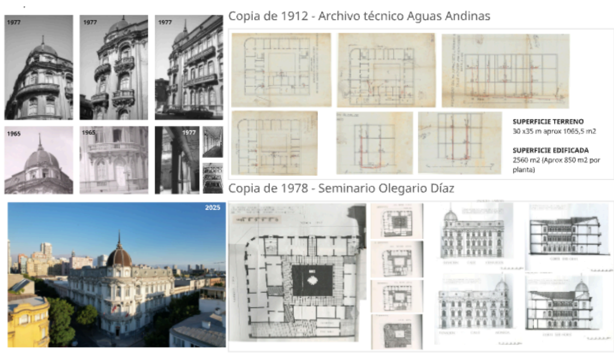


Figure 4. Background information on the building.

[2] National Agency for Research and Development of Chile.

3.2 Processing and Modeling

Processing was carried out using non-specialized drones (Dji Air 2S and DJI Air3) and a photographic camera (Sony NEX-5N), complemented by control points and on-site measurements using laser distance meters. The collected information was processed using Agisoft Metashape software, from which a high-density point cloud was generated that served as the basis for the three-dimensional modeling. Processing was performed on a computer with the following specifications: Intel Core i7-13700K processor at 3.40 GHz, 32 GB RAM, 16 GB GPU, and 1 TB SSD.

For HBIM modeling, a hybrid approach was adopted using two software platforms:

Autodesk Revit 2024: Used to model architectural entities that could be represented with basic parametric families, taking advantage of the software's native tools. This included elements such as walls, openings, and simple carpentry, whose complexity remained compatible with Revit's parametric modeling capabilities.

Rhinoceros 8: Used for complex geometries (ornaments, cornices, railings), integrated into the Revit environment through the Rhino.Inside.Revit plugin.

3.3 HBIM Model Structure

Additionally, four models were created (site, architecture, structure, and federated), with differentiated file paths and standardized naming according to the BIM standard for public projects, adapted to this heritage case.

3.3.1 Visual Classification of Components:

To organize the modeling of Revit families (RFA) and ensure traceability of each architectural component, a classification matrix was designed in Miro (see Figures 5 & 6), grouping elements into various categories such as doors, windows, railings, etc. Each component was reviewed, labeled, and assigned to a team member, facilitating collaborative modeling.

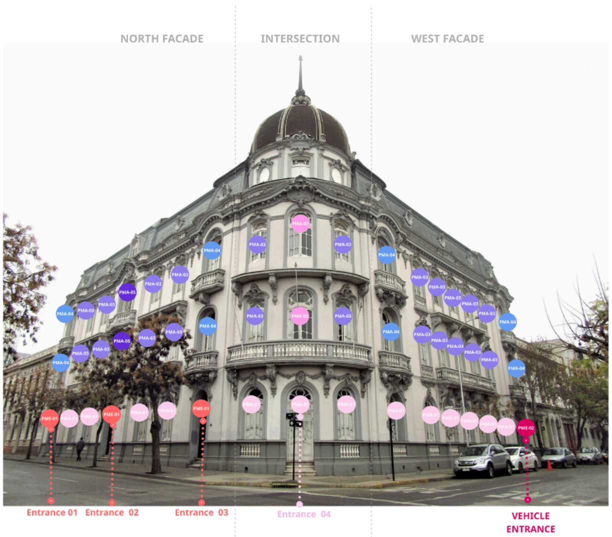
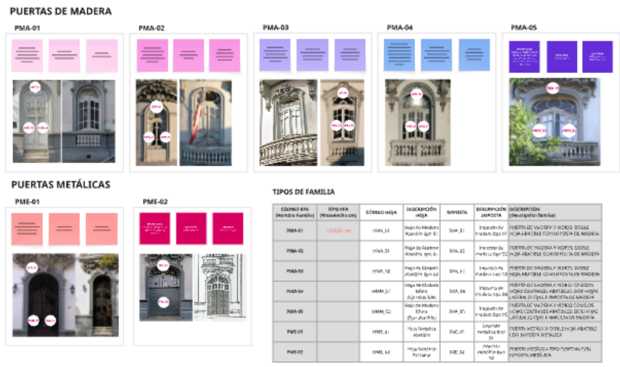


Figure 5. Classification and location of openings for standardization in BIM.



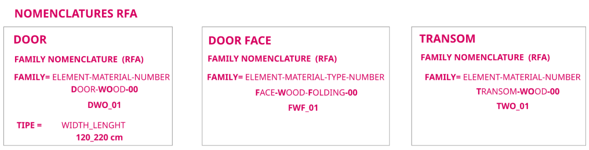


Figure 6. BIM organization nomenclatures.

3.3.2 Standardization of Information in Notion:

Geometric and parametric information was systematized in a database developed in Notion (see Figure 8), in which the following elements were defined:

- Unique code per element (by category)
- Detailed description
- Dimensions (width and height)
- Type of leaf and cornice (in the case of doors and windows)
- Specific location within the building
- Responsible modeler
- Software used
- Instance itemization

VENTANAS

CÓDIGO	DESCRIPCIÓN	ANCHO	ALTO	HOJA	UBICACIÓN	SOFTWARE	MODELADOR	ESTADO DE AVANCE
VMA-01	Ventana circular marco de madera y hoja fija	154	132	Hoja de marco de madera fija	Fachada Norte, Fachada Poniente	Rhino	@Dafne González @I	Listo
VMA-02	Ventana rectangular marco de madera y doble hoja abatible			Hoja de marco de madera doble abatible	Intersección, Fachada Norte	Revit	@Nicole Trejo	Sin empezar
VMA-03	Ventana ovalada marco de madera y hoja fija	150	200	Hoja de marco de madera fija	Intersección	Rhino	@Dafne González @I	Listo

Figure 7. Structuring of parameters for BIM.

4. Results

Based on the research developed, five key aspects were identified to evaluate the attributes and limitations of the HBIM workflow implemented at the LMP. These observations are based on both the surveying process and the modeling phase, recognizing that the success of a heritage model largely depends on its preliminary methodological structure.

Initially, a typological recognition and decomposition of the architectural elements that compose the palace façade were carried out in order to simplify complex shapes into basic geometric components. This strategy facilitated the creation of nested families, reusable throughout the model. Meanwhile, the point cloud provided a significant advantage by allowing detailed analysis of profiles in sections, plans, and elevations, though it also presented challenges related to the interpretation and geometric adjustment of the recorded elements.

4.1 Software Limitations

Although Revit is a well-established BIM software for architectural modeling, its application to heritage buildings presents certain limitations due to the inflexibility of its tools and the specific data requirements of the models (Panayiotou, 2024). From the modeling conducted, one of the main difficulties encountered relates to geometric rigidity, which limits the representation of organic surfaces, irregular curves, and non-orthogonal elements. This forces the simplification or idealization of complex shapes that are essential to preserving the character of the heritage asset.

Modeling the LMP involved addressing ornamental geometries and unique components such as decorative elements, masks over openings, and the dome (see Figure 8), in addition to corbels, which were challenging to adapt to Revit's standard modeling systems. To achieve this, Rhinoceros 3D was used, a software known for its flexibility, freedom in modeling complex geometries, and parametric design capabilities.

Rhinoceros 8 enabled modeling based on NURBS, meshes, and SubD surfaces, offering the required flexibility to generate high-degree curves, complex lofts, ornaments, and organic geometries such as scrolls and moldings. Furthermore, its capacity to manipulate various types of surfaces and mesh-based geometries, including their repair, editing, and conversion to Boundary Representations (BRep), allowed the elements to be recognized by Revit as native entities through the Rhino.Inside.Revit integration.

In contrast, Revit 2024 operates primarily under a parametric modeling system based on families, limited to simpler geometric operations such as extrusions and blends. The software has limitations when handling curved geometry or subdivisions smaller than 0.794 mm and lacks native tools for mesh or soft surface modeling like SubD. On the other hand, while Revit is robust in BIM documentation and attribute management, it lacks native tools to represent material pathologies, aging processes, or visible deformations.

4.2 Modeling complexity

Figure 8. Dome Modeling – View in Rhinoceros.

In addition to software limitations, the geometric complexity inherent to the architectural style and the deformations caused by the mechanical behavior of materials over time make it difficult to clearly define the level of accuracy achievable in the model. Consequently, determining the appropriate Level of Detail (LOD) required choosing between prioritizing the geometric fidelity of the LMP or the informational richness of each component's parameters, which directly impacted the modeling strategy.

However, the modeler's experience and judgment proved to be crucial in determining the appropriate level of formal complexity needed for the model to fulfill its purpose. The quality and precision of the modeled information largely depend on the ability to interpret the point cloud, decompose elements, and structure a functional HBIM asset. However, this process is not exempt from information loss: accurately interpreting a point cloud requires a high level of expertise, as it involves techniques not only for modeling but also for recognizing geometries based on partial data. This is often supplemented by additional resources such as photographic records and on-site measurements, which aid in visually reconstructing complex elements. This stage, therefore, still relies heavily on the professional's judgment, introducing a degree of subjectivity that is difficult to standardize.

A concrete example of this situation was observed during the modeling of the volutes (see Figure 9), mascarons, and corbels located above the main openings, where the lack of specific experience in modeling organic sculptural forms led to formal simplification. Despite having the base geometry available in the point cloud, an accurate reconstruction in Rhino was not achieved due to the complexity of the forms and the absence of a clear strategy for approaching them.

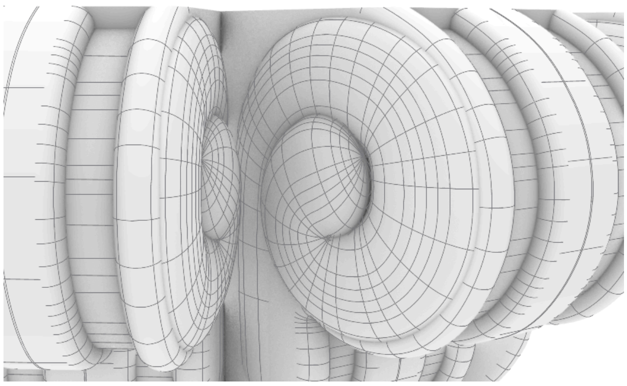


Figure 9. Volute´s isocurves.

4.3 Workflow and Interoperability

The workflow was structured as a sequence of complementary stages that included on-site surveying, image processing with Agisoft Metashape, modeling of complex geometries in Rhinoceros, and consolidation of the information model in Revit. This strategy made it possible to combine geometric precision with informational organization, but it also revealed a series of technical challenges.

One of the main issues was the considerable increase in file size, which affected workflow fluidity, processing time, and interoperability between platforms. For instance, the Metashape file reached 76.2 GB; the RCP file used in Revit was 1.24 GB; the E57 file imported into Rhino weighed 1.31 GB; and the Rhino model, including the point cloud, dome, and ornaments, totaled 2.14 GB. This computational load slowed down editing and visualization processes, especially during collaborative review stages. The most complex case was the transfer of the dome via Rhino.Inside.Revit (see Figure 11): to diagnose the import errors, the geometry had to be decomposed into groups using Grasshopper in a trial-and-error process that required more than five minutes of waiting per attempt. Ultimately, the cause of the failure was the high level of detail in the volutes, whose extremely subdivided surfaces (with dimensions smaller than 0.794 mm) and overlapping edges could not be recognized by Revit as valid geometry.

On the other hand, handling dense point clouds requires high computational power and extended processing times, which becomes a critical factor in resource planning. This, in essence, reflects the complexity of the input data present in the LMP point cloud.

Additionally, the transfer of objects between platforms resulted in partial loss of information, both in geometry and attributes, which required certain elements to be reinterpreted or reconstructed to fit the capabilities of the receiving software. These tasks demand intensive manual adjustments, which affect the overall efficiency of the process.

Despite the use of tools such as Rhino.Inside.Revit, which enable the transfer of complex geometries from Rhino into Revit as family components—thereby allowing informational parameters to be added to these elements—interoperability remains partial and depends on the type of geometry being transferred. This capability compares favorably to other exchange formats such as .obj or .sat, which, while capable of representing complex forms, do not support the incorporation of BIM data. However, Rhino.Inside.Revit presents limitations when importing geometries that more closely resemble the point cloud, such as meshes, which must be converted to BRep in order to be recognized by Revit, as depicted in Figure 10. This conversion process leads to a loss of geometric definition, as it simplifies the original surface, particularly in organic or highly subdivided geometries. As a result, complex surfaces, curved elements, or components with high polygonal density proved especially problematic when integrating them into the HBIM model.

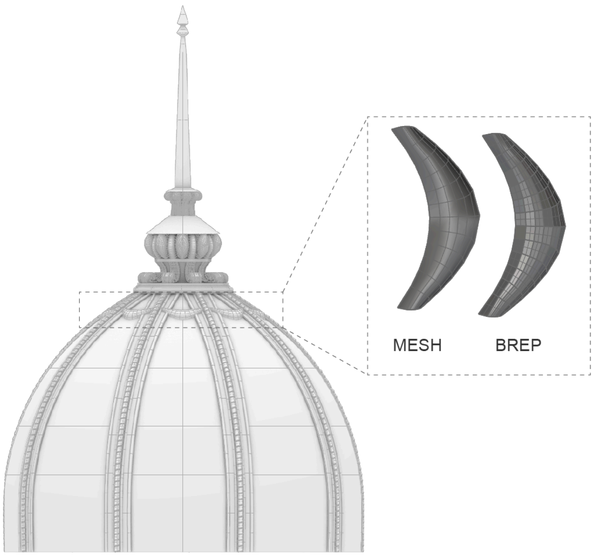


Figure 10. Differences between the mesh and its transfer to Brep.

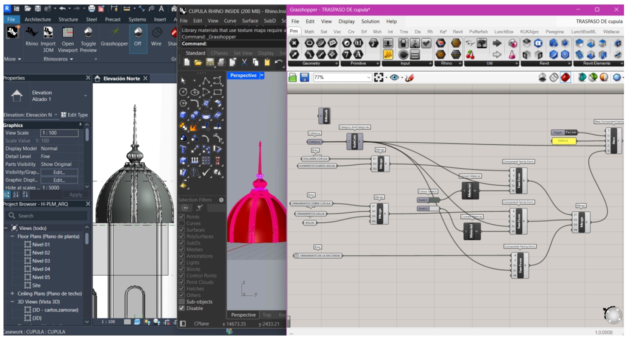


Figure 11. Workflow - Rhino.Inside.Revit.

4.4 Standardization and Semantic Classification

The communication between platforms not only posed technical challenges but also revealed a critical lack of specific regulatory standards for HBIM projects in heritage contexts. Currently, there is no local regulation that clearly defines the levels of detail (LOD), nomenclatures, or modeling criteria applicable to historically protected assets. This methodological gap creates uncertainty when deciding what to model, with what degree of geometric fidelity, and under which classification system.

This lack of standardization affects not only the geometric representation but also the semantic content of the model, limiting its ability to express constructive, historical, and pathological relationships between components. In this regard, semantic classification is still a developing field, since heritage structures—even those from the same period—exhibit unique characteristics that hinder standardization under conventional BIM standards (Zarogianni et al., 2021, p. 283).

Along the same lines, the demand for geometric accuracy has, in many cases, required the initial development of architectural drawings in AutoCAD, which are then linked and used as support in later, less critical phases in Revit (Zarogianni et al., 2021, p. 276). This tension between fidelity and standardization may challenge the scalability of the HBIM methodology to public policies or robust institutional frameworks.

4.5 Identification and Representation of Pathologies and Deformations

The representation of material pathologies and structural deformations was one of the greatest challenges of the process. Despite the fact that the point cloud made it possible to record the building’s deviations and deterioration with high fidelity, translating these conditions into the BIM environment was not straightforward.

Since Revit does not natively support modeling irregular deformations, the decision was made to represent idealized geometries and to document damage through custom parameters, graphic annotations, and links to photographic records. This approach allowed for the inclusion of relevant information without compromising the model's stability, although it limits its potential as a diagnostic tool.

A concrete example was the case of a deteriorated corbel (see Figures 12 & 13), whose pathology was clearly visible in the photogrammetric survey. The geometry was modeled as a mesh, achieving a high degree of fidelity to the original object. However, when attempting to convert this mesh into a BRep to transfer it into Revit, the software issued a warning due to the high number of faces (>20,000) as shown in Figure 14, resulting in wait times exceeding 10 minutes and ultimately causing the geometry to break. Since the mesh could not be successfully converted, the element became unusable for integration into the BIM environment. This example highlights the urgent need to automate interpretation and transfer processes between platforms, as well as to expand compatibility with complex geometries typical of heritage structures. It is therefore proposed to move toward the development of libraries of deformed families and deterioration typologies, along with the integration of external tools to accurately represent the conservation state.

Figure 12. Mesh model of the corbel.

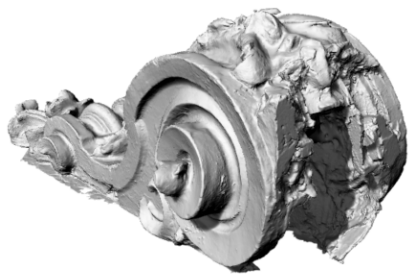


Figure 13. Mesh modeled pathology.

Figure 14. Error transferring a high-definition mesh to Brep.

5. Discussion

While the HBIM methodology offers advantages in data synchronization and the efficient management of heritage buildings (Brumana et al., 2013), its practical implementation in the LMP modeling process highlights tensions between the uniqueness of heritage and the standardization inherent to BIM. Unlike contemporary projects, where parametric families are reused, heritage elements and their geometric particularities require case-by-case modeling. This condition limits the possibility of applying geometric standards, such as height and width parameterization for components like doors and windows.

A representative example was observed during the modeling of the LMP's doors. While many had the same leaf (which allowed the use of nested families for that component), the cornices and ornaments on the upper parts showed significant differences among them. In total, seven different door typologies were identified out of a universe of 48 doors, requiring the development of unique families for each case. Each family included specific information parameters such as height, width, extended description, nested leaf, nested cornice, and model location, enabling information traceability despite formal diversity.

Regarding standardization, it is observed that to date, it is not possible to find a common model or standard among heritage-specific parameters, as they are not yet integrated into the levels of information developed in Chile's existing BIM standard. These include general dimensions, pathologies, detailed descriptions, locations, and conservation status.

Another relevant aspect is the influence of the modeler. Their technical experience and personal judgment directly impact the fidelity and quality of the model. Given that much of the process is not automated, it is recommended to establish collaborative modeling protocols with decision traceability, quality control (QC) review, and documentation of the criteria used, in order to reduce modeling subjectivity.

In terms of time and resources, the HBIM models for the LMP required a significantly greater production time compared to a conventional BIM model. This is due to the absence of repeatable geometries, the high information density, and the use of diverse tools. Based on this, it is suggested to implement productivity metrics per type of modeled element to improve planning and resource estimation for future projects.

Finally, opportunities for improvement were identified through emerging tools. The incorporation of machine learning to classify ornaments, or the automation of point clouds using artificial intelligence, and the development of plugins that generate data sheets per component could optimize the process.

It is also considered necessary to create a manual of best practices for HBIM projects in Chilean heritage, integrating technical, ethical, and operational criteria.

Although this study focuses on the LMP, the identified challenges are applicable to other heritage buildings, characterized by formal diversity, scarce prior documentation, and limited technical resources. Therefore, this experience is expected to help strengthen the adaptability and application of HBIM in contexts with similar conditions.

6. Conclusion

The digital surveying of the Larraín Mancheño Palace highlights the need to adapt the HBIM methodology to the particularities of built heritage, both in terms of geometric complexity and information management. This research demonstrates that the effective application of HBIM depends on a critical balance between geometric fidelity and computational capacity, as well as on the modeler's judgment in the selection of tools and workflows.

Among the main findings, it is noted that:

- HBIM models can significantly increase production time compared to conventional BIM models due to the uniqueness of heritage elements.
- Resources, such as computer components, also influence HBIM processing times.
- Specific training and regulatory frameworks that recognize heritage demands are required.
- Standardization must progress without nullifying the formal diversity of heritage, through acknowledgment by Chile's existing standard.
- Interoperability between platforms must be strengthened to avoid information loss in hybrid workflows.
- The quality of the HBIM model is deeply influenced by the experience of the modeler and the chosen representation strategy.

Despite its limitations, HBIM presents a powerful framework for integrating technical, historical, and material information about heritage, offering new possibilities for its conservation and dissemination. The experience with the Larraín Palace opens a line of inquiry into the viability and scalability of HBIM in Chile and in similar contexts characterized by high formal diversity, limited prior documentation, and constrained technical resources.

However, as highlighted in recent studies, "interoperability remains a critical issue in HBIM" (Zarogianni et al., 2021, p. 276). In this case, the integration between Rhinoceros and Revit led to partial losses of complex geometric information. Furthermore, it is acknowledged that the modeler's experience influences these losses, as a different modeling strategy or geometry reconstruction approach could have prevented excessive subdivision and, consequently, the inability to transfer the element.

In this context, it is worth asking how much geometric fidelity is truly necessary for an HBIM model to be useful. The experience with the Larraín Palace suggests that an exact reproduction of every shape is not always essential for achieving an operational and meaningful model. In many cases, a simplified representation—properly documented and enriched with contextual information—can be more than sufficient for conservation, management, or heritage analysis purposes.

What makes the model valuable is not just its visual accuracy, but its ability to concentrate and link technical, historical, and conservation data that support decision-making. Thus, a slightly idealized but well-structured model may be more functional than a hyper-realistic one that compromises interoperability or requires unattainable technical resources. Geometric fidelity should not be understood as an end in itself, but as a tool calibrated according to the purpose, resources, and characteristics of the heritage building.

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